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A preliminary report on the air temperature in Reindalen, west Spitsbergen

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Abstract

Observations of air temperature were carried out from August 1989 to July 1990 in the Reindalen valley, Spitsbergen. Mean annual air temperature was − 8.6 °C, and the freezing and thawing indices were 3336.1 and 220.9 °C day/a on the top of Merckollfjellet (885 m), which imply that the area is underlain by continuous permafrost. There was a relatively warm period lasted for two months in the winter. The lapse rate of the air temperature was close to the values from 5 to 6 °C/km from August to December, while it slightly increased toward the spring of 1990.

1. Introduction

Air temperature is one of the most important parameters when we discuss geomorphological as well as glaciological processes in periglacial and glacial environments. For example, the freezing and thawing indices, both determined by air temperature, have been used empirically in order to explain an occurrence of periglacial phenomena (Harris, 1981).

It has, however, been scarcely measured through one year in the very points where geomorphological researches were done ; the air temperature used to be estimated by that obtained in permanent observatories nearby using an arbitrary lapse rate.

We observed the air temperature from July 1989 to July 1990 in the Reindalen valley, Spitsbergen, as a part of the Japanese Geomorphological Expedition to Svalbard 1989. This research expedition aimed at clarifying present periglacial environment in the Reindalen and the Adventdalen valleys, Spitsbergen (Ono *et al.*, 1991). The data of air temperature will, therefore, provide basic information on the present periglacial condition there. In this preliminary report, we present some characteristics of the air temperature, and discuss the lapse rate in this area.

2. Outline of the observations

The valley of Reindalen is located in the central part of Spitsbergen (Fig. 1). It opens to the west, along which planation surfaces called "fjellet" develop. Many tributary glaciers are flowing into the main valley, and the termini of the glaciers are marked by bulky terminal moraines of the Little Ice Age (Werner, 1988; Shiraiwa *et al.*, in press).

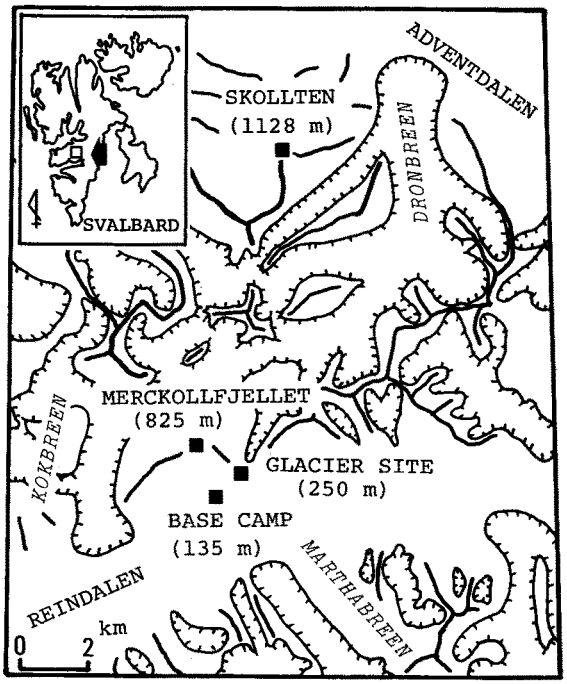

Fig. 1. Location of the observation sites in Reindalen. The term "breen" denotes glacier.

Air temperature was observed from 6 to 19 July, 1989 at the following sites ; the Base Camp (135 m) located at the bottom of the main valley, the Glacier Site (250 m) located at the terminus of a small valley glacier (Fig. 2), and the top of Merckollfjellet (885 m). The three sites represent three different micro-climatic conditions of the valley ; valley bottom, glacier fore-field and summit area. Weather type and cloud amount were also observed at 08 : 00, 14 : 00 and 20 : 00 (GMT) at the Base Camp. The air temperature was measured additionally at the summit of Mt. Skolten (1128 m), the highest peak around the study area, from 7 August, 1989. Since both the Base Camp and the Glacier Site were withdrawn on 21 July, 1989, the annual data are available from the Merckollfjellet and the Skolten sites only.

Fig. 2. The Glacier Site was established in front of Arebreen, a small valley glacier.

The air temperature was measured at 150 cm above the ground using a thermistor sensor shaded with a silver-coated pipe. Artificial ventilation of the pipe was not considered. The measurement sites were selected to locate at wind-blown flat places to prevent a possible effect of snow cover. The air temperature was measured every 30 minutes between 6 and 19 July, 1989, and every 60 minutes from 21 July, 1989 to 31 July, 1990. The data were stored in automatic data logger systems.

3. Results

3.1. Air temperature

Figure 3-A shows diurnal variations of the air temperature every 30 minutes at the three sites ; the Base Camp, the Glacier Site and the Merckollfjellet site from 6 to 19 July, 1989. The air temperature was higher in the clear days such as 7 and 11 July than in the cloudy or rainy days (Figure 3-C). Correlation of the air temperature between the Base Camp and the Glacier Site is better ($r = 0.91$) than those between the Base Camp and the Merckollfjellet site ($r = 0.70$) or the Glacier Site and the Merckollfjellet site ($r = 0.80$). This may imply that the Base Camp and the Glacier Site are located under the same microclimatic condition.

Figure 4-B and Table 1 show the annual variation of the daily mean air temperatures at the Merckollfjellet site and at the Skolten site from 21 July, 1989 to 31 July, 1990. Mean annual air temperature was −9.9 ℃ in the Skolten site, and −8.6 ℃ in the Merckollfjellet site. The freezing and thawing indices in the Merckollfjellet site were 3336.1 and 220.9 ℃ day/a, respectively, which imply that the area is underlain by continuous permafrost according to the diagram in Harris (1981).

Annual march of solar radiation of the Svalbard is characterized by the polar night in winter, daily sun both in spring and autumn, and midnight sun in summer (Fig. 4-A). Hence, a minimum air temperature can be expected to occur in the mid-winter. The air temperature decreased toward the winter, however, a relatively warm period which lasted from 24 December, 1989 to 24 February, 1990 interrupted further decreasing of the air temperature. This relatively warm period in the winter may be called as "warm core" which is considered to be caused by a warm stationary anticyclone derived from a blocking phenomenon over arctic region (Umemoto, written comm., 1991). We inspected monthly mean charts of 500 mb height during this period (figures not shown), and found a persistent warm anticyclone in January and a weak warm ridge in February over this region. There are high frequency temperature fluctuations, which may be caused by small scale atmospheric disturbances during this period. After the relatively warm period, the temperature increased gradually.

3.2. Variation of the lapse rate

Figure 3-B shows the diurnal variations of the air temperature lapse rate between the Base Camp and the Merckollfjellet site from 6 to 19 July, 1989. The lapse rate varied from 1 to 13 ℃/km, having the average value of 5.9 ℃/km, in this period. The lapse rate became generally greater during the day time. The lapse rate is higher during the clear weather condition due to the rapid increase of the air temperature at the Base Camp (Fig. 3-C).

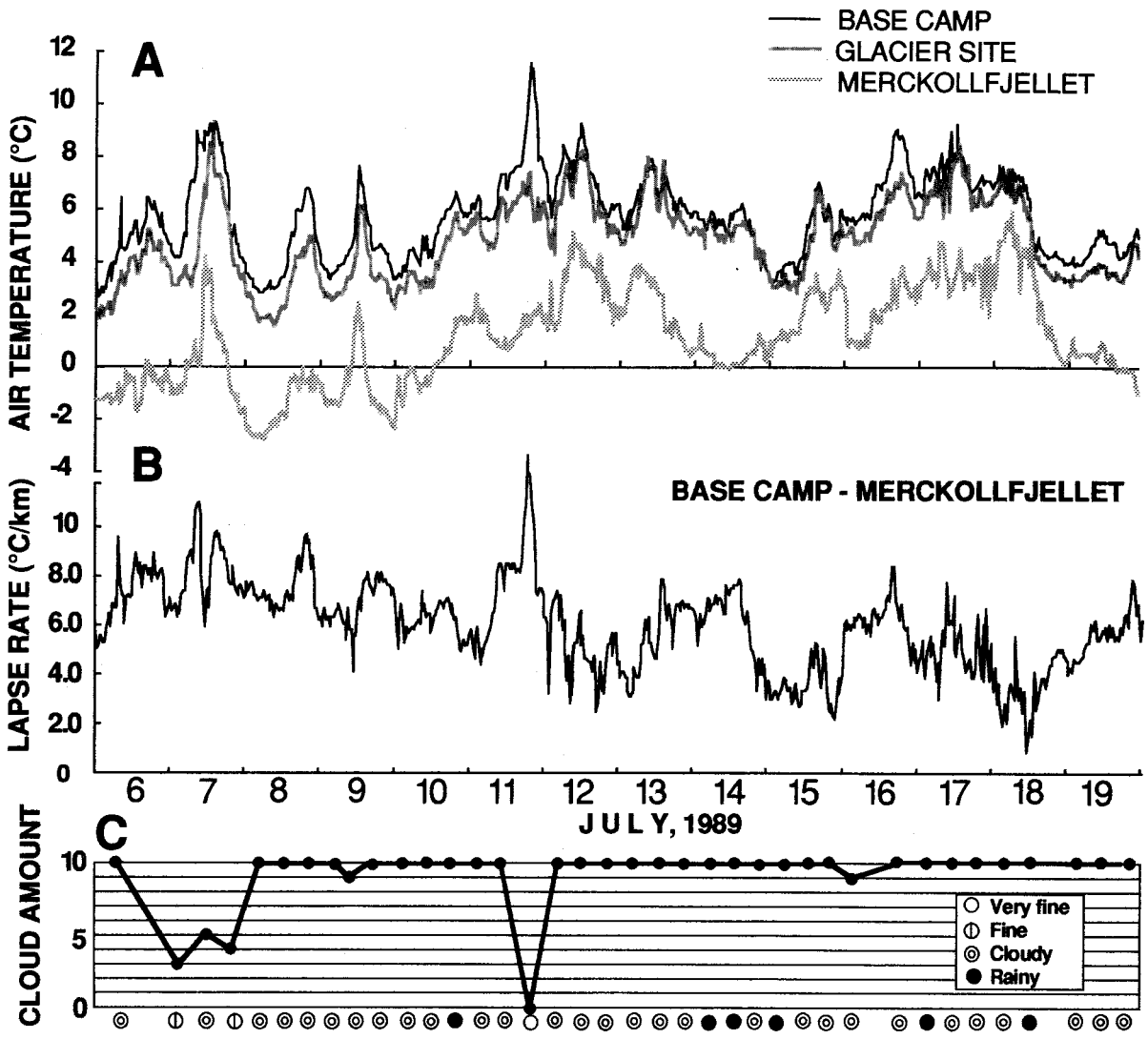

Fig. 3. A : Diurnal variations of the air temperature every 30 minutes at three sites ; the Base Camp (135 m), the Glacier Site (250 m) and Merckollfjellet (825 m) from 6 to 19 July, 1989. B : Diurnal variations of the air temperature lapse rate calculated between the Base Camp and Merckollfjellet. C : Cloud amount and weather type at 08 : 00, 14 : 00 and 20 : 00 (GMT) observed at the Base Camp.

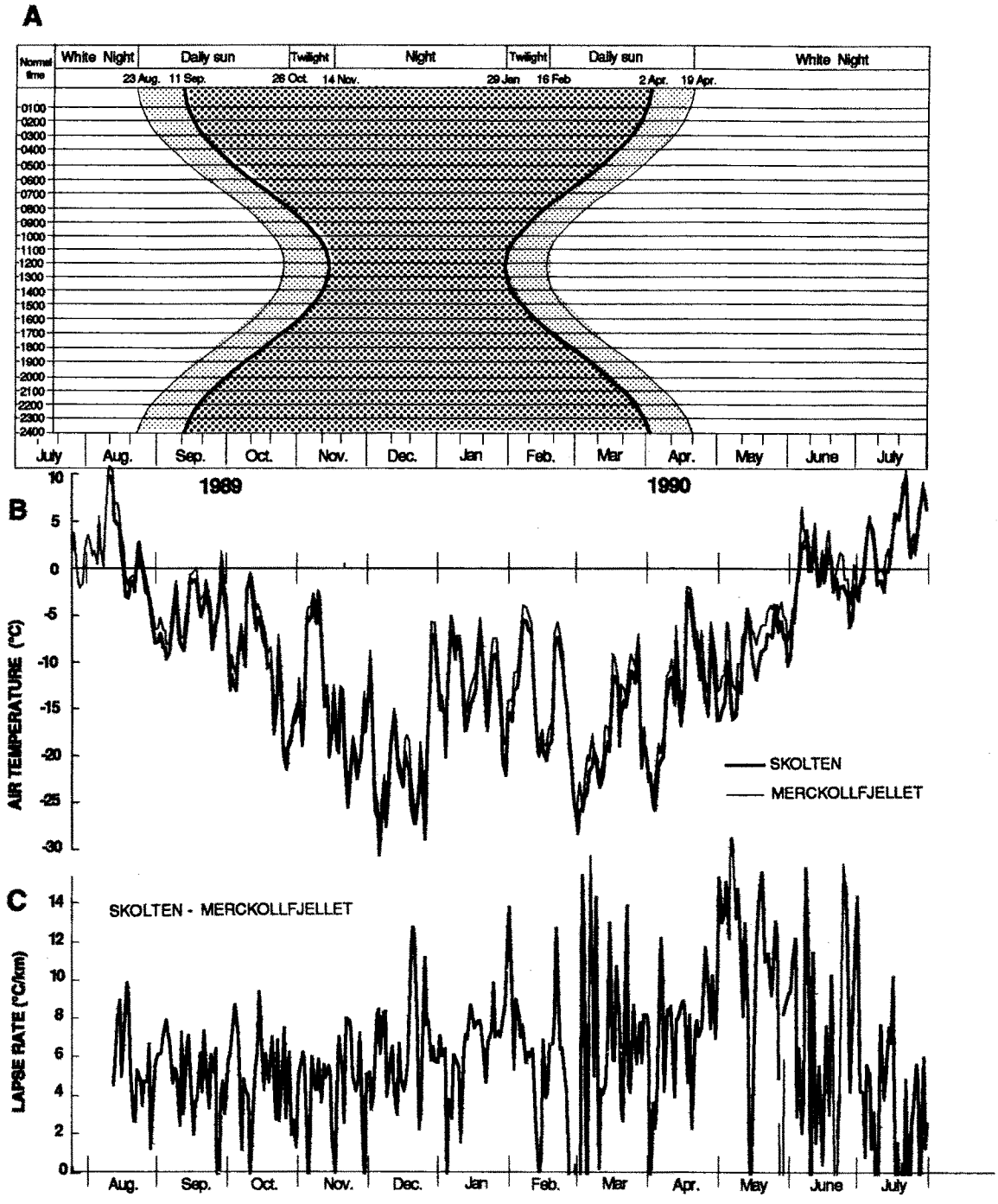

Fig. 4. A : The annual march of solar radiation of the study area. Dark hatched, light hatched and white parts indicate the polar night, the twilight and the midnight sun, respectively. B : Annual variation of the daily mean air temperature at the Skolten (1128 m) and the Merckollfjellet (825 m) sites. C : Annual variation of the daily mean air temperature lapse rate calculated between the Skolten and the Merckollfjellet sites.

Table 1. Daily air temperature recorded at the Skolten and the Merckollfjellet.

JULY 1989			AUGUST 1989			SEPTEMBER 1989			OCTOBER 1989		
DATE	SKOL	MERCK	DATE	SKOL	MERCK	DATE	SKOL	MERCK	DATE	SKOL	MERCK
			1		0.5	1	-9.6	-8.0	1	-13.1	-11.3
			2		5.5	2	-9.0	-7.9	2	-9.6	-9.3
			3		2.4	3	-7.1	-5.8	3	-7.2	-6.0
			4		0.2	4	-4.1	-2.9	4	-8.5	-7.4
			5		4.3	5	-2.0	-1.4	5	-10.4	-9.4
			6		10.3	6	-7.5	-5.7	6	-2.3	-2.3
			7	9.7	10.8	7	-8.1	-7.4	7	-0.8	-0.4
			8	8.9	10.3	8	-8.7	-7.2	8	-2.3	-1.1
			9	5.1	7.0	9	-7.0	-5.3	9	-4.1	-2.6
			10	4.6	6.8	10	-5.3	-4.2	10	-6.6	-4.3
			11	4.6	5.8	11	-1.1	-0.6	11	-5.3	-3.8
			12	2.0	3.7	12	-1.5	-0.6	12	-6.2	-5.1
			13	-0.3	2.1	13	-1.1	-0.2	13	-7.6	-6.1
			14	-2.9	-0.8	14	-1.5	0.0	14	-8.3	-7.2
			15	-3.1	-1.8	15	-4.2	-3.2	15	-10.6	-9.2
			16	-1.6	-1.0	16	-5.1	-3.3	16	-10.1	-8.3
			17	-1.4	-0.7	17	-3.8	-2.7	17	-12.1	-11.4
			18	-2.4	-1.1	18	-2.1	-1.2	18	-17.7	-16.0
			19	1.6	2.8	19	-3.6	-2.1	19	-14.6	-13.9
20			20	1.9	2.8	20	-5.2	-3.9	20	-8.3	-7.0
21		1.3	21	0.4	1.6	21	-8.7	-7.1	21	-14.4	-12.5
22		3.8	22	-1.0	0.2	22	-5.9	-7.2	22	-19.5	-18.9
23		0.5	23	-2.4	-0.8	23	-5.6	-4.6	23	-21.4	-19.8
24		-1.3	24	-2.9	-2.6	24	-2.5	-1.4	24	-19.2	-18.7
25		-2.1	25	-4.7	-3.6	25	1.1	1.8	25	-18.3	-17.6
26		-1.6	26	-7.2	-5.8	26	-3.8	-2.4	26	-16.4	-16.1
27		2.0	27	-7.9	-6.4	27	-4.6	-3.1	27	-16.4	-15.3
28		3.5	28	-7.8	-6.3	28	-13.0	-11.3	28	-15.5	-14.2
29		3.2	29	-7.0	-5.2	29	-11.4	-9.2	29	-13.2	-11.7
30		1.3	30	-8.4	-6.5	30	-12.1	-10.2	30	-18.9	-17.6
31		1.9	31	-8.4	-6.6				31	-15.5	-15.7
MEAN					0.9		-5.5	-4.3		-11.4	-10.3

NOVEMBER 1989			DECEMBER 1989			JANUARY 1990			FEBRUARY 1990		
DATE	SKOL	MERCK	DATE	SKOL	MERCK	DATE	SKOL	MERCK	DATE	SKOL	MERCK
1	-5.1	-4.6	1	-25.7	-23.7	1	-20.0	-19.1	1	-12.7	-10.9
2	-5.6	-4.1	2	-26.7	-25.2	2	-12.7	-12.0	2	-11.3	-9.4
3	-5.1	-4.0	3	-30.5	-28.5	3	-6.5	-5.0	3	-7.4	-6.0
4	-3.7	-2.6	4	-27.6	-25.6	4	-6.9	-5.5	4	-5.4	-3.9
5	-5.9	-4.4	5	-23.0	-22.0	5	-9.6	-8.3	5	-5.6	-4.1
6	-3.2	-2.3	6	-27.5	-26.0	6	-7.6	-7.2	6	-6.4	-4.9
7	-4.3	-3.0	7	-22.8	-21.2	7	-8.8	-7.2	7	-7.0	-5.9
8	-10.1	-8.9	8	-19.2	-18.1	8	-10.9	-9.1	8	-9.8	-9.2
9	-14.8	-13.4	9	-15.7	-14.9	9	-17.2	-15.5	9	-13.6	-13.5
10	-13.7	-12.4	10	-17.9	-16.3	10	-17.3	-15.2	10	-18.7	-18.5
11	-20.1	-19.7	11	-21.4	-20.2	11	-16.3	-14.3	11	-20.0	-18.3
12	-17.5	-17.5	12	-22.1	-21.0	12	-14.3	-12.5	12	-18.2	-17.2
13	-13.5	-12.5	13	-23.3	-22.1	13	-14.0	-12.1	13	-19.7	-18.6
14	-18.9	-17.2	14	-19.6	-18.2	14	-12.7	-10.8	14	-20.5	-18.8
15	-19.6	-18.4	15	-20.5	-17.7	15	-10.8	-8.9	15	-19.0	-17.3
16	-13.1	-12.5	16	-21.4	-18.3	16	-6.7	-5.3	16	-18.4	-16.4
17	-15.0	-13.1	17	-25.1	-22.2	17	-8.8	-7.7	17	-14.3	-11.2
18	-19.8	-17.9	18	-27.0	-25.4	18	-14.0	-12.4	18	-8.5	-6.9
19	-25.4	-23.6	19	-27.1	-26.6	19	-17.3	-15.5	19	-7.3	-5.7
20	-23.2	-22.0	20	-23.7	-23.0	20	-12.8	-10.5	20	-8.0	-6.6
21	-18.9	-17.8	21	-21.3	-18.6	21	-10.2	-8.5	21	-10.2	-9.2
22	-19.8	-18.7	22	-24.5	-22.6	22	-9.3	-7.5	22	-12.7	-12.3
23	-22.4	-20.6	23	-28.9	-27.0	23	-9.1	-7.4	23	-15.1	-15.5
24	-21.0	-20.6	24	-20.0	-18.6	24	-12.1	-10.3	24	-17.9	-19.3
25	-20.3	-20.5	25	-11.2	-9.5	25	-15.9	-13.8	25	-21.5	-21.4
26	-14.4	-13.1	26	-7.1	-5.7	26	-20.5	-17.8	26	-24.4	-24.9
27	-17.4	-16.1	27	-7.2	-5.8	27	-22.1	-18.7	27	-26.5	-26.8
28	-13.2	-12.4	28	-10.0	-8.3	28	-16.4	-14.2	28	-28.3	-24.5
29	-9.7	-8.7	29	-15.1	-13.6	29	-15.3	-14.0			
30	-20.5	-18.5	30	-15.1	-13.5	30	-16.4	-14.2			
			31	-15.3	-15.4	31	-13.1	-11.1			
MEAN	-14.5	-13.4		-20.8	-19.2		-13.1	-11.3		-14.6	-13.5

DATE	MARCH 1990 SKOL	MERCK	DATE	APRIL 1990 SKOL	MERCK	DATE	MAY 1990 SKOL	MERCK	DATE	JUNE 1990 SKOL	MERCK
1	-25.8	-22.8	1	-22.4	-21.8	1	-16.1	-12.8	1	-9.3	-6.3
2	-25.4	-26.0	2	-25.2	-24.1	2	-15.2	-11.5	2	-5.1	-4.4
3	-24.3	-22.5	3	-25.7	-22.7	3	-14.2	-11.2	3	-5.6	-4.1
4	-23.8	-19.8	4	-21.1	-18.7	4	-9.9	-5.7	4	-1.6	-1.0
5	-21.6	-20.4	5	-20.6	-19.6	5	-10.2	-6.1	5	-0.8	0.1
6	-21.1	-17.6	6	-20.0	-17.9	6	-14.7	-11.5	6	2.7	6.6
7	-19.5	-19.5	7	-16.5	-14.5	7	-16.0	-12.4	7	2.2	4.3
8	-21.3	-20.3	8	-13.6	-11.5	8	-15.6	-13.0	8	4.0	2.9
9	-22.5	-21.5	9	-11.8	-10.8	9	-12.1	-10.1	9	-0.2	2.6
10	-23.3	-22.1	10	-11.6	-9.6	10	-13.3	-10.1	10	-0.2	0.2
11	-22.0	-20.3	11	-14.5	-12.5	11	-9.3	-7.3	11	1.9	2.8
12	-19.8	-16.6	12	-8.2	-6.1	12	-6.7	-6.6	12	3.5	4.9
13	-18.4	-16.9	13	-14.5	-12.3	13	-4.3	-4.4	13	-1.9	-1.7
14	-19.5	-18.1	14	-16.7	-14.6	14	-7.1	-5.3	14	-1.7	-0.6
15	-11.7	-9.1	15	-13.5	-12.3	15	-9.3	-6.5	15	0.1	1.9
16	-11.5	-9.5	16	-7.1	-5.1	16	-10.1	-6.6	16	-1.5	-0.7
17	-12.6	-11.7	17	-2.5	-1.9	17	-11.8	-8.0	17	0.8	3.3
18	-18.9	-18.2	18	-3.8	-2.0	18	-10.6	-7.3	18	2.2	4.0
19	-15.6	-12.2	19	-5.2	-3.2	19	-8.8	-6.1	19	0.6	-1.1
20	-14.0	-12.9	20	-8.4	-6.7	20	-8.7	-5.9	20	-2.4	-2.0
21	-14.7	-13.7	21	-8.5	-6.7	21	-8.4	-5.9	21	-1.1	-0.1
22	-12.5	-10.4	22	-11.8	-9.5	22	-6.9	-4.6	22	-3.2	0.7
23	-10.8	-9.1	23	-9.5	-6.6	23	-7.1	-3.9	23	-1.9	1.7
24	-11.3	-9.9	24	-14.2	-11.9	24	-7.3	-4.3	24	-1.8	1.3
25	-12.2	-10.3	25	-14.3	-12.5	25	-4.9	-3.7	25	-2.1	-1.1
26	-8.3	-6.9	26	-15.7	-13.2	26	-3.9	-6.2	26	-2.9	-1.1
27	-15.9	-13.9	27	-7.4	-5.7	27	-6.7	-4.6	27	-6.2	-3.8
28	-21.2	-19.2	28	-9.5	-7.1	28	-5.6	-3.5	28	-5.1	-1.6
29	-18.7	-16.9	29	-13.4	-9.6	29	-7.2	-4.9	29	-1.8	0.5
30	-19.3	-19.6	30	-16.2	-13.0	30	-7.8	-5.5	30	-2.9	-1.8
31	-22.6	-21.7				31	-10.3	-7.7			
MEAN	-18.1	-16.4		-13.4	-11.5		-9.7	-7.2		-1.4	0.2

DATE	JULY 1990 SKOL	MERCK
1	-3.4	-2.4
2	-1.6	-1.4
3	-1.3	0.1
4	0.3	1.5
5	4.3	4.6
6	4.8	5.6
7	4.1	3.1
8	2.4	2.9
9	-1.7	0.2
10	-1.2	-0.3
11	-1.2	0.0
12	-2.4	-0.6
13	-0.4	1.3
14	-0.3	2.2
15	0.8	0.2
16	4.0	4.4
17	5.9	4.7
18	5.6	5.8
19	5.4	5.1
20	8.0	9.2
21	9.0	8.3
22	9.9	10.5
23	3.4	4.2
24	1.3	2.6
25	2.6	3.8
26	1.9	1.5
27	5.0	6.5
28	6.4	6.7
29	8.6	9.2
30	7.6	
31	6.3	
MEAN	3.0	

The annual variation was obtained from the daily mean air temperature differences between the Skolten and the Merckollfjellet sites (Fig. 4-C). Although the variations are large, they are close to the values from 5 to 6 ℃/km in the first five months, namely August, September, October, November and December. They varied greatly after the first five months, and the mean values increased towards 10 ℃/km. They finally decreased again in the summer of 1990.

Acknowledgments

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