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CLIMATE STATISTICS & LONGTERM SERIES OF TEMPERATURE AND PRECIPITATION AT SVALBARD AND JAN MAYEN

E. J. FØRLAND, I. HANSSEN-BAUER AND P.Ø. NORDLI

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Norwegian Meteorological Institute

Abstract

A general description of the climate at Svalbard and Jan Mayen is presented. Climate statistics updated to 1996 are given for eight Norwegian weather stations in the Arctic: Bjørnøya, Hopen, Sveagruva, Isfjord Radio, Longyearbyen, Svalbard Airport, Ny-Ålesund and Jan Mayen. The climate statistics include temperature, precipitation, wind, fog, clouds and snow conditions.

The oldest regular weather stations in the Norwegian Arctic dates back to 1911. Homogenised series for temperature and precipitation at Svalbard Airport are established for the period 1912-96, and for temperature in Ny-Ålesund 1933-96. Trend analysis is performed for all long-term temperature and precipitation series at Norwegian Arctic stations, and the results are compared to results from Northern Europe and the Northern Hemisphere.

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FOREWORD AND ACKNOWLEDGMENT

During the years 1996-1999, the Norwegian Research Council Programme (NRC) is running the research programme «ALV» («Arktisk Lys og varme (Arctic Light and Heat»). The Norwegian Meteorological Institute (DNMI) is participating in this programme through the project «Long term variations in atmospheric circulation and climate in Norwegian Arctic» (NRC-No 112890/720).

The main aims of the DNMI-project is to:

a). Establish a climatological dataset of daily values for all Norwegian Arctic stations

b). Work out comprehensive surveys of climatological statistics for the Norwegian Arctic

c). Analyse long-term variations in atmospheric circulation and climate in the Norwegian Arctic

This report is presenting some results from the work within project NRC-No 112890/720 «Long term variations in atmospheric circulation and climate in Norwegian Arctic»

Thanks to Martin Iden, Per Vidal and Åse Moen Vidal, DNMI for excellent assistance in preparing the dataset, and to Ole Einar Tveito for producing the map in Figure 2.1.

A special thank to Dr. Rudolf Brazdil, Masaryk University of Brno, Czech Republic, for supplying climate data and metadata for Barentsburg.

1. Introduction

Global surface temperatures have increased by about 0.3 to 0.6 °C since the late 19th century (Nicholls et al., 1996). Scenarios based on further increase in greenhouse gases imply that in the middle of the 21st century, the winter temperature in Northern Europe will increase by 2.5 - 4 °C and in summer by 1.0 - 3.0 °C . Precipitation will increase in both winter and summer by 5 - 15%. Most of the results from General Climate Models (GCMs) indicate that the Arctic areas are especially vulnerable to climate change caused by increased greenhouse effect. It is therefore crucial to establish the present conditions and monitor long-term variations of climatic elements in the Arctic.

The climate and long-term climatic variations at the Norwegian Arctic stations are described in earlier reports from the Norwegian Meteorological Institute (Birkeland (1930), Hesselberg & Johannessen (1958), Steffensen (1969), Steffensen (1982)). Other relevant information on the climate of Svalbard are given by Hisdal (1976) and Vinje (1982). A general description of the climate (including climate statistics up to 1990) from Spitsbergen was presented by Hanssen-Bauer et al (1990). The present report updates and extends the climate statistics to include observations up to 1996. In addition to the Spitsbergen series (Svalbard Lufthavn/Longyearbyen, Isfjord Radio, Ny-Ålesund and Sveagruva), also series from Bjørnøya, Hopen and Jan Mayen are included.

Real climatic trends may be masked or amplified when analyses are based upon inhomogeneous series, and it is accordingly important to adjust series for inhomogeneities before they are used in studies of long-term climate variations. Earlier studies have revealed that inhomogeneities in meteorological elements often are of the same magnitude as typical long-term trends (Hanssen-Bauer & Førland,1994, Nordli et al.,1996a). Unfortunately it is complicated to establish reliable long-term climatic series. Inhomogeneities in Arctic series may be caused by relocations of sensors, changed environment (buildings etc.) and instrumental improvements. Because of the harsh weather conditions, even small changes at Arctic measuring sites may cause substantial changes in measuring conditions for precipitation. Identification of inhomogeneities in Arctic series is also complicated by the sparse station network. A survey of inhomogeneities and adjustment factors for the Norwegian Arctic temperature and precipitation series are given by Nordli et. al., 1996b.

2. Area and stations

The Norwegian part of the Arctic consists of Svalbard (Spitsbergen, Bjørnøya (Bear Island) and Hopen) and Jan Mayen (Figure 2.1). The oldest meteorological observations from this area were made during expeditions, usually of about one years duration, to different places on Svalbard or Jan Mayen. In 1911 a permanent weather station was established in Green Harbour at Vest-Spitsbergen, and in the years 1920-30 weather stations were also established at Bjørnøya, Jan Mayen and in East-Greenland. Table 2.1 shows a list of closed meteorological stations at Svalbard, East-Greenland and Jan Mayen that are not used in this report.

Table 2.1. Survey of closed Norwegian Arctic meteorological stations

Station	Latitude	Longitude	Observation period
Storøya	76° 30' N	16° 30' E	1908-09, 1911-12,1914-15
Akseløya	77° 42'N	14° 50'E	1898-99, 1900-01, 1902-03, 1904-05, 1910-11
Green Harbour	78° 02'N	14° 14'E	1911-30
Kvadehuken	78° 57'N	11° 42'E	1912-24 (incomplete)
Andersonøya	78° 20'N	20° 44'E	1894-95
Kap Lee	78° 06'N	20° 55'E	1904-05
Hvalfiskpynten	77° 30'N	21° 00'E	1894-95, 1904-05, 1906-07, 1908-09
Zieglerøya	77° 20'N	22° 02'E	1904-05
Halvmåneøya	77° 17'N	23° 05'E	1906-07
Nordaustlandet	80° 04'N	22° 24'E	1944-45 (German observations)
Hotellneset	78° 15'N	15° 33'E	1964-??
Båtvika (Jan Mayen)	70° 56'N	08° 43'W	1960-62
Myggbukta (Greenland)	73° 29'N	21° 34'W	1922-23, 1926-40, 1946-59
Finnsbu (Greenland)	63° 24'N	41° 17'W	1932-35
Torgilsbu (Greenland)	60° 32'N	43° 11'W	1932-40

The available climate data from Norwegian Arctic is rather limited. The present network of weather stations (cf. Table 2.2) consists of five stations at Spitsbergen (Hornsund, Sveagruva, Barentsburg, Svalbard Airport and Ny-Ålesund) and three stations at Arctic islands (Bjørnøya, Hopen and Jan Mayen). Detailed description of the *Norwegian* Arctic stations are given in Appendix A1-A8. The weather stations Hornsund and Barentsburg are operated by Poland resp. Russia. All stations on Spitsbergen are situated at the western coast (Figure 2.1), and none of the stations have higher altitudes than 80 m a.s.l. The highest mountains on Spitsbergen are ranging more than 1700 m a.s.l., and very little is known about the climate conditions in the mountain areas. In addition to the stations in Table 2.2, DNMI is operating four automatic stations recording pressure and air temperature at Edgeøya (78° 15'N, 22° 47'E), Gråhuken (77° 10'N, 16° 30'E), Phippsøya (80° 68'N, 20° 86'E) and Kvitøya (80° 10'N, 31° 40'E).

Table 2.2. Survey of meteorological stations in the Norwegian Arctic used in this report

St.no	Station name	Latitude	Longitude	Observation period
99710	Bjørnøya	74° 31' N	19° 01' E	1920- *
99720	Hopen	76° 30'N	25° 04'E	1944- *
99750	Hornsund	77° 00'N	15° 34'E	1978-
99760	Sveagruva	77° 54'N	16° 48'E	1978-
99790	Isfjord Radio	78° 04'N	13° 38'E	1934-76 *, (1996-, reduced obs.programme)
99820	Barentsburg	78° 07'N	14° 13'E	1933- *
99821	Green Harbour	78° 05'N	14° 14'E	1911-1930
99840	Svalbard Airport	78° 15'N	15° 28'E	1975-
99860	Longyearbyen	78° 13'N	15° 35'E	1916-77 *
99900	Ny-Ålesund I	78° 56'N	11° 53'E	1969-74
99910	Ny-Ålesund II	78° 55'N	11° 56'E	1974-
99950	Jan Mayen	71° 01'N	8° 40'W	1921- *

* For survey of missing data, see Nordli et al., 1996b

Figure 2.1 Location of meteorological stations in the Norwegian Arctic

3. Climate at the Norwegian Arctic stations

According to Köppens system of climate classification, the stations at Spitsbergen have a «Polar Tundra climate (ET)» (Hanssen-Bauer et al.,1990). However, because of topographical effects and various geophysical factors affecting the Arctic climate, there are large variations in climate elements both in time and space. The longterm variations are described in chapter 4; in this section some climate statistics from the Arctic stations are presented.

Tables with basic statistics for Bjørnøya, Hopen, Svalbard Lufthavn, Longyearbyen, Sveagruva, Isfjord Radio, Ny-Ålesund and Jan Mayen are given in Appendix A1-A8. The statistics are based on observations for an optimal data period at each station. The periods of observations are different for different stations and elements (see Appendix A1-A8). One should therefore be careful in drawing conclusions by comparing frequencies or mean values from different stations. For conclusions concerning significant differences between stations, a common data period or the international standard normal period 1961-1990 should be used as reference. Some normal values are presented in section 3.7.

3.1 Factors affecting the Arctic climate

3.1.1. Light and radiation conditions

The closer one comes to the North pole, the more marked is the annual variation and the less marked the diurnal variation in light conditions. All the Norwegian Arctic stations experience continuous daylight 3-4 months in summer with a net radiative heat gain, and 3-4 months continuous darkness during winter with a net radiative heat loss. As minimum cloudiness occurs in winter (cf. Figs. 3.5 & 3.6), there is a considerable radiation heat loss from the ground during this season. Maximum cloudiness occurs in summer, resulting in few hours of bright sunshine. Hanssen-Bauer et al (1990) studied the influence of cloudiness on temperature throughout the year. In January-March, the daily temperature was more than 10 °C higher on overcast than on clear days at both Svalbard Lufthavn, Ny-Ålesund and Sveagruva. During June-August however, the temperature on clear days was found to be a few degrees centigrade higher than on overcast days.

3.1.2. Sea currents and ice limits

The prevailing warm and cold sea currents are factors of great importance to the climate in the Arctic. The warm Norwegian Current flows partly into the Barents Sea, and partly towards the west coast of Spitsbergen where in winter it creates the northernmost area of open water in the Arctic. To the west, the cold East Greenland Current flows southwards along the coast of Greenland. East of Svalbard a similar cold current moves southwest towards Bjørnøya, with a branch passing northwards between the warm Atlantic Current and the west coast of Spitsbergen. Maps of sea ice concentration in the Greenland and Barents Seas are presented by Vinje (1982).

3.1.3 General atmospheric circulation

The general large scale air currents over the Northern Atlantic Ocean are determined by the low pressure area near Iceland and an area with relatively high pressure over Greenland and the Arctic Ocean. Between Iceland and Norway the prevailing winds are westerly or southwesterly, resulting in a transport of mild air from lower latitudes towards the Svalbard area. Winter maps show, on the average, four to six cyclones per month over the Norwegian-Barents-Kara Seas (Orvig 1970). Further north circulation is mostly anticyclonic with prevailing easterly and northeasterly winds. Great temperature differences occur between the two air masses originating from the southwest and northeast. Variation in the extension of air masses and sea ice causes great fluctuations in weather conditions. The largest variation occurs in winter, when the contrast in temperature between the two air masses is most marked.

3.2 Air temperature

The most remarkable features concerning winter air temperature are the relatively high mean values and great fluctuations which occur, considering the high latitude. At e.g. Svalbard Airport, the difference between the highest and lowest monthly mean in December - March is about 25 °C (cf. Figure 3.1). At Bjørnøya the similar difference is about 20 °C and at Jan Mayen 15 °C.

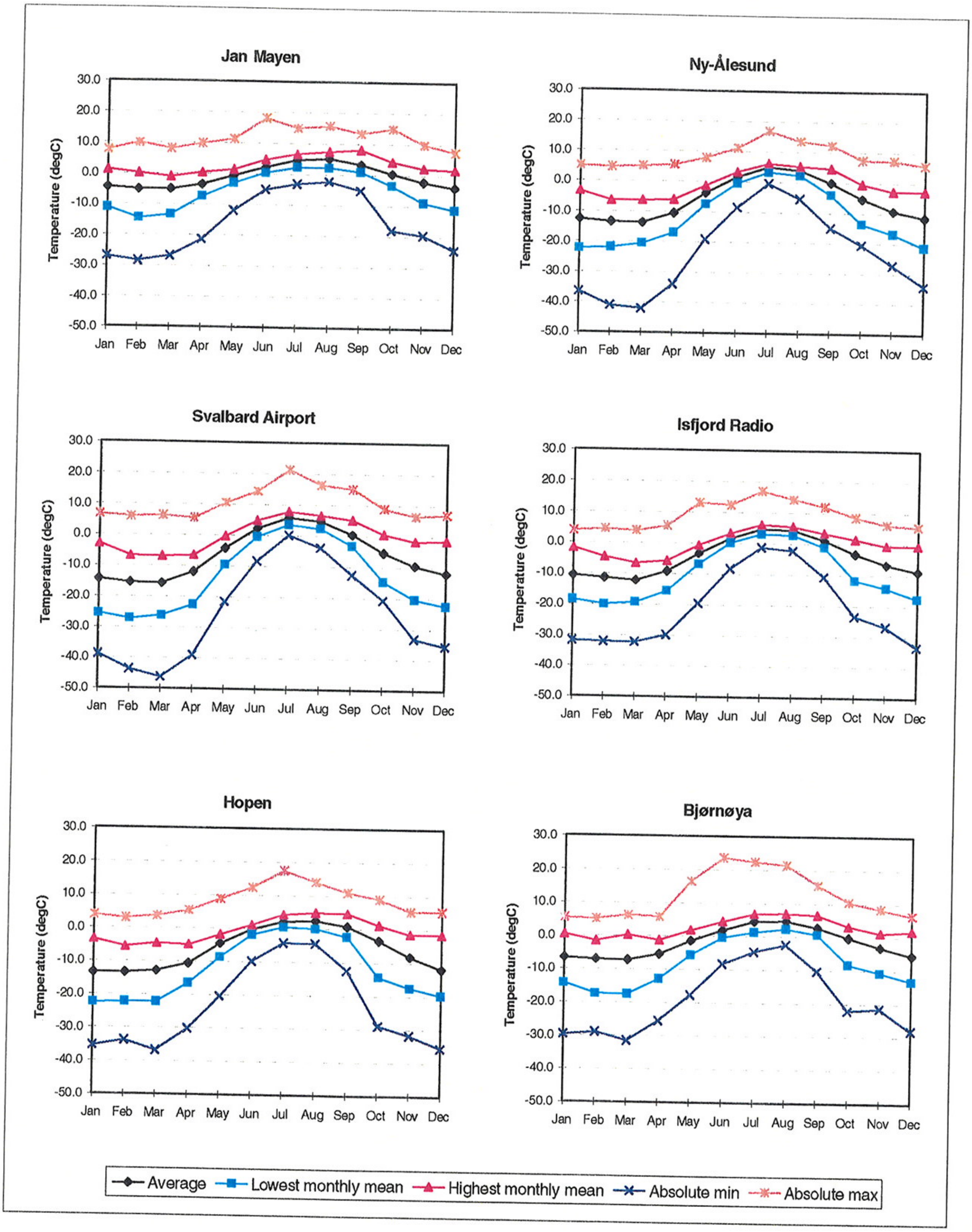

Figure 3.1 Average and extreme temperatures at six Arctic stations
(For further details, see Appendix A1-A8)

Among the stations on Spitsbergen; Sveagruva and Longyearbyen/ Svalbard Airport have the most continental climate, with winter temperatures 2 - 5 °C lower, and summer temperatures 1-2 °C higher, than at the coastal station at Isfjord Radio. Sveagruva usually has the lowest winter temperatures, while the two southernmost stations Bjørnøya and Jan Mayen have the highest. The mean winter temperature at Ny-Ålesund and Longyearbyen are similar. During summer, Longyearbyen has the highest temperatures, while the mean temperatures at Ny-Ålesund and Isfjord Radio are similar. This tendency for a more «continental» climate during winter than during summer is, to some extent , also found at other stations. It may be explained by the stations proximity to fjords that are frozen during winter.

January-March is normally the coldest part of the year (cf. also fig 3.8). Even during these months, temperatures of 3-7 °C have been recorded at all stations. At Jan Mayen even temperatures up to 10 °C may occur during this time of the year. At the stations covered by this report, the lowest recorded temperature in the Norwegian Arctic is -46.3 °C (Svalbard Airport 4.March 1986). Also at Sveagruva and Ny-Ålesund temperatures below -40 °C have been recorded. At Bjørnøya the lowest recorded temperature is -31.6 °C, and at Jan Mayen -28.4°C.

Summer temperatures show a marked uniformity in the Arctic. The normal temperatures during the two warmest months is around 2 °C at Hopen, compared to 4-6 °C for the other stations (see Table 3.1). Differences between the highest and the lowest monthly means in June, July and August are only 2 - 5 °C at all stations. Minimum temperatures of several degrees below 0°C occur throughout summer. Only rarely do maximum temperatures reach above 15°C, but temperatures above 20 °C have occasionally been recorded at Bjørnøya and Svalbard Airport.[1]

During the winter season, minimum temperatues are below 0°C for most days even at the southernmost stations Bjørnøya and Jan Mayen (Appendix A1-A8). During July and August the daily maximum temperatures usually exceeds 0°C .

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[1] On the 31. August 1997, the maximum temperature in Ny-Ålesund was 18.3°C. This is the highest maximum temperature recorded at Spitsbergen in August. At the same day the maximum temperature was 18.1°C at Svalbard Airport and 18.8°C at Bjørnøya.

3.3 Precipitation

Precipitation is normally low in the Arctic because air masses usually are stable stratified and contain small amounts of water vapour. The normal (1961-1990) annual precipitation in the Svalbard region is 190 - 525 mm, and at Jan Mayen 687 mm/yr (cf. Table 3.3 and Figure 3.10). The annual value at Svalbard Airport (190 mm/yr) is the lowest normal value at any Norwegian station. Mean monthly precipitation is at a minimum during the period April - June (Figure 3.11). It should be emphasized that except for the normal values, the monthly values for different stations plotted in Figure 3.2 originate from measurements taken during different periods (See tables in Appendix A1-A8). The highest annual precipitation amount recorded at Spitsbergen is 750 mm (Isfjord Radio, 1972), the highest monthly is 230 mm (Ny-Ålesund, November-1993), and highest daily 57 mm (Ny-Ålesund 1.Dec 1993).

One peculiar feature is that both rain and snow (mixed precipitation) may occur at any time of the year at all Norwegian Arctic stations (Appendix A). It should be stressed that reliable measurements of precipitation are difficult to obtain under certain weather conditions. At the Arctic stations blowing or drifting snow may cause substantial problems. For instance, the gauge at *Hopen* caught 190 mm «precipitation» due to blowing snow during 3 days in January 1995. «Precipitation» just caused by blowing snow are excluded through the quality control at DNMI, but in several occasions there are a combination of precipitation and blowing snow. In such cases it is difficult to distinguish the proportions of real precipitation and blowing snow.

On the other hand, the harsh weather conditions in the Arctic increase dramatically the catch deficiency of the precipitation gauges. A large proportion of the precipitation falls as snow during high wind speeds, and under such conditions the conventional gauges just catch a small fraction of the "ground true" precipitation (Førland et.al.,1996). Based on field measurements in Ny-Ålesund, Hanssen-Bauer et al. (1996b) deduced correction factors for the aerodynamic catch deficiency in the Norwegian precipitation gauge. The correction factor was found to increase exponentially with increasing wind speed. For solid precipitation, the correction factor was increasing with decreasing air temperatures, and for liquid precipitaton it was increasing with decreasing rain intensities.

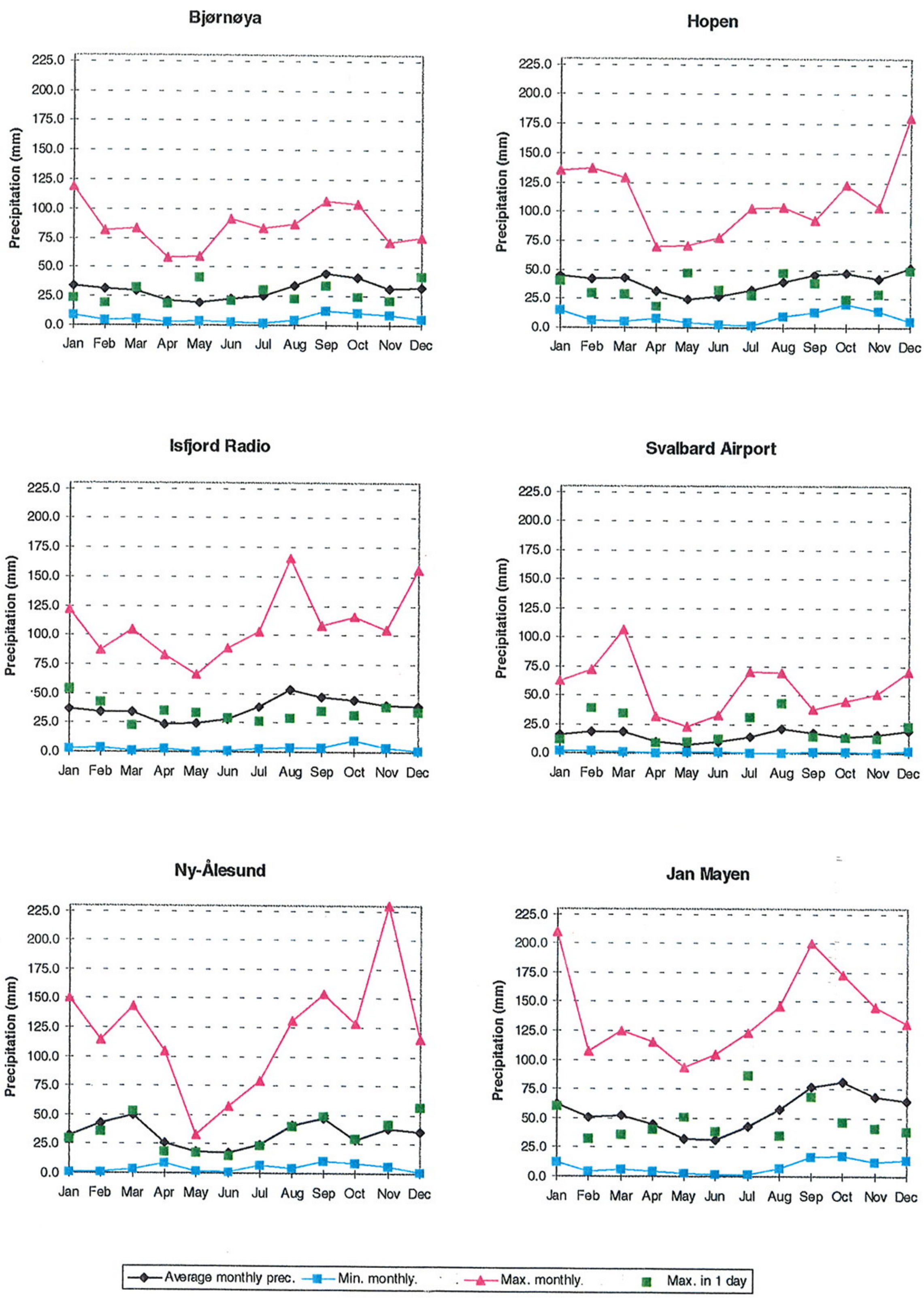

Figure 3.2 Average and extreme precipitation amounts at six Arctic stations
(For further details, see Appendix A1-A8)

Hanssen-Bauer et al. (1996b) concluded that for solid precipitation, a typical aerodynamic correction factor in Ny-Ålesund would be 1.65-1.75, for liquid precipitation it would be 1.05-1.10 and for sleet and mixed precipitation it would be around 1.40. As a rough estimate it was suggested that for a «normal» year in Ny-Ålesund, the true normal precipitation would be about 50% higher than the official uncorrected value in Table 3.3.

Most of the precipitation in the Svalbard region occurs in connection with cyclones coming in from the Southwest-Northwest sector. However, as Spitsbergen is situated at the northern side of the main cyclone track, precipitation under easterly winds is common. The mountain regions receive the greatest amounts of precipitation and the inner fjord districts the least; but the topography causes large local differences. Maps of distribution of annual precipitation at Spitsbergen have been based mainly on snow depth measurements, glacier accumulation studies and scattered streamflow measurements. Investigations of the distribution of glacial ice and the height of the snow line indicate large differences in annual snow accumulation on Spitsbergen (Hagen & Liestøl, 1990). The highest accumulation is found along the coastal mountains, especially in southeast, while the lowest accumulation occurs in the inner fjord areas, especially in northeast.

Scattered measurements confirm that the annual precipitation in the mountain areas of Spitsbergen is substantially larger than the measured amounts at the regular weather stations at the coast (see e.g. Steffensen, 1982; Jania & Pulina, 1994; Osokin et al.,1994). Even after subtracting contribution from glacier ablation, the streamflow measurements from e.g. the river Bayelva near Ny-Ålesund are indicating substantially higher river discharge than can be explained by the precipitation measured at the weather station in Ny-Ålesund (Killingtveit et al.,1994; Pettersson, 1994). Hagen & Lefauconnier (1995) found that the mean *winter* snow accumulation on Brøggerbreen during the period 1967-1991 was 720±160 mm in water equivalent. On the other hand the mean *annual* precipitation (1961-90) measured at the weather station in Ny-Ålesund is just 385 mm/year (Table 3.3).

Because of lifting and consequent cooling of airmasses over hills and mountains, precipitation is usually increasing with increasing altitude (see e.g. Førland, 1979). Preliminary analyses of precipitation distribution on Spitsbergen based on an extended network of gauges, indicated a

5-10% increase in measured summer precipitation for each 100 m increase in altitude (Killingtveit et al., 1994). Based on snow surveys in two catchments, a probable vertical gradient of 14% per 100 m was assumed (Tveit & Killingtveit, 1994) In the Ny-Ålesund/Brøggerbreen area, Hagen & Lefauconnier (1995) found that the altitudinal increase of snow accumulation had a fairly constant gradient of 100 mm per 100m;- equivalent to a 25% increase per 100 m altitude.

In a profile study across the glacier Austre Brøggerbreen, Førland et al. (1997) found that the total precipitation amount at the glacier during the summer seasons 1994-95 was about 45% higher than recorded at the weather station in Ny-Ålesund. It was also found that the precipitation distribution in the Ny-Ålesund area was strongly dependent on the wind direction. For large-scale winds from South and Southwest, the precipitation at the glacier was about 60% higher than in Ny-Ålesund, while for winds from Northwest Ny-Ålesund got more precipitation than the stations at the glacier. The high precipitation amounts recorded at the central areas of the glacier are probably caused by a combination of spillover and seeder/feeder effects. A rough altitude-precipitation increase in the Ny-Ålesund area was estimated to be 20% per 100 m, at least up to 300 m a.s.l.

Førland et al. (1997) concluded that the apparent discrepancy between precipitation measured in Ny-Ålesund and runoff/massbalance estimates for the Bayelva catchment could be fully explained by aerodynamic catch deficiency in the precipitation gauge in Ny-Ålesund and orographic precipitation enhancement in the glacier area.

3.4 Wind

Seasonal percentage frequencies of different wind directions demonstrate that the prevailing winds are from the northeast-southeast sector at Spitsbergen, except during summer (Hanssen-Bauer et al.,1990). At each station the most common wind direction is along valleys or fjords from the inland to the coast. This is partly caused by the topography's channeling effect on the large-scale windfield, which often has an easterly component, and partly by drainage winds transporting cold «heavy» air from the inland glaciers to the warmer sea.

As the Norwegian Arctic lies in the border zone between cold arctic air from the north and mild maritime air from the south, the cyclonic activity is great. Unstable and stormy weather is therefore common in winter. During October-March, Bjørnøya, Isfjord Radio and Jan Mayen have an average of more than 15-20 days/month with maximum wind force ≥ 6 Beaufort, and 1-5 days with wind force stronger than fresh gale (9B). (See Appendix A1-A8). The wind at Isfjord Radio is strengthened locally by Isfjorden, which is narrower at the mouth than further in. At the other Spitbergen stations, the frequencies of strong winds are substantially lower than at Isfjord Radio (Figure 3.3).

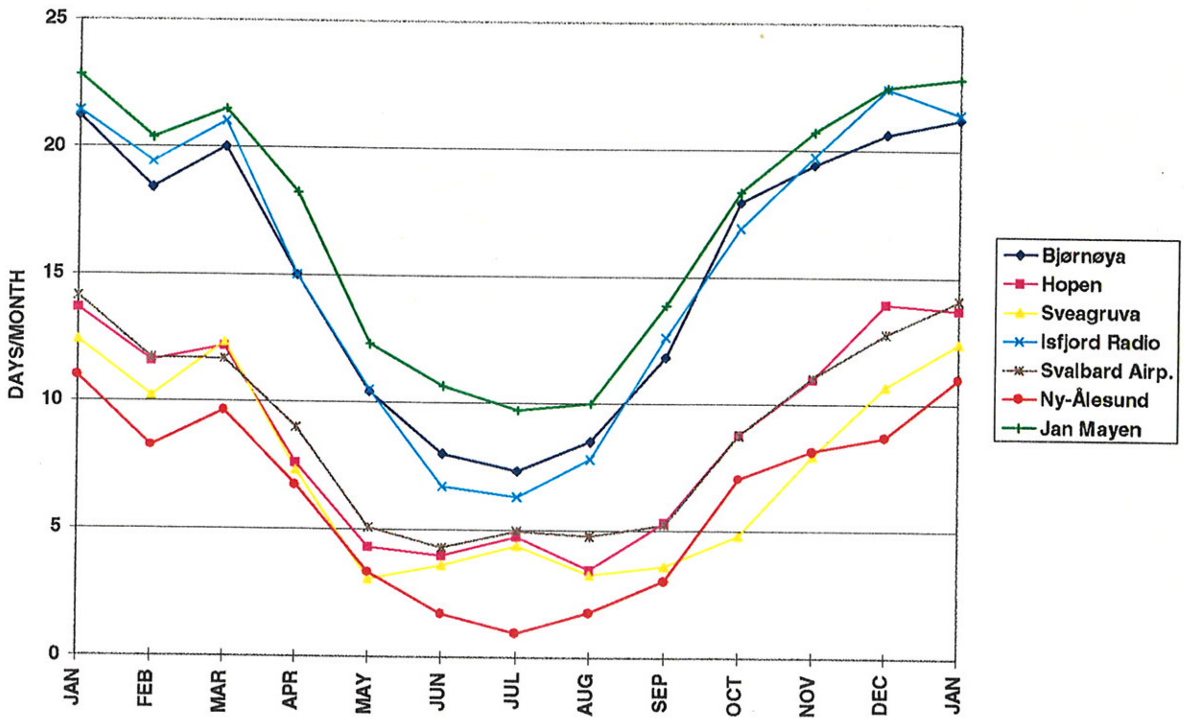

Figure 3.3. Number of days with maximum wind force ≥ 6 Beaufort (Strong Breeze)

3.5 Clouds and fog

During the summer, arctic sea fog is formed by advection of mild, humid air over a colder surface. Consequently, the mean monthly percentage frequencies of fog at the Arctic stations show maxima in June-August (Figure 3.4). The fog frequency is highest at the the islands Bjørnøya, Hopen and Jan Mayen. At Hopen, fog is present at almost half of the observations during July and August. However, in the inner fjord districts of Spitsbergen fog seldom occurs.

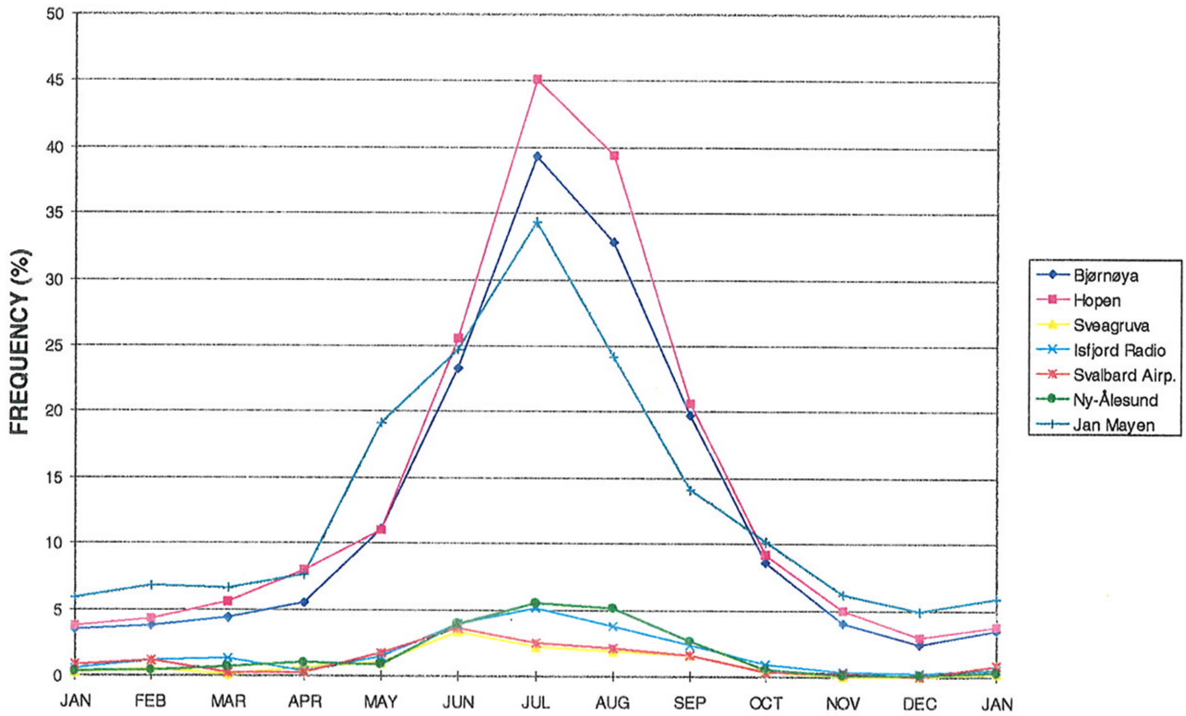

Figure 3.4. Frequencies of fog

The number of overcast days is high during summer (Figure 3.5). From May to October, more than 50% of the days are overcast at most Arctic stations.

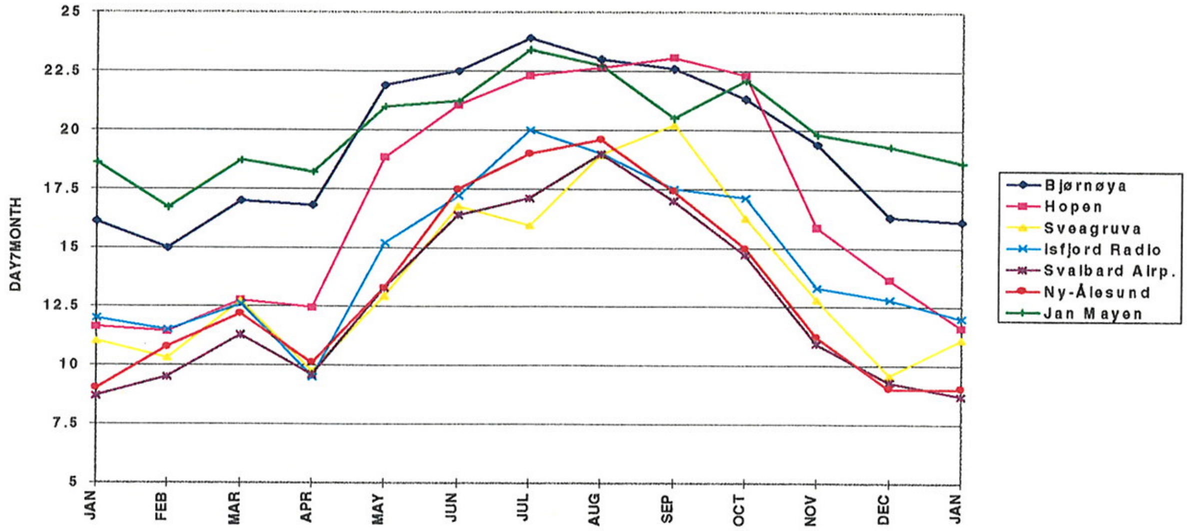

Figure 3.5. Number of days with overcast sky

The greatest number of clear days occurs during November-April (Figure 3.6). At Ny-Ålesund the number of clear days is 8-9 in December and January. At Bjørnøya and Jan Mayen, clear skies occur less than 1 day/month through the whole year. The annual values of global radiation and duration of bright sunshine are small at the west coast of Spitsbergen. At Isfjord Radio, the annual mean duration of sunshine is 25% of the theoretical maximum (Hanssen-Bauer et al.,1990). Highest duration of bright sunshine occurs in May; maximum value for global radiation in June.

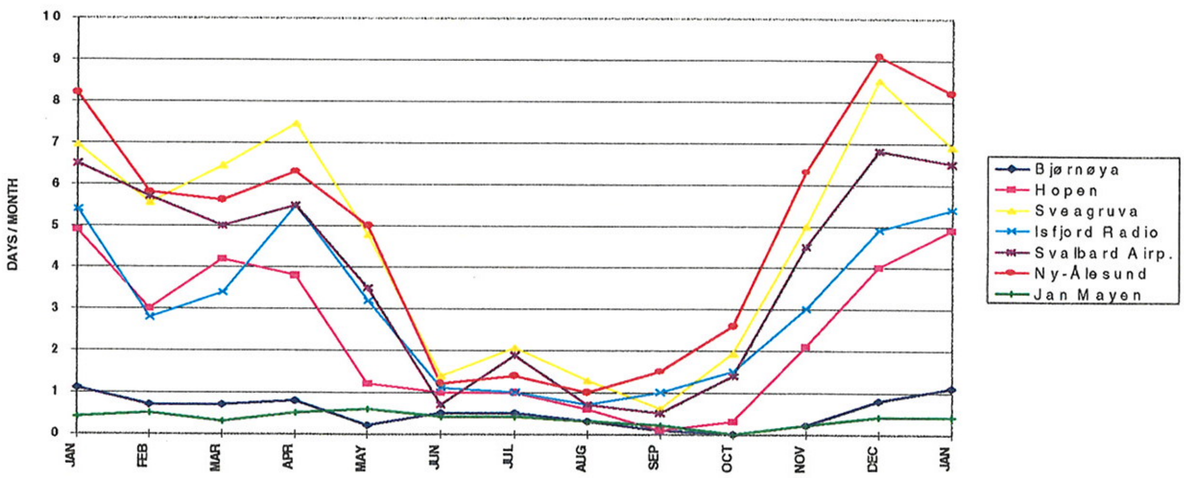

Figure 3.6. Number of days with clear sky

3.6 Snow

Precipitation as snow (and rain) may occur at any time of the year at all Norwegian Arctic stations (cf. Appendix A1-A8). E.g. at Svalbard Airport there is 1-3 days/month even in July and August with precipitation ($\geq$0.1 mm) as snow or mixed liquid/solid precipitation.

At the Arctic stations, the combination of dry snow and open tundra results in considerable snow drifting, even at moderate windspeeds. During November - March, drifting or blowing snow is observed at more than 20% of the observations at Hopen, Sveaguva and Jan Mayen (Figure 3.7). Drifting/blowing snow often occurs in combination with snowfall, and complicates the precipitation measurements (see section 3.2).

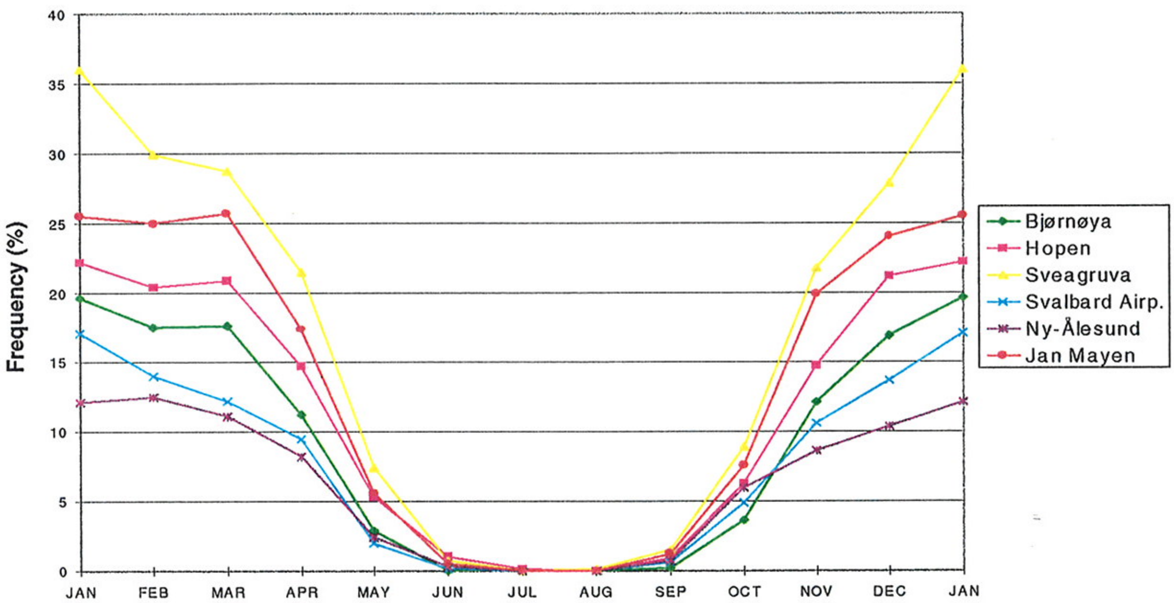

Figure 3.7 Frequencies of observations with drifting/blowing snow

Because of the harsh weather conditions, measurements of snow depth and snow cover are difficult to perform at most Arctic stations. Snow depth is likely to vary locally, and the snow depth measurements are therfore seldom representative of the snow accumulation or the mean snow depth over large areas. Consequently, measurements of snow cover and depth have been given little priority at Arctic stations. There are significant gaps in the data, and the data should therefore be used with caution. At Svalbard Airport (1977-93), the maximum observed snow depth was 56 cm (April, 1986, Appendix A5), and at Isfjord Radio (1956-75) 110 cm (May 1964, Appendix A4)

3.7 Normal values (1961-90) of temperature and precipitation

Normals are defined (WMO, 1989) as «period averages computed for a uniform and relatively long period comprising at least three consecutive ten-year periods». *Climatological standard normals* are defined as «averages of climatological data computed for consecutive periods of 30 years as follows: 1901-30, 1931-60,1961-90 etc». In the case of series where some data are missing, provisional normals are calculated, based on comparisons with neighbouring stations with complete records. In this report «normals» are used synonymous with «climatological standard normals».

Temperature normals (1961-90) are presented in Table 3.1 and Figure 3.8. Due to recent homogeneity testing and adjustments (Nordli et al.,1996b), the normals for Svalbard Airport and Ny-Ålesund deviate from those published by Aune (1993). The normals for Bjørnøya, Hopen, Barentsburg and Jan Mayen are calculated from the original data without adjustments, whereas the normals for Isfjord Radio and Sveagruva are according to Aune (op.cit.). The normals for Hornsund are calculated by use of data given by Dr. M.Mietus Inst.of Meteorology and Water Management, Gdynia, Poland. Missing data during the period 1981.08-1982.07 is interpolated by Przybylak (1992).

The largest variations in monthly temperatures are found during the winter season (Table 3.2), when the standard deviation is more than four times larger than for the summer months. Hopen has the largest year-to-year variations; Jan Mayen the lowest.

By analysing the period 1946-65, Steffensen (1969) stated that the coldest month in the Arctic area was March. This was valid also for the normal period 1931-60 (DNMI, 1989) with Jan Mayen as the only exception. Since the 1930's the spring temperature has increased, whereas the winter temperature has decreased (see section 4.4). This has led to that for most of the stations February now is the coldest month (Figure 3.8). The change has been especially drastic in the south-eastern part of the area where the coldest month was March (1931-60), but are now January (1961-90).

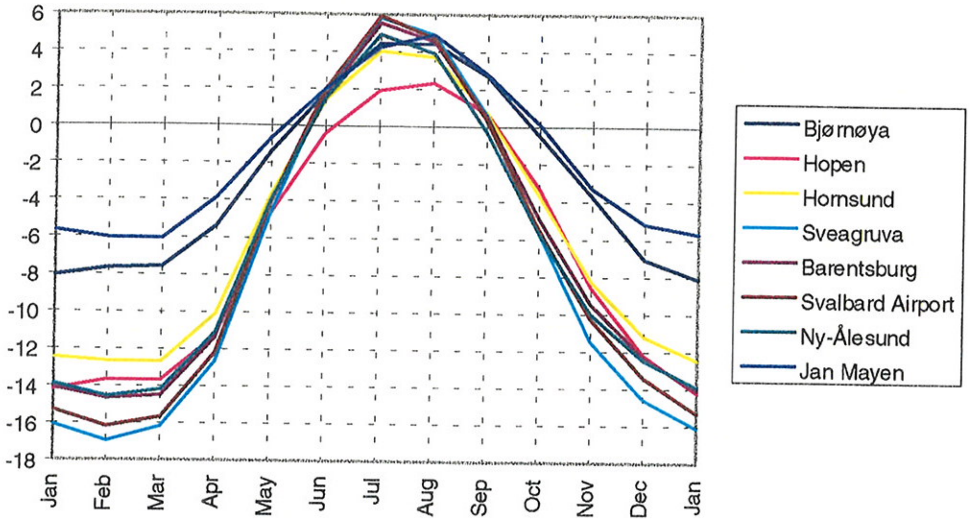

Figure 3.8 Standard normals (1961-90) of air temperature (°C)

Table 3.1. Normal values (1961-90) for air temperature (°C)

ST.NO.	STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
99710	BJØRNØYA	-8.1	-7.7	-7.6	-5.4	-1.4	1.8	4.4	4.4	2.7	-0.5	-3.7	-7.1	-2.4
99720	HOPEN	-14.2	-13.7	-13.7	-11.3	-4.7	-0.4	1.9	2.3	0.7	-3.3	-8.6	-12.2	-6.4
99750	HORNSUND	-12.5	-12.7	-12.7	-10.1	-3.7	1.4	4.0	3.7	0.7	-3.7	-8.3	-11.2	-5.4
99760	SVEAGRUVA	-16.1	-17.0	-16.2	-12.7	-4.7	1.9	5.8	4.9	0.6	-5.7	-11.5	-14.6	-7.1
99790	ISFJORD RADIO	-12.1	-12.4	-12.0	-9.5	-3.2	1.6	4.8	4.2	0.6	-4.0	-8.0	-10.6	-5.1
99820	BARENTSBURG	-14.1	-14.7	-14.5	-11.4	-4.1	1.6	5.5	4.5	0.5	-4.9	-9.5	-12.3	-6.1
99840	SVALBARD AIRPORT	-15.3	-16.2	-15.7	-12.2	-4.1	2.0	5.9	4.7	0.3	-5.5	-10.3	-13.4	-6.7
99860	LONGYEARBYEN	-14.6	-15.2	-14.5	-11.0	-3.1	2.9	6.5	5.2	0.5	-5.5	-10.2	-12.9	-6.0
99900	NY-ÅLESUND	-13.9	-14.6	-14.2	-11.1	-4.0	1.5	4.9	3.9	-0.3	-5.7	-10.0	-12.5	-6.3
99950	JAN MAYEN	-5.7	-6.1	-6.1	-3.9	-0.7	2.0	4.2	4.9	2.8	0.1	-3.3	-5.2	-1.4

Table 3.2 Standard deviation of air temperature (°C) during the normal period 1961-90.

ST.NO.	STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
99710	BJØRNØYA	3.7	3.9	4.0	2.2	1.4	1.2	1.2	1.0	1.2	2.0	2.7	3.7	1.4
99720	HOPEN	5.1	4.4	4.8	3.0	1.4	0.8	0.9	1.0	1.3	3.0	4.6	5.2	1.8
99820	BARENTSBURG	4.7	3.4	4.0	2.8	1.4	1.1	0.8	0.6	1.5	2.5	3.3	4.3	1.5
99840	SVALBARD AIRPORT	5.1	3.9	4.1	2.9	1.5	1.2	0.9	0.6	1.6	2.8	3.6	4.6	1.6
99910	NY-ÅLESUND	4.5	3.4	3.7	2.8	1.3	0.9	0.8	0.6	1.7	2.5	3.2	4.1	1.4
99950	JAN MAYEN	3.0	3.1	2.8	1.7	1.0	0.8	0.7	0.9	0.9	1.7	2.1	2.5	1.0

The variation of the thirty years seasonal running means is shown in Figure 3.9. The figure clearly demonstrates the increasing difference between spring and winter mean temperature. It will also be seen that a rather peculiar coincidence of events has occurred in winter and autumn: The 1931-60 normal is one of the highest, and the 1961-90 normal one of the lowest 30-years means during the whole observation period. Thus, comparing the old normals to the new ones leaves a somewhat exaggerated impression of the temperature decrease in the Arctic.

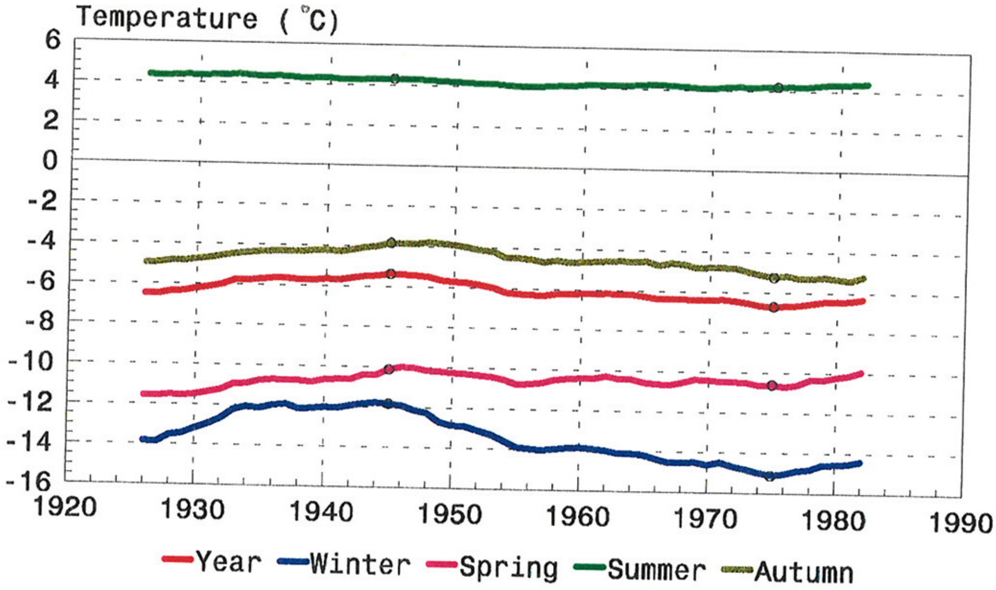

Figure 3.9 Seasonal and annual thirty years running mean temperatures at Svalbard Airport. The standard normals 1931-60 and 1961-90 are marked by circles.

The monthly and annual normals of precipitation amount and number of days with precipitation exceeding some threshold values are given in tables 3.3-3.6. Due to recent homogeneity testing and adjustments (Nordli et al.,1996b), the normals in Table 3.3 for Hopen, Isfjord Radio, Svalbard Airport, Ny-Ålesund and Jan Mayen deviate from those published by Førland (1993). The normals for Bjørnøya are calculated from the original data without adjustments.

Table 3.3. Normal values (1961-90) of precipitation amount (mm)

ST.NO.	STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
99710	BJØRNØYA	30	33	28	21	18	23	30	36	44	44	33	31	371
99720	HOPEN	39	42	41	32	24	30	35	39	46	47	47	54	476
99750	HORNSUND	28	30	32	20	18	36	40	46	48	45	32	30	405
99760	SVEAGRUVA	29	35	31	24	15	9	11	19	19	20	22	26	260
99790	ISFJORD RADIO	41	36	40	34	25	30	37	54	54	45	41	43	480
99820	BARENTSBURG *	49	46	50	39	26	23	28	39	54	62	59	50	525
99840	SVALBARD AIRP.	15	19	23	11	6	10	18	23	20	14	15	16	190
99910	NY-ÅLESUND II	32	36	45	23	18	18	28	38	46	37	33	31	385
99950	JAN MAYEN	56	53	55	40	40	37	47	61	82	82	65	65	683

* The normal values for Barentsburg are based on preliminary data, and are not official normal values

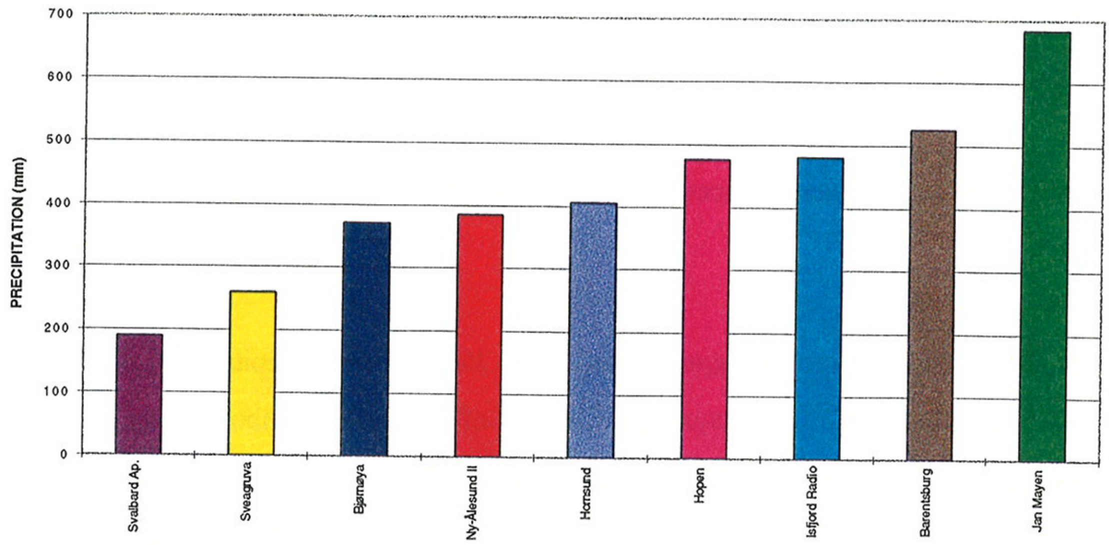

Figure 3.10 Standard normals (1961-90) of annual precipitation

Figure 3.10 shows that the mean annual precipitation amount at the stations on Spitsbergen, Bjørnøya and Hopen is 200-500 m, while it is almost 700 mm at Jan Mayen. Most of the precipitation in the area occurs in connection with cyclonic activity in the border zone between cold arctic air and mild maritime air. Jan Mayen lies closer to the most common cyclonic track than the other stations, and thus receives more precipitation. Figure 3.10 illustrates that there are also large differences between the Spitsbergen stations: The measured annual precipitation in Barentsburg is almost 3 times as high as at Svalbard Airport, only 35 km away.

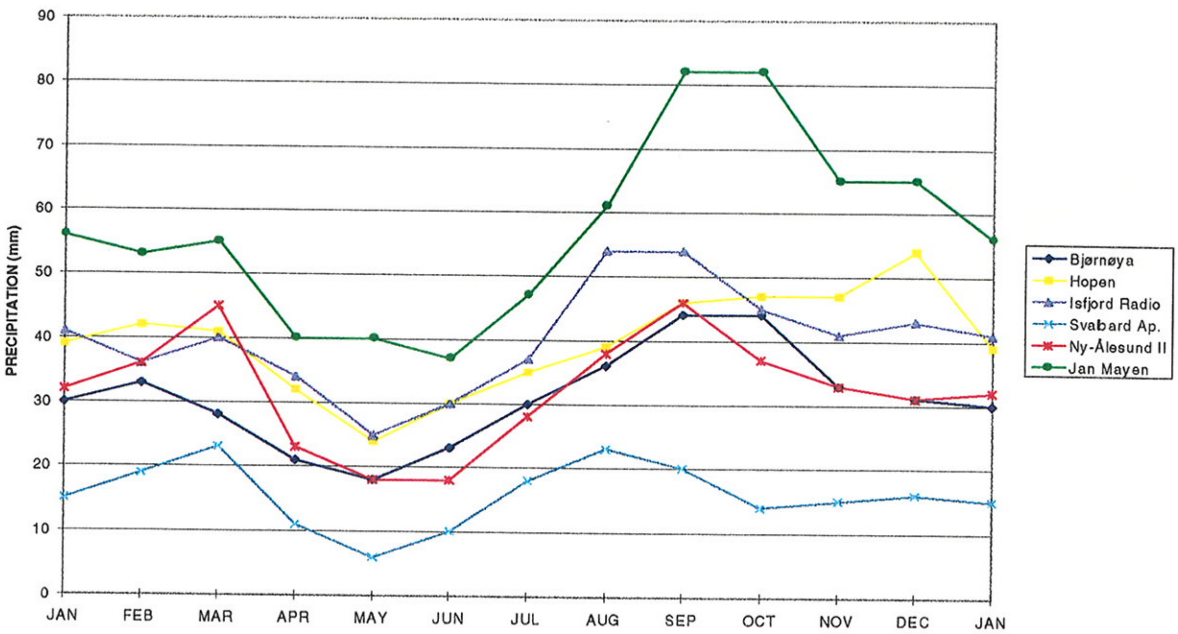

Figure 3.11 Standard normals (1961-90) of monthly precipitation

This difference may be caused by the fact that Svalbard Airport has a more sheltered position further in the fjord Isfjorden.

The highest monthly precipitation occurs in August-October and March, the lowest in May-June (Figure 3.11).

Table 3.4 shows that at both Bjørnøya, Hopen and Jan Mayen precipitation ($\geq$0.1 mm) is observed at more than half of the days in all months of the year. Number of days with high precipitation (>10 mm) is low at all stations (Table 3.6). (For the other Arctic stations, normal values of number of precipitation days are not available, but for each station a survey for the whole observation period is included in the tables in Appendix A1-A8).

Table 3.4 Normal values (1961-90) of number of days with daily precipitation $\geq$ 0.1 mm

ST.NO.	STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
99710	BJØRNØYA	20.4	20.2	20.4	18.4	16.7	15.5	16.8	18.5	21.2	22.5	21.3	21.1	233.0
99720	HOPEN	18.9	18.4	18.0	16.1	17.3	16.3	16.9	19.2	21.8	22.8	21.9	19.7	227.3
99760	JAN MAYEN	22.6	20.5	22.7	19.3	16.8	16.4	18.3	19.7	22.3	23.4	23.8	23.0	248.9

Table 3.5. Normal values (1961-90) of number of days with daily precipitation $\geq$ 1.0mm

ST.NO.	STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
99710	BJØRNØYA	8.6	9.4	8.7	6.5	5.1	6.1	7.0	6.8	10.0	10.3	9.3	8.8	96.6
99720	HOPEN	9.8	9.0	8.9	7.1	5.5	6.2	7.2	8.0	11.2	11.2	10.4	9.8	104.5
99760	JAN MAYEN	12.6	11.1	12.1	9.1	7.6	7.6	9.2	11.1	13.3	14.6	12.9	13.0	134.2

Table 3.6. Normal values (1961-90) of number of days with daily precipitation $\geq$ 10.0mm

ST.NO.	STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
99710	BJØRNØYA	0.1	0.2	0.1	0.0	0.1	0.2	0.4	0.7	0.8	0.7	0.2	0.2	3.9
99720	HOPEN	0.4	0.5	0.5	0.3	0.1	0.2	0.7	0.7	0.4	0.5	0.5	0.9	5.9
99760	JAN MAYEN	1.0	1.0	1.0	0.7	0.7	0.7	0.9	1.6	2.1	2.2	1.4	1.4	14.9

4. Long-term variation of temperature and precipitation

4.1 Methods

4.1.1 Filtering Techniques.

Time series of scattered individual values often give a rather chaotic impression. To identify local maxima and minima as well as trends, the series may be smoothed by a low pass Gaussian filter. The weighting coefficient in year j, G_j is given by:

$$G_j = \frac{\sum_{i=1}^{n} w_{ij} \cdot x_i}{\sum_{i=1}^{n} w_{ij}} \qquad w_{ij} = e^{\frac{-(i-j)^2}{2\sigma^2}}$$

where the x_i is the original series which consists of n years, and σ is the standard deviation in the Gaussian distribution. For the present paper, filters with $\sigma = 3$ (filter 1) and $\sigma = 9$ years (filter 2) are chosen. These are favourable for studying variations on decadal and thirty year time scales . The ends of filtered curves are very dependent on the first or last few values, which may influence the trends seriously. Thus, for filter 1, three years on either ends of the curves are cut, and for filter 2, nine years are cut.

4.1.2 Test for trend.

The nonparametric Mann - Kendall test is chosen for testing the significance of trends, as it can be used without knowing the exact distribution of the time series. Its test statistic t is defined by the equation

$$t = \sum_{i=1}^{n} n_i$$

where n is the number of elements and n_i is the number of smaller elements preceding element x_i (i = 1,2,.. n) (Sneyers 1990). Providing that n > 10 (Sneyers 1995) the test statistic is very nearly normally distributed under the hypothesis of randomness (the null hypothesis). Moreover, its expectation, E(t), and variance, var t, are given by the equations

$$E(t) = \frac{n(n-1)}{4}$$

$$\mathrm{var}\, t = \frac{n(n-1)(2n+5)}{72}$$

The standardised distribution of the test statistic is then

$$u(t) = \frac{t - E(t)}{\sqrt{var\ t}}$$

A percent table of the normal distribution function may be used to decide whether the null hypothesis should be rejected or not.

Time series may be successively tested by adding one by one year reapplying the test for each year added. Using graphical representation of the standardised test statistic the development of trends in the series may easily be traced. It has also proved to be valuable to apply the test by starting with the last year going backward in time (Demarée 1990).

4.2 Time series of temperature

Long-term variation of temperature in the Norwegian Arctic have earlier been presented by Steffensen (1982), Hanssen-Bauer et al. (1990) and Nordli (1990). Since these publications, the Arctic temperature series have undergone thorough homogeneity testing. The Standard Normal Homogeneity Test (Alexandersson 1986, Hanssen-Bauer & Førland 1994) was applied on the series, and the results were validated by a study of the stations history (Nordli et al. 1996b). All temperature series but Jan Mayen turned out to be homogeneous.

Of importance for the homogeneity testing and also for interpolation of missing data were observations from the Russian station Barentsburg, which were available from the start to 1990. The Barentsburg data has made it possible to obtain two long series from Spitsbergen, one valid for Svalbard Airport from 1912 to present (additional data mainly from Green Harbour, Barentsburg and Longyearbyen), the other one valid for Ny-Ålesund from 1933 to present (additional data from Isfjord Radio). The two series represent different climates, the one from Ny-Ålesund is more influenced by the open water west of Spitsbergen than the one from Svalbard Airport. The composite Svalbard Airport series is analysed in section 4.2.1, while both long Spitsbergen series are compared to series from Jan Mayen and Bjørnøya in section 4.2.2. In section 4.2.3 comparisons are drawn to other temperature series.

4.2.1 Analyses of the temperature series 99840 Svalbard Airport 1912-1996

The present composite series valid for Svalbard Airport differ from the earlier one (Hanssen-Bauer et al. 1990) in the period Dec. 1911 - Dec. 1974. The use of the Barentsburg series has established a better relationship between the Longyearbyen series and the Svalbard Airport series. In addition the Barentsburg series has replaced the Isfjord Radio series when possible so that only 16 months in the composite series originate from Isfjord Radio (Nordli et al. 1996b). The mean annual difference between the two versions of the composite series during the years 1912-1974 is only 0.1°C, but there are seasonal differences, i.e. the newly homogenised series is warmer in spring (+0.6°C in May) and colder in autumn and early winter (-0.3°C in December). Since 1975 the original Svalbard Airport series is used. Averages, extremes and standard deviations of monthly and annual temperature means are given in Appendix A5.

In Figures 4.1-4.5 the composite series from Svalbard Airport is shown as annual and seasonal values. In order to visualise the long-term temperature variations, filter 1 and 2 (cf. section 4.1) are applied. The seasons are winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and autumn (Sep-Nov). Test results obtained by use of the non-parametric Mann-Kendall test (section 4.1) are shown in Fig. 4.6 On decadal time scale (filter 1), local temperature minima and maxima largely occur within the same decades for all seasons: More or less pronounced local minima are found in the beginning of the series, late in the 1920's, in the 1940's, in the 1960's and around 1980, while local maxima are found early in the 1920's, in the 1930's, in the 1950's, in the 1970's and towards the end of the series. In all seasons, the minimum in the beginning of the series is the most pronounced one, while the minimum in the 1960's ranges as number 2. The relative strength of the local maxima; on the other hand, vary from season to season, the result being seasonal differences concerning long-term trends.

a) Winter

On decadal time scale the most pronounced maximum for winter temperatures occurred in the 1930's. Thus, the series has a pronounced positive trend from the cold winters before 1920 up to the 1930's. The trend is significant at the 1% level according to the Mann-Kendall test (Fig. 4.6 a). Also the negative trend from the 1930's to present is significant. In the last part of the series, from the 1960's, there seems to have been a temperature increase again, but even at the 5% level this increase is not statistically significant.

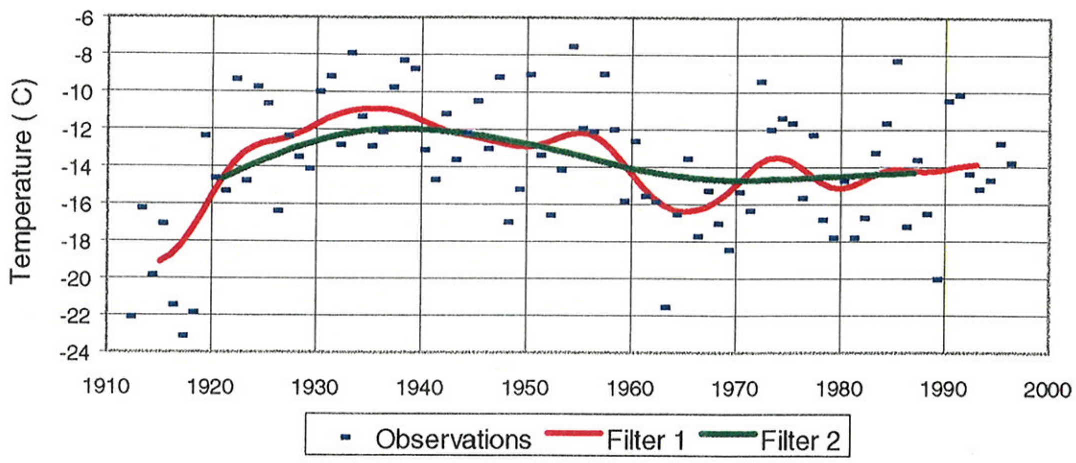

Fig. 4.1 Winter temperature (Dec-Jan-Feb), Svalbard Airport. Seasonal averages 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal averages.

b) Spring

The highest spring temperatures are found in the end of the series. The positive trend in the spring temperatures from the cold period in the beginning of the series until about 1940 is similar to what was found for winter temperatures. However, there was no significant temperature decrease after 1940. On the other hand, the spring temperatures show a statistically significant increase also during the period 1960 to present, and there is a positive trend, significant on the 1% level, from the start to the end of the series. Spring is the only season showing a statistically significant positive temperature trend from 1912 to present.

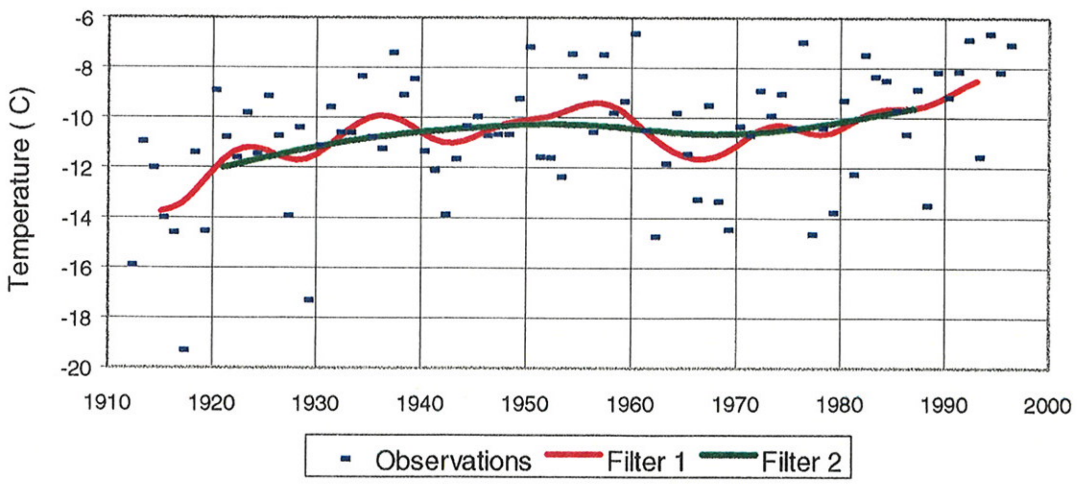

Fig. 4.2 Spring temperature (Mar-Apr-May), Svalbard Airport. Seasonal averages 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal averages.

c) Summer

For summer temperatures the most pronounced maxima are early in the 1920's and in the end of the series. There is no significant trend in the series as a whole, but as shown in Fig 4.6 c there are positive trends (1% level) from the start of the series to the 1920's and from the 1960's to present. The summer temperatures were decreasing from the 1920's to the 1960's.

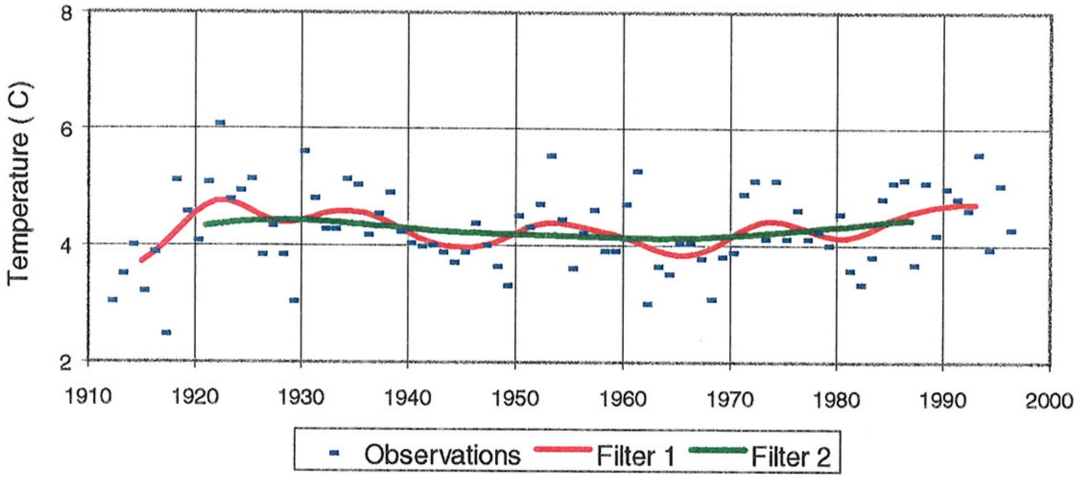

Fig. 4.3 Summer temperature (Jun-Jul-Aug), Svalbard Airport. Seasonal averages 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal averages.

d) Autumn

The most pronounced maximum concerning autumn temperatures is in the 1950's. There is a statistically significant (1% level) positive trend from the beginning of the series to around 1930. A decrease in autumn temperatures, significant on the 5% level, took place from the 1930's to present, Fig. 4.6d. There is no significant trend for the whole period.

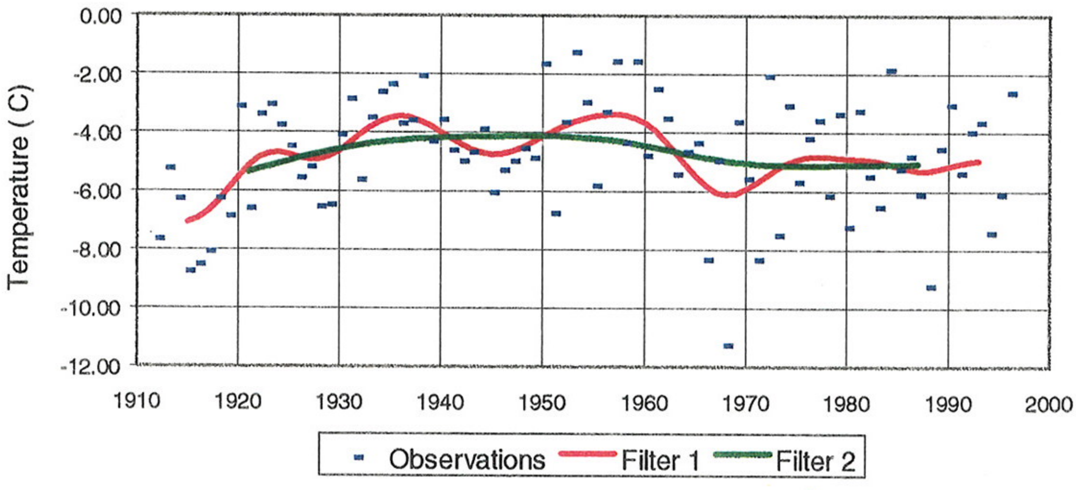

Fig. 4.4 Autumn temperature (Sep-Oct-Nov), Svalbard Airport. Seasonal averages 1912-1996 and low pass filters 1 and 2 (cf.. section 4.1) applied on seasonal averages.

e) Annual means

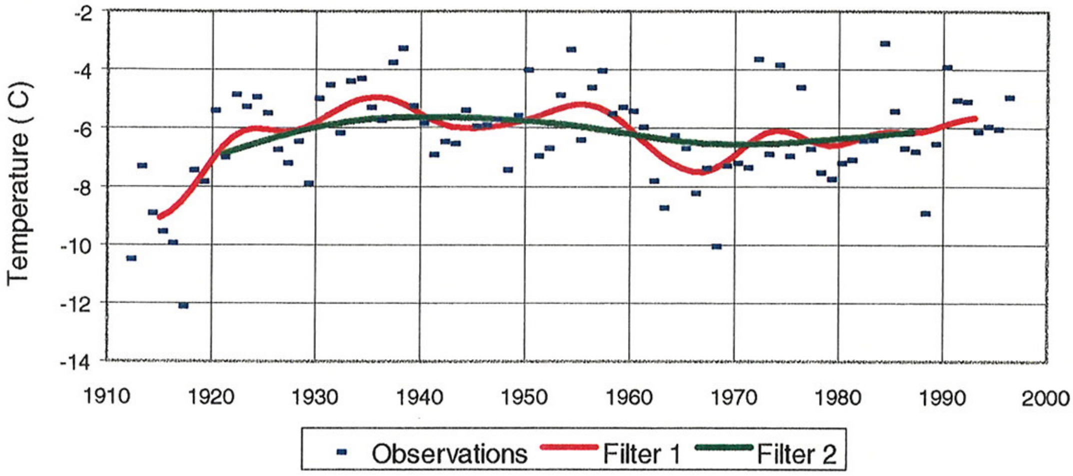

Fig. 4.5 Annual temperature, Svalbard Airport. Annual averages 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on annual averages.

The standard deviation for the whole period of the winter seasonal mean temperatures is 3.5°C, while the standard deviation of summer temperatures is 0.7°C. Thus the variation in annual mean temperatures is more affected by the variation in winter temperatures than by the variation in summer temperatures. The most pronounced warm decades on annual basis were the 1930's and the 1950's. The minimum in the beginning of the series is more than 1°C colder than the local minimum in the 1960's.

There is no trend in the series as a whole. However, a closer examination of the data yields three significant trends (1% level): From the start in 1912 there is a positive trend up to the late 1930's (Fig. 4.6e); there is a statistically significant temperature decrease from the 1930's to the 1960's (not shown in Fig. 4.6e); finally, from the 1960's to present the temperature has increased significantly at Svalbard Airport. Variation in the winter-temperature gave the largest single contribution to the temperature increase up to the 1930's, and also to the temperature decrease from the 1930's to the 1960's. Increased spring temperature gave the largest single contribution to the temperature increase during the last 3 decades.

Przybylak (1997) found that both daily minimum and maximum temperatures increased over a large part of the Arctic (including Svalbard) during the period 1961-90, but that the daily temperature range decreased, as the minimum temperature increased more than the maximum temperature. To some extent, Przybylak (1997) explained this by an increase in the cloud

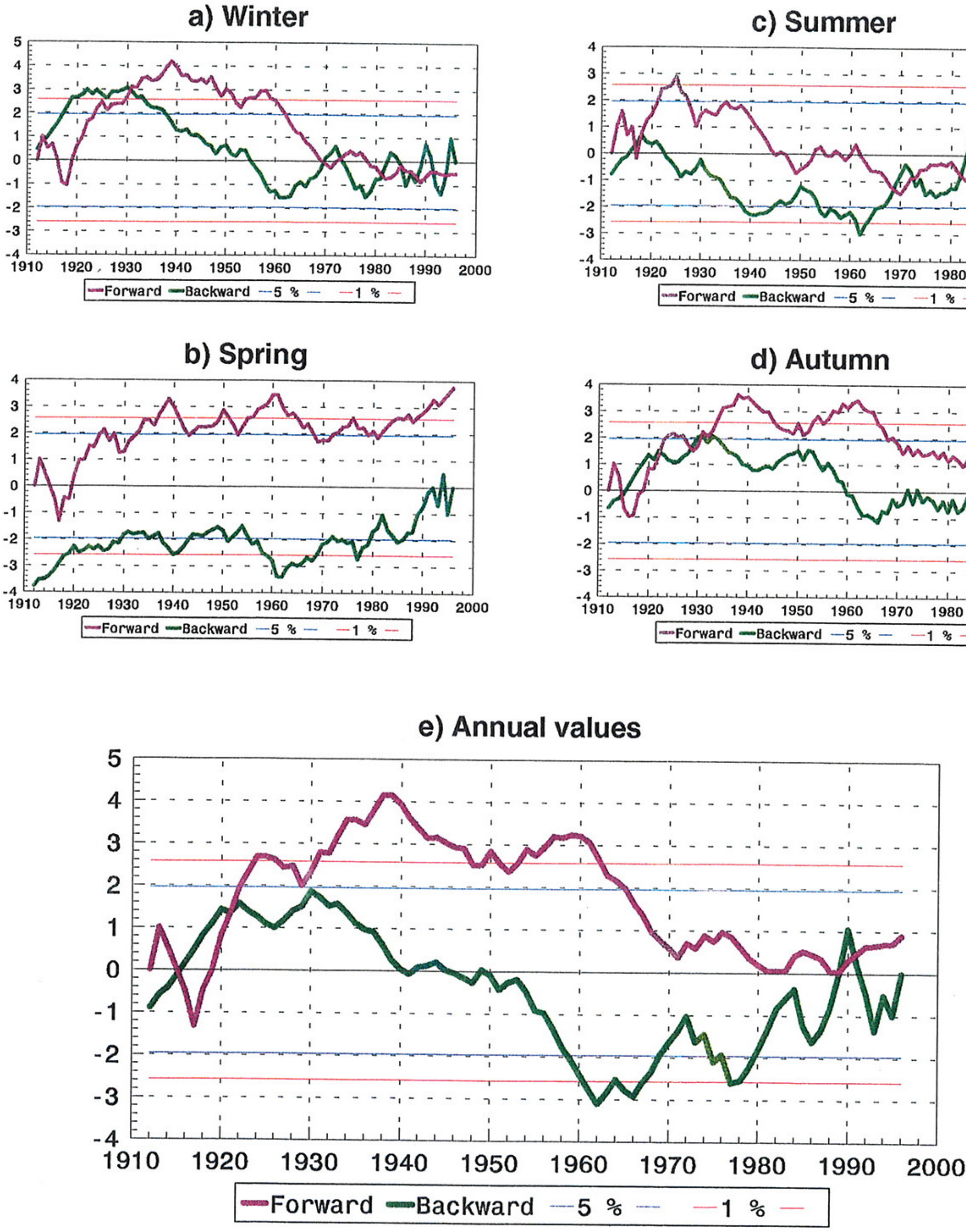

Fig. 4.6 Time series of Mann-Kendall test statistics when the test is applied forward and backward (cf. section 4.1) on seasonal and annual temperature averages.

cover over the area, though he concluded that, especially during the cold half-year, daily temperature range (and temperature) is very much affected by the governing atmospheric circulation pattern.

Although the annual mean temperature on Spitsbergen has increased significantly during the last thirty years or so, the present decadal scale temperature level is still below the maximum value of the 1930's.

4.2.2 Temperature series from the Norwegian Arctic

In addition to the Svalbard Airport series, three other series from the Norwegian Arctic areas consist of more than 60 years of observation. These are Bjørnøya, Jan Mayen, and the composite series valid for Ny-Ålesund (cf. 4.2.1). Filtered annual and seasonal means are shown in Fig. 4.7 a-e. The correlation between all four series is obviously strong on an annual basis. Local maxima and minima largely occur in the same decades. However, the series from Jan Mayen, outside the Svalbard area (see Fig. 2.1), not surprisingly render some discrepancies compared to the others. The decrease from the 1950's to the 1960's and also the increase to the 1970's, seem to have been some years delayed compared to the other series. Concerning seasonal temperatures, the long term increase in spring temperatures, which is present in the series from Svalbard Airport, Ny-Ålesund and Bjørnøya, is not seen in the Jan Mayen series.

During autumn, winter and spring, and also on an annual basis, Jan Mayen is the warmest of the Norwegian Arctic stations, while the Spitsbergen stations (Svalbard Airport and Ny-Ålesund) are the coldest. In summer, however, Svalbard Airport, which is more «continental» than the other stations, is the warmest during most of the period.

In Fig. 4.8 the series are normalised to zero mean and unit standard deviation before filtered with $\sigma = 3$ in the Gaussian distribution. The Jan Mayen series shows a remarkable decrease from its maximum in the 1930's to its minimum in the 1960's and since then a more rapid increase than the other series. An interesting feature is also that the two series from Spitsbergen almost coincide during most of the overlapping period, but since the 1980's the

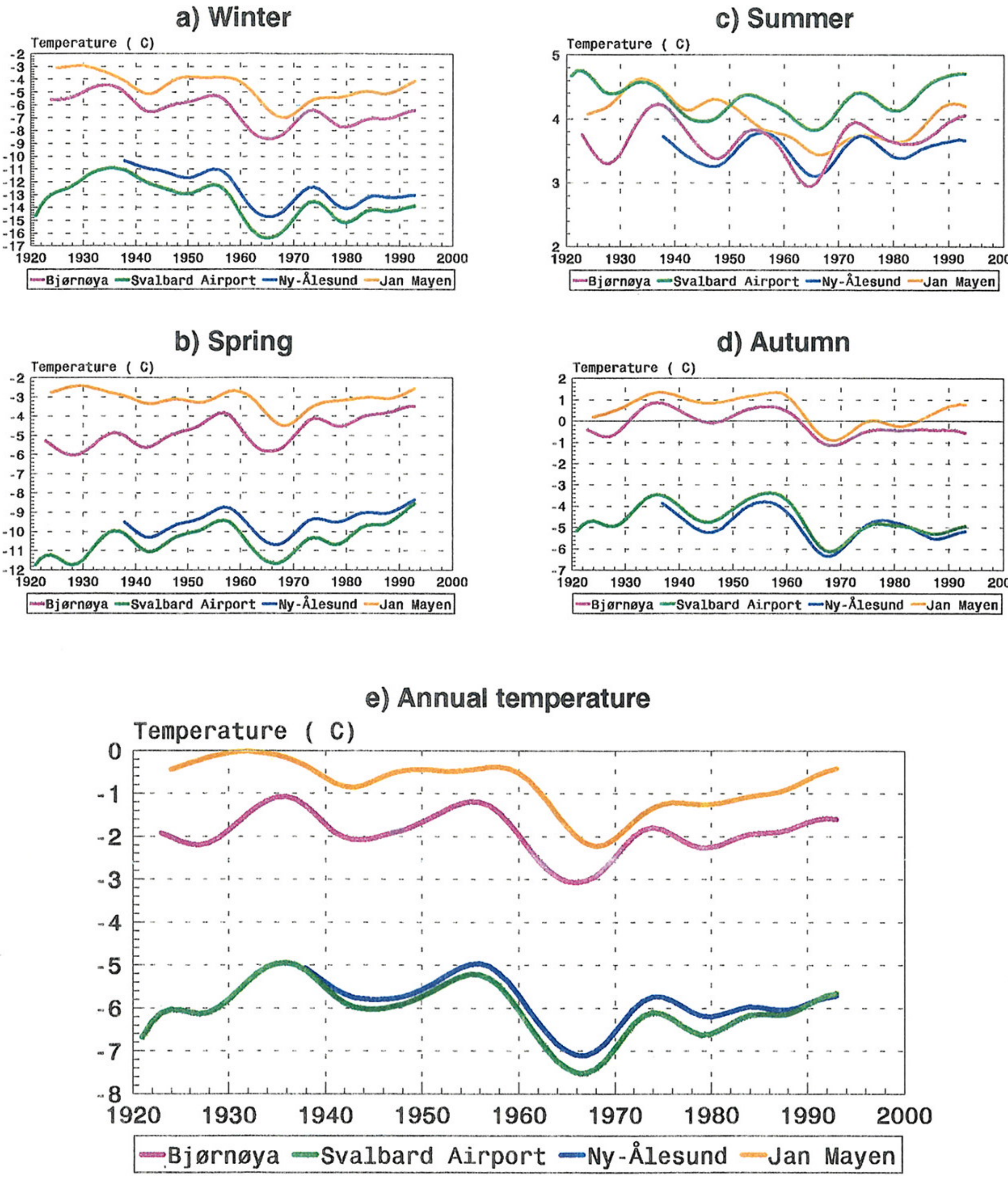

Fig. 4.7 Filtered series of mean air temperature at four Norwegian Arctic stations. Filter 1 (cf.. section 4.1) is applied. a) Winter temperatures, b) Spring temperatures, c) Summer temperatures, d) Autumn temperatures, e) Annual temperatures.

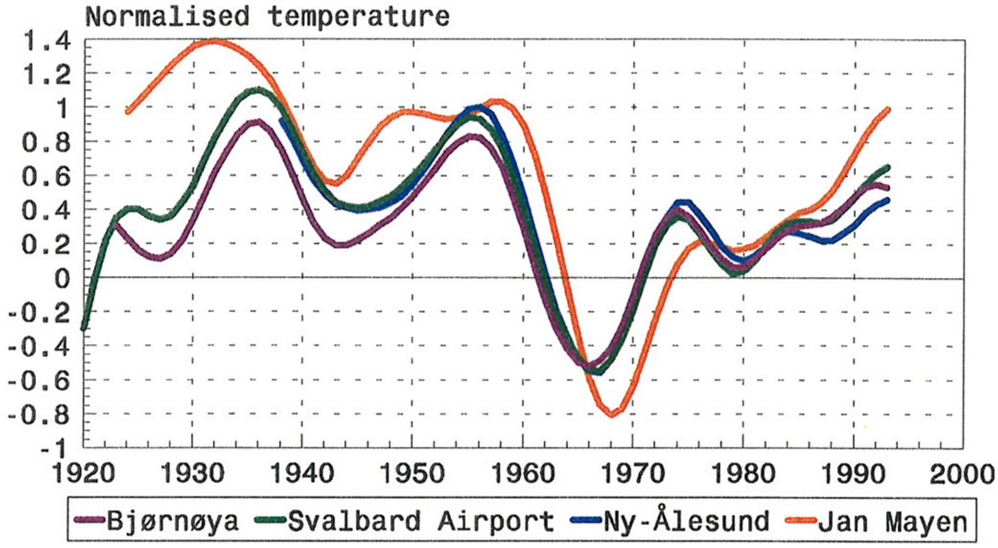

Fig. 4.8 Normalised and filtered series of annual air temperature at 4 Norwegian Arctic stations. Filter 1 (cf. section 4.1) is applied. Means and standard deviations in the normal period 1961-1990 are used for normalisation.

Svalbard Airport series have somewhat lower values. This looks like an inhomogeneity in one of the series. However, neither the location of the stations nor the observing procedure has changed within that decade, and the discrepancies might be due to different response to climatic variations between the maritime and continental climates of Spitsbergen.

4.2.3 Temperature series from the Norwegian Arctic compared to series from the North Atlantic Climatological Dataset and the Northern Hemisphere.

Figure 4.9 shows the station network of the North Atlantic Climatological Dataset (Frich et al. 1996). All complete temperature series from this dataset were analysed using principal component analysis (Hanssen-Bauer et al. 1996a), and series of annual mean temperature representative for the 6 regions marked in figure 4.9 were deduced.

In figure 4.10, the normalised and filtered temperature series from Svalbard Airport is presented together with similarly normalised and filtered temperature series from the 6 regions shown in figure 4.9. Several common features are seen, especially between the Svalbard curve and the northern regions. The main cold spells occurred before 1920 and in the 1960's, while the 1930's (or the decade around 1940) represents the temperature optimum in the series.

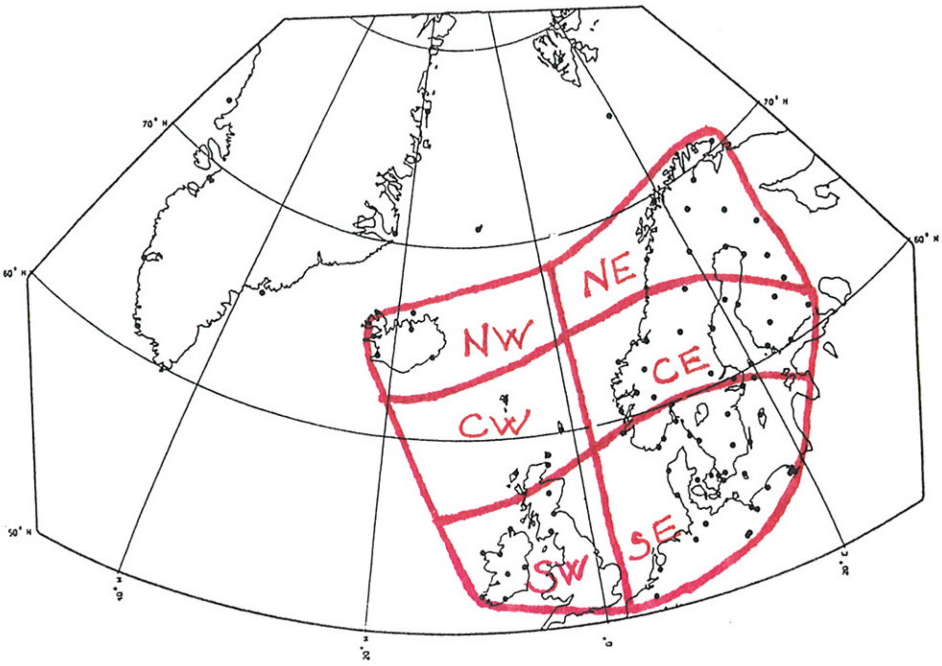

Fig. 4.9 Map showing the station network of the North Atlantic Climatological Dataset, and the 6 regions for which the temperature curves in figure 4.10 are valid.

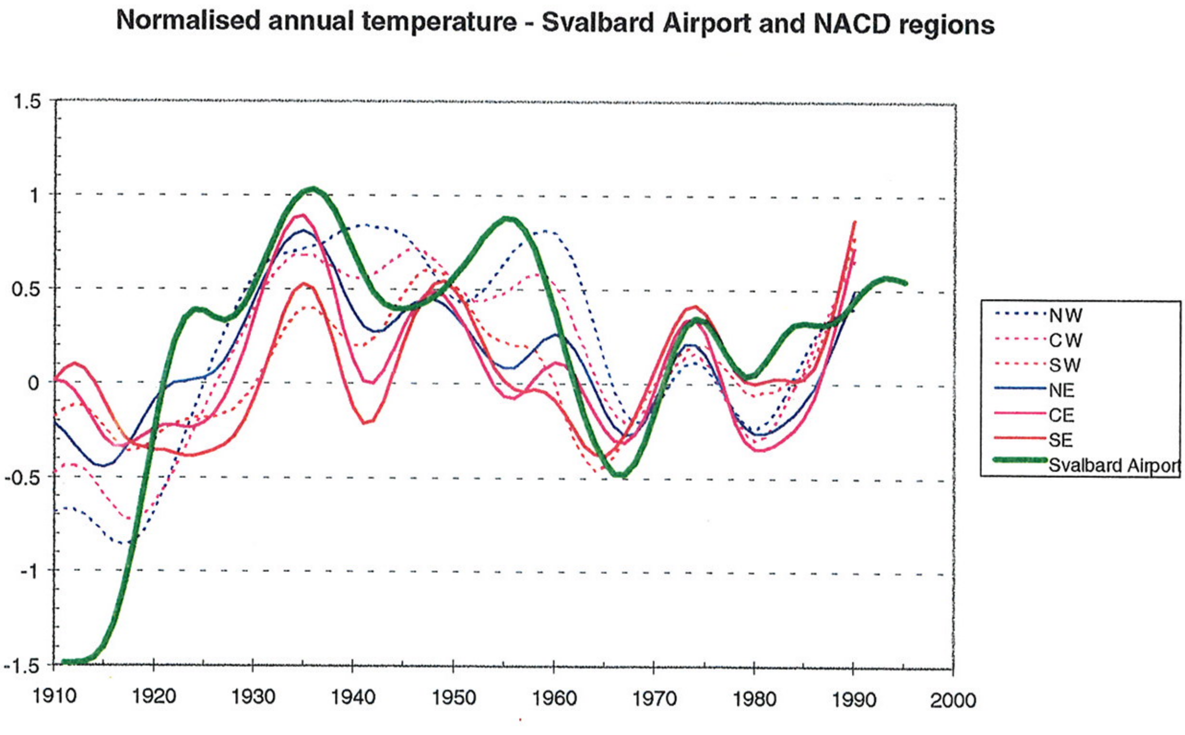

Fig. 4.10 Normalised and filtered series of annual air temperature at Svalbard Airport and from the 6 regions shown in figure 4.9. .
Filter 1 (cf. section 4.1) is applied. Means and standard deviations in the normal period 1961-1990 are used for normalisation.

All series also show a temperature increase from the cold 1960's to present, but both Svalbard and the northern regions are presently somewhat colder than they were in the 1930's. This is contrary to the central and southern regions, where the present temperature level is similar to, or even somewhat higher than the temperature level from the 1930's.

When comparing southern and northern series, one may note that the warming before the 1930's is more dramatic in the northern than in the southern regions, and it is even more dramatic at Svalbard. This is in spite the fact that these series have been normalised, i.e. divided by their inter-annual standard deviation, which is largest for the Svalbard series.

When comparing the Svalbard curve to the eastern and western regional curves, it is noteworthy that Svalbard with some respects reminds most of the eastern regions, while it concerning other features is more like the western regions. E.g., the distinct temperature maximum in the 1930's is an «eastern feature», while the warm 1950's and the distinct temperature drop in the early 1960's is more similar to what the western regions experienced.

When comparing the Svalbard Airport temperature curve to the temperature curve for the Northern hemisphere (Horton & Parker 1997), the periods of temperature increase (up to the 1930's and after the 1960's) and decrease (1930's to 1960's) are recognised, though they seem to occur somewhat later in the hemispheric curve, relatively to the Svalbard Airport curve (Nordli, 1990). There is a major difference, however: On the hemispheric scale, the annual mean temperature increased by about the same amount (~0.5 °C) within the two periods of warming. At Svalbard Airport, on the other hand, the temperature increase which happened during the first period (~4°C) was considerably larger than the warming which has happened during the last 3 decades of the series(~1.5°C). Also, the normalised temperature decrease during 1930-1960, was somewhat smaller for the hemispheric average than at Svalbard .

4.3 Time series of precipitation

Precipitation series from the Norwegian Arctic stations have earlier been presented by Nordli (1990). Several inhomogeneities in these series were, however, detected and adjusted for by Nordli et al. (1996b), who also composed a series from 1912 to present, valid for Svalbard Airport. Recently available data from Barentsburg were used to establish this long precipitation series, in addition to data from Svalbard Airport, Longyearbyen, Green Harbour and Isfjord Radio. The composite Svalbard Airport series is analysed in section 4.3.1, while it is compared to other series from the Norwegian Arctic in section 4.3.2, and to other precipitation series in section 4.3.3.

4.3.1 Analyses of the precipitation series 99840 Svalbard Airport 1912-1996

Series of seasonal and annual precipitation sums valid for Svalbard Airport are presented in Figures 4.11 through 4.15. The seasons are defined as the same 3-month periods which were used for temperature. The figures show single values as well as series smoothed by low-pass filters 1 and 2 (cf. section 4.1). Figure 4.16 shows the test results from the Mann-Kendall trend test. Mean values and standard deviations of monthly and annual precipitation sums are given in Appendix A5.

a) Winter

According to Figure 4.11, winter precipitation at Svalbard Airport has varied about a quite stable level of 50-60 mm during the last 8 decades (filter 2). Because of catch deficiency (which is larger for snow than for rain) the real winter precipitation at Svalbard is considerably higher than this. An investigation in Ny-Ålesund (see section 3.3) showed that the true average winter precipitation there is about 70% larger than the measured precipitation (Hanssen-Bauer et al. 1996b). Using this at Svalbard Airport gives a level for «true» winter precipitation of 85 - 100 mm.

There is no statistically significant trend in the series of winter precipitation (Figure 4.16 a). There is, however a pronounced decadal scale variability in parts of the series (Figure 4.11).

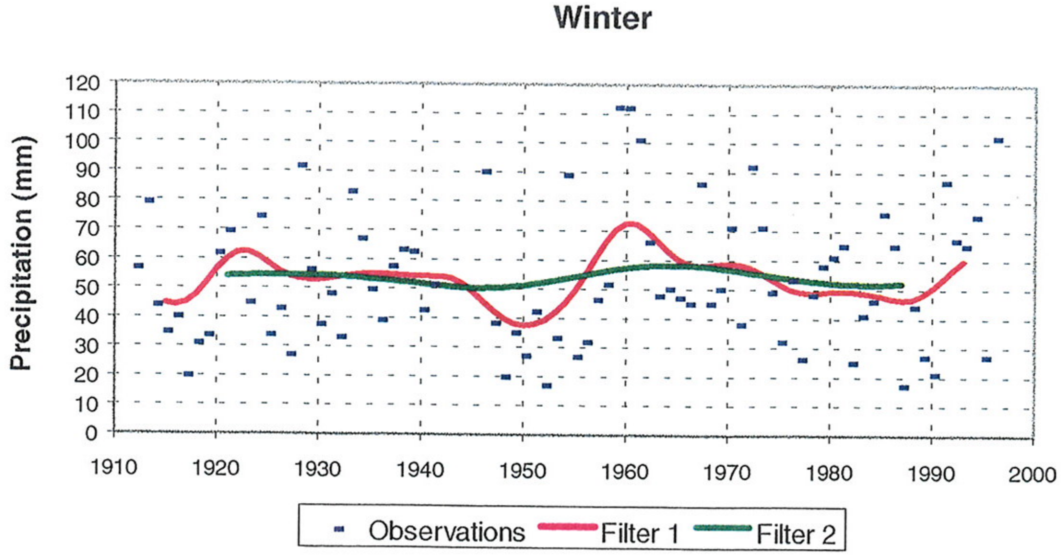

Fig. 4.11 Winter precipitation (Dec-Jan-Feb), Svalbard Airport. Seasonal sums 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal sums.

Concerning winter precipitation, the «driest» periods in the series were in the start of the series and around 1950, while the «wettest» period so far was around 1960. There is a large inter-annual variability in precipitation. The winter 1995-96 had 85% more precipitation than the long-term average, and is the third wettest in the series. The winter 1994-95, on the other hand, had about 50% of the average winter precipitation.

b) Spring

According to Figure 4.12, the level of spring precipitation at Svalbard Airport has increased from about 30 mm to about 45 mm during the last 8 decades (filter 2), i.e. an increase of about 50%. Using the average spring correction factor from Ny-Ålesund (Hanssen-Bauer et al. 1996b) to correct for catch loss, gives a typical «true» spring precipitation of about 70 mm at the end of the period.

The increase in spring precipitation from 1912 to 1996 is statistically significant at the 1% level (Figure 4.16 b), and it happened mainly after 1950. Note that the spring temperature also increased during much of this period (Figures 4.2 and 4.6b). It is thus likely that the percentage of liquid spring precipitation increased during the same period. In this case, the average catch loss would decrease, and some of the measured precipitation increase would be artificial, simply because a larger proportion of the real precipitation is measured in the end of the period than in the beginning. This «artificial» precipitation increase at Svalbard was by

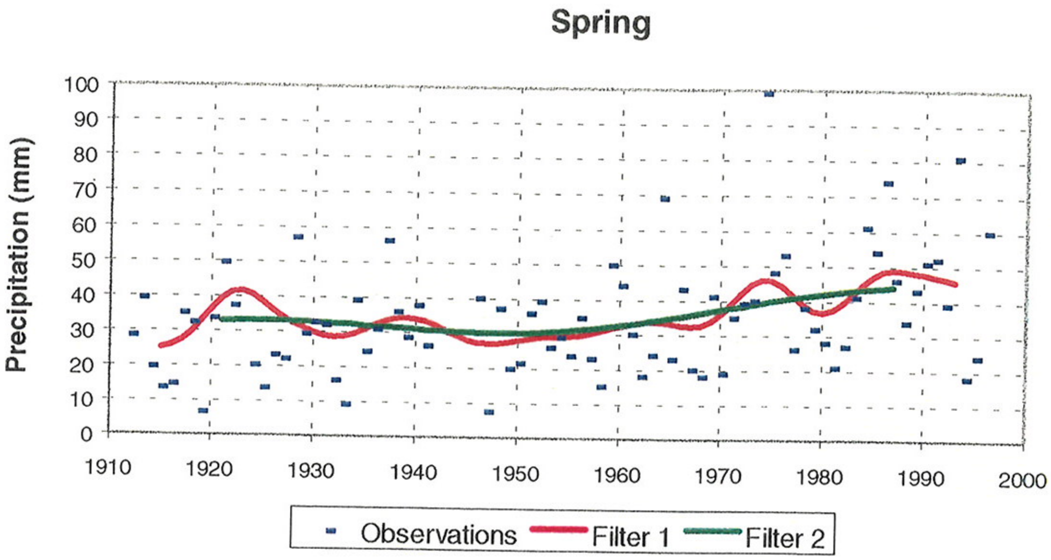

Fig. 4.12 Spring precipitation (Mar-Apr-May), Svalbard Airport. Seasonal sums 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal sums.

Hanssen-Bauer et al. (1996b) estimated to 6% on an annual basis for a constant 2 °C temperature increase in all seasons. This percentage would be somewhat larger during spring, as spring would experience an above average transition from solid to liquid precipitation. However, even a 10% «artificial» precipitation increase (which is not unlikely during spring), would leave a substantial part of the 50% measured precipitation increase as real. We may thus conclude that a major part of the increase measured in spring precipitation is real.

There is also some variability at the decadal scale (Figure 4.12, filter 1). Concerning spring precipitation, the «driest» periods in the series were in the start of the series and around 1950, while the «wettest» period so far was around 1990.

c) Summer

According to Figure 4.13, the level of summer precipitation at Svalbard Airport has increased from about 30 mm to about 50 mm during the last 8 decades (filter 2), i.e. an increase of about 65%. Using the average summer correction factor from Ny-Ålesund (Hanssen-Bauer et al. 1996b) to correct for catch loss, gives a typical «true» summer precipitation at Svalbard Airport of 65 mm .

The increase in summer precipitation is statistically significant (Figure 4.16 c). In contrast to spring precipitation, summer precipitation mainly increased before 1960. The increase may not

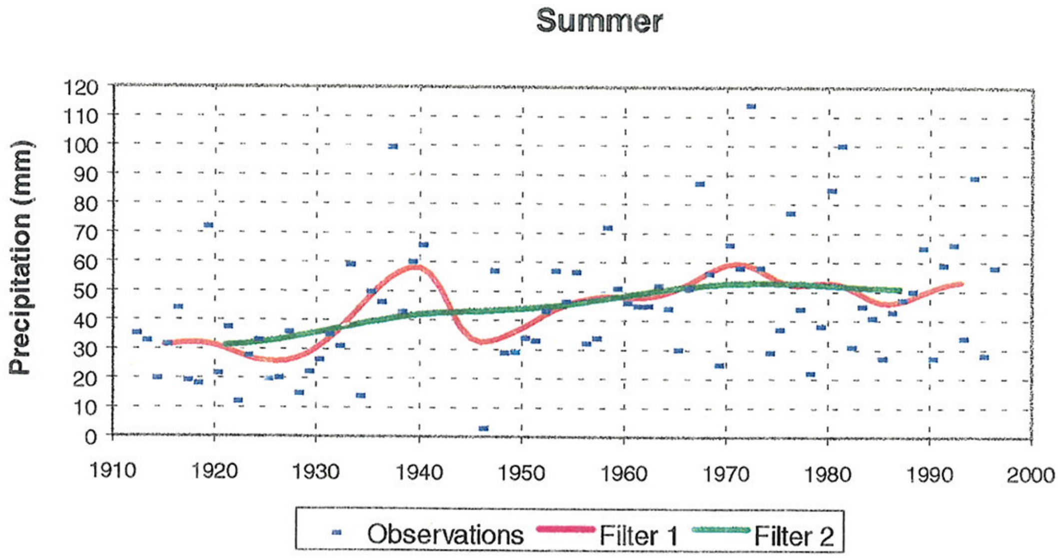

Fig. 4.13 Summer precipitation (Jun-Jul-Aug), Svalbard Airport. Seasonal sums 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal sums.

be explained as an artificial increase caused by increasing temperatures, both because no trend is found in summer temperatures during the actual period, and because the potential for transition from solid to liquid precipitation during summer is small.

On the decadal scale, (Figure 4.13, filter 1), the «driest» period in the series was in the 1920s, while the «wettest» periods so far were around 1940 and 1970.

d) Autumn

According to Figure 4.14, the level of autumn precipitation at Svalbard Airport has increased from about 40 mm to about 50 mm during the last 8 decades (filter 2), e.g. an increase of about 25%. Using the average autumn correction factor from Ny-Ålesund (Hanssen-Bauer et al. 1996b) to correct for catch loss, gives a typical «true» autumn precipitation of about 70 mm at the end of the period.

There is a statistically significant trend in the series of autumn precipitation (Figure 4.16 d). The main increase happened from the 1920s to the 1940s. During this period, there was also an increase in the autumn temperatures of about 2 °C, and some of the measured precipitation increase may thus be a result from increased catch efficiency. Using the argumentation presented in connection with the increased spring precipitation, up to 10% measured

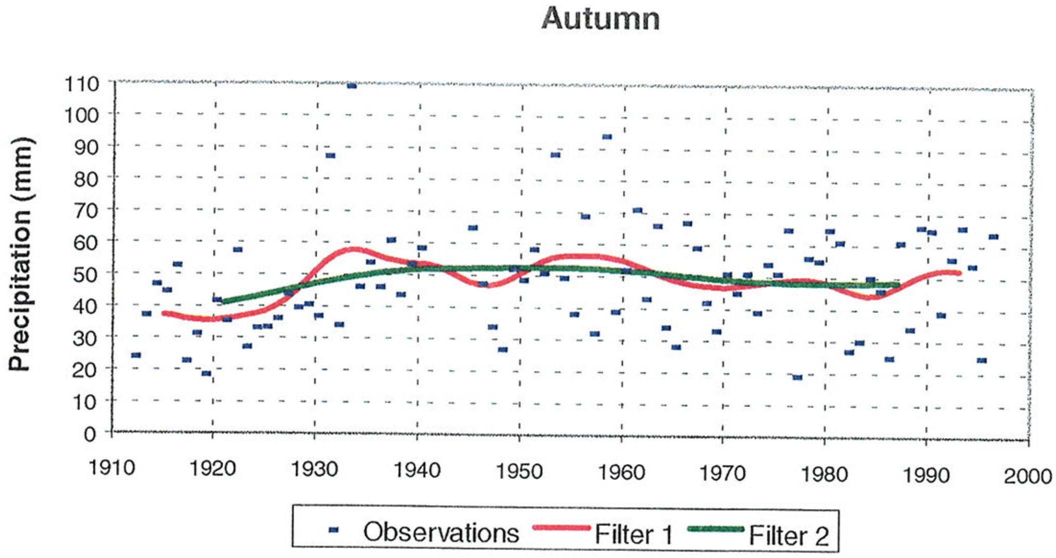

Fig. 4.14 Autumn precipitation (Sep-Oct-Nov), Svalbard Airport. Seasonal sums 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on seasonal sums.

precipitation increase **might** be the result from the temperature increase. Still, less than half the precipitation increase would be explained, thus a substantial part of the increase is real.

On the decadal scale (Figure 4.14, filter 1), the «driest» period in the series was around 1920, while the «wettest» periods so far were in the 1930s, around 1960 and in the end of the series.

e) Annual precipitation

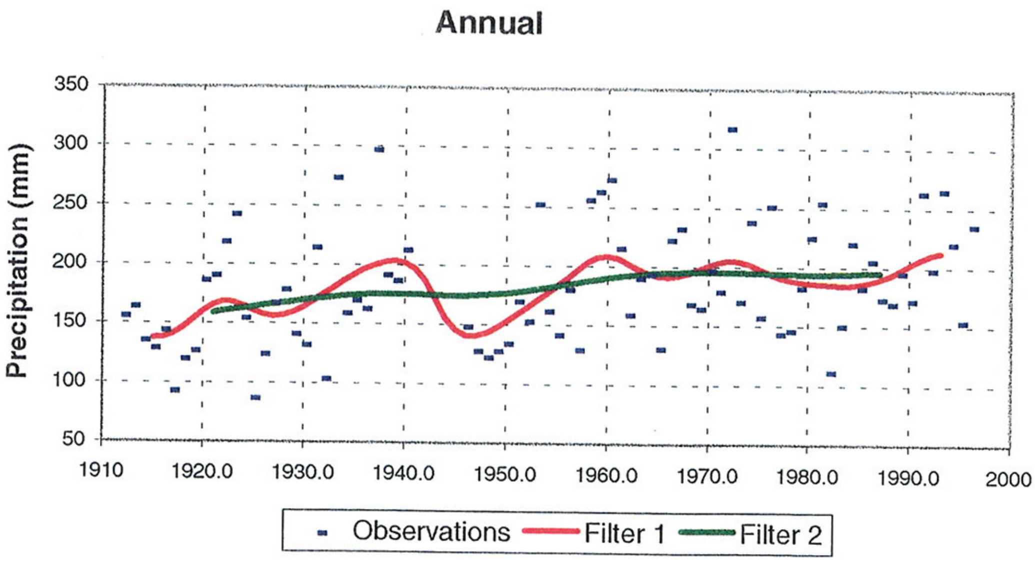

Fig. 4.15 Annual precipitation sum, Svalbard Airport. Averages 1912-1996 and low pass filters 1 and 2 (cf. section 4.1) applied on annual sums.

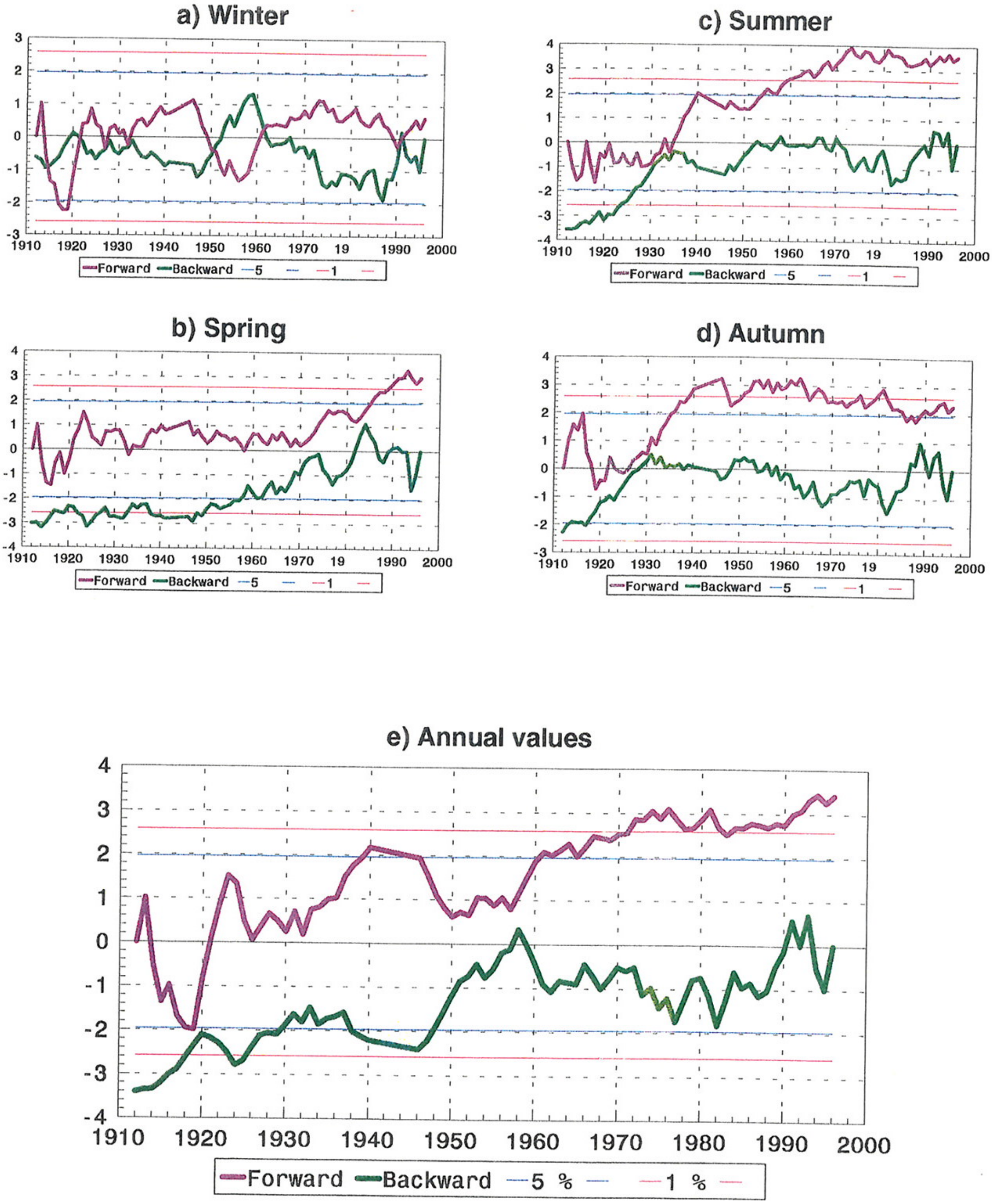

Fig. 4.16 Time series of Mann-Kendall test statistics when the test is applied forward and backward (cf. section 4.1) on seasonal and annual precipitation sums.

According to Figure 4.15, the level of annual precipitation at Svalbard Airport has increased from about 150 mm to about 200 mm during the last 8 decades (filter 2), i.e. an increase of more than 30%. Using the average correction factors from Ny-Ålesund (Hanssen-Bauer et al. 1996b) to correct for catch deficiency, gives a typical value of «true» annual precipitation of 300 mm in the end of the period.

There is a statistically significant trend in the series of annual precipitation from 1912 to 1996 (Figure 4.16 e). Increased precipitation during spring, summer and autumn all contribute to the increase in annual precipitation. Increased catch efficiency may explain some of the measured precipitation increase during spring and autumn, but this would maximum account for a 6% increase in the precipitation on an annual basis (Hanssen-Bauer et al. 1996b). Thus «true» annual precipitation at Svalbard Airport has increased by 25 - 30% during the 85 year period.

On the decadal scale (Figure 4.15, filter 1), the «driest» periods in the series were the beginning of the series and the late 1940s, while the «wettest» periods so far is the 1990s, around 1970 and 1960.

4.3.2 Comparison of long-term precipitation variation in the Norwegian Arctic

The level of observed annual precipitation at the Norwegian Arctic stations varies from 150-200 mm at Svalbard Airport to 600-700 mm at Jan Mayen (Figure 4.17). At Jan Mayen, Bjørnøya, Hopen and Ny-Ålesund, winter and autumn are usually the seasons with most precipitation. An increase in measured winter precipitation during the last couple of decades, without a similar increase in autumn precipitation, makes presently winter the number 1 precipitation season at Jan Mayen, Hopen and Bjørnøya. In Ny-Ålesund, the levels of measured winter and autumn precipitation are quite similar at the moment. At Svalbard Airport and Isfjord Radio, the level of the measured summer precipitation is similar to the similar levels of autumn and winter precipitation. Due to the increased catch efficiency for rainfall compared to snowfall, the average *true* summer precipitation at these stations is still probably lower than the similar averages for autumn and winter (cf. estimates for Svalbard Airport in section 4.3.1).

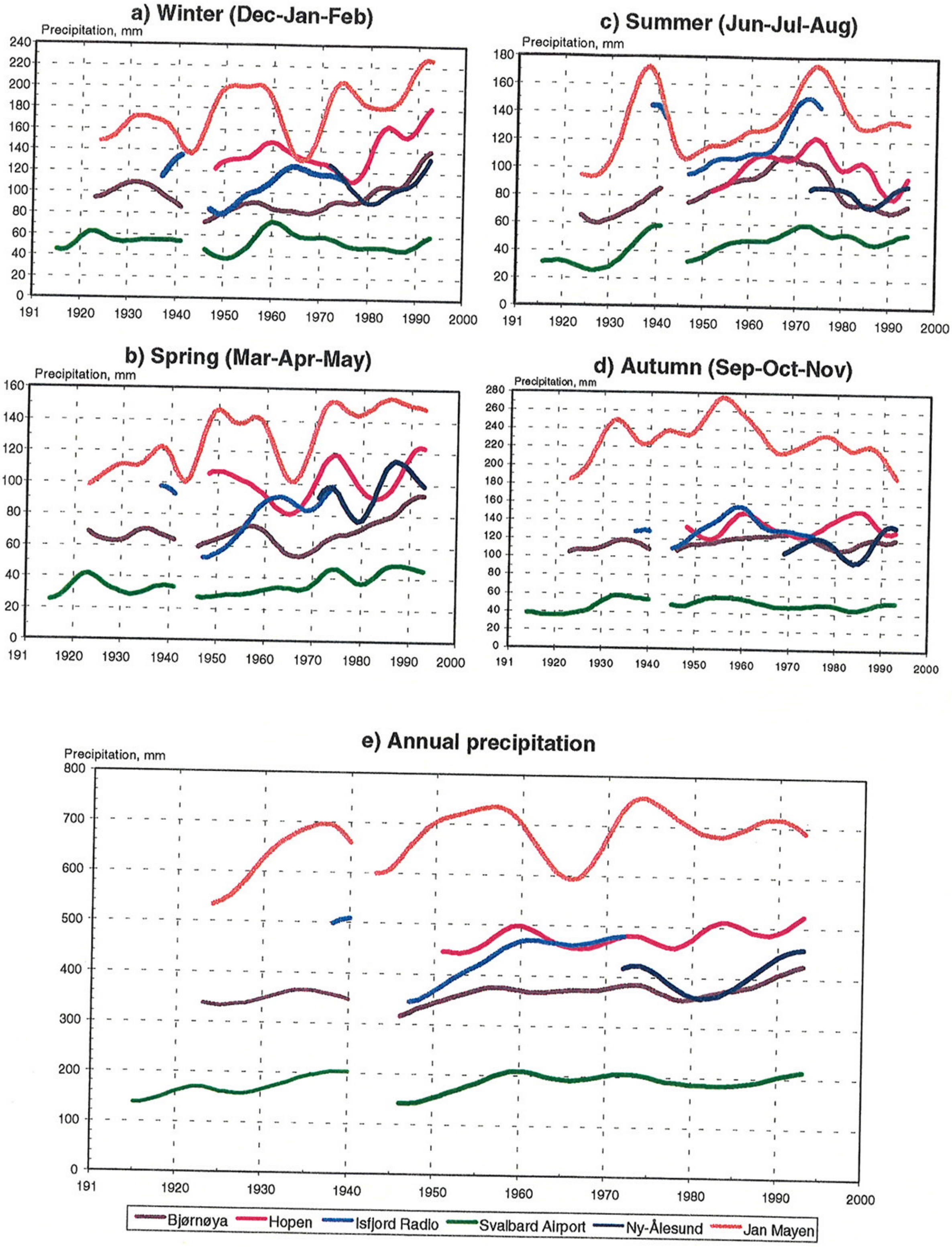

Figure 4.17 Precipitation series from 6 Norwegian Arctic stations. Low pass filter F1 is applied (cf. section 4.1.) a) Winter, b) Spring, c) Summer, d) Autumn, e) Annual values

Thus, winter and autumn are probably the «wettest» seasons also at Svalbard Airport and Isfjord Radio.

Figure 4.17 illustrates that, contrary to the decadal scale temperature variations, which in most cases show similar patterns at all the Norwegian Arctic stations on annual as well as seasonal basis, decadal scale precipitation variations are different within different part of the Norwegian Arctic. When normalising the series by dividing by their respective 1961-1990 average, however, it is seen that at least the stations at Spitsbergen show several common features (Figure 4.18). The Russian series from Barentsburg is included in this comparison. It should be noted that the Barentsburg precipitation in the period 1912-1930 was interpolated from observations in Green Harbour (Nordli et al. 1996b). The Green Harbour data were also applied for gap-filling in the Svalbard Airport series during the same period on occasions when data from Longyearbyen were missing. Thus, the first 2 decades of the Barentsburg series and the Svalbard Airport series are not independent.

Fig. 4.18 indicates that the major features in the decadal scale variation of annual precipitation at Svalbard Airport are quite representative for the western coast of Spitsbergen. This is true also for spring, summer and autumn precipitation. In winter, however, series from the different Spitsbergen stations occasionally show large discrepancies. This is probably because errors caused by aerodynamic catch deficiency and by blowing and drifting snow are at maximum during this season. Still, Figure 4.18 a) supports the impression that there is no clear trend in the winter precipitation at Spitsbergen from 1912 to present, while there are positive trends in the precipitation in the other seasons. While autumn precipitation mainly increased before 1940, spring precipitation increased mainly after 1950.

Also Jan Mayen, Bjørnøya and Hopen seem to have experienced an increase in the spring precipitation (Figure 4.17 b), though the statistical significance of this increase has not been tested. In combination with the earlier mentioned increase in winter precipitation at these stations, and probably an increase in summer precipitation up to about 1970 (Figure 4.17 c) , positive trends in annual precipitation may be expected also at these stations.

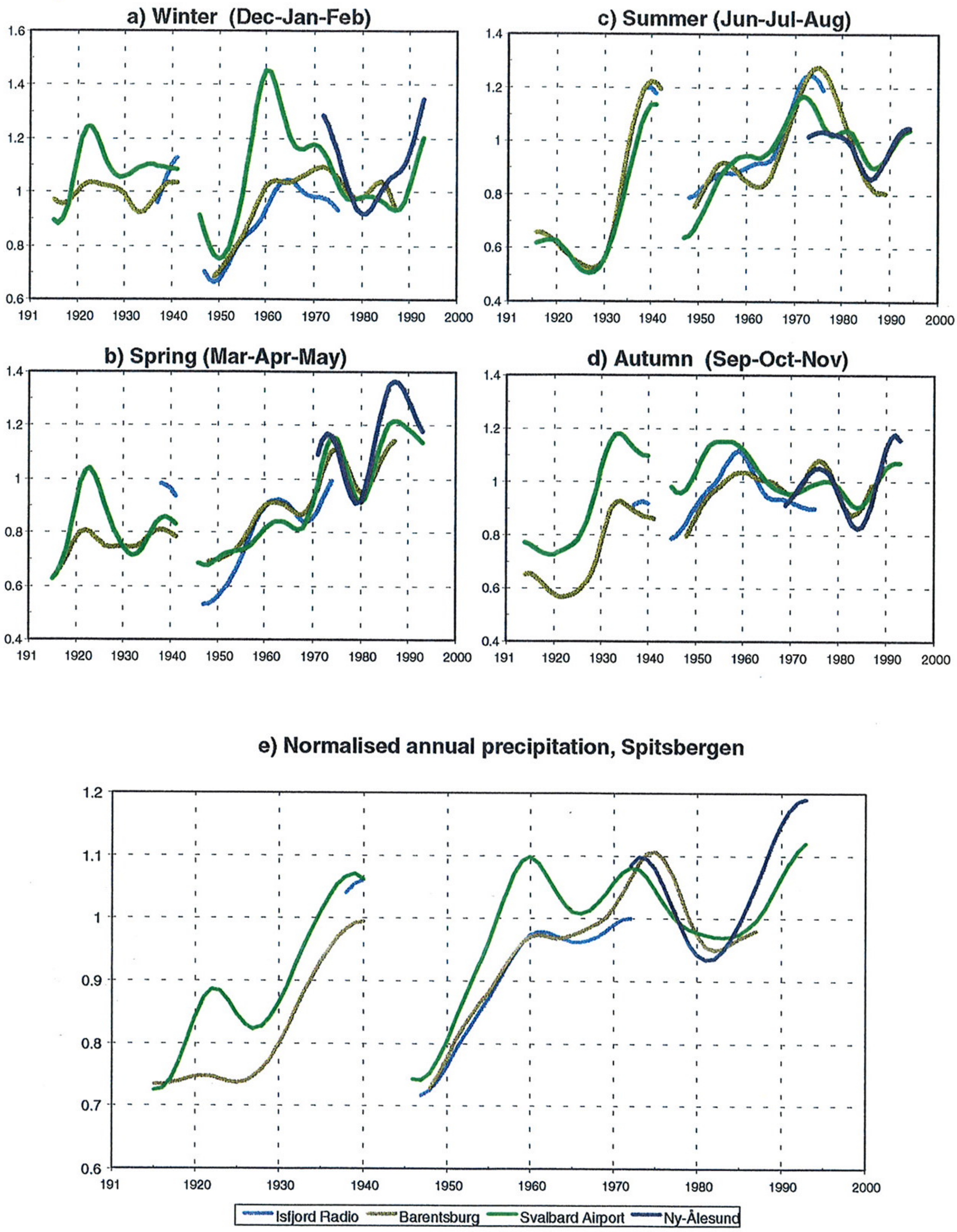

Figure 4.18 Precipitation at the Spitsbergen stations divided by their respective 1961-90 average. Low pass filter F1 is applied (cf.. section 4.1.)
a) Winter, b) Spring, c) Summer, d) Autumn, e) Annual values

Figure 4.19 shows the long-term trends in annual precipitation as illustrated by the normalised filter 2 precipitation curves, both from the Spitsbergen stations and from Hopen, Bjørnøya and Jan Mayen. There seems to have been an increase in the level of annual precipitation during the last 7-8 decades in the entire area. At Spitsbergen, the increase is probably about 25%. At Hopen, Bjørnøya and Jan Mayen, it is probably somewhat smaller. At Jan Mayen, most of the increase in annual precipitation happened before 1960, while the increase at the other stations seems to be more evenly distributed throughout the period.

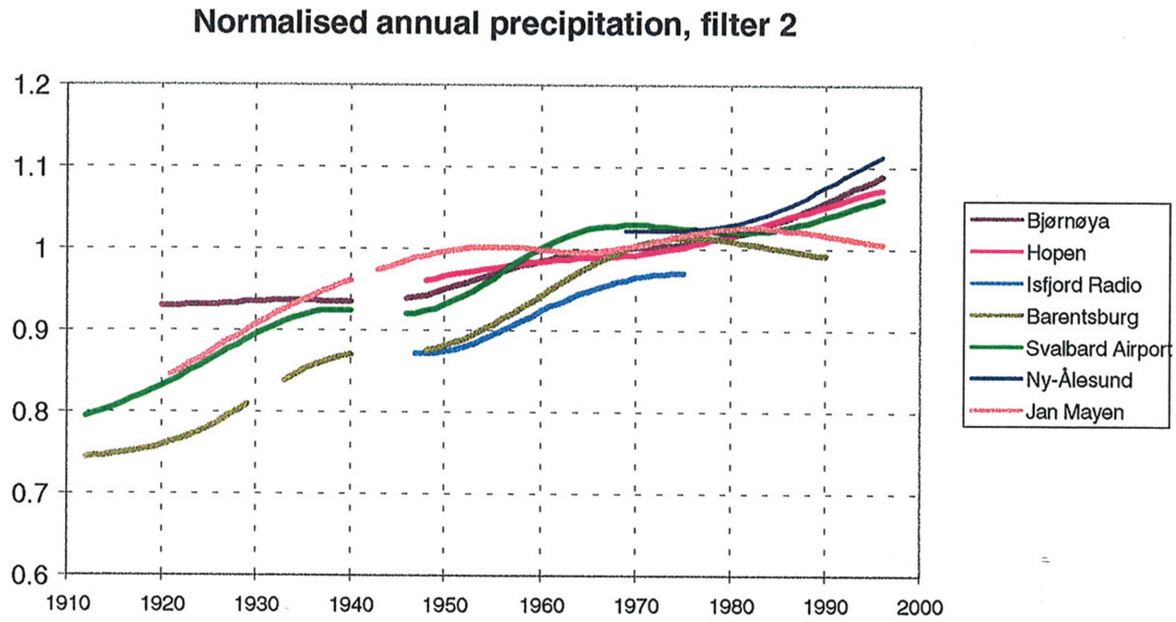

Figure 4.19 Annual precipitation at 7 Arctic stations divided by their respective 1961-90 average. Low pass filter F2 is applied (cf. section 4.1.)

4.3.3 Comparison of variation in the Arctic and in adjacent areas

An investigation of precipitation at the Norwegian mainland during the period 1895- 1995 (Hanssen-Bauer et al. 1997), showed that the precipitation in that area also has been increasing since the beginning of the century. In most parts of the area, the precipitation increased by 8-14% during the period. Different parts of the country showed differences concerning when the increase happened and the relative size of the seasonal contributions. The precipitation increase at Svalbard reminds most of the increase in coastal parts of Northern Norway, as the trend seems to be fairly constant throughout the period, and several seasons contribute to the increase. Further south in Norway, increased precipitation during autumn gave a main contribution to the total annual precipitation increase. This is definitely not the case in the Norwegian Arctic.

Hulme (1995) estimated zonally averaged precipitation series for 1900-92 for land areas north of 50 °N. This series shows an increase of approximately 10%, which mainly took place after 1940.

The relative precipitation increase at Spitsbergen during the last 8 decades was considerably higher than the similar increase at the Norwegian mainland, and also than the «average high latitude increase» estimated by Hulme (1995). At Bjørnøya, the increase was probably closer to this average.

5. Summary and conclusions

The Arctic is especially vulnerable to climate change caused by increased greenhouse effect. It is therefore crucial to establish the present conditions and monitor long-term variations of climatic elements in the Arctic. The oldest meteorological observations from the Norwegian Arctic were made during sporadic expeditions, but since 1911 permanent weather observations have been performed at Spitsbergen; since 1920 at Bjørnøya and since 1921 at Jan Mayen.

There are pronounced fluctuations in the Arctic climate, both on a daily, monthly and annual scale. For Svalbard Airport, the difference between the highest and lowest *monthly mean* in December-March is about 25 °C. The lowest recorded temperatures at the stations covered by this report is -46.3 °C. But even during winter, maximum temperatures of +3 to +7 °C have been recorded at all stations. Summer maximum temperatures above 20 °C have occasionally been recorded at Bjørnøya and Svalbard Airport.

The precipitation is usually low in the Arctic, and the normal annual precipitation at Svalbard Airport is the lowest at any Norwegian station. There are however large gradients in precipitation at Spitsbergen;- although the horizontal distance is just 35 km, the normal annual precipitation at Barentsburg is almost 3 times higher than at Svalbard Airport. Because of blowing/drifting snow and large gauge catch deficiencies, reliable measurements of precipitation are difficult to obtain in the Arctic. One peculiar feature is that precipitation as snow (and rain) may occur at any time of the year at all Norwegian Arctic stations.

The Norwegian Arctic series have undergone thorough homogeneity testing, and it was possible to establish homogenised series of temperature and precipitation from Svalbard Airport from 1912 to present and temperature series for Ny-Ålesund from 1933 to present.

The long-term series from Svalbard Airport show that on decadal time scale, local temperature minima and maxima largely occur within the same decades for all seasons. Because of substantial differences in standard deviations, the variation in annual mean temperatures is more affected by the variation in winter temperatures than by summer temperatures. The most pronounced warm decades on annual basis were the 1930's and the 1950's. The minimum in the beginning of the series is more than 1°C lower than the local minimum in the 1960's.

There is no significant trend in the Svalbard Airport annual temperature series as a whole (Table 5.1). However, a closer examination of the data yields three significant trends (1% level): From the start in 1912 there is a positive trend up to the late 1930's; there is a temperature decrease from the 1930's to the 1960's; and from the 1960's to present the temperature has increased significantly. Variation in the winter-temperature gave the largest single contribution to the temperature increase up to the 1930's, and also to the temperature decrease from the 1930's to the 1960's. Increased spring temperature gave the largest single contribution to the temperature increase during the last 3 decades.

Table 5.1 Significant trends at the 1% level (Mann-Kendall) during the whole period 1912-96
(Significant positive trends are marked by +, no significant trends by O)

	Annual	*Spring*	*Summer*	*Autumn*	*Winter*
Temperature	O	+	O	O	O
Precipitation	+	+	+	+	O

The filtered temperature series from Spitsbergen have several common features with series from other northern European regions. All series show a temperature increase from the cold 1960's to present, but both Svalbard and the northern regions are presently somewhat colder than they were in the 1930's. This is contrary to the rest of Northern Europe and for the Northern Hemisphere as a whole, where the present temperature level is similar to, or even somewhat higher than the temperature level from the 1930's. The warming before the 1930's is far more dramatic at Svalbard than for the Northern Hemisphere as a whole.

For precipitation at Svalbard Airport, there are significant positive trends on annual basis and for all seasons except winter (Table 5.1). For spring and autumn precipitation, up to 10% of the increase may be artificial, caused by reduced catch deficiency during warmer climate.

The major features in the decadal scale variation of annual precipitation at Svalbard Airport are quite representative for the western coast of Spitsbergen. Both at the Spitsbergen stations and at Hopen, Bjørnøya and Jan Mayen there seems to have been an increase in the level of annual precipitation during the last 7-8 decades. At Spitsbergen, the increase is probably about 25%. At Hopen, Bjørnøya and Jan Mayen, it is probably somewhat smaller. At Jan Mayen, most of the increase in annual precipitation happened before 1960, while the increase at the other stations seems to be more evenly distributed throughout the period.

The progress of the precipitation increase at Svalbard reminds the increase in coastal parts of Northern Norway, as the trend seems to be fairly constant throughout the period, and several seasons contribute to the increase. Further south in Norway, increased precipitation during autumn gave a main contribution to the total annual precipitation increase. This is definitely not the case in the Norwegian Arctic.

The relative precipitation increase at Spitsbergen since 1912 is considerably higher than the similar increase at the Norwegian mainland, and also higher than the «average high latitude increase» estimated by Hulme (1995).

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APPENDIX A: Station description[1] and climate statistics for:

A1: 99710 Bjørnøya (Bear Island)

A2: 99720 Hopen

A3: 99760 Sveagruva

A4: 99790 Isfjord Radio

A5: 99840 Svalbard Airport

A6: 99860 Longyearbyen (climate statistics 1957-75, see also 99840 Svalbard Airport)

A7: 99910 Ny-Ålesund

A8: 99950 Jan Mayen

A9: 99821 Green Harbour (no climate statistics)

The statistics are updated including 1996, and are based partly on digitized daily values (1956-96) and partly on digitized monthly summaries from old protocols. The monthly summaries cover different periods for the various elements; see column «period» in the tables. The temperature and precipitation series are homogeneity tested, and some series are adjusted for inhomogeneities (see station description). As a part of the ALV-project (see Foreword), all daily observations from the Norwegian Arctic stations will be digitized. Accordingly the climate statistics will gradually be extended and updated during the next years. Updated climatological statistics for the Norwegian Arctic stations will therefore be available in the DNMI Internet pages during 1998.

Climate elements included in the statistics in Appendix A1-A8:

- Atmospheric pressure at sea level: *Average and standard deviation*
- Air temperature: *Average, standard deviation, average and absolute maximum and minimum values, monthly (annual) number of frost days (Tmin<0°C), cold days (Tmin<-10 °C), ice days (Tmax< °0C)*
- Relative humidity: *Average*
- Precipitation: *Average, standard deviation, maximum and minimum of monthly (annual) sums, maximum 1-day precipitation, average precipitation sums and number of days with precipitation as rain (liquid), snow (solid) and mixed (sleet, rain + snow), average number of days with precipitation ≥0.1, 1.0 and 10.0 mm/day*
- Snow (only for Svalbard Airport and partly Isfjord Radio): *Average and maximum snow depths, average number of days with more than 50% of the ground covered by snow, average percentage of observations where drifting snow is observed*
- Cloud cover: *Average number of clear days (sum cloud cover <20%), number of overcast days (sum cloud cover>80%), average cloud cover in octas (0 is clear sky, 8 is totally overcast sky)*
- Cloud height: *Percentage of observations with lowest cloud height lower than 100 resp. 300 m*
- Fog: *Percentage of observations where fog is observed*
- Visibility: *Percentage of observations with horizontal visibility less than 1 resp. 4 km*
- Wind force: *Number of days where maximum wind force is higher than or equal to 6 Beaufort (Strong breeze), 8B (Fresh gale), 9B Strong gale*

[1] Updated from Nordli et al 1996b, Hanssen-Bauer et al 1990, Steffensen 1982

Appendix A1

99710 Bjørnøya (Bear Island)

Position 74°,31'N, 19°01'E
Station height 15 m a.s.l.
Midnight sun 1 May - 10 August
Dark season 8 November - 3. February

Bjørnøya is situated halfway between the southern tip of Spitsbergen and the coast of Finnmark, but is considered as one of the Svalbard Islands. The weather station was established in 1920 at Tunheim in the North-eastern part of the island. Temperature was during the first two years measured in two wall screens, but in August 1922 the instruments were moved into a single louvered free standing screen of the Edlund pattern (conc. different screens, cf. Nordli et. al., 1996a). At the same time the precipitation gauge was equipped with a wind shield.

In 1929 there was a small relocation that altered the station's height from 38 m a.s.l to 29 m a.s.l and in 1933 there was a change of screen type, from the Edlund pattern to the pattern of 1930 (MI-30).

In August 1941 the station was destroyed by war actions, but rebuilt in 1945 at a site about 90 m ENE to the old one. The observations were resumed on 25 August that year, now with a radiation screen of pattern 1933 (MI-33). The station height was further reduced to 23 m a.s.l.

On 12 July 1947 the station was moved 7.5 km to Herwigshamna on the Northern side of the island and the station height reduced to 15 m a.s.l. In 1969 a new station was ready for use and the precipitation gauge and radiation screen were moved 82 m and 77 m respectively, to E. The height of the station remained approximately the same.

Homogeneity: The series was found to be homogeneous for temperature but for precipitation the test results from Bjørnøya revealed two inhomogeneities. The first one is connected to the installation of a windshield in 1926. Precipitation then increased during winter, while the summer precipitation was not affected. The second one is attributed to the relocation in 1947 Apparently this relocation led to decreased precipitation during winter, while the summer precipitation was not affected.

In addition, it should be mentioned that when the Bjørnøya series was tested against series from Spitsbergen (Isfjord Radio/Barentsburg) an inhomogeneity significant on the 1% level was found in 1957/58. However, this was not found when testing against other stations, and no reason for such an inhomogeneity was found in the metadata. It may be caused by real differences in the climate evolution on Bjørnøya and Spitsbergen.

Sea Ice

Period 1971-1981, concentration in oktas

Mean day	above 0	7 or more
Freezing up	13.12	22.12
Melting	21.05	19.04

99710 Bjørnøya

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1003.4	1005.1	1007.2	1011.5	1015.4	1012.3	1011.6	1011.5	1007.6	1005.4	1004.7	1002.8	1008.2	1920-
Std.deviation	7.8	7.7	7.1	4.4	3.7	3.6	3.3	3.4	4.2	5.1	5.5	6.5	1.9	1920-
AIR TEMPERATURE, (deg C)														
Average	-6.7	-7.1	-7.4	-5.5	-1.4	1.9	4.5	4.7	2.8	-0.3	-3.0	-5.4	-1.9	1920-
Std.deviation	3.6	3.4	3.5	2.4	1.4	1.2	1.1	1.0	1.1	1.8	2.5	3.5	1.2	1920-
Extreme values														
Lowest monthly/ annual mean	-14.4	-17.5	-17.7	-13.0	-5.8	-0.5	1.3	2.3	0.6	-8.4	-10.8	-13.4	-5.5	1920-
Year lowest mean	1971	1963	1962	1929	1962	1928	1965	1965	1927,68	1968	1971	1987	1968	1920-
Highest monthly/annual mean	0.4	-1.6	0.2	-1.3	1.8	4.4	6.7	7.0	6.5	3.1	1.2	1.8	0.4	1920-
Year highest mean	1933	1984	1974	1994,60	1960	1953	1920	1937	1990	1961	1931	1938	1974	1920-
Average daily minimum	-9.7	-10.1	-10.3	-8.0	-3.1	0.3	2.7	3.1	1.4	-2.1	-5.3	-8.3	-4.1	1923-
Average lowest monthly min.	-19.8	-20.7	-20.9	-17.2	-9.5	-3.5	-0.5	0.0	-2.2	-8.0	-12.9	-17.6		1923-
Absolute min	-29.8	-29.1	-31.6	-25.6	-17.8	-8.4	-4.7	-2.4	-10.4	-22.2	-21.5	-28.1	-31.6	1923-
Year abs. min	1964	1963	1927	1941	1948	1962	1977	1982	1968	1968	1988	1988	1927	1923-
Average daily maximum	-4.3	-4.3	-4.1	-2.6	0.5	3.8	6.6	6.6	4.5	1.4	-1.2	-3.3	0.3	1937-
Average highest monthly maxim	2.8	2.4	2.5	2.8	4.9	9.1	12.8	12.0	8.8	6.0	3.8	3.1		1923-
Absolute max	5.3	5.0	6.2	5.7	16.5	23.6	22.4	21.5	15.5	10.5	8.4	6.4	23.6	1923-
Year abs. max	1937	1938	1948	1937	1960	1953	1972	1989	1990	1924	1977	1953	1953	1923-
No. of days with:														
Daily min. <=0	29.7	27.5	29.7	28.3	25.0	12.9	2.6	1.1	6.8	21.0	26.2	29.3	240.2	1923-
Daily min <=-10	14.4	13.3	14.2	9.8	1.1	0.0	0.0	0.0	0.0	0.7	5.1	11.9	70.4	1937-
Daily max <=0	22.0	19.6	21.4	19.3	12.0	2.0	0.0	0.0	0.6	8.5	15.5	20.3	141.2	1937-
RELATIVE HUMIDITY (%)														
Average	87.4	87.4	87.8	87.1	87.7	90.2	92.0	90.6	89.0	85.7	86.4	87.3	88.2	1923-
PRECIPITATION (mm)														
Average monthly/annual prec.	33.7	31.2	29.6	20.8	19.1	22.5	25.5	34.0	44.2	40.7	31.5	32.3	365.1	1920-
Std . deviation	18.5	16.8	15.0	11.1	11.4	14.2	15.8	19.9	21.7	19.6	14.5	16.9	64.6	1920-
Min. monthly/annual	8.4	4.5	5.2	3.0	3.4	3.0	2.0	4.0	11.8	10.2	8.3	5.2	214.8	1920-
Year min. monthly/annual	1926	1946	1931	1931	1931	1949	1953	1930	1990	1923	1925	1922	1946	1920-
Max. monthly/annual	119.1	81.9	83.3	57.8	58.7	90.7	83.0	87.0	107.1	104.0	71.4	75.1	486.7	1920-
Year max monthly/annual	1993	1922	1920	1928	1933	1967	1952	1949	1929	1970	1996	1992	1933	1920-
Max. in 1 day	23.5	18.8	32.3	17.9	40.5	20.9	30.8	23.0	34.0	24.5	20.5	41.5	41.5	1926-
Year max 1 day obs.	1933	1930	1933	1938	1933	1967	1974	1949	1989	1926	1972	1988	1988	1926-
Rain (mm)	2.0	1.8	1.5	1.9	4.6	15.2	25.4	32.4	31.1	15.9	6.9	2.6	141.3	1956-
Snow (mm)	19.2	19.5	17.7	11.6	6.4	1.3	0.0	0.0	2.3	9.5	14.4	17.9	120.1	1956-
Mixed (mm)	12.9	11.8	11.2	9.2	7.7	7.2	2.4	3.2	10.3	17.5	12.7	11.8	117.9	1956-
No. of days with														
>=0.1 mm	20.2	18.6	19.6	16.6	15.8	13.8	13.9	16.7	20.2	21.0	19.9	20.2	216.4	1920-
>=1.0 mm	9.6	8.9	9.0	6.5	5.5	5.6	5.7	6.7	9.6	9.8	9.1	9.1	95.0	1920-
>=10.0 mm	0.4	0.3	0.2	0.1	0.1	0.2	0.5	0.7	0.8	0.6	0.3	0.3	4.5	1931-
Rain >=0.1 mm	1.1	0.9	1.2	1.5	4.0	8.9	14.6	17.2	14.3	7.3	3.0	1.5	75.5	1956-
Snow >= 0.1 mm	15.3	14.5	14.9	12.4	7.7	2.7	0.1	0.0	2.1	8.0	12.8	14.9	105.4	1956-
Mixed>=0.1 mm	4.3	4.5	4.7	4.3	5.0	3.8	1.0	0.9	4.7	6.9	5.4	4.4	49.9	1956-
Perc. freq. of														
Drifting snow	19.6	17.5	17.6	11.2	2.9	0.0	0.1	0.0	0.2	3.6	12.1	16.9	8.4	1956-
CLOUDS & VISIBILITY														
No. of clear days	1.1	0.7	0.7	0.8	0.2	0.5	0.5	0.3	0.1	0.0	0.2	0.8	5.9	1920-
No. of overcast days	16.1	15.0	17.0	16.8	21.9	22.5	23.9	23.0	22.6	21.3	19.4	16.3	235.8	1920-
Average, octas	6.6	6.7	6.7	6.7	7.4	7.4	7.5	7.5	7.5	7.3	7.2	6.6	7.1	1920-
Perc. freq. of:														
Fog	3.5	3.8	4.4	5.5	11.1	23.3	39.3	32.8	19.7	8.6	4.0	2.4	13.2	1956-
Horizontal visibility (%):														
1 km or less	7.2	7.3	6.2	4.9	6.6	12.4	21.8	19.2	11.8	6.6	5.1	5.1	9.5	1958-
4 km or less	17.8	18.7	21.4	17.4	14.8	22.3	34.8	30.0	22.0	15.8	15.4	16.0	20.6	1958-
Lowest cloud height (%):														
100 m or less	0.9	1.3	0.8	1.2	2.2	5.2	10.9	10.4	5.9	3.2	1.4	1.2	3.7	1956-
300 m or less	17.4	21.0	25.4	26.8	28.2	38.0	49.4	45.1	37.3	30.5	24.4	15.1	29.9	1956-
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	21.2	18.4	20.0	15.0	10.4	8.0	7.3	8.5	11.8	17.9	19.4	20.6	178.5	1937-
>=8 B	6.8	6.1	4.7	2.3	0.9	0.5	0.2	0.6	1.4	3.3	4.4	5.0	36.2	1937-
>=9 B	2.6	2.4	1.7	0.7	0.2	0.1	0.0	0.1	0.6	0.9	1.5	1.9	12.7	1920-

Missing/incomplete data: For the years 1941-45, data is missing for all parameters except mean temperature.

Appendix A2

99720 Hopen

Position 76° 30' N, 25° 04' E
Station height 6 m a.s.l.
Midnight sun: 26. April - 16. August
Dark season: 2. November - 9. February

Hopen is situated in the Barents Sea, about 220 km east of the southern point of Spitsbergen, see Fig. 2.1. The island is long and narrow, extending southwest-northeast. The weather station lies in Husdalen on the east coast of the island, about 7 km from the southern point on a plain declining slightly towards the sea. In northeast and southwest hills rise up to 300 m a.s.l, quite near the station.

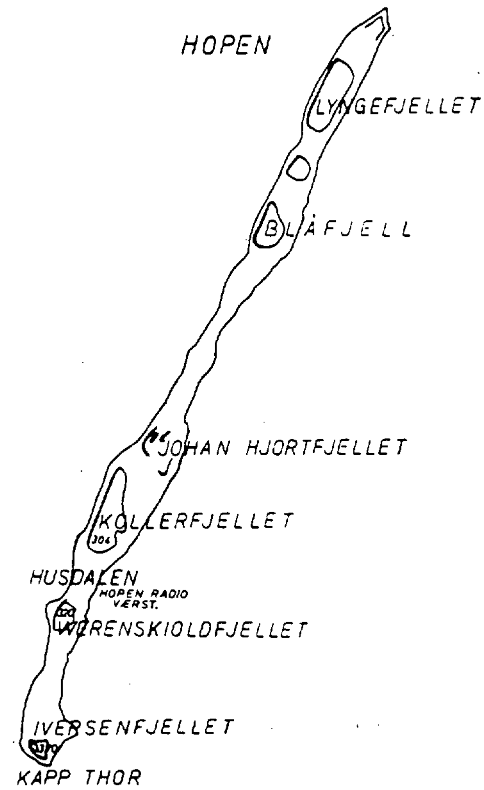
The weather station at Hopen was established by German soldiers in November 1944 and operated through July 1945. The radiation shield of the German type Johannes Blume was in decay and the inner cage was lost. The barometer is reported to have had a rather bad position in the house. Precipitation was not observed.

On 14 October 1945 the station was re-established at Hopen Radio by the Norwegian Marine and has been situated on this place since then. However, there has been some changes of instrument types. In 1945 the radiation screen MI-30 replaced the German type and in 1948 MI-33 replaced MI-30. In 1948 the precipitation gauge was equipped with a shield.

In the years 1957 to 1976 there were changes of the station buildings. About 1970 a building was removed and replaced by a much lower one which might have reduced the lee turbulence effect at the site of the precipitation gauge, see below.

Homogeneity

The temperature series was tested and found to be homogeneous.



The precipitation series is tested from 1948, when a windshield was installed. An inhomogeneity significant on the 1% level was found in 1974. This was probably caused by several changes in the environments during 1971-1975. Old buildings were removed and new ones built during this period, and the exposure of the precipitation gauge was certainly affected by these changes.

Sea Ice

Period 1971-1981, concentration in oktas

Mean day	above 0	7 or more
Freezing up	01.11	12.11
Melting	27.07	08.07

99720 Hopen

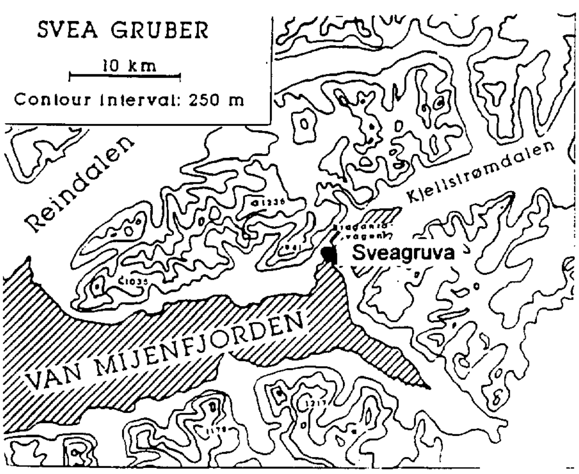
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1005.8	1007.6	1008.7	1012.9	1016.2	1012.6	1011.6	1011.8	1008.3	1006.5	1006.6	1004.3	1009.4	1946-
Std.deviation	7.2	7.9	7.2	4.9	3.8	3.7	3.5	3.9	4.3	5.4	5.3	6.3	2.1	1946-
AIR TEMPERATURE, (deg C)														
Average	-13.0	-12.7	-12.9	-10.5	-4.6	-0.3	2.1	2.5	0.9	-3.1	-7.8	-11.2	-5.9	1946-
Std.deviation	5.1	4.4	4.5	3.0	1.4	0.8	0.9	1.0	1.3	2.8	4.8	5.3	1.7	1946-
Extreme values														
Lowest monthly/ annual mean	-22.6	-22.3	-22.3	-16.6	-8.7	-1.9	0.5	0.0	-2.3	-14.3	-17.5	-19.8	-10.6	1946-
Year lowest mean	1971	1963	1968	1988	1962	1962	1965	1962	1968	1968	1971	1968	1968	1946-
Highest monthly/annual mean	-0.8	-5.1	-4.6	-5.0	-1.9	1.8	4.2	4.9	4.6	1.3	0.1	-1.2	-2.9	1946-
Year highest mean	1947	1954	1974	1992	1960	1953	1960	1991	1990	1957	1953	1953	1954	1946-
Average daily minimum	-16.4	-16.1	-16.1	-13.4	-6.5	-1.6	0.7	1.2	-0.3	-4.8	-10.2	-14.1	-8.1	1946-
Average lowest monthly min.	-27.1	-28.1	-27.7	-23.4	-14.6	-5.4	-1.9	-1.6	-4.2	-12.0	-19.4	-24.9		1946-
Absolute min	-35.5	-34.7	-36.9	-30.2	-22.1	-9.9	-4.3	-4.4	-12.4	-29.0	-31.7	-35.6	-36.9	1946-
Year abs. min	1981	1952	1986	1988	1948	1962	1963	1968	1968	1966	1968	1968	1986	1946-
Average daily max.	-9.7	-8.9	-9.2	-7.3	-2.5	1.4	4.0	4.2	2.2	-1.3	-5.0	-8.1	-3.4	1949-
Average highest monthly max	1.1	1.0	1.0	1.5	3.0	5.4	8.4	8.2	6.1	4.1	2.2	1.3		1946-
Absolute max	4.0	4.5	3.6	5.4	8.8	15.7	17.4	14.1	11.0	9.1	7.1	5.5	17.4	1946-
Year abs. max	1954	1951	1957	1959	1960	1953	1973	1996	1990	1953,61	1953	1984	1973	1946-
No. of days with:														
Daily min <=0	30.8	28.0	30.7	29.7	29.7	23.6	10.1	7.0	15.2	26.3	28.4	30.6	290.2	1946-
Daily min <=-10	22.3	19.9	21.8	20.1	6.6	0.0	0.0	0.0	0.1	4.6	14.4	19.8	129.5	1946-
Daily max <=0	27.6	24.5	26.0	24.9	21.1	6.9	0.3	0.2	4.4	16.4	21.9	26.2	200.4	1949-
RELATIVE HUMIDITY (%)														
Average	86.3	86.8	86.1	86.0	86.3	90.9	93.3	92.4	89.7	86.9	88.2	87.6	88.4	1946-
PRECIPITATION (mm)														
Average monthly/annual prec.	44.7	42.1	42.4	31.7	24.8	26.8	32.1	39.4	45.1	47.2	42.1	51.8	470.2	1946-
Std . deviation	24.2	27.4	23.0	14.4	13.3	15.1	22.3	21.5	17.3	20.6	20.4	32.4	98.3	1946-
Min. monthly/annual	15.0	6.2	5.0	8.0	4.7	2.4	2.0	10.0	12.7	19.8	14.0	5.5	210.0	1946-
Year min. monthly/annual	1946	1970	1947	1946,87	1996	1953	1947	1946	1973	1981,82	1946	1956	1946	1946-
Max. monthly/annual	135.2	136.5	129.3	70.0	70.9	77.6	102.5	103.6	92.0	123.0	103.7	180.2	753.2	1946-
Year max monthly/annual	1996	1959	1992	1951	1975	1961	1974	1995	1949	1994	1966	1982	1983	1946-
Max. in 1 day	40.4	29.3	28.9	18.6	46.7	32.2	28.3	47.2	38.2	24.7	29.0	49.1	49.1	1948-
Year max 1 day	1996	1989	1992	1994	1975	1981	1995	1995	1982	1983	1983	1986	1986	1948-
Rain (mm)	0.8	0.3	0.3	0.1	1.4	10.1	26.8	27.7	23.6	7.2	2.8	0.5	101.6	1956-
Snow (mm)	35.2	32.3	33.3	22.8	13.6	6.1	2.0	1.0	7.3	21.5	31.1	37.7	243.9	1956-
Mixed (mm)	4.7	5.7	4.9	4.8	6.7	10.4	5.6	11.2	13.6	16.6	8.3	5.7	98.2	1956-
No. of days with														
>=0.1 mm	19.4	18.3	18.4	16.7	17.8	15.7	16.0	19.4	21.2	23.2	21.4	20.4	227.8	1946-
>=1.0 mm	9.9	9.0	9.0	7.3	5.7	5.8	6.6	7.9	10.8	11.3	10.0	9.8	103.2	1946-
>=10.0 mm	0.5	0.5	0.5	0.3	0.1	0.2	0.7	0.7	0.5	0.5	0.4	0.8	5.7	1947-
Rain >=0.1 mm	0.4	0.2	0.4	0.3	1.5	5.4	13.3	15.5	9.5	3.2	1.4	0.2	51.3	1956-
Snow >= 0.1 mm	17.1	16.2	16.1	14.3	12.7	6.0	0.7	0.8	5.8	13.4	17.2	17.0	137.3	1956-
Mixed>=0.1 mm	1.6	1.8	1.9	1.9	3.2	4.6	2.2	2.8	5.8	5.5	3.1	1.7	36.1	1956-
Perc. freq. of														
Drifting snow	22.2	20.4	20.9	14.7	5.3	1.0	0.1	0.0	0.9	6.3	14.8	21.2	10.6	1956-
CLOUDS & VISIBILITY														
No. of clear days	4.7	3.0	4.2	4.0	1.1	1.0	1.0	0.5	0.2	0.3	2.1	4.0	26.0	1946-
No. of overcast days	11.6	11.5	12.8	12.5	18.8	21.1	22.3	22.7	23.1	22.3	15.9	13.6	208.0	1946-
Average, octas	5.0	5.2	5.1	5.1	6.3	6.7	6.8	6.8	7.0	6.8	5.9	5.3	6.0	1946-
Perc. freq. of:														
Fog	3.8	4.3	5.6	8.0	11.0	25.5	45.1	39.4	20.6	9.2	5.0	2.9	15.0	1956-
Horizontal visibility (%):														
1 km or less	7.0	6.5	7.2	6.8	6.2	13.4	26.1	22.6	13.1	7.3	5.0	6.5	10.6	1958-
4 km or less	17.7	17.7	20.9	18.5	14.5	24.0	39.0	32.9	23.8	18.0	17.8	16.3	21.8	1958-
Lowest cloud height (%):														
100 m or less	1.4	2.2	3.0	4.7	5.4	9.3	17.2	13.1	8.3	4.0	1.8	1.3	6.0	1956-
300 m or less	17.4	23.2	28.6	32.1	35.7	47.1	54.6	51.1	40.9	26.9	24.4	18.3	33.4	1956-
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	13.7	11.6	12.2	7.6	4.3	4.0	4.7	3.4	5.3	8.7	10.9	13.9	100.4	1946-
>=8 B	3.1	2.2	2.2	1.1	0.1	0.2	0.2	0.0	0.5	1.3	1.6	3.3	15.7	1946-
>=9 B	1.2	0.9	0.8	0.3	0.0	0.0	0.0	0.0	0.1	0.3	0.5	1.2	5.3	1947-

Appendix A3

99760 Sveagruva

Position 77°54' N, 16° 48' E
Station height 9 m a.s.l.
Midnight sun 21. April - 21. August
Dark season 27. October - 13. February

The station is situated on the bank at Sveabukta in the inner part of Van Mijenfjorden. High mountains 700-950 m above sea level, are situated in the sector west to north. Between the station and these mountains is a plain of level tundra. Northeast of the station is the bay, Braganzavågen, and further away the valley, Kjellstrømdalen. The terrain southwest of the station consists of moraines, and west-southwest is the direction out Van Mijenfjorden.



The station was opened in May 1978 and is run by the Committee on Permafrost together with Meteorological Institute. Some data from the first two years are missing. In the summer 1981 the radiation screen and the precipitation gauge were moved about 100 m NW to an area also used for permafrost measurements.

Homogeneity
The temperature series correlated well with the reference series. As no significant break was detected, the series was found homogeneous.

An inhomogeneity significant on the 1% level was found in the precipitation series in 1982. The inhomogeneity is probably a consequence of the relocation in 1981. The precipitation values in the table on next page are not adjusted for this homogeneity.

99760 Sveagruva

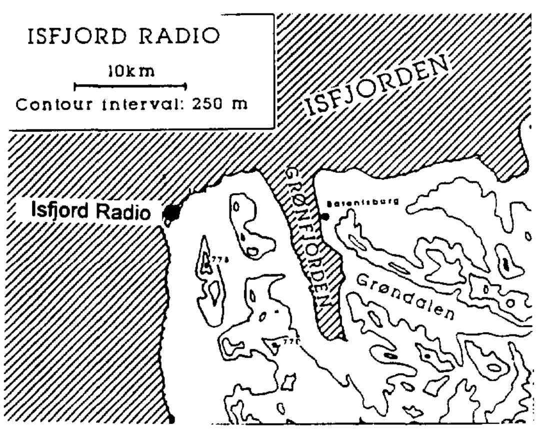
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1005.2	1006.8	1009.6	1014.3	1016.5	1012.4	1010.9	1011.0	1009.5	1008.0	1006.4	1005.3	1009.7	1979-
Std.deviation	7.8	8.0	7.8	5.2	4.4	3.7	4.0	4.2	3.4	4.7	5.4	7.4	2.3	1979-
AIR TEMPERATURE, (deg C)														
Average	-15.8	-15.9	-14.1	-11.7	-4.1	2.1	6.2	5.0	0.8	-6.0	-11.0	-15.0	-6.6	1979-
Std.deviation	4.2	3.5	3.4	3.0	1.4	1.0	0.8	0.7	1.7	2.4	4.5	4.4	1.3	1979-
Extreme values														
Lowest monthly/ annual mean	-22.7	-20.8	-20.4	-16.3	-8.0	-0.1	4.6	3.5	-2.8	-11.2	-18.5	-22.2	-8.9	1979-
Year lowest mean	1981	1979,86	1981	1988	1979	1979	1982	1982	1982	1988	1988	1988	1988	1979-
Highest monthly/annual mean	-7.0	-10.0	-8.2	-7.3	-1.6	3.7	7.8	6.3	5.0	-2.0	-2.9	-3.2	-3.5	1979-
Year highest mean	1990	1984	1996	1989	1989	1980	1993	1991	1990	1984	1993	1984	1984	1979-
Average daily min	-20.3	-20.4	-18.1	-15.5	-6.9	0.3	4.1	3.3	-0.7	-8.6	-14.5	-19.1	-9.8	1979-
Average lowest monthly min	-33.7	-35.2	-33.1	-26.6	-17.2	-4.4	1.3	-0.5	-6.5	-18.2	-25.0	-31.3		1979-
Absolute min	-44.1	-44.8	-43.7	-33.0	-23.3	-8.0	0.0	-3.5	-11.3	-26.7	-32.5	-38.7	-44.8	1979-
Year abs. min	1981	1992	1986	1988	1990	1983	1989	1994	1988	1988	1980	1988	1992	1979-
Average daily max	-12.0	-11.8	-10.5	-8.3	-1.6	4.2	8.7	7.1	2.7	-3.8	-7.9	-11.6	-3.7	1979-
Average highest monthly max	0.9	1.4	1.7	1.8	3.8	9.0	12.3	12.0	7.8	3.7	2.1	2.0		1979-
Absolute max	6.5	4.6	5.4	4.6	5.6	13.3	16.1	15.3	13.5	7.5	6.3	6.5	16.1	1979-
Year abs. max	1996	1980	1983	1989	1995	1984	1993	1988	1990	1979	1993	1984	1993	1979-
No. of days with:														
Daily min. <=0	31.0	28.2	30.7	29.6	28.4	9.8	0.0	1.3	15.4	29.2	29.8	30.8	264.2	1979-
Daily min <=-10	26.6	23.7	24.4	23.0	9.1	0.0	0.0	0.0	0.2	12.0	21.0	26.3	166.2	1979-
Daily max <=0	27.9	25.2	27.2	26.3	17.8	1.7	0.0	0.0	5.6	22.4	25.7	27.5	207.4	1979-
RELATIVE HUMIDITY (%)														
Average	82.9	81.8	81.1	79.9	81.8	82.5	81.1	81.9	83.6	79.4	80.0	80.0	81.3	1982-
PRECIPITATION (mm)														
Average monthly/annual prec.	33.1	39.6	36.0	25.2	14.2	9.0	11.5	18.1	18.3	17.6	25.8	32.8	281.2	1979-
Std . deviation	14.5	27.7	14.3	15.5	11.7	7.9	8.9	10.5	9.4	11.9	21.9	22.4	57.6	1979-
Min. monthly/annual	13.8	6.4	6.7	5.2	0.5	1.0	1.1	5.6	5.9	2.4	4.9	2.9	155.2	1979-
Year min. monthly/annual	1980	1987	1980	1994	1980	1987	1992	1995	1986	1981	1983	1986	1983	1979-
Max. monthly/annual	65.7	115.0	58.0	64.2	42.0	28.1	31.4	40.1	35.4	47.4	78.3	79.2	375.1	1979-
Year max monthly/annual	1992	1991	1996	1990	1979	1992	1994	1981	1990	1986	1993	1995	1981	1979-
Max. in 1 day	16.1	29.0	18.0	25.1	20.5	13.1	11.8	17.6	12.7	13.0	15.9	20.3	29.0	1979-
Year max 1 day	1996	1981	1982	1982	1979	1979	1995,96	1981	1985	1979	1993	1995	1981	1979-
Rain (mm)	0.5	0.8	2.2	0.1	0.1	3.2	10.3	14.5	7.3	2.0	1.0	1.7	43.7	1979-
Snow (mm)	28.8	30.5	24.9	20.1	10.9	2.5	0.0	0.6	2.4	10.9	18.1	25.4	175.1	1979-
Mixed (mm)	3.8	8.3	8.9	5.0	3.2	3.3	1.2	3.0	8.6	4.7	6.6	5.7	62.3	1979-
No. of days with														
>=0.1 mm	15.1	14.1	14.8	11.9	7.8	6.7	7.8	9.3	12.2	12.7	12.8	12.8	138.1	1979-
>=1.0 mm	8.4	7.9	8.6	6.0	2.8	2.4	3.1	4.4	5.8	4.9	6.3	6.8	67.4	1979-
>=10.0 mm	0.3	0.9	0.6	0.2	0.3	0.1	0.1	0.3	0.1	0.1	0.4	0.6	4.1	1979-
Rain >=0.1 mm	0.3	0.2	0.6	0.1	0.4	2.7	7	7.3	4.8	1.1	0.4	0.2	25.1	1979-
Snow >= 0.1 mm	13.7	12.7	12.6	10.2	5.5	1.7	0	0.4	2.7	9.3	10.4	11.3	90.5	1979-
Mixed>=0.1 mm	1.1	1.3	1.7	1.6	1.8	2.4	0.8	1.7	4.7	2.3	2	1.3	22.7	1979-
Perc. freq. of														
Drifting snow	36.0	29.9	28.7	21.5	7.4	0.7	0.0	0.1	1.5	8.9	21.8	27.9	15.4	1979-
CLOUDS & VISIBILITY														
No. of clear days	6.9	5.6	6.4	7.4	4.8	1.4	2.1	1.3	0.6	1.9	5.0	8.5	51.9	1979-
No. of overcast days	11.1	10.3	12.7	9.7	12.9	16.8	15.9	18.9	20.2	16.3	12.8	9.6	167.3	1979-
Average, octas	4.6	4.7	4.8	4.3	5.0	6.0	5.9	6.3	6.6	5.9	5.0	4.1	5.3	1979-
Perc. freq. of:														
Fog	0.2	0.5	0.1	0.6	1.0	3.3	2.2	1.9	1.6	0.4	0.0	0.0	1.0	1979-
Horizontal visibility (%):														
1 km or less	7.8	6.0	5.9	2.7	2.2	1.4	0.7	0.7	0.7	0.8	1.9	5.6	3.0	1979-
4 km or less	15.1	13.5	13.4	6.9	5.0	4.9	1.8	1.9	1.9	6.2	7.0	9.9	7.3	1979-
Lowest cloud height (%):														
100 m or less	0.3	0.3	0.3	0.1	0.4	1.5	1.7	1.4	1.3	0.5	0.0	0.1	0.6	1979-
300 m or less	1.7	1.9	3.2	4.1	5.4	12.2	18.4	17.6	13.0	6.2	1.7	1.5	7.2	1979-
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	10.3	8.7	10.3	6.1	2.4	2.8	3.7	2.6	2.8	4.3	6.7	9.0	69.7	1978-
>=8 B	1.1	1.8	1.0	0.5	0.1	0.1	0.0	0.2	0.1	0.3	0.6	0.8	6.6	1978-
>=9 B	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.5	1978-

Appendix A4

99790 Isfjord Radio

Position 78° 04' N, 13° 38' E
Station height 5 m.
Midnight sun 21. April - 22. August
Dark season 26. October - 15. February

Isfjord Radio is situated at Kapp Linne on the western coast of Spitsbergen. The station is situated on a low plain, 5-10 m a.s.l. The plain extends east-northeast about 6 km to Kapp Starostin and south to Bellsund. To the north of the station lies Isfjorden, and to the east and southeast a mountain range with heights up to 600-800 m a.s.l.



The station was established 1 September 1934. It was destroyed by war actions in September 1941 but re-established at the same place after the war. From August 1946 observations were resumed, but from 30 June 1976 the station was taken out of the official network, the observation program was reduced, and data not any longer controlled and stored in the files of DNMI. However, from 2 September 1996 temperature data is logged every hour and stored at DNMI. But still no solution for more extended observations are found.

The radiation screen has altered between the patterns of 1930 and 1933, but since 1951 it has remained unchanged (MI-33).

On 15 August 1939 the precipitation gauge was equipped with a wind shield.

In 1958 the radiation screen and precipitation gauge were moved to another site about 60 m to NW. The precipitation gauge was again moved 15 m further in the same direction on 22 August 1966.

Homogeneity
In all seasons the temperature series correlated well with Barentsburg series. All tests revealed homogeneous results.

Three inhomogeneities were found in the precipitation series from Isfjord Radio. The installation of a windshield in 1939 increased the gauge catch in all seasons, but mostly during winter. A relocation in 1958 apparently also led to increased gauge catch, though this may partly be caused by increased influence of drifting snow. A relocation in 1966 led to increased gauge catch during summer, but reduced measured precipitation during winter. The new location was reported to be less affected by drifting snow, which explains the reduced winter precipitation. The gauge catch during summer was increased, as the new position was less wind exposed than the old one.

Sea Ice
No regular observations of sea ice concentration have been made at Isfjord Radio. Some general features concerning ice conditions, however, are summarised here. Ice conditions vary markedly from ice-free to total coverage, both in Isfjorden and in the ocean to the west. The outer part of Isfjorden is often ice-free, while simultaneously the ocean to the immediate west is filled with pack ice. The frequent presence of open water creates a climate at Isfjorden that is more "coastal" than at any other Spitsbergen station.

99790 Isfjord Radio

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1007.1	1007.5	1009.7	1012.7	1016.4	1012.6	1011.8	1011.5	1008.1	1006.6	1007.5	1005.0	1009.7	1935-75
Std.deviation	6.3	8.3	7.2	5.9	3.5	3.9	3.2	3.4	4.0	5.1	4.9	6.3	2.0	1935-75
AIR TEMPERATURE, (deg C)														
Average	-10.7	-11.5	-12.2	-9.3	-3.3	1.7	4.7	4.3	1.1	-3.2	-6.8	-8.9	-4.5	1935-75
Std.deviation	4.5	3.1	3.3	2.3	1.5	0.8	0.8	0.8	1.1	2.6	3.4	4.0	1.5	1935-75
Extreme values														
Lowest monthly/ annual mean	-18.6	-20.2	-19.4	-15.7	-6.9	0.1	3.0	2.7	-1.2	-11.9	-14.3	-17.8	-8.1	1935-75
Year lowest mean	1967	1963	1969	1969	1966	1969	1962	1948	1966	1968	1968	1968	1968	1935-75
Highest monthly/annual mean	-1.8	-4.7	-6.7	-5.8	-0.7	3.3	6.0	5.5	3.4	1.4	-0.6	-0.6	-2.1	1935-75
Year highest mean	1947	1954	1974	1957	1936	1972	1960	1935	1960	1957	1953	1938	1954	1935-75
Average daily min	-13.6	-14.5	-15.0	-11.6	-4.9	0.3	3.3	3.0	-0.3	-5.2	-9.2	-11.6	-6.6	1947-75
Average lowest monthly min	-22.7	-24.1	-23.3	-21.1	-11.5	-3.4	1.0	0.2	-5.0	-12.2	-17.1	-20.8		1935-75
Absolute min	-32.0	-32.2	-32.3	-29.9	-19.6	-8.2	-1.3	-2.3	-10.8	-23.6	-26.9	-33.5	-33.5	1935-75
Year abs. min	1967	1963	1966	1941	1963	1962	1948	1971	1968	1968	1951	1968	1968	1935-75
Average daily max.	-8.5	-8.5	-9.3	-6.7	-1.6	3.3	6.5	5.8	2.6	-1.6	-4.8	-6.9	-2.5	1935-75
Average highest monthly max	0.7	0.6	0.0	1.1	3.3	7.6	11.0	10.0	7.1	4.4	2.5	1.5		1935-75
Absolute max	3.8	4.4	3.9	5.6	13.1	12.5	17.0	14.3	12.0	8.5	6.2	5.6	17.0	1935-75
Year abs. max	1972	1954	1972	1952	1960	1953	1966	1961	1960	1961	1953	1938	1953	1935-75
No. of days with:														
Daily min <=0	30.8	28.2	30.9	24.9	28.6	11.1	0.1	0.7	15.1	27.4	28.4	30.6	256.8	1956-75
Daily min <=-10	22.5	20.6	24.2	18.4	2.8	0	0	0	0.1	4.8	14.1	18.6	126.1	1956-75
Daily max <=0	27.1	25.5	28.0	26.6	19.5	1.8	0	0	4.5	18.4	22.5	26.5	200.4	1956-75
RELATIVE HUMIDITY (%)														
Average	82.0	81.0	83.0	81.0	82.0	86.0	88.0	86.0	84.0	81.0	81.0	82.0	83.0	1956-75
PRECIPITATION (mm)														
Average monthly/annual prec.	38.6	33.8	34.3	23.8	24.5	28.2	38.3	53.1	47.2	44.4	40.5	39.3	443.9	1935-76
Std . deviation	29.3	21.7	25.4	19.8	17.3	19.1	24.9	34.0	27.5	25.8	23.8	32.7	115.4	1935-75
Min. monthly/annual	2.8	3.8	1.0	2.5	0.0	1.2	2.3	3.7	3.8	10.0	3.5	1.2	277.8	1935-75
Year min. monthly/annual	1959	1952	1962	1938	1949	1955	1950	1966	1935	1970	1950	1950	1935	1935-75
Max. monthly/annual	121.7	87.2	104.7	82.5	66.1	89.1	102.4	165.6	107.6	116.2	104.6	156.0	749.8	1935-75
Year max monthly/annual	1965	1976	1964	1937	1937	1970	1973	1937	1958	1951	1958	1953	1972	1935-75
Max. in 1 day	54.0	31.0	23.0	21.0	33.0	29.0	26.0	29.0	35.0	30.0	38.0	34.0	54.0	1956-75
Year max 1 day. obs.	1965	1962	1959	1967	1971	1970	1973	1969	1969	1972	1958	1965	1965	1956-75
Rain (mm)	2.0	0.1	0.1	1.4	5.1	17.5	37.3	39.9	27.1	10.6	5.1	0.8	147.0	1956-75
Snow (mm)	23.8	27.2	24.7	16.3	8.8	1.9	0.3	0.1	4.1	13.8	20.5	23.2	164.7	1956-75
Mixed (mm)	14.3	8.0	12.9	7.6	11.3	12.6	2.6	4.6	19.2	14.9	18.0	17.1	143.1	1956-75
No. of days with														
>=0.1 mm	13.1	12.3	14.1	10.7	11.7	12.9	15.1	15.1	14.9	14.9	12.8	13.6	161.2	1956-75
>=1.0 mm	6.6	6.8	6.6	5.5	5.3	6.4	8.4	8.8	8.9	8.2	8.2	6.7	86.4	1956-75
>=10.0 mm	0.6	0.8	0.8	0.4	0.4	0.6	0.8	1.0	1.2	1.0	0.9	1.0	9.5	1956-75
Rain >=0.1 mm	0.3	0.1	0.1	0.3	1.4	5.3	13.9	13.2	6.2	2.7	0.8	0.2	44.5	1956-75
Snow >= 0.1 mm	10.2	10.5	12.1	8.1	6.8	2.8	0.2	0.2	3.6	8.9	8.6	11.3	83.3	1956-75
Mixed>=0.1 mm	2.5	1.6	1.7	2.0	3.5	4.5	0.9	1.4	4.9	3.3	3.2	2.0	31.5	1956-75
SNOW														
Absolute max. snow depth (cm)	90	90	100	105	110	92	12	2	5	40	50	60	110.0	1956-75
Year max snow depth	1965	1959	1965	1964	1964	1964	1964	1962	1958	1965	1967	1957	1964	1956-75
CLOUDS & VISIBILITY														
No. of clear days	5.4	2.8	3.4	5.5	3.2	1.1	1.0	0.7	1.0	1.5	3.0	4.9	33.5	1956-75
No. of overcast days	12.0	11.5	12.6	9.5	15.2	17.2	20.0	19.0	17.5	17.1	13.3	12.8	177.7	1956-75
Average, octas	4.9	5.3	5.2	4.6	5.5	6.2	6.5	6.4	6.3	6.0	5.4	5.0	5.6	1956-75
Perc. freq. of:														
Fog	0.5	1.1	1.3	0.3	1.4	3.9	5.1	3.8	2.3	0.9	0.3	0.2	1.8	1956-75
Horizontal visibility (%):														
1 km or less	3.0	4.8	4.0	1.2	2.3	3.7	3.7	4.0	2.0	1.8	2.1	2.9	3.0	1956-75
4 km or less	10.1	14.3	14.7	7.9	6.8	8.4	10.1	9.7	8.6	8.0	9.0	9.3	9.7	1956-75
Lowest cloud height (%):														
100 m or less	2.9	5.2	3.3	0.9	1.6	3.4	6.5	4.5	2.4	3.0	6.2	3.2	3.6	1956-75
300m or less	5.0	9.4	10.2	6.8	11.2	18.5	26.0	19.4	13.5	11.5	10.7	4.4	12.2	1956-75
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	21.4	19.4	21.0	15.0	10.5	6.7	6.3	7.8	12.6	16.9	19.7	22.4	179.7	1956-75
>=8 B	6.2	6.6	6.8	2.5	1.4	0.7	0.4	0.6	1.6	3.3	5.4	7.8	43.3	1956-75
>=9 B	2.2	2.8	2.3	0.8	0.3	0.1	0.0	0.1	0.2	0.8	1.6	3.0	14.2	1956-75

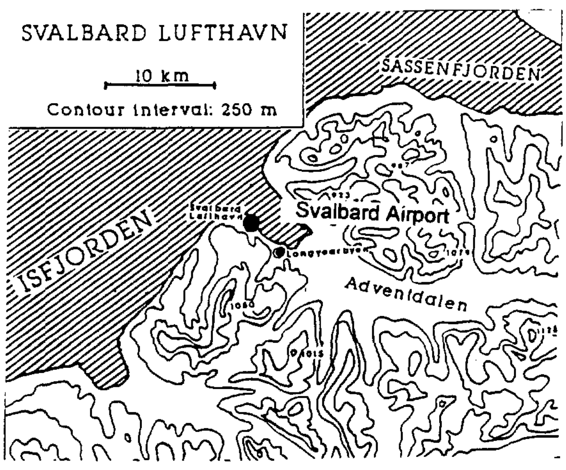
Missing/incomplete data: No observations 1941-46

Appendix A5

99840 Svalbard Airport (lufthavn)

Position 78° 15' N, 15° 28' E
Station height 28 m a.s.l.
Midnight sun 20. April - 22. August
Dark season 26. October - 16. February

The airport, Svalbard Lufthavn, is situated at Hotellneset, 3-4 km northwest of the old station Longyearbyen, see next page. Measurements began in August 1975 and the station is still in operation. There has been no changes at the station that should be expected to influence measurements.



Homogeneity

The temperature and precipitation series is tested against a reference group consisting of the four nearest stations and the series were found to be homogeneous.

Composite temperature and precipitation series valid for Svalbard Airport

The series from Svalbard Airport, Longyearbyen and Green Harbour were nested together to form a composite series starting in December 1911. (Nordli et al. 1996b). In addition the gaps in the series were filled with data from Barentsburg. During World War II missing values were interpolated.

For homogeneity reasons the early series were adjusted. In spite of only 3-4 km difference between Svalbard Airport and Longyearbyen, the Longyearbyen temperature series had to be adjusted varying from -1.1°C (late winter) to -0.1°C in October. The adjustments of Green Harbour was more complicated as a temperature dependant adjustment term was used in winter (Nordli et al. 1996b).

No inhomogeneity was found when the precipitation series from Svalbard Airport and Longyearbyen were joined. This is not quite in agreement with the 1961-1990 precipitation normals which have been estimated for both locations (Førland, 1993). According to these, the gauge catch during winter is lower at the airport than in Longyearbyen. This might also be expected, as the airport position probably is less sheltered against the wind than the earlier position. However, parallel measurements during 1974-1976 indicate that the airport position also may catch more drifting snow.

A more detailed analysis of this difference is given in section 4 of Nordli et al. (1996b). The wind conditions are also different at the two stations, but the other data show only minor differences.

99840 Svalbard Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1005.2	1007.1	1009.0	1013.6	1016.4	1012.4	1011.2	1011.1	1009.2	1008.4	1005.7	1005.3	1009.6	1976-
Std.deviation	8.1	8.3	7.3	5.3	4.2	3.6	3.7	4.6	3.2	5.2	5.3	7.1	2.2	1976-
AIR TEMPERATURE, (deg C)														
Average	-14.4	-15.5	-15.8	-12.1	-4.2	2.3	5.8	4.7	0.3	-5.4	-9.5	-12.0	-6.3	1912-
Std.deviation	5.2	4.4	4.4	3.3	1.7	1.0	0.9	0.8	1.5	2.5	3.9	4.5	1.7	1912-
Extreme values														
Lowest monthly/ annual mean	-25.7	-27.3	-26.3	-22.7	-9.6	-0.5	3.6	2.3	-3.2	-14.8	-20.4	-22.5	-12.2	1912-
Year lowest mean	1916	1912	1929	1917	1917	1979	1962	1912	1912	1968	1915	1988	1917	1912-
Highest monthly/annual mean	-3.0	-6.9	-7.0	-6.6	-0.3	4.8	7.8	6.5	5.2	0.6	-1.6	-1.3	-3.1	1912-
Year highest mean	1937	1954	1996	1992,94	1936	1922	1922	1993	1990	1957	1931	1938	1984	1912-
Average daily min	-18.7	-19.7	-17.8	-14.7	-5.6	0.8	4.4	3.4	-1.2	-8.1	-12.6	-16.2	-8.8	1976-
Average lowest monthly min	-29.0	-32.4	-31.3	-25.0	-15.1	-3.7	1.4	-0.4	-7.4	-16.3	-21.8	-26.3		1976-
Absolute min	-38.8	-43.7	-46.3	-39.1	-21.7	-8.4	0.2	-3.9	-12.6	-20.8	-33.2	-35.6	-46.3	1976-
Year abs. min	1981	1979	1986	1988	1978	1979	1989	1994	1988	1994	1994	1988	1986	1976-
Average daily max	-10.8	-11.1	-9.9	-7.4	-1.1	4.6	8.7	7.2	2.6	-3.1	-6.6	-9.5	-3.0	1976-
Average highest monthly max	1.3	1.6	2.5	2.2	4.8	10.1	14.1	12.8	8.0	4.6	2.8	3.1		1976-
Absolute max	6.7	5.9	6.3	5.5	10.6	14.3	21.3	16.5	15.2	8.9	6.6	7.2	21.3	1976-
Year abs. max	1996	1980	1983	1987	1976	1978	1979	1979,96	1990	1984	1993	1995	1979	1976-
No. of days with:														
Daily min <=0	31.0	28.2	30.6	29.8	28.8	9.5	0.0	1.7	16.8	29.0	29.4	30.6	265.3	1976-
Daily min <=-10	26.3	23.2	23.9	22.0	6.3	0.0	0.0	0.0	0.5	11.7	19.1	24.1	157.1	1976-
Daily max <=0	28.0	24.6	26.1	25.8	17.0	1.4	0.0	0.0	5.7	22.0	24.7	26.4	201.7	1976-
RELATIVE HUMIDITY (%)														
Average	73.0	75.1	73.9	72.2	72.8	72.3	75.0	75.1	75.0	72.5	72.2	71.3	73.4	1976-
PRECIPITATION (mm)														
Average monthly/annual prec.	16.0	18.8	18.7	9.7	7.2	9.3	14.0	20.9	17.8	14.2	16.1	19.1	181.7	1912-
Std . deviation	10.3	14.5	17.2	6.7	5.2	7.5	11.1	14.4	9.6	8.7	10.6	14.6	49.5	1912-
Min. monthly/annual	2.0	1.4	1.0	0.0	0.5	0.7	0.0	0.0	1.0	1.3	0.2	1.5	86.4	1912-
Year min. monthly/annaul	1932	1919	1962	1917	1949	1947	1914	1946	1932	1918	1923	1975	1925	1912-
Max. monthly/annual	62.0	72.2	106.6	31.8	22.8	32.8	70.0	69.2	37.7	44.6	51.0	70.0	317.0	1912-
Year max monthly	1933	1959	1923	1990	1992	1992	1972	1981	1922	1951	1966	1995	1972	1912-
Max in 1 day	20.0	38.2	34.0	9.0	16.0	12.0	31.1	43.2	13.7	28.0	12.7	22.5	43.2	1912-*
Year max 1 day	1933	1960	1974	1980	1934	1992	1972	1981	1980	1933	1989	1995	1981	1912-*
Rain (mm)	0.0	0.0	0.9	0.3	0.6	4.4	12.7	22.3	8.1	1.8	0.5	1.0	52.6	1976-
Snow (mm)	11.6	15.2	13.6	9.8	4.3	1.7	0.0	0.6	4.1	7.6	10.0	9.6	88.1	1976-
Mixed (mm)	2.5	6.6	8.4	2.2	2.6	4.1	1.8	3.6	8.0	2.6	6.0	6.3	54.7	1976-
No. of days with														
>=0.1 mm	14.1	13.9	14.5	12.4	11.0	9.0	10.8	14.5	13.4	15.2	14.0	14.0	156.8	1976-
>=1.0 mm	4.3	5.1	5.3	3.9	2.1	3.0	4.7	6.4	5.8	3.8	4.9	3.9	53.2	1976-
>=10.0 mm	0.0	0.3	0.4	0.0	0.0	0.1	0.0	0.5	0.2	0.0	0.1	0.3	2.0	1976-
Rain >=0.1 mm	0.0	0.0	0.1	0.2	0.6	4.1	9.6	11.7	4.9	1.2	0.3	0.2	32.9	1976-
Snow >= 0.1 mm	12.3	12.2	12.2	10.7	7.7	2.0	0.0	0.5	4.5	12.3	11.0	12.1	97.5	1976-
Mixed>=0.1 mm	1.5	1.5	2.1	1.4	2.5	2.8	1.1	2.2	4.0	1.7	2.5	1.6	24.9	1976-
Perc. freq. of														
Drifting snow	17.1	14.0	12.2	9.5	2.0	0.1	0.0	0.0	0.6	4.9	10.6	13.7	7.0	1976-
SNOW														
Average snow depth (cm)	13.2	17.6	21.5	24.4	11.9	0.7	0.0	0.0	1.1	4.2	7.8	9.2		1977-93
Average max snow depth (cm)	19.1	23.8	28.8	31.6	22.4	6.2	0.0	2.5	5.7	9.1	12.1	15.5		1977-93
Absolute max snow depth (cm)	35	38	50	56	53	10	0	3	16	30	28	48	56	1977-93
Year max snow depth	1979	1988	1993	1986	1979	1979		1989	1980	1982	1992	1978	1986	1977-93
No. of days w/snow cover > 2/4	31.0	28.3	31.0	30.0	22.4	1.7	0.0	0.4	7.7	23.9	27.9	29.3	233.6	1977-93
CLOUDS & VISIBILITY														
No. of clear days	6.5	5.7	5.0	5.5	3.5	0.7	1.9	0.7	0.5	1.4	4.5	6.8	42.7	1976-
No. of overcast days	8.7	9.5	11.3	9.6	13.3	16.4	17.1	19.0	17.0	14.7	10.9	9.3	156.8	1976-
Average, octas	4.4	4.6	4.9	4.5	5.1	6.0	5.9	6.3	6.2	5.7	4.9	4.4	5.2	1976-
Perc. freq. of:														
Fog	0.8	1.1	0.2	0.2	1.7	3.6	2.5	2.1	1.6	0.3	0.2	0.0	1.2	1976-
Horizontal visibility (%):														
1 km or less	1.0	1.4	1.1	0.5	1.0	1.9	1.0	0.8	0.8	0.2	0.2	0.5	0.9	1976-
4 km or less	4.9	6.1	5.9	4.4	3.0	3.4	1.9	1.5	2.0	1.8	3.2	3.2	3.4	1976-
Lowest cloud height (%):														
100 m or less	0.4	0.6	0.2	0.4	2.4	5.0	5.7	3.5	3.3	0.6	0.4	0.2	1.9	1976-
300 m or less	5.1	6.3	6.5	7.8	14.0	24.8	36.2	30.7	18.3	6.6	3.7	2.8	13.6	1976-
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	14.1	11.7	11.7	9.0	5.1	4.3	5.0	4.8	5.2	8.8	11.0	12.8	103.4	1976-
>=8 B	3.2	2.0	2.0	1.2	0.2	0.1	0.1	0.4	0.3	0.9	1.8	2.7	14.9	1976-
>=9 B	0.5	0.4	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.5	0.5	2.7	1976-

Missing /incomplete data: Precipitation data 1940-45

*) Combined series from Svalbard Airport and Longyearbyen, some years missing

Appendix A6

99860 Longyearbyen

Position 78° 13' N, 15° 35' E
Station height 37 m.
Midnight sun 20. April - 22. August
Dark season 26. October - 16. February

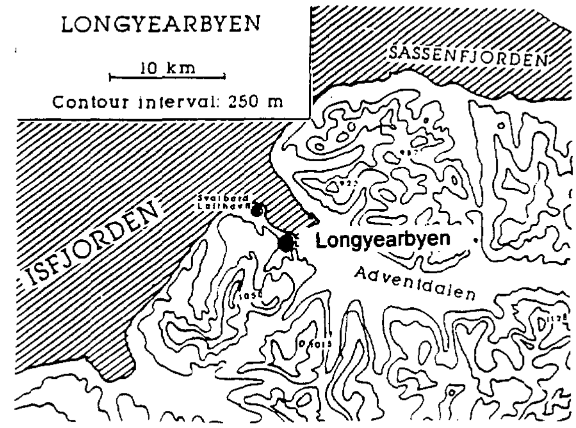
Longyearbyen is situated on Spitsbergen at the inner end of Adventfjorden, which is a branch of Isfjorden. The station lies at the lower end of the valleys Longyeardalen, extending from south-southeast towards north-northeast, and Adventdalen extending southeast-northwest. The station is sheltered by the mountains Sverdruphamaren to the west, and Gruvefjellet to the northeast, 2-3 km. away. The station has during history been situated at nearly the same place.

Observations began in November 1916 and were stopped in 1977. There have been several long interruptions.

Period 1911.12 - 1923.08: The station in Longyearbyen was during this time administrated by a mining company called «Store Norske Spitsbergen Kulkompani». Our knowledge of the station is rather sparse. In the inspection reports the name used was Advent Bay. However, from the descriptions it is clear that the location was Longyearbyen. In 1920 the observations were made at the hospital. During the inspection that year a free standing screen with double louvered walls replaced the wall screen. The measuring site was moved about 50 m. At the same time the precipitation gauge was also moved about the same distance. Its site was before the relocation «too close to the hospital».

As a private station the data has not been published in DNMI's yearbooks.

Period 1930.09 - 1939.06: Under the administration of DNMI, observations were continued at Svalbard Radio. The site was close to the former place, but 3 m higher station elevation indicates a minor relocation.



From the inspection in 1930 there exist photos. Judged from the photos, the radiation screen seems to be of the Edlund pattern, i.e. single louvered. The precipitation gauge is not equipped with a wind shield.

Period 1957.01 - 1977.07: The new place was located about 450 m NNE of the old hospital building and the first station.

In 1964 the radiation screen and precipitation gauge were relocated 61 m S and 68 m SSE respectively. The station's height was reduced from 38 to 37 m a.s.l.

Homogeneity
The series was tested against Bjørnøya and Isfjord Radio. All tests indicated homogeneous series. It should be stated, however, that in the summer seasons before 1937, this result is only nominal because of poor correlation with reference station Bjørnøya.

In spite of three known relocations, only one inhomogeneity was found in the precipitation series. This was connected to the relocation from the hospital to Svalbard Radio which led to increased gauge catch.

99860 Longyearbyen (From Hanssen-Bauer et al., 1990)

MEAN VALUES 1957-1976

	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DES	YEAR
ATM.PRESSURE, MB													
Average sea level *	1007.3	06.4	09.6	14.0	16.9	13.7	09.5	09.8	08.4	10.2	08.0	02.7	1009.4
AIR TEMPERATURE °C													
Average	-14.1	-15.3	-14.4	-10.7	-3.2	2.8	6.3	5.1	0.8	-5.2	-9.6	-12.4	-5.8
Extreme values:													
High. monthly/annual	-2.2	-8.3	-6.5	-5.5	-0.8	5.5	8.4	6.9	3.3	0.7	-1.4	-0.8	-2.6
Low. monthly/annual	-24.8	-26.1	-24.7	-21.6	-8.8	1.1	4.2	3.1	-2.7	-14.7	-17.1	-21.0	-11.5
Std. deviation	5.2	3.4	4.5	2.6	1.6	1.1	0.8	0.7	1.3	3.6	3.8	4.2	1.6
Aver.daily max.	-10.6	-11.5	-10.9	-7.5	-1.1	4.8	8.5	7.0	2.6	-2.8	-6.6	-9.2	-3.1
Aver.monthly max.	1.0	0.7	0.4	1.6	5.1	10.6	14.2	12.0	7.6	4.5	2.8	1.7	
Absolute max.	5.2	4.5	4.8	5.6	14.3	15.5	18.2	15.8	12.8	9.9	7.0	5.2	
Aver.daily min.	-17.8	-19.3	-18.1	-14.3	-5.2	1.1	4.6	3.4	-1.1	-7.7	-12.8	-16.0	-8.6
Aver.monthly min.	-28.9	-30.5	-29.0	-25.7	-13.6	-3.3	1.9	-0.4	-7.3	-16.5	-21.9	-27.4	
Absolute min.	-37.2	-39.5	-37.2	-31.6	-21.4	-8.8	0.3	-1.8	-13.2	-24.9	-31.6	-38.1	
No. of days with:													
Daily min.0 or less	30.7	28.2	30.6	29.3	27.6	8.6	-	1.5	17.3	27.5	29.1	30.5	260.9
D.min.-10 or less	24.4	24.0	25.1	21.5	4.5	-	-	-	0.1	10.4	19.4	23.2	152.6
D.max. 0 or less	27.0	25.8	27.5	25.0	17.9	1.1	-	-	5.5	19.7	24.2	27.4	201.1
RELATIVE HUMIDITY, %													
Average	71	73	72	71	73	73	75	74	75	72	71	71	73
PRECIPITATION, MM													
Average monthly fall	17	24	24	8	6	12	21	22	19	14	18	23	208
Max.fall in 24 hrs.	12	38	34	8	6	11	31	11	9	13	10	21	
No. of days with:													
0.1mm or more	10.9	11.2	13.1	8.6	7.2	7.0	10.7	11.6	12.2	11.1	11.4	11.8	126.8
1.0mm or more	4.7	5.4	6.5	3.3	2.3	3.4	5.6	5.9	5.6	4.7	5.5	5.4	58.3
10.0mm or more	0.2	0.4	0.4	-	-	0.1	0.2	0.2	-	0.1	0.1	0.5	2.2
rain 0.1mm or more	0.8	1.0	1.1	0.8	2.2	5.6	10.7	11.2	7.7	2.7	2.0	1.2	47.0
snow 0.1mm or more	10.4	10.8	12.8	8.5	6.4	2.9	0.7	1.6	7.0	9.6	10.8	11.4	92.9
CLOUDS, VISIBILITY													
Average, octas	4.6	4.6	4.7	4.1	5.2	6.0	6.3	6.3	6.3	5.8	5.1	4.4	5.3
No. of clear days	7.9	6.0	6.3	7.5	4.8	1.6	1.5	1.4	1.2	2.6	5.1	8.1	54.0
No. of overcast days	12.0	10.2	11.4	8.8	14.1	16.2	18.3	18.8	18.3	16.4	13.9	11.9	170.3
Perc. freq. of:													
Fog	-	0.1	0.6	0.3	1.2	1.7	1.1	0.9	0.5	0.4	-	-	0.6
Horizontal visibility:													
1km or less	0.8	1.5	1.5	0.6	1.1	1.4	0.4	0.6	0.5	0.7	0.9	1.1	0.9
4km or less	4.7	7.7	8.2	3.4	2.9	2.4	1.7	1.8	1.9	3.2	5.3	6.1	4.1
WIND FORCE,BEAUFORT													
Perc.freq. of:													
0	34.1	31.6	37.6	45.5	26.1	12.3	10.8	15.7	23.8	24.8	22.4	27.4	26.0
1-2	25.2	25.3	23.8	25.0	41.0	52.0	55.3	51.1	39.8	34.0	30.7	27.6	36.0
3-5	32.6	32.6	30.6	24.0	31.3	34.2	32.6	31.1	32.7	38.5	38.7	36.3	33.0
6-8	7.9	10.0	7.6	5.6	1.6	1.5	1.3	2.1	3.7	2.7	8.0	8.4	5.0
9 or more	0.2	0.5	0.4	-	-	-	-	-	-	-	0.2	0.3	0.1

* Mean values of air pressure for the period 1968-1976

Appendix A7

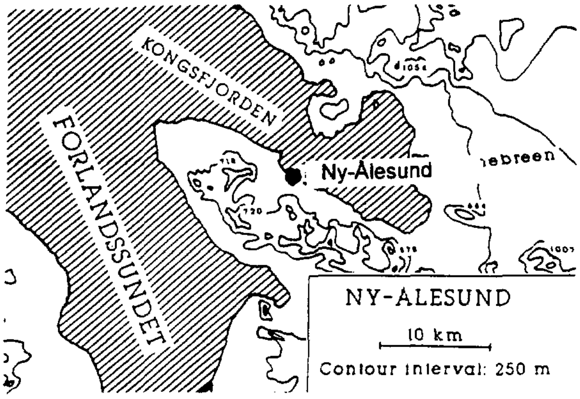
99910 Ny-Ålesund (I and II)

Position (1969-1974) 78°56'N, 11°53'E
Station height 42 m a.s.l.
Position (1974 -) 78° 55N, 11° 5' E
Station height 8 m a.s.l.
Midnight sun 18 April - 24 August
Dark season 25 October - 17 February

Ny-Ålesund is situated on Brøggerhalvøya, a peninsula on the south bank of Kongsfjorden. The station lies on a fairly even tundra plain with mountains and glaciers to the south and west. The nearest mountain slope is about 1.5 km away. During the years 1950-53 and 1961-68 irregular observation were recorded by employees of the Kings Bay Kull Comp. and the ESRO telemetry station. Regular observations are available from 1969. In July 1974 the station was moved from the ESRO station to the telegraph station 1.6 km east-southeast, and the observational duties assumed by personnel at the research station of the Norwegian Polar Institute.

Homogeneity
Because of the relocation in 1974, the observation here are therefore not strictly homogenous. Only small differences, however, are to be expected in all parameters measured except for wind, where considerable deviation may exist. Wind conditions are more representative at the new station than at the old, as the old was more exposed to local drainage winds from the south.

The temperature series was tested against Hopen and Barentsburg and found homogeneous in all seasons. In the precipitation series only one inhomogeneity was found, which could be explained by the relocation in 1974. The gauge catch was increased after this



relocation, especially during winter and spring.

The series of mean temperature from Isfjord Radio and Ny-Ålesund are joined so as to form a composite series starting in 1934. By adjustment of the Isfjord Radio data, the series is homogenised and made valid for Ny-Ålesund (Nordli et al. 1996b). It is used in the statistics for mean temperature on next page.

99910 Ny-Ålesund

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1004.5	1006.5	1008.2	1013.2	1016.4	1012.5	1011.0	1011.1	1008.7	1008.7	1005.6	1004.6	1009.2	1975-
Std.deviation	8.0	8.1	7.1	5.2	4.0	3.6	3.9	4.5	3.9	5.1	5.1	7.3	2.2	1975-
AIR TEMPERATURE, (deg C)														
Average	-12.6	-13.6	-13.8	-10.6	-3.8	1.7	4.9	4.0	-0.1	-5.4	-9.3	-11.4	-5.8	1935-
Std.deviation	4.2	3.3	3.4	2.6	1.4	0.8	0.7	0.8	1.4	2.4	3.3	3.8	1.3	1935-
Extreme values														
Lowest monthly/ annual mean	-22.4	-22.0	-20.5	-17.0	-7.5	-0.5	3.2	2.4	-4.0	-13.7	-16.9	-21.3	-9.3	1935-
Year lowest mean	1981	1963	1977	1988	1966	1979	1962	1948,94	1982	1968	1971	1988	1968	1935-
Highest monthly/annual mean	-3.4	-6.5	-6.3	-6.1	-1.3	3.2	6.2	5.3	4.7	-0.4	-2.8	-2.8	-3.3	1935-
Year highest mean	1947	1954	1976	1992	1936	1971,72	1960,85	1974	1990	1957	1993	1938,84	1984	1935-
Average daily min	-17.6	-18.4	-17.1	-13.9	-6.1	0.3	3.4	2.6	-2.1	-8.7	-12.5	-16.0	-8.8	1975-
Average lowest monthly min	-27.7	-30.8	-29.2	-23.6	-15.1	-4.3	0.8	-1.3	-9.1	-17.5	-21.8	-25.9		1975-
Absolute min	-36.6	-41.1	-42.2	-34.0	-19.1	-8.5	-0.5	-5.5	-15.0	-20.6	-27.2	-34.3	-42.2	1975-
Year abs. min	1981	1979	1986	1988	1990	1979	1977	1982	1986	1989	1994	1988	1986	1975-
Average daily max	-10.0	-10.1	-9.2	-6.6	-0.7	3.9	6.9	6.0	2.1	-3.3	-6.1	-9.1	-3.0	1975-
Average highest monthly max	0.8	1.7	1.8	2.1	4.8	7.9	11.3	11.0	7.2	3.7	2.5	2.0		1975-
Absolute max	5.1	4.7	5.0	5.5	8.0	11.2	17.0	13.6	12.3	7.5	7.4	5.8	17.0	1975-
Year abs. max	1996	1975	1976,85	1990	1976	1978,88	1979	1989	1990	1984	1975	1995	1979	1975-
No. of days with:														
Daily min <=0	31.0	28.2	30.7	29.5	27.9	10.8	0.2	2.9	19.7	29.1	29.4	30.7	270.0	1975-
Daily min <=-10	25.1	22.8	24.1	21.3	7.2	0.0	0.0	0.0	1.2	12.6	20.0	23.9	158.2	1975-
Daily max <=0	28.3	24.9	26.5	26.1	16.0	1.7	0.0	0.2	7.4	23.0	24.8	27.3	206.2	1975-
RELATIVE HUMIDITY (%)														
Average	72.7	78.4	77.0	75.3	77.9	83.0	86.0	84.2	81.5	74.5	71.4	71.1	77.8	1975-
PRECIPITATION (mm)														
Average monthly/annual prec.	32.2	42.8	50.0	26.3	18.3	17.2	24.1	41.5	47.1	29.0	38.4	36.0	402.9	1975-
Std . deviation	31.5	33.8	41.0	19.9	10.0	13.3	16.9	33.1	36.6	25.2	46.8	30.6	114.7	1975-
Min. monthly/annual	1.1	1.3	3.3	8.8	2.1	1.2	7.2	4.2	10.3	8.4	5.8	0.9	228.1	1975-
Year min. monthly/annual	1994	1987	1977	1978	1996	1978	1990	1995	1986	1992	1990	1985	1982	1975-
Max. monthly/annual	150.4	114.3	143.0	105.3	33.5	57.8	79.4	131.2	154.1	128.9	230.3	115.4	675.3	1975-
Year max monthly/annual	1996	1991	1987	1990	1977	1988	1994	1980	1990	1979	1993	1995	1993	1975-
Max. in 1 day	29.7	36.1	53.0	18.7	17.3	15.0	23.8	40.4	49.4	29.4	41.8	57.0	57.0	1975-
Year max 1 day	1996	1994	1986	1987	1978	1988	1975	1980	1989	1979	1993	1993	1993	1975-
Rain (mm)	0.5	1.0	1.7	0.3	0.9	7.4	18.5	33.0	25.5	5.9	5.2	2.8	102.7	1975-
Snow (mm)	22.4	27.7	27.5	20.7	9.8	2.4	0.1	3.0	10.9	15.9	16.2	19.0	175.6	1975-
Mixed (mm)	9.3	14.1	20.8	5.3	7.6	7.4	5.5	5.5	10.7	7.2	17.0	14.2	124.6	1975-
No. of days with														
>=0.1 mm	11.2	12.7	13	11.1	9.6	8.8	11.6	13.7	13.5	13.2	12.1	10.9	141.4	1975-
>=1.0 mm	6.4	7.6	8.4	6.7	4.8	4.4	6.6	8.5	8.5	7.8	6.9	6.4	82.9	1975-
>=10.0 mm	0.6	1.1	1.4	0.4	0.2	0.2	0.3	0.8	1.3	0.4	1.0	0.7	8.3	1975-
Rain >=0.1 mm	0.0	0.1	0.2	0.2	0.5	3.6	9.5	11.1	4.8	1.0	0.4	0.3	31.7	1975-
Snow >= 0.1 mm	10.3	11.3	10.8	9.6	6.9	1.8	0.0	0.9	5.5	10.5	9.5	9.0	86.1	1975-
Mixed >=0.1 mm	0.9	1.4	2.0	1.3	2.3	3.4	2.0	1.6	3.1	1.8	2.2	1.6	23.6	1975-
Perc. freq. of														
Drifting snow	12.1	12.5	11.1	8.2	2.4	0.3	0.0	0.0	0.7	6.0	8.6	10.4	6.0	1975-
CLOUDS & VISIBILITY														
No. of clear days	8.2	5.8	5.6	6.3	5.0	1.2	1.4	1.0	1.5	2.6	6.3	9.1	53.9	1975-
No. of overcast days	9.0	10.8	12.2	10.1	13.3	17.5	19.0	19.6	17.4	15.0	11.2	9.0	164.0	1975-
Average, octas	4.1	4.8	4.9	4.6	5.2	6.2	6.3	6.4	6.1	5.7	4.7	4.0	5.2	1975-
Perc. freq. of:														
Fog	0.3	0.4	0.7	1.0	0.8	3.9	5.5	5.1	2.6	0.5	0.1	0.1	1.7	1975-
Horizontal visibility (%):														
1 km or less	1.7	3.6	3.3	2.3	0.9	2.2	2.5	2.6	1.5	1.9	1.4	0.8	2.1	1975-
4 km or less	8.7	11.8	11.3	9.3	4.6	4.2	4.4	5.4	5.5	7.6	9.2	9.9	7.7	1975-
Lowest cloud height (%):														
100 m or less	0.2	0.6	1.4	0.9	0.8	1.9	4.1	3.6	1.3	1.3	0.1	0.1	1.4	1975-
300 m or less	1.3	3.9	6.0	6.1	9.0	14.1	19.6	14.3	8.9	5.4	1.9	0.5	7.6	1975-
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	11.0	8.3	9.6	6.7	3.3	1.7	1.0	1.8	3.0	7.0	8.1	8.7	70.2	1975-
>=8 B	2.4	1.4	1.7	0.8	0.3	0.1	0.0	0.1	0.2	0.4	1.2	1.9	10.5	1975-
>=9 B	0.8	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.5	2.6	1975-

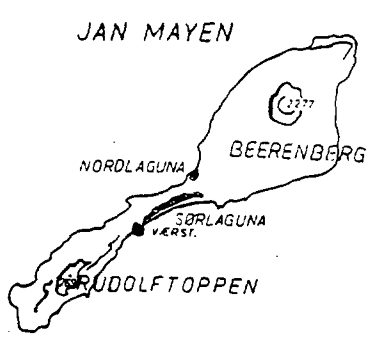
Appendix A8

99950 Jan Mayen

Position 70°56' N, 8°40' W
Station height 10 m a.s.l.
Midnight sun 13. May - 31. July
Dark season 21. November - 22. January

Jan Mayen is situated between Iceland and Spitsbergen, see Fig. 2.1. The island is long and narrow, extending southwest-northeast. The northeastern part is a volcano, Beerenberg, with highest point 2277 m a.s.l. Also the southwestern part of the island consists partly of mountains, 400-800 m a.s.l., while the middle of the island consists mainly of low plains with two lagoons, Nordlaguna and Sørlaguna, and some lower mountains.

The meteorological station has always been located in the middle of the island, and except for the period of World War II either at the NW or SE shores. It was established in September 1921 on the SE shore.



In September and October 1940 the station was hit and at last destroyed by war actions but already in March 1941 reestablished. During the period from 1941 to 1949 the station was located at five different sites. However, from 5. September 1949 to 1. October 1962 it remained at the same position on the NW shore.

1. October 1962 the station was again moved to the SE shore, 11.3 km to a more southern position than where it started in 1921. On 25 August 1969 there was a minor relocation of the station to its present position.

Homogeneity
The temperature series was tested against reference series in Svalbard (Bjørnøya and Svalbard Airport), Iceland (Stykkisholmur and Teigarhorn), and Greenland (Ammassalik and Scoresbysund) and a significant break in summer season was found 1939. Its magnitude was -0.6°C, i.e. the first part of the series being too warm compared with the later one. The year of the break was very close to the end of the station's first stable period on the SE shore and the first part of the series was adjusted.

The installation of a windshield led to increased precipitation gauge catch from 1932. This inhomogeneity, as well as inhomogeneities in 1940 and in 1946 were revealed during the testing. The latter inhomogeneities were caused by relocations. The measurements between 1940 and 1946 should be used with care as there also were several relocations during this period.

The wind conditions are quite different at the two shores. The fog frequency seems to be greater at the southwestern shore than at the northeastern.

Sea Ice
Period 1971-1981, concentration in oktas

Mean day	above 0	7 or more
Freezing up	08.01	22.01
Melting	21.04	26.04

Number of days with sea ice in a season: Mean 51, highest 117, lowest 0.

99950 Jan Mayen

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Period
ATM. PRESSURE (hPa)														
Average sea level	1003.1	1005.8	1007.9	1011.9	1016.7	1012.9	1010.9	1010.4	1007.6	1005.8	1004.9	1002.7	1008.4	1921-
Std.deviation	8.7	8.7	7.1	5.1	4.0	3.8	3.0	3.1	4.3	5.4	5.3	6.8	2.1	1921-
AIR TEMPERATURE (deg. C)														
Average	-4.5	-5.2	-5.1	-3.5	-0.7	2.2	4.7	5.2	3.3	0.3	-2.1	-3.9	-0.8	1921-
Std.deviation	2.8	2.8	2.4	1.7	1.0	0.9	0.8	1.1	1.2	1.6	2.1	2.4	1.0	1921-
Extreme values														
Lowest monthly/ annual mean	-11.1	-14.5	-13.4	-7.4	-3.1	0.3	2.2	2.1	0.8	-3.5	-8.9	-11.1	-4.1	1921-
Year lowest mean	1966	1943	1968	1973	1968	1951	1968	1943	1964	1968	1971	1987	1968	1921-
Highest monthly/annual mean	1.2	0.1	-1.0	0.4	1.4	4.7	6.5	7.4	8.0	4.2	2.2	1.7	0.7	1921-
Year highest mean	1947	1929	1923	1930	1947	1930	1947	1953	1934	1938,61	1954	1938	1984	1921-
Average daily min	-7.0	-7.9	-7.7	-5.7	-2.2	0.6	3.1	3.7	1.7	-1.6	-4.3	-6.3	-2.8	1922-
Average lowest monthly min	-15.3	-16.3	-16.4	-12.8	-7.5	-2.4	0.1	0.6	-2.5	-7.5	-10.8	-14.3		1922-
Absolute min	-26.9	-28.4	-26.8	-21.4	-12.0	-5.1	-3.2	-2.3	-5.2	-18.0	-19.5	-24.2	-28.4	1922-
Year abs. min	1966	1963	1969	1942	1978	1923	1968	1941	1954	1968	1964	1968	1963	1922-
Average daily max	-2.5	-2.9	-2.8	-1.2	1.3	4.2	6.6	7.0	4.8	2.2	-0.3	-2.0	1.2	1951-
Average highest monthly max	3.5	3.1	2.8	4.0	6.0	9.4	10.9	11.0	9.1	7.2	5.1	4.1		1922-
Absolute max	7.7	10.0	8.0	9.8	11.3	18.1	15.0	15.7	13.4	15.0	10.0	7.5	18.1	1922-
Year abs. max	1992	1965	1984	1984	1954	1953	1927	1939	1934	1961	1953	1979	1953	1922-
No. of days with:														
Daily min <=0	28.3	26.9	29.4	27.7	24.5	11.6	1.1	0.7	7.5	20.4	24.6	27.5	230.3	1922-
Daily min <=-10	9.3	9.6	10.7	5.2	0.3	0.0	0.0	0.0	0.0	0.2	3.0	7.9	46.3	1937-
Daily max <=0	19.5	17.7	19.5	16.4	8.8	0.8	0.0	0.0	0.6	7.7	14.2	18.2	123.3	1951-
RELATIVE HUMIDITY (%)														
Average	83.5	83.2	83.7	82.7	84.8	87.4	89.6	87.8	84.7	82.9	82.3	82.8	84.6	1921-
PRECIPITATION (mm)														
Average monthly/annual prec.	61.8	50.8	52.2	44.4	32.0	31.5	43.0	57.3	76.7	81.4	68.4	64.8	664.4	1921-
Std . deviation	32.8	26.9	27.8	22.9	22.9	20.1	22.6	31.7	35.3	37.6	28.0	29.9	130.9	1921-
Min. monthly/annual	12.0	4.8	6.0	4.8	3.0	2.0	2.0	7.0	16.4	17.8	12.5	13.8	279.9	1921-
Year min. monthly/annual	1948	1942	1962	1944	1955	1955	1953	1948	1978	1960	1926	1926	1926	1921-
Max. monthly/annual	210.0	107.9	125.1	115.4	93.9	104.7	123.6	146.0	200.0	173.2	145.1	131.2	949.9	1921-
Year max monthly/annual	1949	1985	1994	1932	1971	1988	1936	1951	1979	1956	1931	1931	1938	1921-
Max. in 1 day	60.0	32.0	36.0	40.0	51.0	38.7	87.0	35.0	68.5	46.6	40.9	38.2	87.0	1922-
Year max 1 day	1949	1923	1951	1953	1949	1988	1936	1951	1979	1931	1980	1928	1936	1922-
Rain (mm)	6.5	2.0	4.3	5.0	14.6	23.7	41.8	54.2	47.9	30.1	14.0	7.2	251.3	1956-
Snow (mm)	33.9	31.0	32.4	18.2	8.6	1.9	0.0	0.1	2.9	9.2	23.3	33.1	194.6	1956-
Mixed (mm)	25.1	20.1	20.7	18.0	14.1	9.3	2.9	5.4	27.2	40.9	24.8	25.5	234.0	1956-
No. of days with														
>=0.1 mm	22.2	20.2	21.7	18.8	15.9	14.9	16.6	17.9	20.3	21.8	22.1	22.4	234.9	1922-
>=1.0 mm	11.9	10.8	11.3	8.9	6.3	6.2	8.1	10.3	12.3	13.1	12.3	12.4	123.9	1922-
>=10.0 mm	1.4	0.9	0.9	0.8	0.5	0.6	0.8	1.5	2.0	2.1	1.6	1.6	14.8	1931-
Rain >=0.1 mm	2.1	1.2	1.7	1.9	5.4	9.6	17.2	18.8	13.9	7.9	3.8	2.2	85.7	1956-
Snow >= 0.1 mm	15.6	14.4	15.1	11.9	6.9	2.6	0.1	0.2	2.3	6.3	12.4	15.0	102.8	1956-
Mixed >=0.1 mm	5.6	5.1	5.5	5.2	4.5	3.9	1.1	1.2	6.0	8.3	5.9	5.7	58.0	1956-
Perc. freq. of														
Drifting snow	25.5	25.0	25.7	17.4	5.6	0.5	0.0	0.0	1.2	7.6	19.9	24.0	12.7	1956-
CLOUDS & VISIBILITY														
No. of clear days	0.4	0.5	0.3	0.5	0.6	0.4	0.4	0.3	0.2	0.0	0.2	0.4	4.2	1922-
No. of overcast days	18.6	16.7	18.7	18.2	21.0	21.2	23.4	22.7	20.5	22.1	19.8	19.3	242.0	1922-
Average, octas	83.5	83.2	83.7	82.7	84.8	87.4	89.6	87.8	84.7	82.9	82.3	82.8	84.6	1921-
Perc. freq. of:														
Fog	5.9	6.8	6.6	7.6	19.1	24.7	34.3	24.2	14.1	10.2	6.2	4.9	13.7	1956-
Horizontal visibility (%):														
1 km or less	11.8	11.5	14.1	8.8	13.9	14.6	20.4	14.2	8.7	7.9	8.5	10.8	12.1	1958-
4 km or less	28.7	28.3	31.4	22.4	23.4	24.6	31.3	24.3	19.5	18.5	21.6	26.1	25.0	1958-
Lowest cloud height (%):														
100 m or less	1.9	2.7	3.6	3.9	7.1	11.8	18.6	13.8	8.1	4.4	2.8	1.6	6.7	1956-
300 m or less	23.0	29.7	34.5	34.3	35.7	47.6	57.5	51.9	41.9	31.9	26.7	21.9	36.4	1956-
WIND FORCE, BEAUFORT														
No. of days with max														
>=6 B	22.8	20.4	21.5	18.2	12.3	10.7	9.7	10.0	13.8	18.3	20.7	22.4	200.8	1937-
>=8 B	9.8	8.0	7.9	5.4	2.7	2.2	1.8	1.3	2.9	4.7	7.0	8.6	62.4	1937-
>=9 B	5.0	4.3	4.0	2.4	1.1	0.7	0.4	0.6	1.2	2.5	3.5	3.7	29.3	1922-

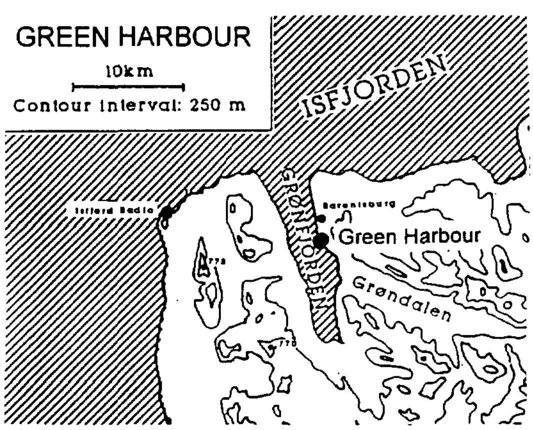
Missing/incomplete data: Max./min. temperatures 1940-42 Precipitation data 1940-42 Cloud &visibility data 1940-42

Appendix A9

99821 Green Harbour

Position 78°05' N, 14° 14' E
Station height: 4 m a.s.l.
Midnight sun 21. April - 22. August
Dark season 26. October - 15. February

The station was established at Grønfjorden on 1 December 1911 and is thus the oldest of the regular stations on Spitsbergen. The equipment for temperature and precipitation measurements were not of conventional type. It consisted of four 3 m x 3 m walls mounted together so that their lower borders were 85 cm above the ground. As there was no roof over the walls, they could serve as a combined shield for precipitation and temperature. The thermometers got additional screening by an inside cage.



The precipitation gauge should have been placed on the top of the shield, but the observers found it more convenient to move it down to a lower position inside this construction. It is documented that this was sometimes done. Its upper surface was then 1.1 m lower than the upper edges of the walls. In 1924 the precipitation gauge was moved 1.9 m from its original site and equipped with a wind shield of conventional type.

On request in 1928 from DNMI the Geophysical Institute in Tromsø could state that the temperature equipment had remained at its old site and had been unchanged (Birkeland, 1930). It is thus very likely that the situation had not changed during the remaining years before the station was closed on 27 August 1930.

Homogeneity
Green Harbour and Barentsburg stations are situated in the same fjord, Grønfjorden, only 2 km apart from each other. Their series were therefore joined before the testing procedure started.

For the temperature series one inhomogeneity was detected during winter in connection with the change from Green Harbour data to Barentsburg data (1930). No significant breaks were detected in the other seasons or other years.

The testing of the precipitation series led to 5 adjustments. The Green Harbour gauge was relocated and equipped with a windshield in 1924. This led to increased gauge catch during all seasons except summer. The series was adjusted for this, however, the data from the years before 1924 were not as reliable as data from later years because of the quite awkward installation of the gauge during the earlier years.

The combination of the series of Green Harbour and the Barentsburg led to an inhomogeneity. During winter, the gauge catch in Barentsburg was lower than that in Green Harbour, while during summer it was slightly higher.

Three more inhomogeneities in the Barentsburg series were revealed by the test, in 1956, 1978 and 1984. The two last ones could be explained by relocations of the gauge.