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THE CLIMATE OF SPITSBERGEN

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THE CLIMATE OF SPITSBERGEN

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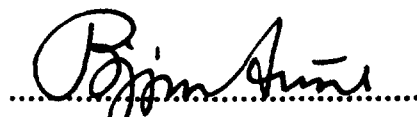
SAMMENDRAG

A general description of the climate at Spitsbergen is presented. Climate statistics from the Norwegian stations at Spitsbergen are updated to include data up to 1990. A temperature series for the periode 1912-1990 for Svalbard Lufthavn is estimated. Permafrost depth and active layer depth are estimated for the stations.

UNDERSKRIFT



Inger Hanssen-Bauer
SAKSBEHANDLER



Bjørn Aune
FAGSJEF

THE CLIMATE ON SPITSBERGEN

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1. THE CLIMATE AT THE METEOROLOGICAL STATIONS ON SPITSBERGEN

1.1 Introduction

The publication "The Climate and its recent variations at the Norwegian Arctic Stations" (Steffensen 1969) consisted of two parts. Part 1 dealt with a survey of the climatic conditions at Isfjord Radio, Longyearbyen, Bjørnøya, Hopen and Jan Mayen, based mainly on observations for the period 1946-65. Part 2 dealt with the recent climatic fluctuations in air pressure at sea level and air temperature illustrated by running 5-year means for seasons and years. This was a continuation of earlier investigations made by Birkeland (1930) and by Hesselberg and Johannessen (1958). "The Climate at Norwegian Arctic Stations" (Steffensen 1982) was a supplement to these publications, and was based on observations taken from 1951-80 at the same stations, as well as at the station at Ny-Ålesund. The present report up-dates statistics to include observations up to 1990 and includes observations from the station at Svea Gruber. The present report does not include the Bjørnøya, Hopen and Jan Mayen stations. Other relevant information on the climate of Svalbard are given by Hisdal (1976), and in the publication "Været" (Det Norske Meteorologiske Institutt, 1981).

1.2 Basic observations and tables

The hours of observation are 07, 13, 19 C.E.T. The frequency tables are based on daily observations and the tables of mean and extreme values are based on monthly and annual data published in Norsk Meteorologisk Årbok (Det Norske Meteorologiske Institutt, 1956-89). Data on duration of bright sunshine are given for Isfjord Radio. Global radiation data from Ny-Ålesund have been processed by T. Vinje (1977-82), who has also drawn the maps on sea ice concentration shown in figure 1 (Vinje 1982).

Table 1.1 Data periods for the Spitsbergen stations.		
Station	Years of record	Basis for mean values/frequencies
Isfjord Radio	Sept.1934-Sept.1941 Aug.1946-June 1976	1951 - 1975/1956 - 1975
Longyearbyen	1916-23 (incomplete) Sept.1930-Aug.1934 1935-39 (incomplete) Oct.1941-June 1942 Sept.1945-Aug.1946 Jan.1957-July 1977	1957 - 1976
Svalbard Lufthavn	Aug.1975 up to present	1976 - 1989
Ny-Ålesund I	1961-1968 (incomplete) 1969-July 1974	
II	Aug.1974 up to present	1975 - 1989
Svea	May 1978 up to present (incomplete)	1980 - 1989

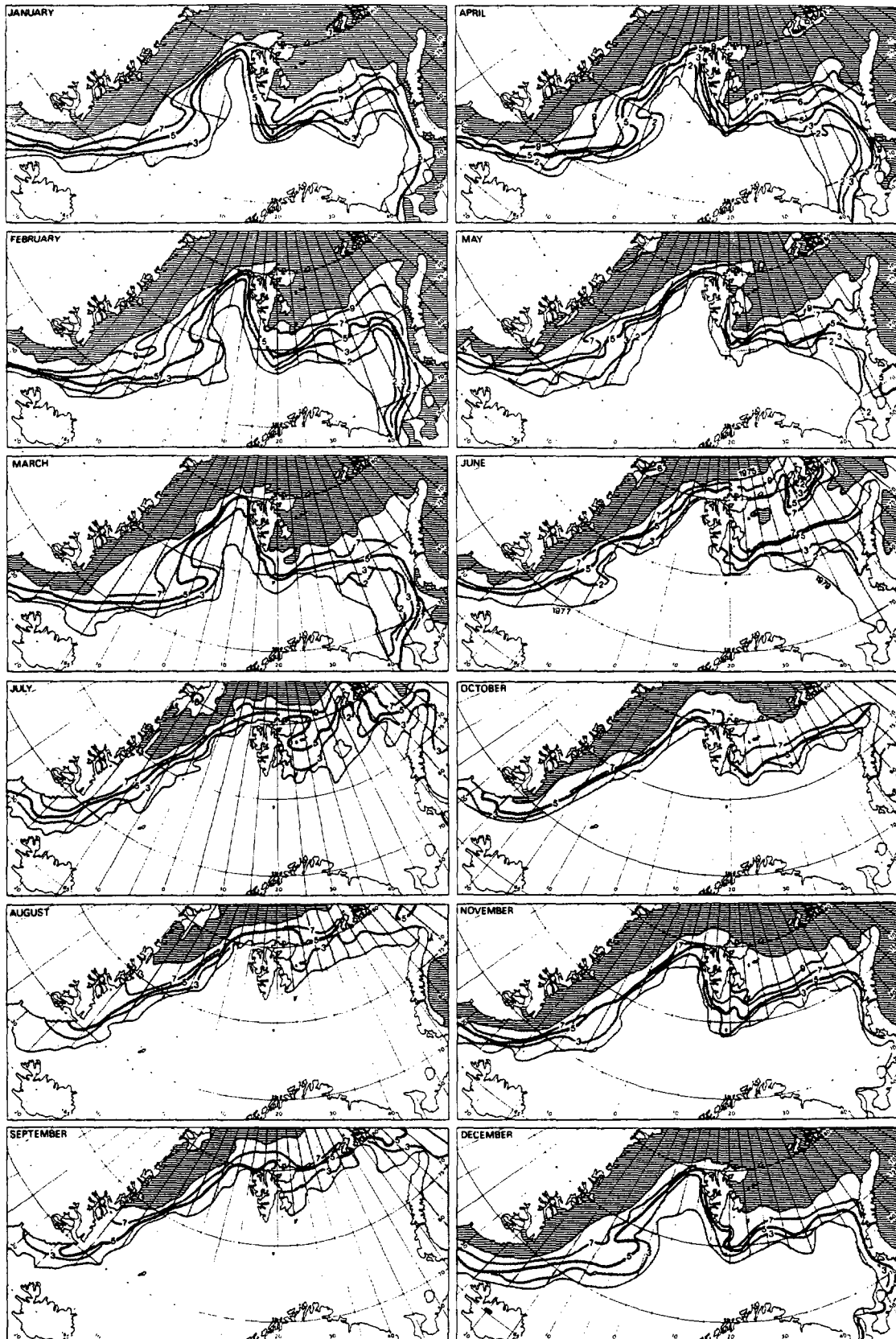


Figure 1. Frequency distribution (in tenths) of sea ice concentration above 4/10 at the end of each month, during 1971-80. I. e. the curve marked 5 gives in 5 out of 10 years the southern border for ice concentration above 4/10. The southernmost and northernmost curves give the extreme borders.

Table 1.1 shows years of records at each station. It also shows the periods that are used to compute frequencies and mean values shown in the figures in this section, and in the tables in section 3. Note that these periods are different for different stations. One should therefore be careful when comparing frequencies or mean values from different stations.

1.3 Climatic control

a) 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. The stations all 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 (fig.8) there is a considerable radiation heat loss from the ground then. Maximum cloudiness occurs in summer, resulting in few hours of bright sunshine.

b) Sea currents and ice limits

The prevailing warm and cold sea currents are factors of great importance to the climate in the area. 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, and 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.

c) General circulation

The general large scale air currents over the Northern Atlantic Ocean are determined by the low pressure area near Iceland and relatively high pressure area 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. 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 fluctuation in weather and temperature conditions. Periods of ice-covered sea and continental-influenced weather conditions are followed by periods of open sea and maritime-influenced weather conditions. The greatest variation occurs in winter, when the contrast in temperature between the two air masses is most marked.

1.4 Climate

a) Classification

By Köppens's system of classification, those climates in which the mean air temperature of the warmest month is less than 10°C are called Polar (E). These have been further subdivided into Tundra climate (ET), where at least one month has a mean air temperature above 0°C , and Frost or Ice Cap climate (EF), in which all months have mean air temperatures below the freezing point. Some areas with climates classified as ET are under strong maritime influence. These areas have been designated as Polar Marine (EM) when the coldest month has a mean air temperature above -6.7°C (Shear 1964). According to this

classification the stations at Spitsbergen have an ET climate. The temperature data used are 30-year means (or less where records are shorter).

b) Wind

Seasonal percentage frequencies of different wind directions (figures 2 a to e) illustrate that the prevailing winds are from the northeast-southeast sector at Spitsbergen, except during summer. 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 this area 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 winter the mean monthly frequency of days with maximum wind force 6 Beauforts or more is 65-75% at Isfjord Radio (the wind here is strengthened locally by Isfjorden, which is narrower at the mouth than further in), 35-45% at Svalbard Lufthavn, about 30% at Svea Gruber, and only 20-30% at Ny-Ålesund. The complete wind statistics, including data up to 1978, have been published by Det Norske Meteorologiske Institutt (Andresen 1979).

c) Air temperature

i) General:

The most remarkable features concerning winter air temperature are the relatively high mean values and great fluctuations which occur, considering the high latitude. For Longyearbyen and Isfjord Radio, which have the longest periods of observation, the difference between the highest and lowest monthly mean in January-February is about 22 °C.

Among the stations on Spitsbergen, Svea Gruber, Longyearbyen and Svalbard Lufthavn 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. Svea Gruber usually has the lowest winter temperatures, while Longyearbyen has the highest temperatures during summer. The mean winter temperature at Ny-Ålesund and Longyearbyen are similar. During summer, however, the mean temperature 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. Even during these months, however, temperatures of 3 - 6 °C have been recorded at all stations. Summer temperature shows a marked uniformity in the Arctic. Differences between the highest and the lowest monthly means in June, July and August were 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.

Figure 3 shows monthly mean temperatures on clear and overcast days, and illustrates the influence of cloud cover on temperature throughout the year. A clear day is defined as one when the sum of the amount of cloud cover at the three daily observation is 4/8 or less. Similarly, an overcast day occurs when this sum is 20/8 or more. The great temperature differences between clear and overcast days in the months October-April, and the small differences in the months May-September

should be noted.

ii) Recent temperature fluctuations.

The recent fluctuations in air temperature, shown by curves of running 5-year means for seasons and years up to 1968, have been published by Steffensen (1982) for Isfjord Radio and Longyearbyen. Figure 4 shows these curves, including data up to 1989, for Svalbard Lufthavn, Ny-Ålesund and Svea Gruber. Temperature fell in the 1960's, increased in the early 1970's, and declined again in the late 1970's. Temperature rose during the first part of the 1980's, and declined during latter years. With the exception of summer, when only minor temperature variation occurred, the pattern of temperature variation was similar for all seasons. Temperature variation was most pronounced during winter.

d) Precipitation

Precipitation is normally low in the Arctic because air masses usually are stably stratified and contain small amounts of water vapour. Most of the precipitation at Spitsbergen occurs in connection with cyclones coming in from the southwest-northwest sector. The mean yearly precipitation at the stations on Spitsbergen is 180-440 mm. Mean monthly precipitation measured at the Spitsbergen stations is shown in fig. 5. Precipitation is at a minimum during the period April-June. Most of the stations have maxima both in August and February-March.

Mountain regions on Spitsbergen receive the greatest amount of precipitation and inner fiord districts the least; but the topography of the land causes great local differences. Both rain and snow may occur throughout the year at all the stations. It should be noted that reliable measurements of precipitation are difficult under certain conditions. For example, most measurements of maximum precipitation during a 24-hour period occurred in connection with strong wind and drifting snow. Under such conditions, large catch losses in the precipitation gauges occur. It should also be emphasized that the monthly values different stations plotted in fig. 5 originate from measurements taken during different periods (see section 1.2).

Investigations of the distribution of glacial ice and the height of the snow line conducted by the Norsk Polarinstitut have provided valuable information concerning the actual distribution of precipitation on Spitsbergen. A map showing the height of the snow line has been prepared by Liestøl and Roland (fig. 6), which roughly illustrates the yearly distribution of precipitation.

e) Clouds and fog

Arctic sea fog in the summer, formed by advection of mild, humid air over a colder surface, is a well known phenomenon. The mean monthly percentage frequencies of fog at the Spitsbergen stations show maxima in June-July (fig. 7). However, fog seldom occurs in the inner districts of Spitsbergen. The number of overcast days, on the other hand, is great during summer (fig. 8). From June to October, at least 50% of the days are usually overcast at all stations. December and April usually have the greatest number of clear days, averaging around 25%.

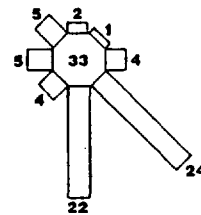
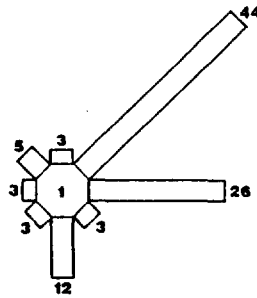
The yearly values of global radiation and duration of bright sunshine are small at the west coast of Spitsbergen. At Isfjord Radio the yearly mean duration of sunshine is 25% of the theoretical maximum. Maximum duration of bright sunshine occurs in May, maximum value for global radiation in June (12).

Figure 2 a,b) Wind roses.

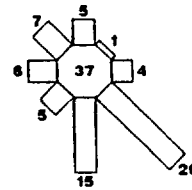
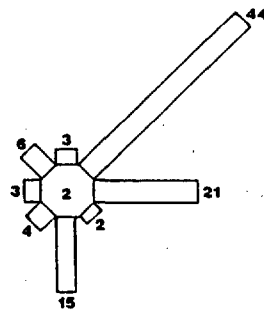
Isfjord Radio

Longyearbyen

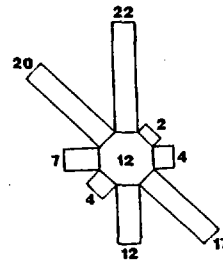
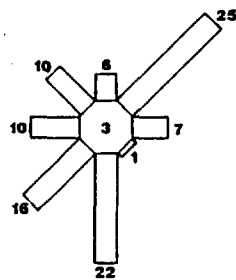
winter



spring



summer



fall

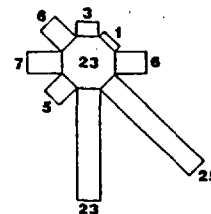
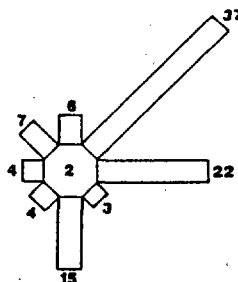


Figure 2 c,d,e) Wind roses.

Svalbard Lufthavn

Ny-Alesund

Svea Gruber

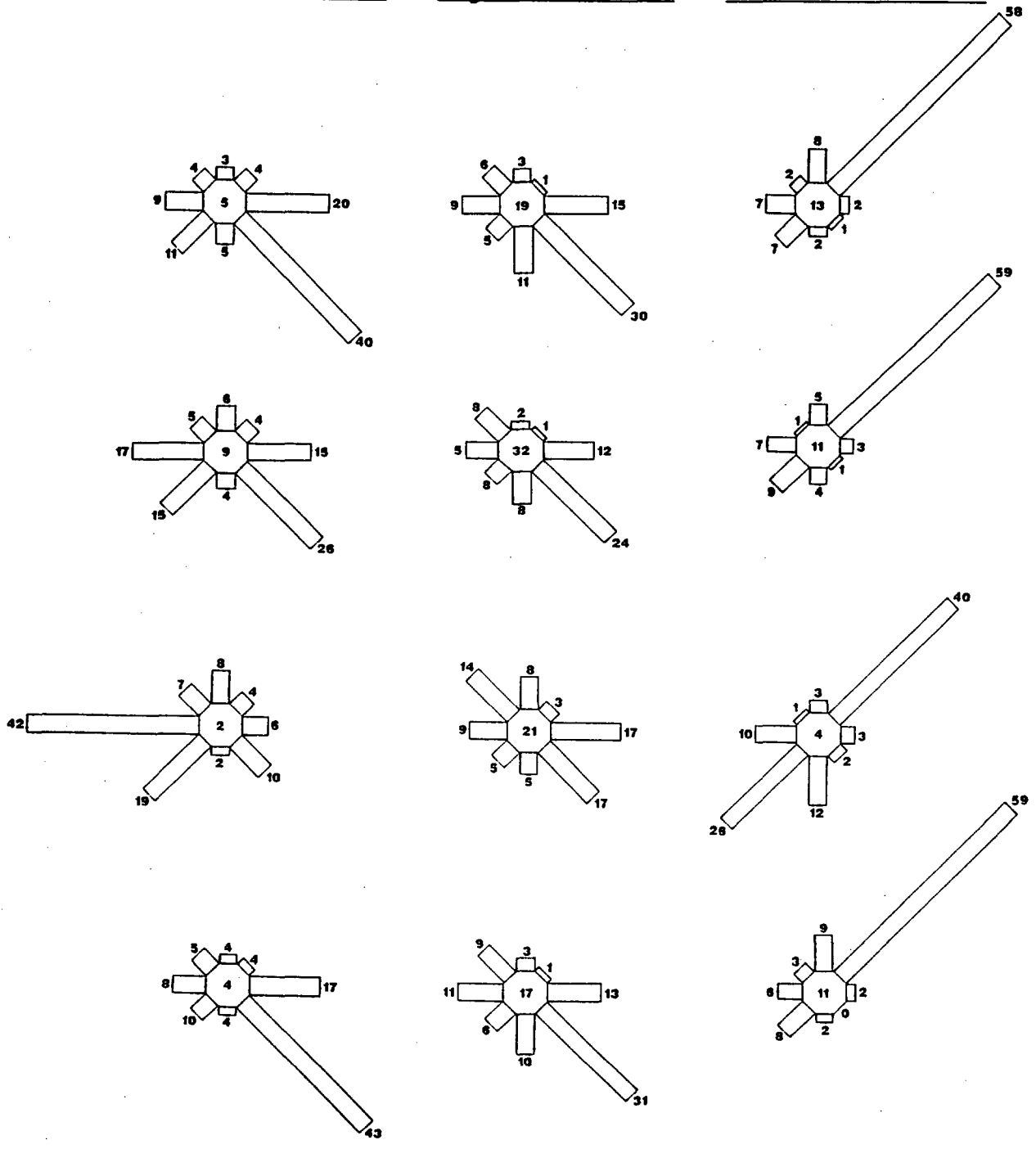
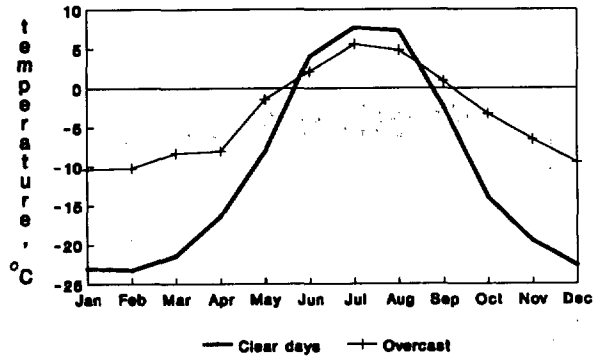


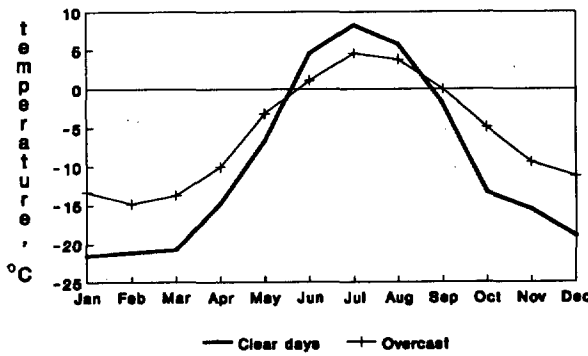
Figure 3.

Temperature on
clear and
overcast days.

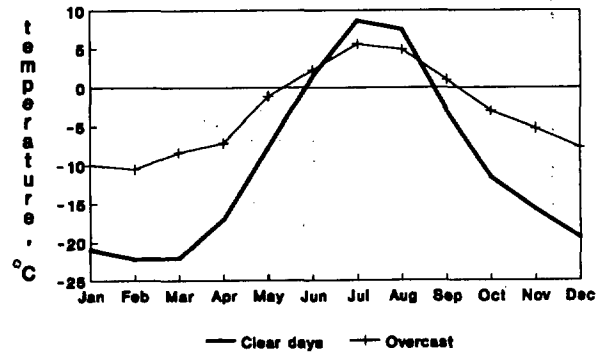
SVEA GRUBER



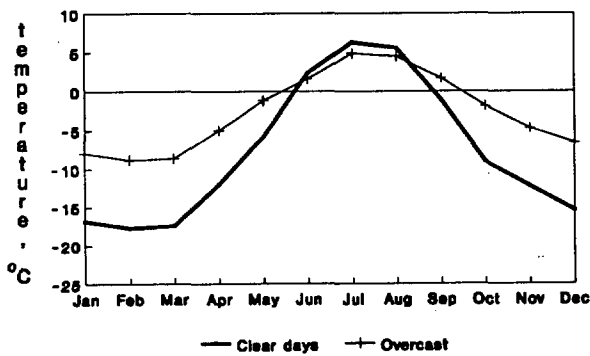
LONGYEARBYEN



SVALBARD LUFTHAVN



ISFJORD RADIO



NY-ALESUND

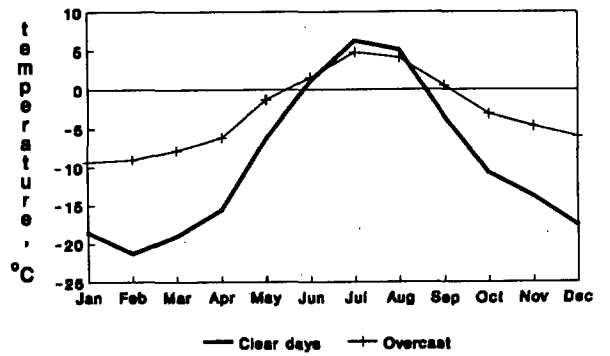


Figure 4.

Temperature series from Spitsbergen.

5-year running mean.

a) year, b) winter, c) spring, d) summer, e) fall

Fig. 4 a) year

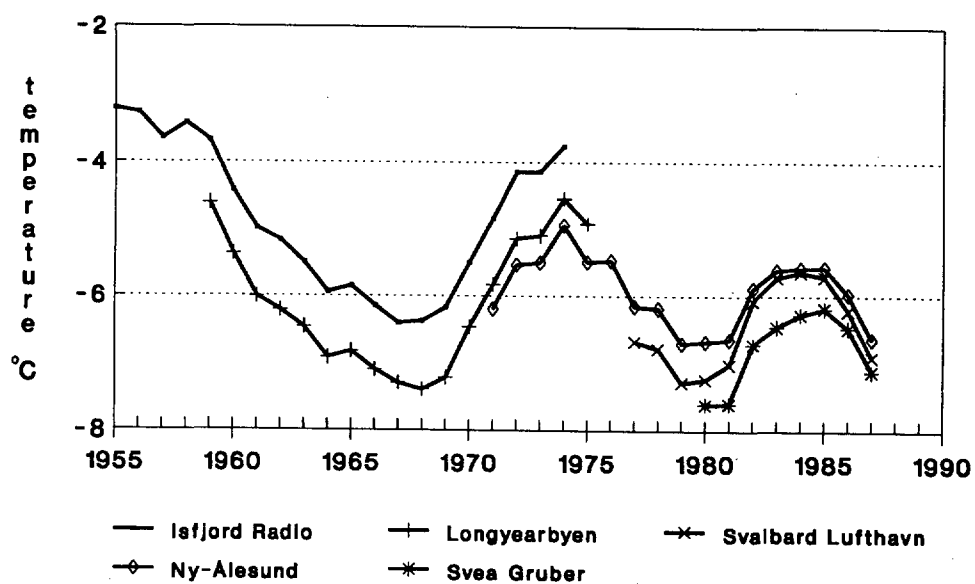


Fig. 4 b) Des-Jan-Feb

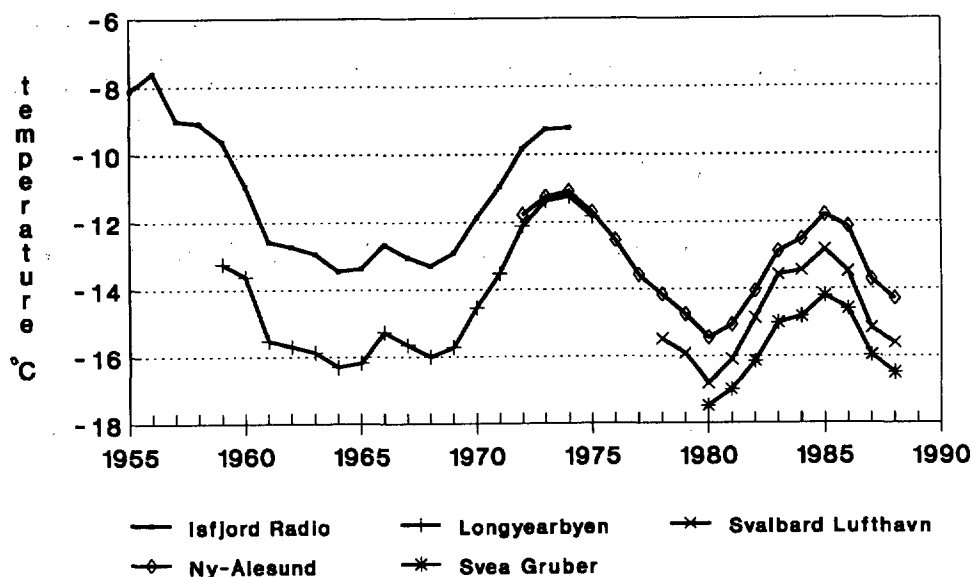


Fig. 4 c) Mar-Apr-May

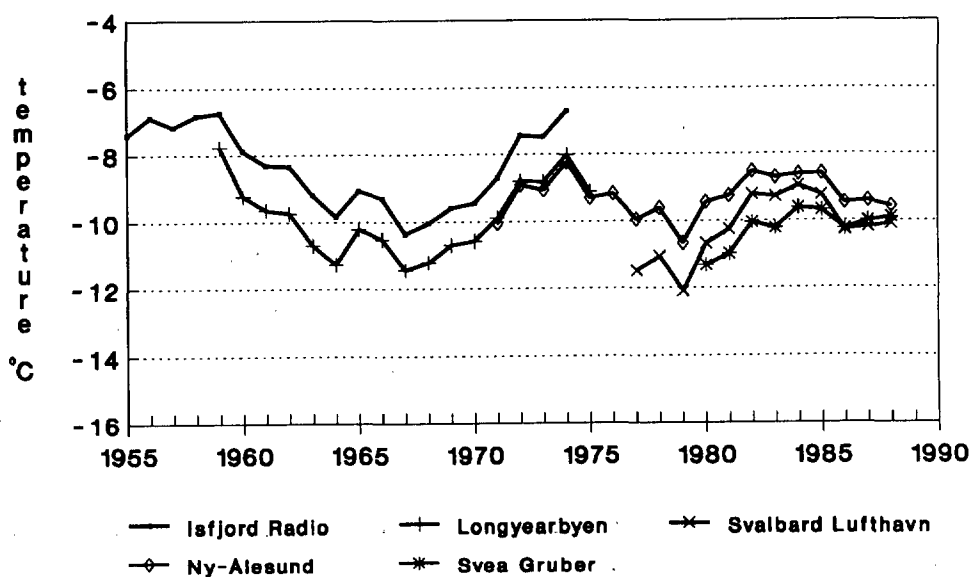


Fig. 4 d) Jun-Jul-Aug

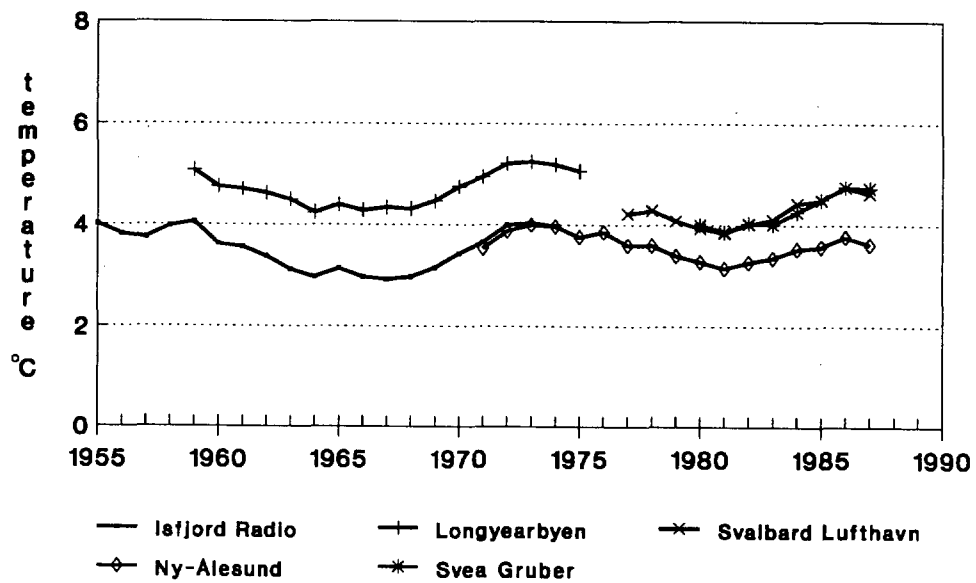


Fig. 4 e) Sep-Oct-Nov

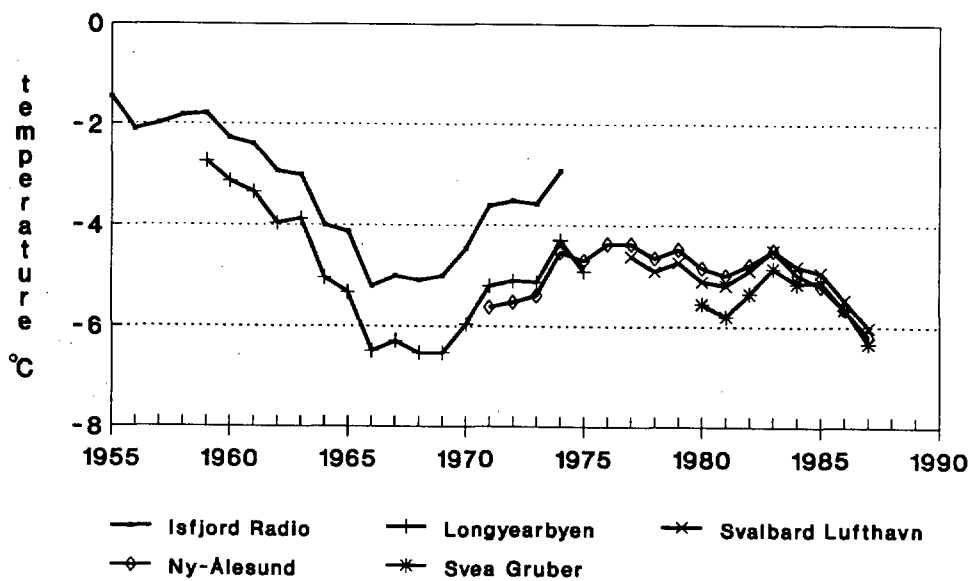
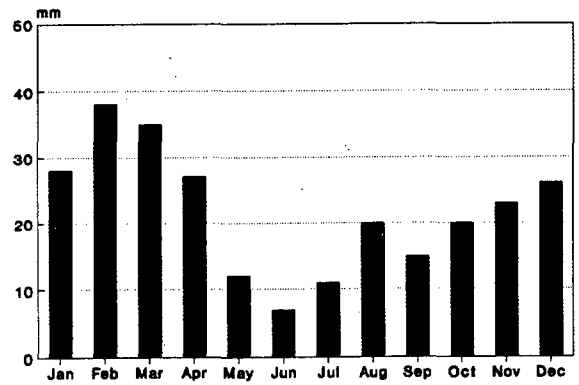


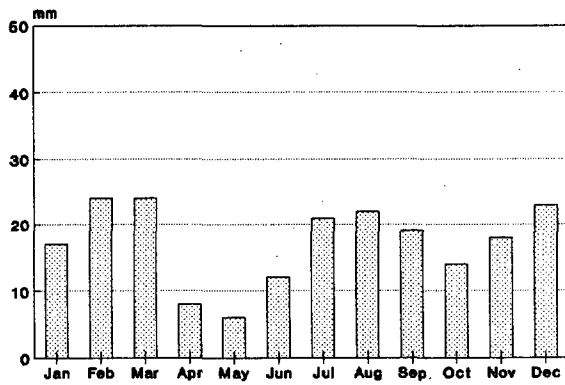
Figure 5.

Mean monthly precipitation.
(mm)

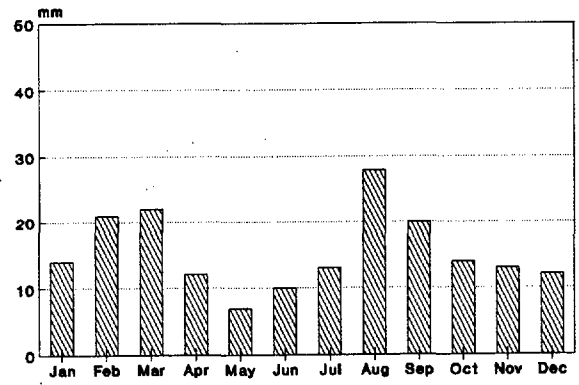
SVEA GRUBER



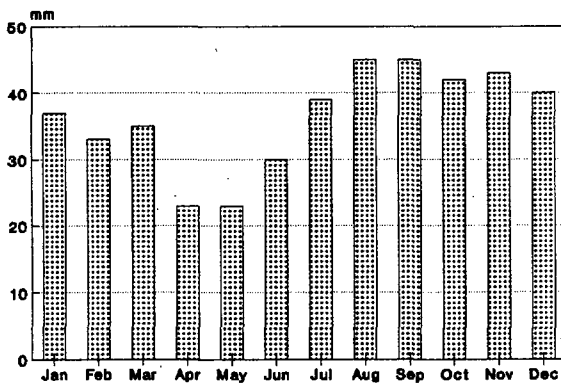
LONGYEARBYEN



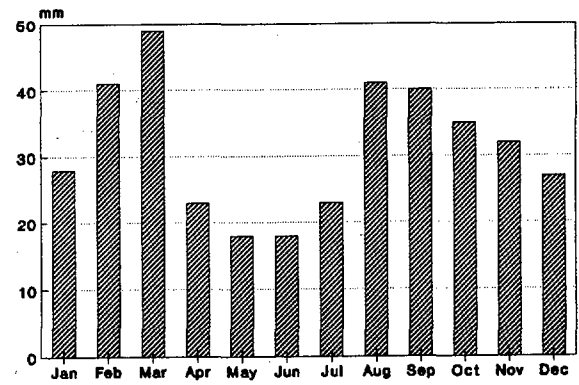
SVALBARD LUFTHAVN



ISFJORD RADIO



NY-ALESUND



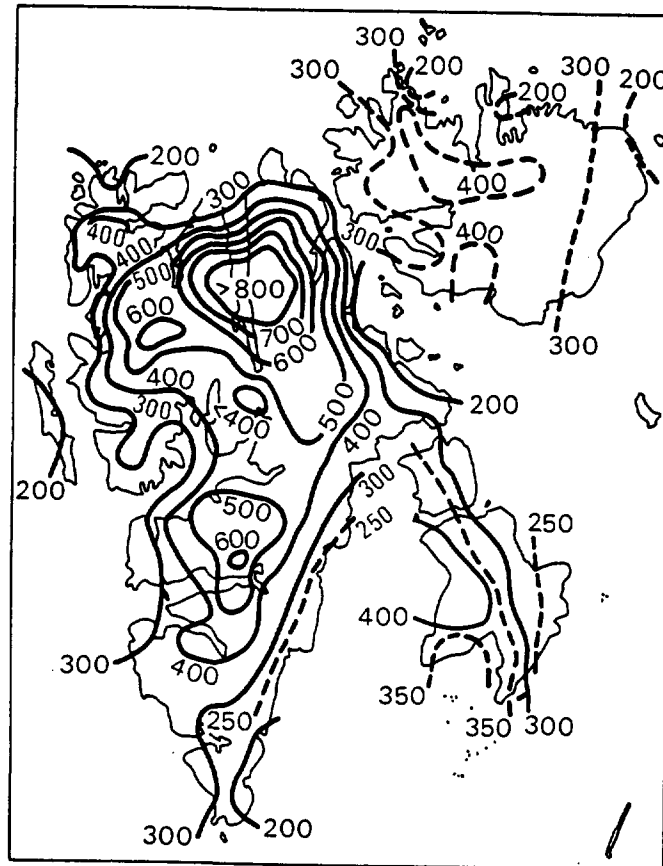
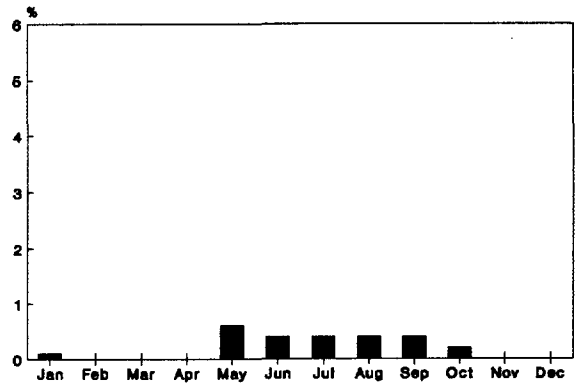


Figure 6. The glacier equilibrium line in Svalbard based on aerial photographs and direct measurements. The figure shows the equilibrium line altitude (ELA) on the glaciers in Svalbard when the glaciers are in steady-state balance with the climate. However, the glaciers are not in balance with the existing climate. The ice masses are shrinking and the ELA is now on average about 100 m higher. The general pattern is, however, the same, and thus reflects the precipitation pattern in Svalbard. The higher the ELA, the lower the snow accumulation. (Hagen 1990)

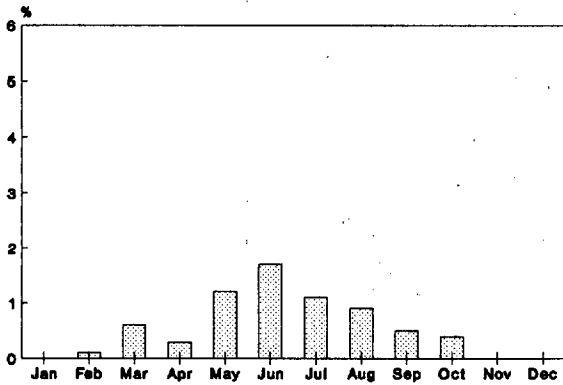
Figure 7.

Frequencies
of fog.
(%)

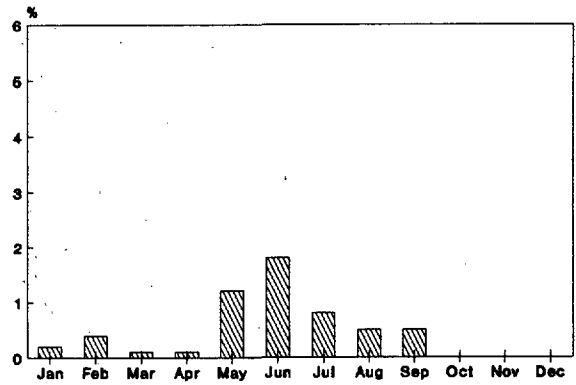
SVEA GRUBER



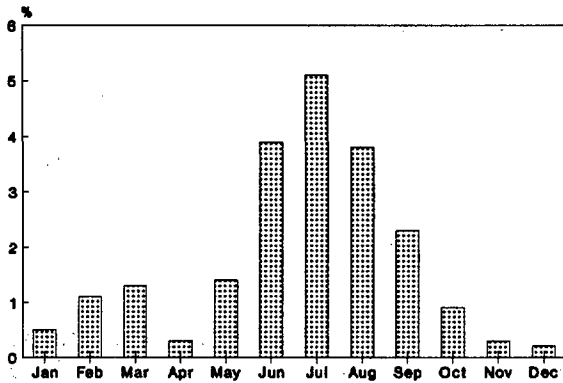
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SVALBARD LUFTHAVN



ISFJORD RADIO



NY-ALESUND

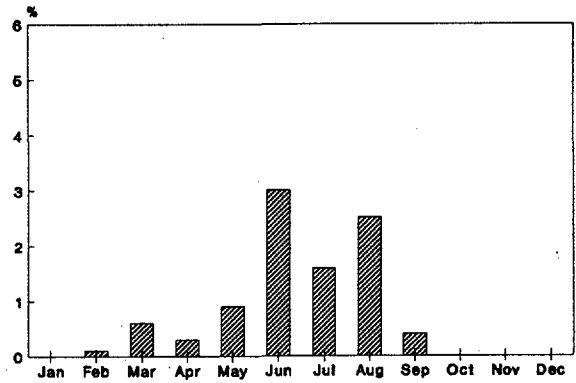
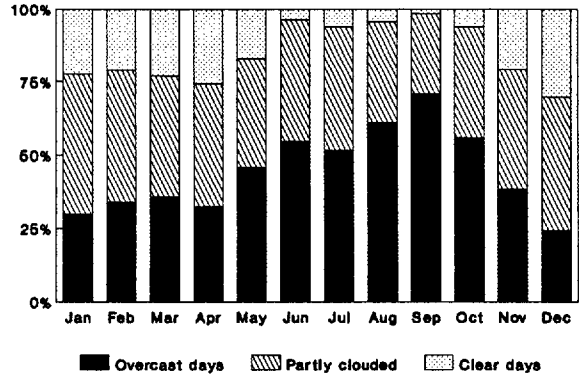


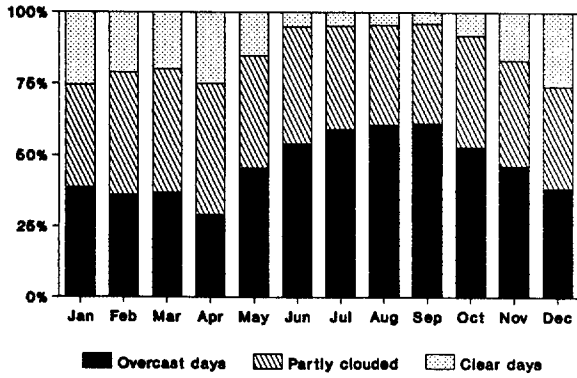
Figure 8.

Frequencies of clear and overcast days.

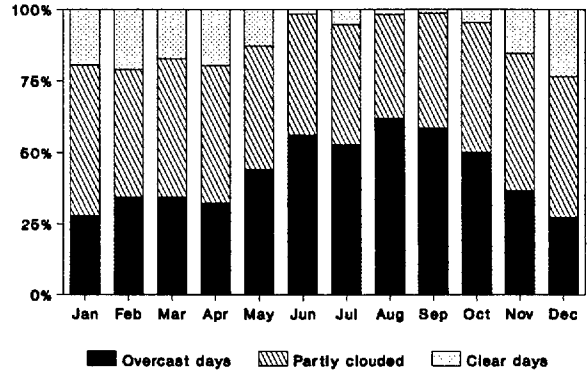
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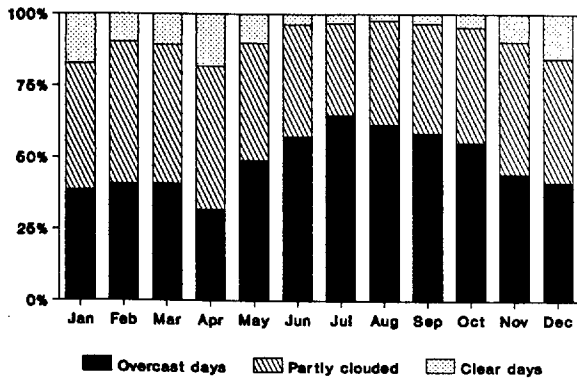
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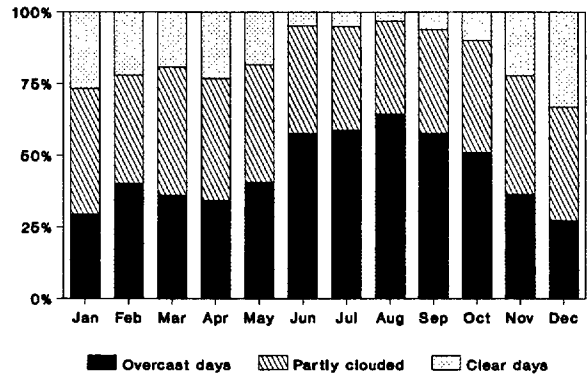
SVALBARD LUFTHAVN



ISFJORD RADIO



NY-ALESUND



2. THE HISTORY OF THE NORWEGIAN ARCTIC STATIONS

The Norwegian part of the Arctic consists of Svalbard (Spitsbergen, Bjørnøya and Hopen) and Jan Mayen (fig. 9). The oldest meteorological observations from this area were made during expeditions, usually of about one years duration, to different places on Svalbard and 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. Below is a list of the meteorological stations no longer in operation at Svalbard, East-Greenland and Jan-Mayen, with respective periods of observation:

<u>Station</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Years of record</u>
Storøy	76° 30' N	16° 30' E	1908-09, 11-12, 14-15
Akseløy	77° 42' N	14° 50' E	1898-99, 1900-01, 02-03, 04-05, 10-11
Green Harbour	78° 02' N	14° 14' E	1911-30
Quade Hook	78° 57' N	11° 42' E	1912-24 (incompl.)
Andersonøy	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, 06-07, 08-09
Zieglerøya	77° 20' N	22° 02' E	1904-05
Halvmåneøya	77° 17' N	23° 05' E	1906-07
Nordostlandet	80° 04' N	22° 24' E	1944-45 (German obs.)
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, 26-40, 46-59
Finnsbu (Greenland)	63° 24' N	41° 17' W	1932-35
Torgilsbu (Greenland)	60° 32' N	43° 11' W	1932-40

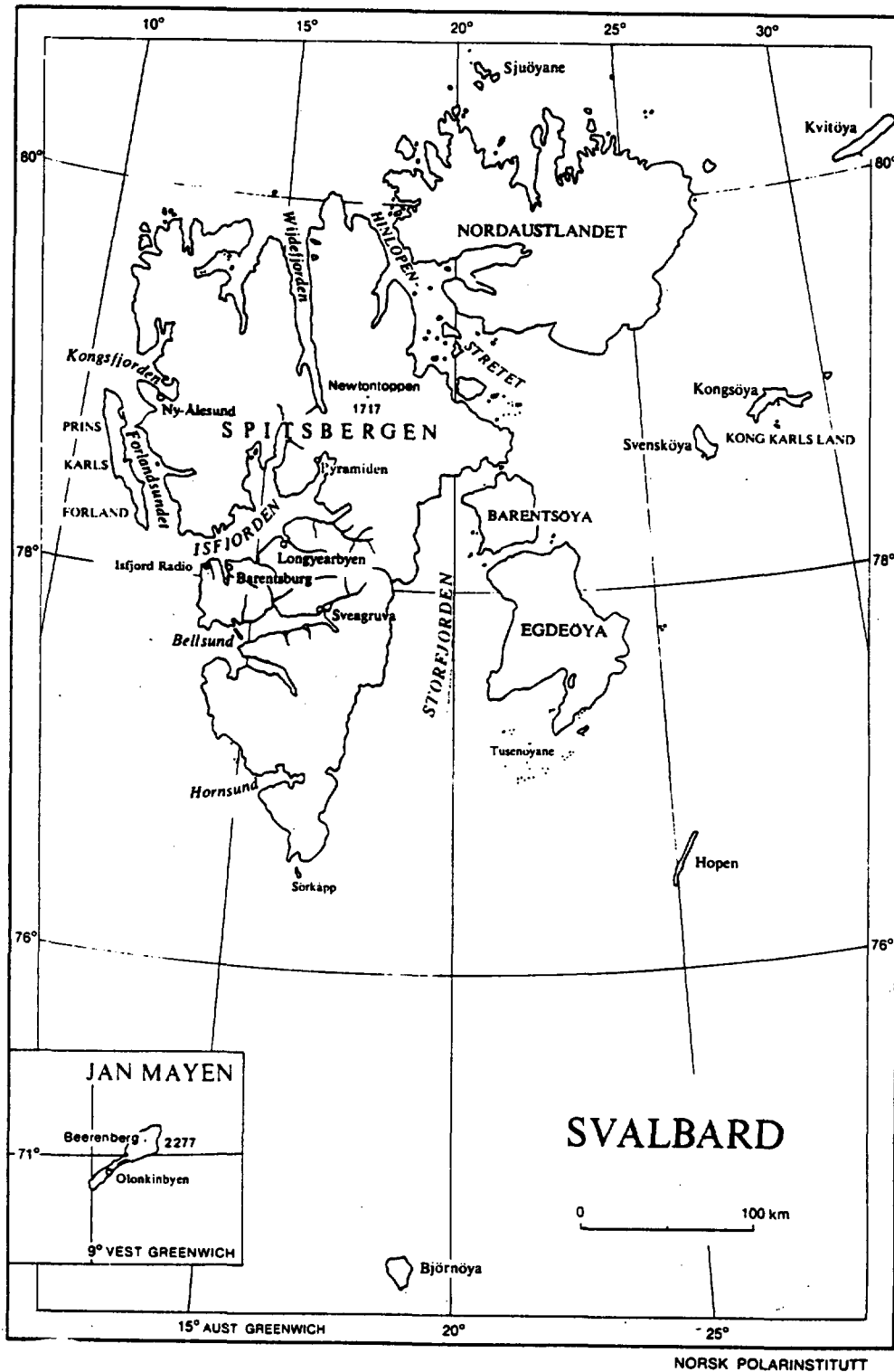


Figure 9. Map of Svalbard.

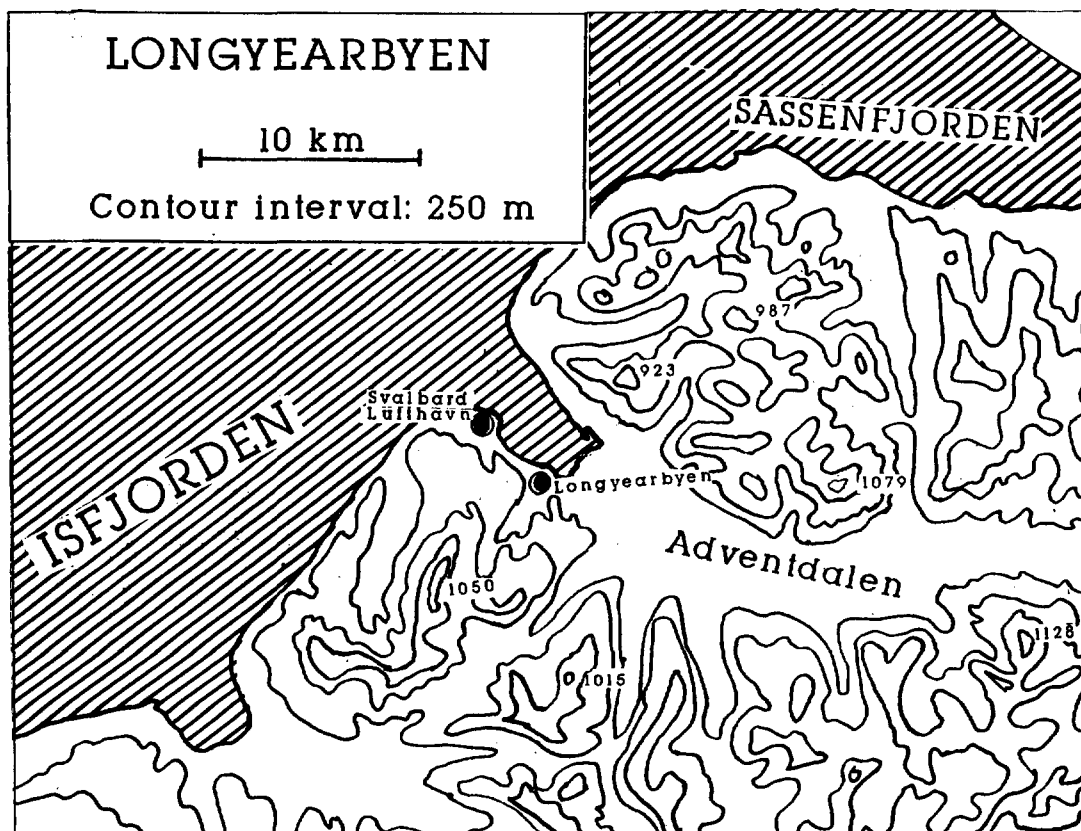
3. THE METEOROLOGICAL STATIONS ON SPITSBERGEN

3.1 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 been situated continually at nearly the same place.

Irregular observations were carried out during the period 1916-46, and regular observations are available from 1957. The station was closed in July 1977, after which observations continued at Svalbard Lufthavn situated 3-4 km northwest of Longyearbyen. The tables of frequency distributions and mean values except for air pressure, are given for the period 1957-76. Air pressure measurements were started in Longyearbyen in 1968, and the table gives mean values from 1968-76. Maximum wind force between the hours of observation were not recorded here, so the number of days with maximum wind force equal to or greater than 6, 8 and 9 Beaufort are not available. The observations of cloud heights are probably unreliable, and are therefore not presented here. Rather, data for maximum wind force and cloud height are given for Svalbard Lufthavn.



MEAN VALUES 1957-1976

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
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
AIR 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
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

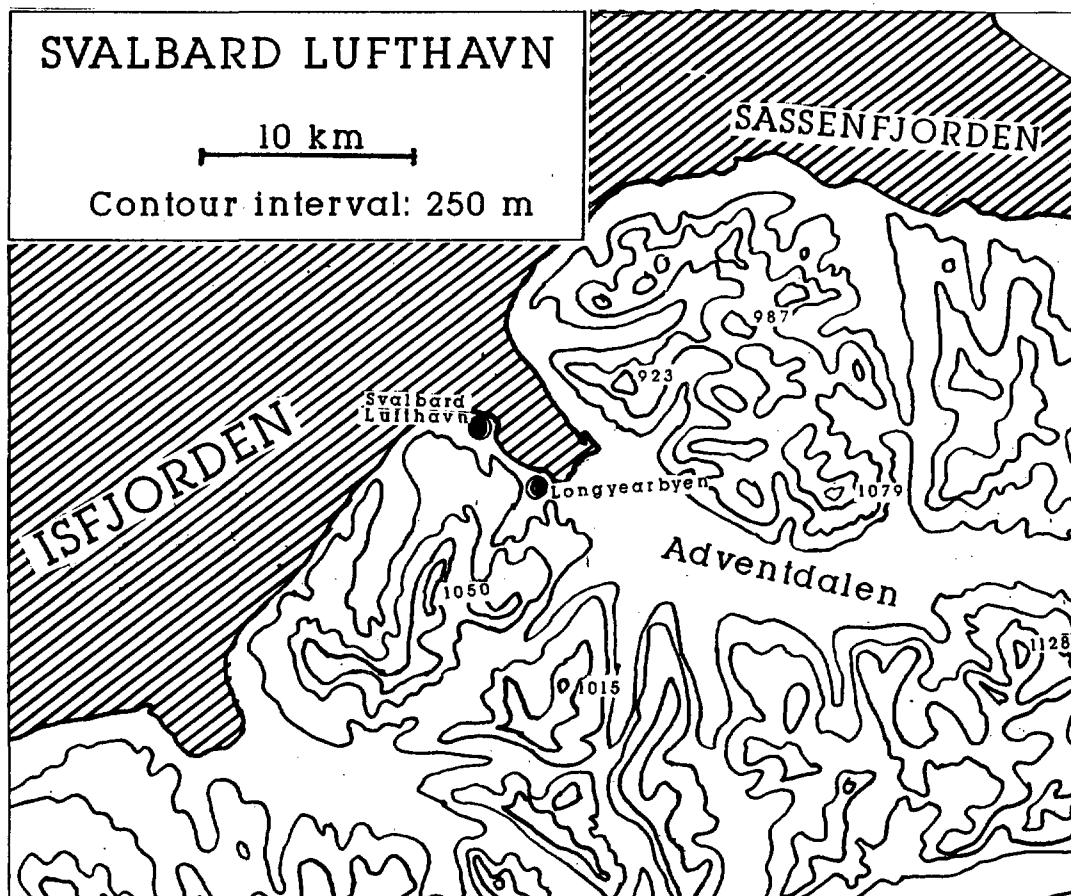
* Mean values of air pressure for the period 1968-1976

3.2 Svalbard Lufthavn

Position:	78° 15' N, 15° 28' E
Station height:	28 m
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 in Longyearbyen. The station was established in July 1975. Simultaneous observations were carried out at both stations during the period August 1975-July 1977.

The air temperature is usually somewhat lower at the airport than at the old station. The difference between monthly means at the two stations ranges from 0.0-1.5 °C, reaching a maximum in spring. A more detailed analysis of this difference is given in section 4 of this report. The wind conditions are also different at the two stations, but the other data show only minor differences.



MEAN VALUES 1976-1989

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DES	YEAR
AIR PRESSURE, MB													
Average sea level	1007.2	09.3	10.8	14.3	17.1	12.3	11.5	11.8	08.4	08.1	05.2	07.2	1010.3
AIR TEMPERATURE °C													
Average	-15.8	-16.0	-14.9	-12.1	-3.7	2.0	6.1	4.8	-0.1	-5.4	-9.9	-13.6	-6.5
Extreme values:													
High. monthly/annual	-8.8	-9.1	-7.8	-8.1	-1.5	3.7	7.6	5.5	1.5	-2.5	-4.6	-2.7	-3.1
Low. monthly/annual	-22.0	-22.6	-23.5	-18.2	-8.0	-0.5	4.8	3.9	-2.6	-9.4	-16.9	-22.5	-8.9
Std. deviation	4.2	4.1	4.4	3.4	1.5	1.3	0.8	0.5	1.4	1.8	3.5	5.0	1.4
Aver. daily max.	-11.5	-11.4	-10.7	-8.2	-1.1	4.4	8.7	7.1	2.0	-2.8	-6.7	-10.1	-3.3
Aver. monthly max.	0.9	1.4	2.1	1.7	5.1	10.3	14.2	12.7	7.8	5.3	3.5	2.2	
Absolute max.	4.3	5.9	6.3	5.5	10.6	14.3	21.3	16.5	10.8	8.9	5.8	4.8	
Aver. daily min.	-19.8	-20.3	-18.9	-15.8	-5.7	0.5	4.4	3.3	-1.8	-7.9	-12.6	-16.7	-10.0
Aver. monthly min.	-30.0	-32.8	-32.4	-26.4	-15.1	-4.0	1.5	-0.4	-8.7	-16.3	-21.4	-27.2	
Absolute min.	-38.8	-43.7	-46.3	-39.1	-21.7	-8.4	0.2	-2.5	-12.6	-20.4	-29.5	-35.6	
No. of days with:													
Daily min. 0 or less	31.0	28.2	30.7	29.9	28.6	11.4	-	1.9	18.3	28.3	29.4	30.7	268.9
D. min. -10 or less	27.2	24.2	24.6	23.6	6.3	-	-	-	0.8	11.4	19.6	24.2	161.9
D. max. 0 or less	28.6	25.0	26.3	26.2	16.7	2.1	-	-	6.9	21.4	24.6	26.5	204.2
RELATIVE HUMIDITY, %													
Average	73	75	74	72	73	72	75	75	75	73	72	71	73
PRECIPITATION, MM													
Average monthly fall	14	21	22	12	7	10	13	28	20	14	13	12	186
Max. fall in 24 hrs.	8	16	15	9	6	11	7	43	14	10	35	15	
No. of days with:													
0.1mm or more	13.1	13.3	13.4	12.1	10.4	8.7	9.9	14.1	12.3	15.1	13.1	12.7	148.1
1.0mm or more	4.1	5.1	5.0	3.9	2.1	2.7	4.4	6.7	5.8	4.6	4.1	3.3	51.8
10.0mm or more	-	0.3	0.4	-	-	0.1	-	0.6	0.3	-	0.1	0.1	1.7
rain 0.1mm or more	1.2	1.3	2.1	1.5	3.0	6.5	9.9	13.5	7.6	3.6	2.8	1.4	54.4
snow 0.1mm or more	12.9	13.2	13.2	11.9	9.5	5.4	1.0	3.4	8.7	13.6	12.8	12.6	118.3
CLOUDS, VISIBILITY													
Average, octas	4.3	4.6	4.7	4.4	5.1	6.1	5.9	6.3	6.2	5.7	4.9	4.2	5.2
No. of clear days	6.1	6.1	5.4	6.0	4.1	0.5	1.7	0.6	0.4	1.5	4.7	7.4	44.5
No. of overcast days	8.6	9.7	10.6	9.7	13.6	16.8	16.4	19.1	17.5	15.5	11.0	8.4	157.1
Perc. freq. of:													
Fog	0.2	0.4	0.1	0.1	1.2	1.8	0.8	0.5	0.5	-	-	-	0.5
Horizontal visibility:													
1km or less	0.6	1.7	1.1	0.5	1.4	1.8	0.8	0.5	0.7	0.2	0.1	0.3	0.8
4km or less	5.0	7.0	5.7	4.4	3.7	4.0	1.7	1.2	2.4	1.9	2.6	2.4	3.5
Lowest cloud height:													
100m or less	0.3	1.0	0.2	0.4	3.3	5.5	6.2	3.9	3.0	0.7	0.3	0.3	2.1
300m or less	6.0	9.9	7.0	8.8	15.4	22.6	38.7	33.5	17.4	8.4	4.4	3.3	14.7
WIND FORCE, BEAUFORT													
Perc. freq. of:													
0	4.9	8.0	10.3	11.3	7.5	1.6	2.1	4.2	5.9	3.5	2.9	2.9	5.4
1-2	32.2	34.4	40.7	42.8	44.8	40.0	31.5	37.4	37.5	26.8	19.4	27.6	34.5
3-5	51.0	45.6	39.9	38.6	43.8	56.0	63.6	56.4	54.0	64.0	68.6	60.9	53.8
6-8	11.9	11.9	9.2	7.2	3.9	2.4	2.8	2.0	2.7	5.6	9.0	8.3	6.3
9 or more	-	0.2	0.1	-	-	-	-	-	-	-	0.1	0.2	0.0
No. of days with max.													
6 or more	13.0	12.4	11.0	8.8	5.4	4.3	5.9	4.9	5.6	9.0	11.6	11.1	103.2
8 or more	2.8	2.2	2.4	1.4	0.3	0.1	0.1	0.4	0.4	0.9	1.9	2.0	14.9
9 or more	0.1	0.5	0.6	0.1	0.2	0.1	-	-	-	0.1	0.6	0.4	2.7

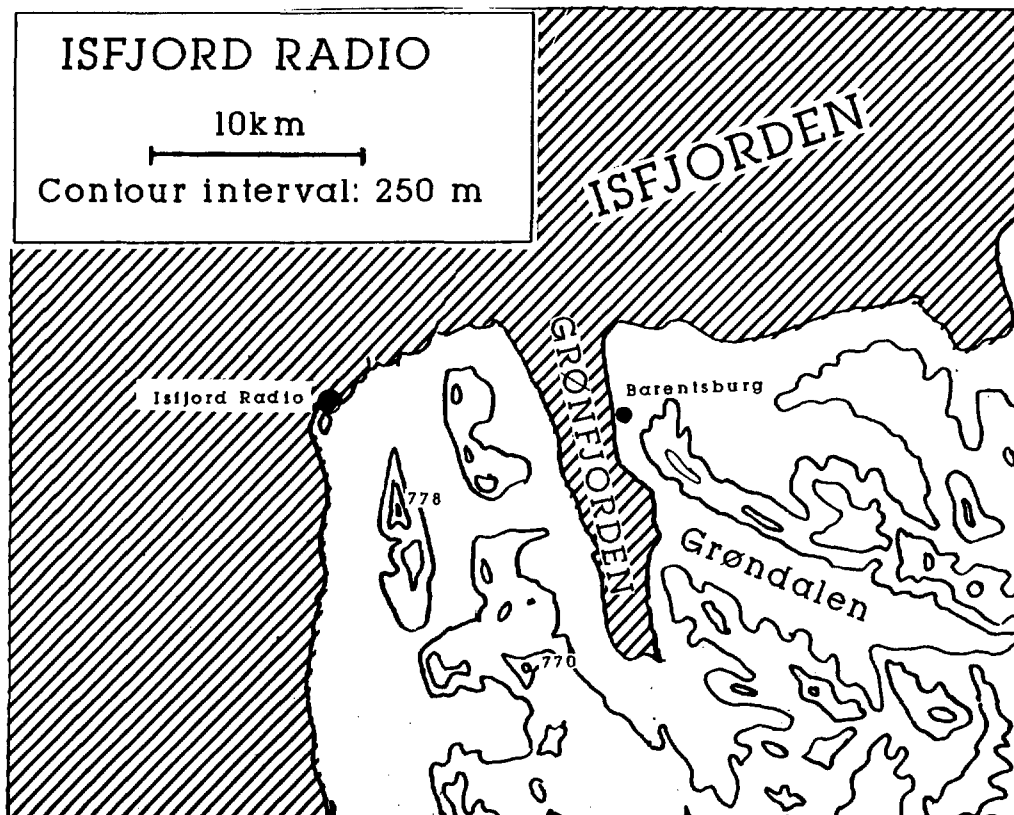
3.3 Isfjord Radio

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 above m.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.

The weather station, established in September 1934, was destroyed during World War II in September 1941 and reestablished in August 1946. After June 1976, no regular observations have been available. The tables of mean values are given for the period 1951-1975, extreme values for the whole observation period, and the frequency tables for the period 1956-1975.

No regular observations of sea ice concentration have been made at Isfjord Radio. Some general features concerning ice conditions, however, are summarized 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.

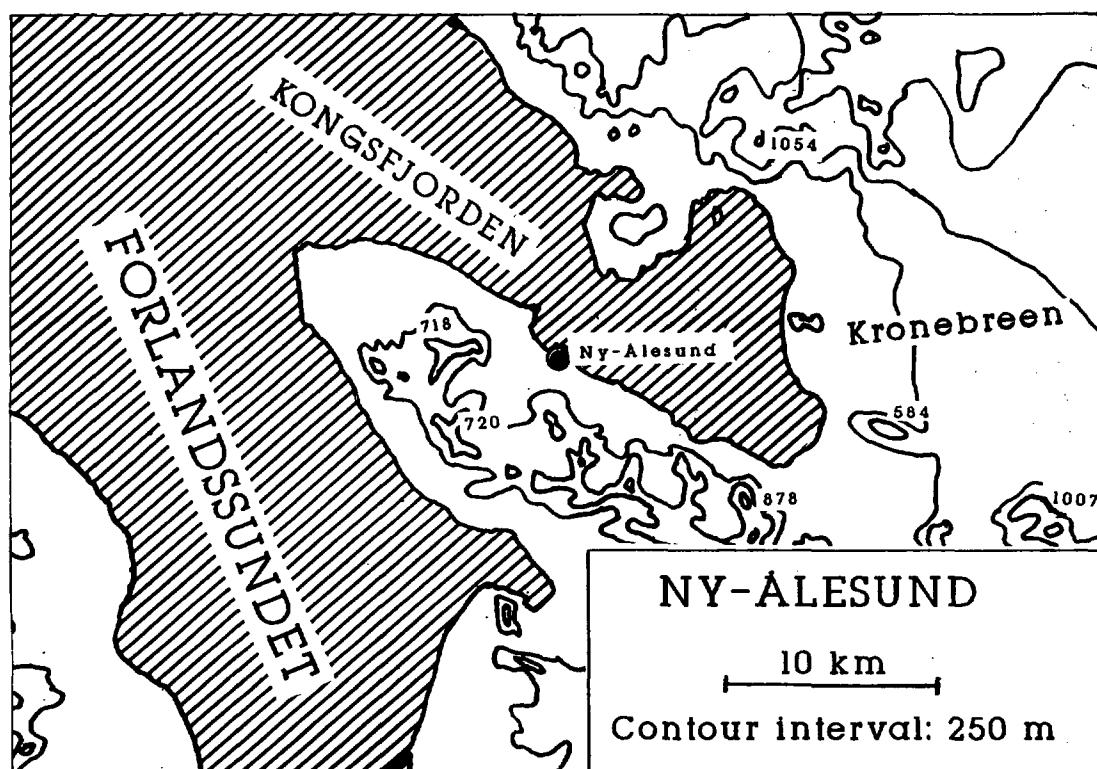


MEAN VALUES 1951-1975													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DES	YEAR
AIR TEMPERATURE, °C													
Average	-11.5	-11.7	-12.5	-9.3	-3.4	1.7	4.7	4.3	1.0	-3.5	-7.1	-9.6	-4.7
Extreme values:													
High. monthly/annual	-1.3	-4.3	-4.4	-4.3	-0.7	4.2	6.8	6.0	4.1	1.4	0.1	-0.6	-2.0
Low. monthly/annual	-23.1	-25.3	-23.5	-20.5	-9.5	0.1	2.6	1.8	-2.6	-11.9	-18.8	-19.3	-11.0
Std. deviation	5.0	4.1	4.1	3.1	1.7	0.9	0.9	0.9	1.3	2.3	3.7	4.1	1.7
Aver. daily max.	-8.7	-8.4	-9.6	-6.8	-1.5	3.4	6.6	5.9	2.5	-1.7	-4.8	-7.0	-2.5
Aver. monthly max.	1.0	0.4	0.1	0.9	3.6	7.8	11.5	10.2	7.1	4.6	2.4	1.3	
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	
Aver. daily min.	-14.4	-14.7	-15.3	-11.7	-4.9	0.4	3.4	3.0	0.4	-5.5	-9.6	-12.4	-6.8
Aver. monthly min.	-23.5	-24.3	-23.9	-21.0	-11.9	-3.2	1.1	0.1	-4.9	-12.3	-17.7	-21.6	
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	
No. of days with:													
Daily min. 0 or less	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
D. min. -10 or less	22.5	20.6	24.2	18.4	2.8	-	-	-	0.1	4.8	14.1	18.6	126.1
D. max. 0 or less	27.1	25.5	28.0	26.6	19.5	1.8	-	-	4.5	18.4	22.5	26.5	200.4
RELATIVE HUMIDITY, %													
Average	82	81	83	81	82	86	88	86	84	81	81	82	83
PRECIPITATION, MM													
Average monthly fall	37	33	35	23	23	30	39	45	45	42	43	40	435
Max. fall in 24 hrs.	54	43	23	35	33	29	26	29	35	31	38	34	
No. of days with:													
0.1mm or more	13.4	12.9	13.8	10.8	11.3	12.2	14.8	15.3	14.5	15.0	13.5	13.6	161.1
1.0mm or more	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
10.0mm or more	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
rain 0.1mm or more	2.6	1.9	1.6	2.1	4.7	9.7	14.8	15.0	10.9	6.8	4.4	2.6	77.1
snow 0.1mm or more	13.1	12.4	13.6	10.5	10.1	7.0	1.1	2.0	8.0	12.4	12.2	13.4	115.8
CLOUDS, VISIBILITY													
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
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
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
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
Horizontal visibility:													
1km 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	2.9
4km 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
Lowest cloud height:													
100m 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
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	12.3
Bright sunshine, hrs													
1953-1973	-	1	74	212	236	165	145	126	62	11	-	-	1032
WIND FORCE, BEAUFORT													
Perc. freq. of:													
0	1.2	1.3	2.2	2.0	3.4	4.5	3.2	3.1	3.0	1.7	1.6	1.0	2.4
1-2	6.2	7.3	5.9	10.3	15.5	22.7	23.2	22.1	14.5	10.3	6.7	4.9	12.5
3-5	57.8	55.6	58.1	65.6	68.4	64.8	66.6	66.5	66.7	64.5	59.4	56.2	62.6
6-8	33.4	34.5	32.2	21.8	12.5	8.0	7.0	8.4	15.6	23.2	31.1	35.5	21.8
9 or more	1.4	1.3	1.6	0.3	0.2	-	-	-	0.2	0.3	1.2	2.4	0.7
No. of days with max.													
6 or more	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
8 or more	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
9 or more	2.2	2.8	2.3	0.8	0.3	0.1	-	0.1	0.2	0.8	1.6	3.0	14.2

3.4 Ny-Ålesund I and II

Position(1969-1974):	78° 56' N, 11° 53' E
Station height:	42 m
Position(1974-):	78° 55' N, 11° 56' E
Station height:	8 m
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 observations were recorded by employees of the Kings Bay Kull Camp. 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 personel at the research station of the Norsk Polarinstitutt. Observations here are therefore not strictly homogenous. Only small differences, however, are to be in 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. Mean values and frequency tables are computed for the new station, using data from the years 1975-1989. In fig. 4, however, the temperature series from Ny-Ålesund I and II are combined. No corrections were made when fitting the two series together, though temperatures at the new station are probably slightly lower during spring and slightly higher during fall than temperatures at the old station.



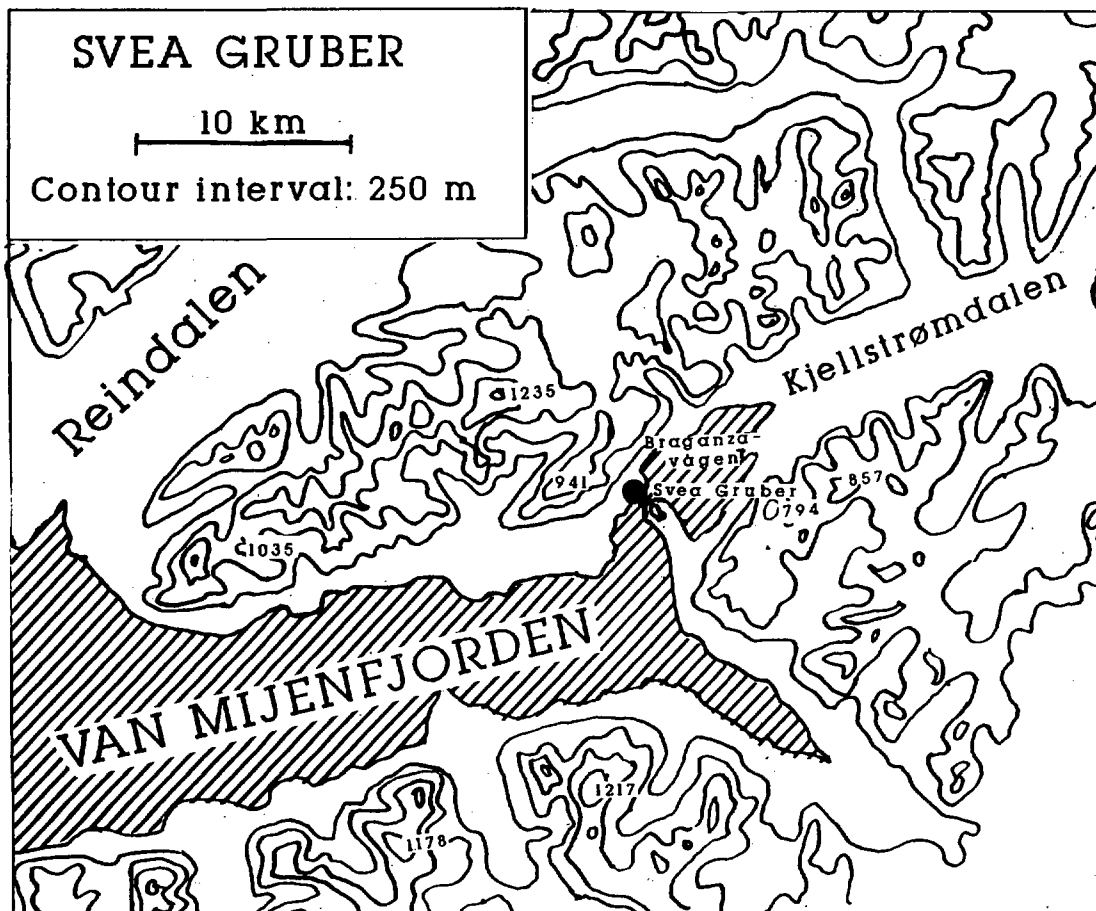
MEAN VALUES 1975-1989													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DES	YEAR
<u>ATM. PRESSURE, MB</u>													
Average sea level	1006.2	08.3	09.7	13.7	17.0	12.4	11.2	11.6	07.7	08.4	05.1	06.1	1009.8
<u>AIR TEMPERATURE °C</u>													
Average	-14.4	-14.6	-13.5	-10.9	-3.5	1.5	5.0	3.9	-0.5	-5.7	-9.1	-12.9	-6.2
Extreme values:													
High. monthly/annual	-8.2	-8.5	-6.3	-6.5	-1.9	2.9	6.2	4.6	1.1	-2.7	-4.8	-2.8	-3.3
Low. monthly/annual	-22.4	-20.7	-20.5	-17.0	-6.9	-0.5	3.7	3.0	-4.0	-9.9	-14.5	-21.3	-8.6
Std. deviation	4.0	3.8	3.7	3.4	1.3	1.0	0.7	0.6	1.6	2.0	2.8	4.6	1.3
Aver. daily max.	-10.7	-10.4	-9.6	-7.2	-0.7	3.6	7.0	5.9	1.6	-3.0	-6.0	-9.6	-3.2
Aver. monthly max.	0.4	1.5	1.7	1.7	4.6	8.0	11.7	11.0	6.9	4.1	3.4	1.3	
Absolute max.	3.5	4.7	5.0	4.8	8.0	11.2	17.0	13.6	10.1	7.5	7.4	5.5	
Aver. daily min.	-18.5	-18.7	-17.6	-14.5	-6.1	0.1	3.6	2.6	-2.6	-8.5	-12.4	-16.4	-9.9
Aver. monthly min.	-28.7	-30.5	-29.3	-24.6	-15.1	-4.6	1.0	-1.2	-10.1	-17.3	-21.5	-26.4	
Absolute min.	-36.6	-41.1	-42.2	-34.0	-19.0	-8.5	-0.5	-5.5	-15.0	-20.6	-26.4	-34.3	
<u>No. of days with:</u>													
Daily min. 0 or less	31.0	28.2	30.6	29.5	27.5	12.4	0.3	2.8	20.8	28.7	29.5	30.7	271.9
D. min. -10 or less	25.8	23.3	24.7	21.7	7.5	-	-	-	1.7	12.1	20.3	23.8	161.0
D. max. 0 or less	28.4	25.2	26.5	26.5	15.8	2.1	-	0.3	8.6	22.4	24.5	27.4	207.9
<u>RELATIVE HUMIDITY, %</u>													
Average	74	79	78	76	79	83	87	85	82	77	72	73	79
<u>PRECIPITATION, MM</u>													
Average monthly fall	28	41	49	23	18	18	23	41	40	35	32	27	372
Max. fall in 24 hrs.	24	23	53	19	17	15	24	40	49	29	34	25	
<u>No. of days with:</u>													
0.1mm or more	11.1	12.6	12.3	10.3	8.1	8.8	10.2	13.1	12.3	13.2	11.3	9.7	133.1
1.0mm or more	6.2	7.7	8.0	6.2	4.3	4.3	6.4	7.7	7.4	8.3	6.5	5.3	78.4
10.0mm or more	0.4	1.1	1.8	0.3	0.3	0.2	0.3	0.9	0.9	0.5	0.7	0.5	7.3
rain 0.1mm or more	0.7	0.9	2.2	1.3	2.5	6.7	10.1	12.1	6.3	3.1	2.6	1.7	50.3
snow 0.1mm or more	11.0	12.5	12.1	10.1	7.5	5.9	1.2	2.5	8.9	11.9	11.0	9.3	104.0
<u>CLOUDS, VISIBILITY</u>													
Average, octas	4.1	4.8	4.7	4.4	5.0	6.1	6.2	6.4	6.1	5.7	4.5	3.8	5.1
No. of clear days	8.3	6.2	6.0	7.0	5.7	1.5	1.6	1.0	1.9	3.1	6.7	10.3	59.4
No. of overcast days	9.1	11.3	11.2	10.3	12.6	17.3	18.2	19.9	17.3	15.8	10.9	8.5	162.4
<u>Perc. freq. of:</u>													
Fog	-	0.1	0.6	0.3	0.9	3.0	1.6	2.5	0.4	-	-	-	0.8
<u>Horizontal visibility:</u>													
1km or less	1.2	3.6	3.0	2.0	0.8	2.6	1.6	2.8	1.9	1.8	1.1	0.8	1.9
4km or less	9.1	11.8	11.4	8.4	5.0	5.3	3.3	5.5	6.3	8.2	8.7	10.3	7.6
<u>Lowest cloud height:</u>													
100m or less	0.3	1.1	2.0	1.1	1.0	1.5	3.8	4.7	1.6	1.5	0.1	0.2	1.6
300m or less	1.3	5.1	6.8	7.1	10.0	15.0	19.5	16.2	9.9	5.7	1.7	0.6	8.3
<u>Global radiation, cal/cm</u>													
1975-1979	-	57	1766	7439	13734	14217	10785	5986	2296	247	-	-	56527
<u>WIND FORCE, BEAUFORT</u>													
<u>Perc. freq. of:</u>													
0	19.2	21.7	27.0	35.3	34.1	25.4	16.8	19.6	22.4	16.1	11.4	16.1	22.1
1-2	37.7	37.0	35.2	33.2	35.1	43.6	56.3	51.9	41.6	39.6	38.8	37.7	40.7
3-5	34.9	35.2	31.7	25.9	29.2	29.9	26.4	27.8	34.7	40.0	43.5	41.7	33.4
6-8	7.3	6.0	6.0	5.7	1.6	1.1	0.4	0.6	1.2	4.4	6.1	4.3	3.7
9 or more	0.7	0.2	0.1	-	-	-	-	-	-	-	0.1	0.3	0.1
<u>No. of days with max.</u>													
6 or more	9.1	8.4	8.3	6.1	2.8	1.5	0.7	1.3	2.6	5.7	7.7	6.1	59.9
8 or more	2.1	1.7	1.8	1.1	0.4	0.1	-	-	0.1	0.3	1.2	2.1	9.9
9 or more	0.9	0.5	0.3	-	0.1	-	-	-	-	0.1	0.4	0.4	2.7

3.5 Svea Gruber

Position:	77° 54' N, 16° 48' E
Station height:	9 m
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, lie in the sector west to north. Between the station and these mountains lies a plain of level tundra. Northeast of the station lies the bay, Braganzavågen, and further away the valley, Kjellstrømdalen. The outer part of the fjord, bordered by mountains 450-1050 m above sea level, lies in the east-south sector. 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 Meteorologisk Institutt. As some data from the first two years are missing, the mean values and frequency tables cover the period 1980-1989.



MEAN VALUES 1980-1989													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DES	YEAR
AIR PRESSURE, MB													
Average sea level	1007.0	09.7	11.5	15.1	17.5	11.9	11.2	11.7	08.3	07.3	06.1	07.2	1010.2
AIR TEMPERATURE °C													
Average	-16.5	-16.3	-14.9	-12.3	-4.0	2.1	6.0	4.8	0.1	-5.8	-11.4	-15.7	-7.0
Extreme values:													
High. monthly/annual	-10.6	-10.0	-9.8	-7.3	-1.6	3.7	6.8	5.6	1.9	-2.0	-4.4	-3.2	-3.5
Low. monthly/annual	-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
Std. deviation	4.0	3.8	3.2	2.9	1.6	1.2	0.7	0.7	1.5	2.4	4.1	5.0	1.4
Aver. daily max.	-12.6	-12.2	-11.8	-9.0	-1.6	4.2	8.5	7.0	2.0	-3.4	-8.4	-12.3	-4.2
Aver. monthly max.	0.2	1.4	1.0	1.0	3.7	9.6	11.9	11.8	7.2	4.1	3.0	0.9	
Absolute max.	4.1	4.6	5.1	4.6	6.9	13.3	14.2	15.3	9.8	7.5	5.6	6.5	
Aver. daily min.	-19.5	-20.9	-18.9	-16.0	-6.6	0.2	3.9	3.2	-1.5	-8.4	-14.8	-19.7	-10.9
Aver. monthly min.	-34.4	-34.7	-33.9	-27.0	-16.9	-4.6	1.3	-0.2	-8.1	-17.9	-24.8	-31.8	
Absolute min.	-44.1	-41.2	-43.7	-33.0	-23.7	-8.0	0.0	-2.0	-11.3	-26.7	-32.5	-38.7	
No. of days with:													
Daily min. 0 or less	31.0	28.3	30.6	29.6	28.0	9.6	-	1.3	17.5	28.4	29.9	30.9	265.1
D. min. -10 or less	26.6	24.5	24.5	23.7	7.5	-	-	-	0.3	11.8	22.6	26.5	168.2
D. max. 0 or less	28.0	25.5	27.3	26.7	16.0	1.9	-	-	7.9	22.1	25.6	28.2	204.1
RELATIVE HUMIDITY, %													
Average	81	80	79	78	82	80	81	82	83	82	80	80	81
PRECIPITATION, MM													
Average monthly fall	28	38	35	27	12	7	11	20	15	20	23	26	262
Max. fall in 24 hrs.	12	29	18	25	16	8	8	18	13	10	16	19	
No. of days with:													
0.1mm or more	14.6	13.9	14.7	12.2	7.6	7.4	7.7	9.4	11.4	13.3	12.7	11.2	136.0
1.0mm or more	7.4	8.1	8.2	6.0	2.3	2.2	3.1	4.2	5.0	5.1	5.8	4.9	62.2
10.0mm or more	0.3	0.9	0.5	0.2	0.3	-	-	0.4	0.2	0.1	0.4	0.5	3.8
rain 0.1mm or more	1.5	1.0	2.2	1.9	2.4	5.1	7.7	9.0	7.7	4.2	2.3	1.0	46.0
snow 0.1mm or more	14.5	13.7	13.9	12.1	7.2	4.7	0.6	2.5	8.1	11.5	12.4	11.2	112.4
CLOUDS, VISIBILITY													
Average, octas	4.3	4.6	4.5	4.3	5.0	6.0	5.9	6.3	6.7	6.0	4.7	3.7	5.2
No. of clear days	7.0	6.0	7.2	7.7	5.3	1.1	1.9	1.4	0.5	1.9	6.3	9.4	55.7
No. of overcast days	9.2	9.6	11.1	9.7	14.2	16.3	16.0	18.9	21.3	17.3	11.5	7.5	162.6
Perc. freq. of:													
Fog	0.1	-	-	-	0.6	0.4	0.4	0.4	0.4	0.2	-	-	0.2
Horizontal visibility:													
1km or less	5.7	4.6	2.6	2.7	1.9	0.9	0.4	0.6	0.8	0.4	0.8	4.0	2.2
4km or less	12.9	13.1	10.7	6.2	5.1	4.2	1.5	2.0	2.1	7.1	6.5	7.4	6.5
Lowest cloud height:													
100m or less	0.3	0.2	0.2	0.1	0.7	0.8	1.6	1.2	1.3	0.6	-	-	0.6
300m or less	2.0	2.6	3.6	5.9	6.5	12.6	22.2	20.8	13.1	8.1	2.2	1.5	8.5
WIND FORCE, BEAUFORT													
Perc. freq. of:													
0	12.5	12.5	11.5	11.6	11.3	4.7	1.3	5.7	11.1	13.0	8.7	15.2	9.9
1-2	26.1	28.5	27.3	33.2	33.5	36.6	33.3	38.5	36.8	33.1	35.6	31.4	33.0
3-5	53.0	50.4	53.6	49.5	53.6	56.2	62.3	54.2	50.1	50.6	50.1	47.6	52.6
6-8	8.5	8.5	7.5	5.7	1.6	2.6	3.0	1.6	2.0	3.4	5.5	5.8	4.5
9 or more	-	-	-	-	-	-	-	-	-	-	0.1	-	0.0
No. of days with max.													
6 or more	10.2	8.7	9.6	6.2	3.1	3.8	4.7	2.6	3.6	6.1	7.9	8.3	74.8
8 or more	1.1	1.8	1.5	0.5	0.1	0.1	-	0.3	0.2	0.4	0.5	0.6	7.1
9 or more	0.2	-	0.3	-	-	-	-	-	-	-	0.1	-	0.6

4. THE LONG TEMPERATURE RECORD AT SVALBARD LUFTHAVN 1912-1990

4.1 Construction of the long temperature record

The history of the Arctic meteorological stations indicates that few long data records exist from the Arctic. None of the present Norwegian stations on Spitsbergen have homogenous time series further back than to the mid-1970's. In the mid-1970's, the stations at Isfjord Radio (which has the longest continuous meteorological series from Spitsbergen) and Longyearbyen (where some observations were recorded as early as 1916) were closed. However, as illustrated in fig. 4, temperature varies much the same at all the Spitsbergen stations. This is true both for annual and monthly temperature means. Therefore, it is possible to estimate monthly mean temperature at one station based on measurements at other stations if a reasonably long period with parallel measurements at these stations exists.

Parallel measurements at Svalbard Lufthavn and Longyearbyen were carried out during the period August 1975-July 1977. Usually, the temperature was lower at Svalbard Lufthavn than in Longyearbyen. The difference between monthly mean temperatures at Svalbard Lufthavn and Longyearbyen is shown in figure 10a. The difference shows a maximum in the spring and a minimum in the fall, and is fairly well described by a sine curve:

$$(1) \quad T_m(\text{Svalb. Lufth.}) - T_m(\text{Longyearbyen}) = -0.7 \langle 1 + \sin 30(7-n) \rangle [^{\circ}\text{C}]$$

where T_m is monthly mean temperature and n is month number (Jan=1, ..., Dec=12). Equation (1) can now be used to estimate the monthly mean temperature at Svalbard Lufthavn, using observations from Longyearbyen. It is more convenient to adjust the combined temperature series to Svalbard Lufthavn rather than to Longyearbyen, thus avoiding the problem of continuously having to correct new observations.

The solid line in figure 10b shows the combined series of annual mean temperature from Longyearbyen and Svalbard Lufthavn valid for Svalbard Lufthavn. The dotted line shows the annual mean temperature observed at Isfjord Radio. The stars filling the gaps in the temperature series from Isfjord Radio indicate annual mean temperature estimated at Isfjord Radio by Steffensen (1969). Estimates of missing data before 1935 are based on temperature measured in Longyearbyen and at Green Harbour. During the years 1941-45, however, there were no continuous temperature measurements on Spitsbergen. Steffensen (1969) therefore used optimal regression analysis of measurements from more distant stations to arrive at the best estimate for the monthly mean temperatures at Isfjord Radio during this period, for those months when data from Spitsbergen were missing. Steffensen concluded that the presence of large error in the estimates for individual months would be of little consequence, as these errors would tend to neutralize each other in studies of seasonal or annual trends.

In order to extend the the Svalbard Lufthavn temperature series back to 1912, observations from Green Harbour and Isfjord Radio as well as estimated temperatures from Isfjord Radio were used. The missing monthly mean temperatures up to 1930 were estimated from the Green Harbour series. Monthly temperature differences between Longyearbyen and Green Harbour for the period 1916-30 published by Birkeland (1936) are given in table 4.1. Using these values, monthly mean temperatures in Longyearbyen were estimated. Estimates valid for Svalbard Lufthavn

were found by adding corrections given by eq. (1).

Missing monthly mean temperatures for the period 1934-56 were estimated from temperatures measured or estimated at Isfjord Radio. Mean monthly temperature differences between Longyearbyen and Isfjord Radio for the period 1935-39 and 1957-66 (Steffensen 1969) are given in table 4.1. These values were used, in addition to the corrections from eq. (1), to estimate monthly mean temperatures valid for Svalbard Lufthavn. The points filling the gaps in the temperature series from Svalbard Lufthavn shown in fig. 10b, show annual mean temperatures that are calculated mainly from estimated monthly mean temperatures.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
$T_m(\text{Longyearbyen}) - T_m(\text{Green Harbour})$	0.7	1.2	1.5	1.0	0.2	1.6	0.9	4.4	-0.1	0.0	0.5	1.4
$T_m(\text{Longyearbyen}) - T_m(\text{Isfjord Radio})$	-2.4	-2.9	-2.2	-1.2	0.1	1.1	1.6	0.9	-0.3	-1.2	-1.5	-2.0

4.2 Analysis of the Svalbard Lufthavn temperature record

Figure 11a shows the series of mean annual temperature for 1912-1989 valid for Svalbard Lufthavn with two Gauss filters having standard deviations of 3 and 9 years. Figs. 11b-e show series of mean seasonal temperature with the same filters. The series for winter, spring and summer include data from 1990. The filters are comparable to 10- and 30-year running means. However, the filters give smoother curves than running means, as temperatures from central years are given larger weight than temperatures from peripheral years. Filter values are also calculated for the years at either end of the series. It should be noted that these values are computed from one-sided Gauss filters, and that values from later years will change when the series is updated.

The STD=3 Gauss filter shows temperature variation on a 10-year scale, and the variation observed during the last decades is in accordance with the description of recent temperature fluctuations given section 1.4 of this report. The STD=9 Gauss filter shows more long-term temperature variation, and is used here to describe temperature trends throughout the complete series.

Figure 11a indicates an increasing trend in the annual mean temperature during the period 1910-40. From 1950-70, however, mean annual temperature fell. During the last 20 years the mean annual temperature fluctuated about a rather constant level. Annual mean temperature around 1940 was about 2° C higher than in the beginning of the series, and about 0.5° C higher than during the later decades. Fig. 11b and e show that the variation in winter and fall temperature are quite similar to the variation in annual temperature. Mean winter temperature rose by about 5° C during 1910-40, and fell about 3° C afterwards. For fall temperature, the increase was of about 2° C and the decrease 1° C. Spring temperature (fig. 11c) increased by about 2° C from 1910-40, and remained fairly constant from 1940-70. From 1970-90, spring temperature increased again by about 1° C. No trend, and only minor variation, is found in summer temperature during the period 1910-90 (fig. 11d).

The major features in the temperature variation at Svalbard Lufthavn agree well with temperature curves from stations on Greenland (Frydendahl 1989). They also show similarities with temperature curves from Scandinavia (Alexandersson and Eriksson 1989, Aune 1989, Danmarks Meteorologiske Institutt 1989), but the temperature in southern parts of Scandinavia has varied less than at Svalbard Lufthavn. Contrary to the temperature curve for the Northern Hemisphere (Jones 1988, Jones et al. 1988), the temperature series from Svalbard Lufthavn shows no increasing trend in mean temperature during the last 20 years. The similarity with Jones et al.'s temperature series for the Arctic, however, is reasonably good.

Fig. 10a) Temperature difference
Svalbard Lufthavn - Longyearbyen

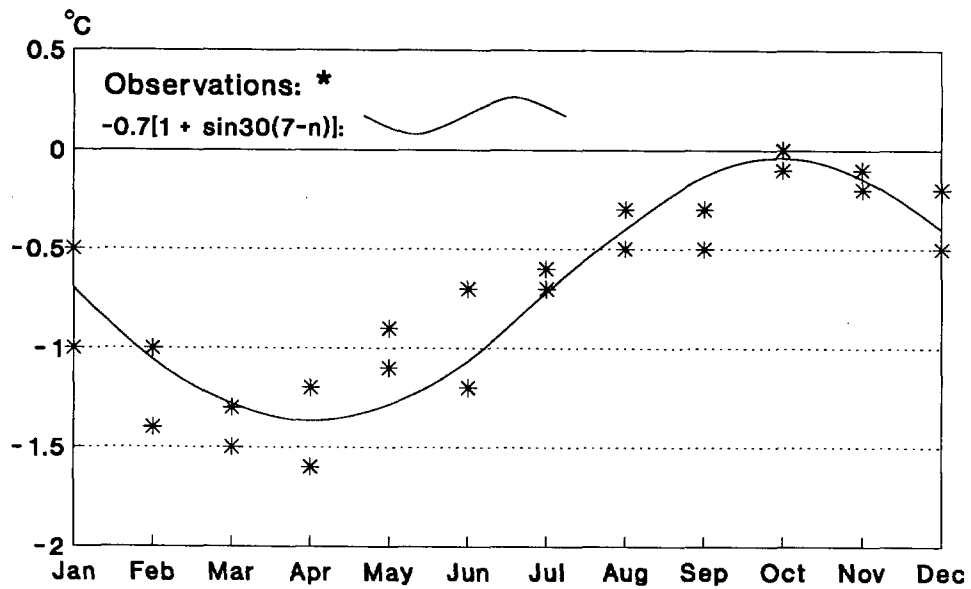


Fig. 10b) Temperature series
Isfjord Radio and Svalbard Lufthavn

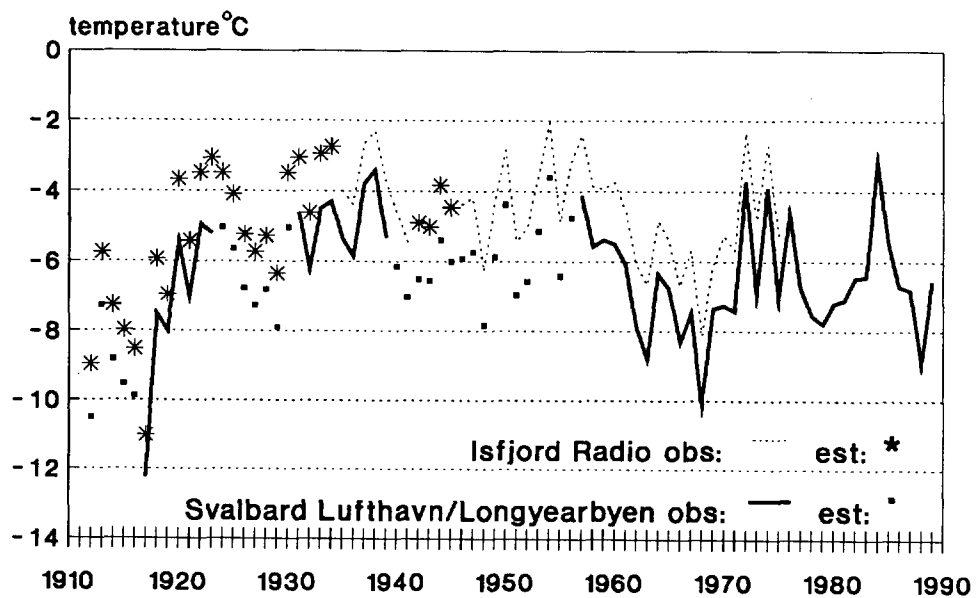


Figure 11.

Temperature at Svalbard Lufthavn 1912-90

a) annual mean,
b) winter, c) spring, d) summer, e) fall

Filt. 1 is a Gaussfilter with STD = 3 years
Filt. 2 is a Gaussfilter with STD = 9 years

Fig. 11a) annual mean

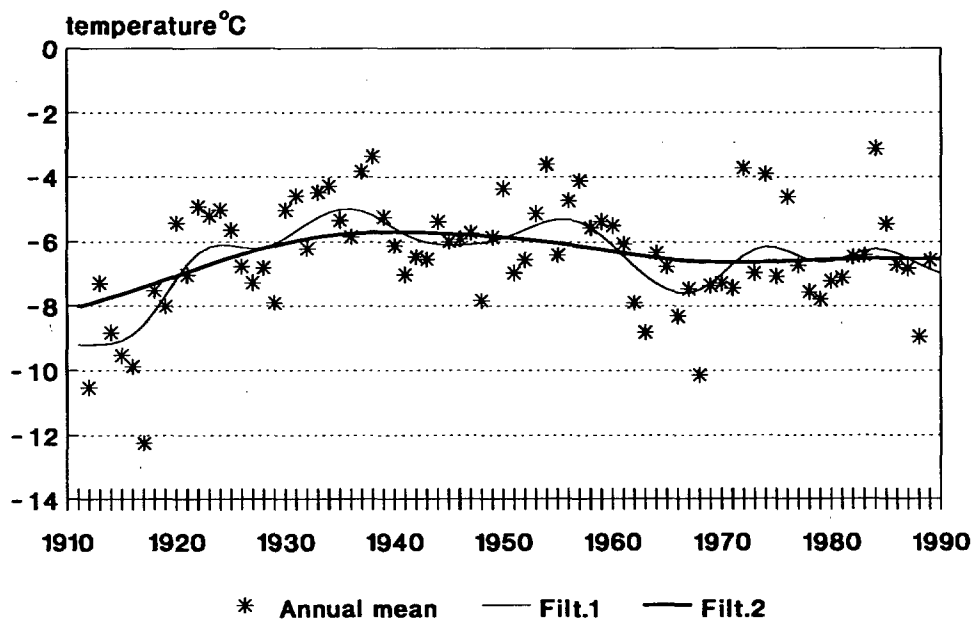


Fig. 11b) Dec-Jan-Feb

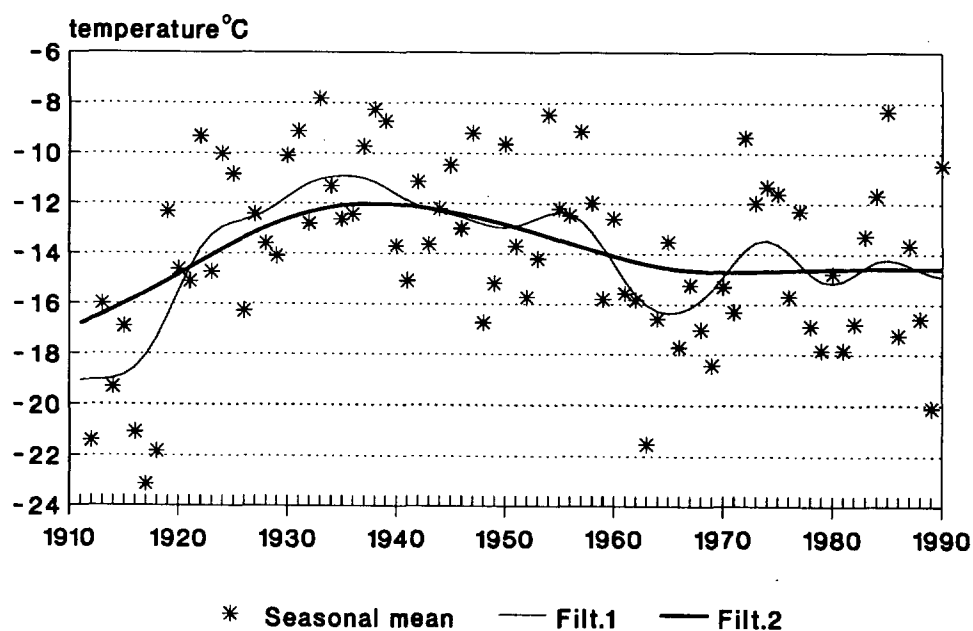


Fig. 11c) Mar-Apr-May

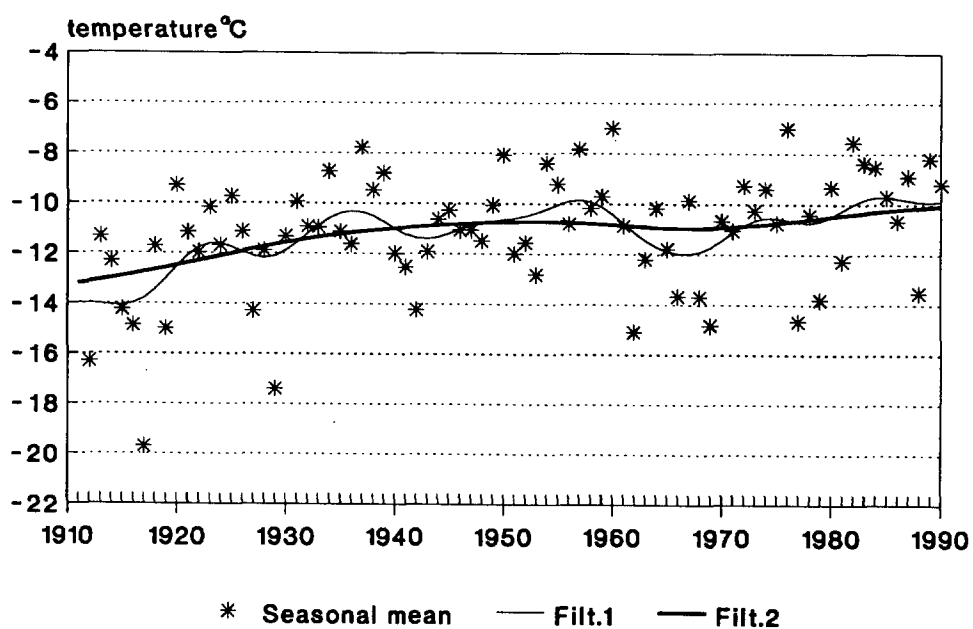


Fig. 11d) Jun-Jul-Aug

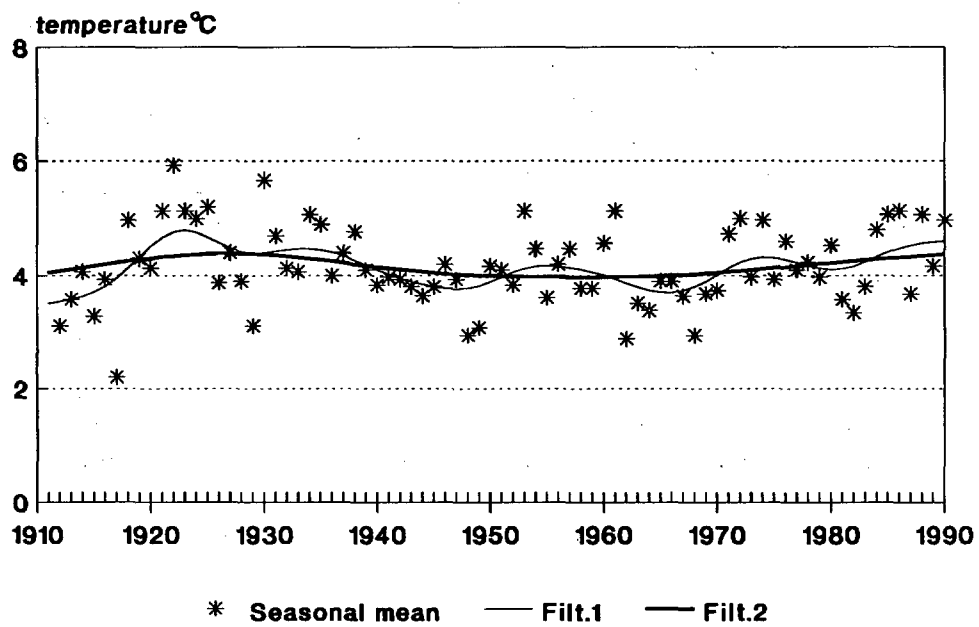
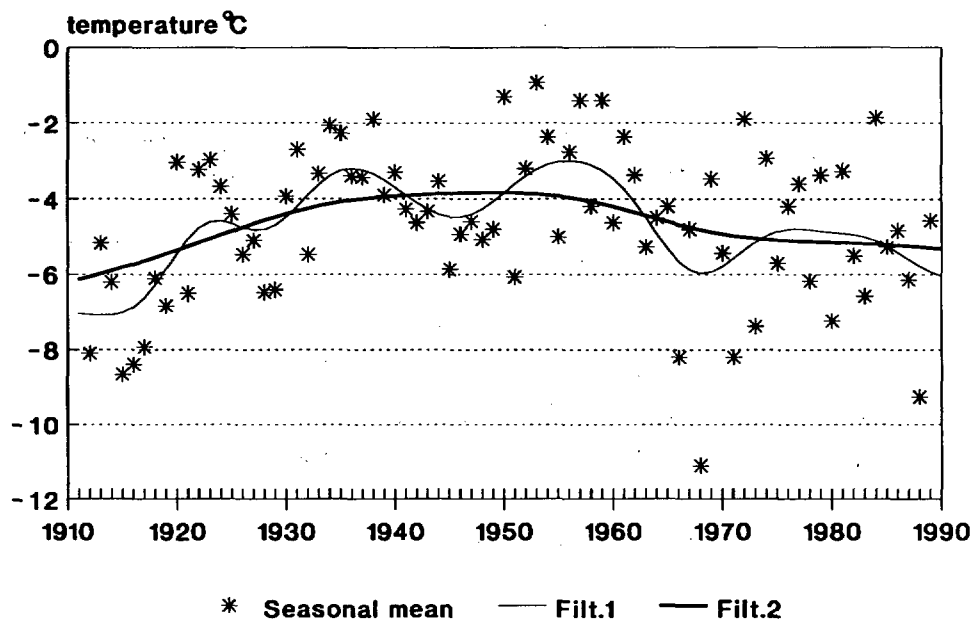


Fig. 11e) Sep-Oct-Nov



5. SNOW COVER AND DEPTH

Snow cover is estimated on a scale from 0 to 4. Days having scale values of 3 or 4 are defined as days with snowcovered ground. Code 3 corresponds to mostly snow covered ground, and 4 to total snow cover. Further information on snow cover is given in the tables for each arctic station. There is, however, a lack of data on most stations. Also, data quality varies as estimates depend on the skill of the observer.

Snow depth is measured with a fixed, vertical snow depth measure, often a stake with markings. The combination of dry snow and open tundra at all the arctic stations results in considerable drifting snow, even at moderate wind windspeeds. Snow depth measurements are therefore unlikely to be representative of the actual precipitation in the form of snow. Snow depth is likely to vary locally, and the snow depth measurements are therefore not always representative of mean snow depth over large areas. Snow depth measurements should be used in connection with wind measurements.

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.

6. PERMAFROST CONDITIONS

As a tool for calculating mean freezing and thawing parameters at the meteorological stations on Spitsbergen, mean temperatures for each day of the year, for a specified period of time, have been calculated. These temperatures form a 'synthetic' year of temperatures, which characterizes temperature variations dependent on location. The small-scale fluctuations, which are typical of the winter months January and February, are evened out in the 'synthetic' representation but local differences in the temperature fluctuations are preserved.

The different meteorological stations on Spitsbergen have recorded data over different time periods. Thus, to enable comparison of permafrost conditions between the stations, the period 1980-1987 has been chosen as the basis for calculation of a 'synthetic' year. The exception is for Isfjord Radio where synopsis observations stopped in 1975. For Isfjord Radio a 'synthetic' year for the period 1961-1968 was calculated. Meteorological parameters relevant for permafrost development are given in table 6.1 together with calculated freezing and thawing indexes. It should be noted that the 1960's were considerably colder than the 1980's. The freezing index at Isfjord radio is therefore probably too high, and the thawing index may be too low compared to the values from the other stations.

Table 6.1

Station	Temp. annual mean (°C)	Clouds annual mean	No. of clear days	Prec.* no. of days	Thawing index (air)	Freezing index (air)
Sv.L.	-6.0	5.3/8	54	93	10095	62232
NÅ	-5.8	5.4/8	52	100	8088	58728
SVE	-6.7	5.2/8	59	112	9907	68064
ISF	-5.9	5.6/8	34	116	7356	58752

Sv.L. = Svalbard Lufthavn
 NÅ = Ny-Ålesund
 SVE = Svea Gruber
 ISF = Isfjord Radio

* Numbers given in this row refer to days with snow fall more than 0.1 mm. Since measurements of snow depth are not consistent, these cannot be statistically treated. The numbers given in the table are therefore indications of snowfall at the stations relative to location.

The thawing index may be used as an indication of the mean depth of the active layer. Comparing the different stations, Svalbard Lufthavn and Svea have larger thawing indexes than Ny-Ålesund and Isfjord Radio. The thawing index of soil, as compared to that of air, is larger if the weather is clear. From the table it may be seen that Isfjord Radio has fewer clear days than the other stations, and one might therefore predict the active layer at Isfjord Radio to be shallower than that at Svalbard Lufthavn and Svea. Accurate estimates, however, are difficult based on meteorological data alone.

The freezing index, together with the mean annual air temperature, may be indicative of the permafrost depth at the stations. Svea Gruber and Svalbard Lufthavn have the largest freezing indexes and the lowest mean annual air temperatures. It is therefore likely that the permafrost is deepest at these two stations. The results are likely to be modified by local geographical and soil conditions.

A condition for the existence of permanently frozen ground is that the mean air temperature is below 0°C . Permafrost depth and cover is dependent on many features of the climate and the landscape, such as variation in snow cover, the presence of melt water in summer, the type of ground and top vegetation, as well as the orientation of slopes. At various locations on Spitsbergen, permafrost depths have been measured from 75 to 450 m.

Permafrost is maintained by mean annual subzero temperatures, while geothermal heat radiation thaws the ground from beneath. The gradient of geothermal heat radiation has been measured in several boreholes on Spitsbergen, and the results give a gradient of approximately 1°C per 40 m. From the local mean annual air temperature, it is therefore possible to establish permafrost depth.

Measurements made in boreholes near Svea and Svalbard Lufthavn confirm the permafrost depth estimated from the mean annual air temperature, and also show a characteristic 'bend' in the upper part of the temperature curves which corresponds to a period of warmer climate from 1920 to 1960. The propagation speed of the 'heat' wave, as estimated from these boreholes, is approximately 3 m per year. It is likely that temperature changes will 'propagate' in the soil at different speeds depending on local characteristics. However, as a rough estimate it is possible to calculate the depth of the active layer by multiplying an average propagation of melting with the number of days at each station when the air temperature is above zero. No corrections have been made to accommodate the fact that soil temperature is likely to be higher than air temperature under certain weather conditions. Melt water also has a significant influence on the depth of the active layer. Table 6.2 shows estimates of permafrost depth and active layer thickness at the various stations.

Table 6.2

Station	Permafrost depth(m)	Active layer depth (m)
Sv.L	240	0.9
NÄ	232	0.8
SVE	268	0.9
ISF	236	0.8

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