THE SUMMER CLIMATE IN THE ACCUMULATION AREA OF THE SALMON GLACIER

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Abstract. During the summer of 1957 a party visited the Salmon Glacier in British Columbia. A meteorological station was established in the accumulation area at an altitude of 1700 m. From 12 June to 16 August pressure, temperature and humidity were recorded continuously and the daily totals of precipitation, ablation and percolation were obtained. Periodic measurements of snow density were made; on the first occasion to a depth of 4·7 m. and later near the surface only. Occasional observations of snow temperatures to a depth of 12 m. were also made. Towards the end of the season the heat balance of the snow surface was examined in detail. The various contributions to the melting are evaluated for several short periods and their relative magnitudes compared.

Résumé. Au cours de l'été 1957 une équipe se rendit au Salmon Glacier en Colombie Britannique. Elle établit une station météorologique dans la région d'accumulation à une altitude de 1700 m. On a enregistré continuellement la pression, la température et l'humidité et a obtenu les totaux quotidiens de précipitation, d'ablation et d'infiltration. On a fait des mensurations périodiques de la densité de la neige, d'abord à une profondeur de 4,7 m, ensuite à la surface seulement. On a fait également d'occasionnelles observations de la température de la neige à une profondeur de 12 m. Vers le fin de la saison on a examiné en detail le régime thermal de le surface de la neige. On évalue les contributions variées à la fonte pendant plusieurs courtes périodes et on compare leurs grandeurs relatives.

1. Introduction

During the summer of 1957, an expedition took place to the Salmon Glacier in British Columbia. The work there included a study of the meteorology of the accumulation area. It is the purpose of this paper to report the findings.

The Salmon Glacier is situated in the Canadian coastal range of mountains, just outside the southern tip of Alaska (lat. 56° 10′ N., long. 130° 7′ W.). The region is one of high annual precipitation, and the climate can most nearly be described as sub-arctic rain forest. From the snow fields at an altitude of about 1700 m. the glacier descends to the east for twelve kilometres and then divides. Some of the ice discharges into a lake to the north, while the greater part descends another 760 m. to the snout eight kilometres to the south and at 210 m. above sea level. From the top of the Salmon, the snow fields rise another 300 m. to the north, but in other directions they descend into other glaciers.

The Salmon is a glacier of the deep valley type. Preliminary seismic and gravity results indicate that in the centre of the upper section where the width is 2·5 km. the depth of the ice is greater then 600 m.

By 11 June, the meteorological station was established at the top of the glacier at an altitude of 1700 m. Although there was considerable snow after this date, the ablation season had already commenced, and when the expedition withdrew on 16 August, the first snow of the 1957-58 accumulation had not yet fallen.

Throughout the period, pressure, temperature and humidity were continuously recorded (the microbarograph and hygro-thermograph used were both Short and Mason instruments, types D2315 and D2362 PP respectively), and measurements of precipitation, ablation and percolation were made daily at about 09.00 hr. local time (MST). Later in the season, a detailed study was made of the heat balance of the snow surface.

Fig. 1 (top). Five day running means of the maximum, minimum and mean daily temperatures

Fig. 2 (centre). The mean diurnal variation of temperature for successive sixteen-day periods. 1, 12-27 June; 2, 28 June-13 July; 3, 14-29 July; 4, 30 July-14 August

Fig. 3 (bottom). Total daily precipitation

2. Temperatures

Throughout the period of the expedition, continuous measurements of the temperature at a height of 1·5 m. above the snow surface were obtained with the hygro-thermograph which was housed in an improvised screen 30 m. to the north of the camp. Maximum, minimum and mean hourly temperatures were taken from the records and mean temperatures were calculated for each day. From these, five day running means were calculated according to the formula

$$T_n' = \frac{(T_{n+2} + T_{n-2}) + 2(T_{n+1} + T_{n-1}) + 3T_n}{9}$$

where T_n and T_n' are the mean and running mean temperatures for the nth day. These are plotted for the season in Fig. 1 (p. 194). The general increase in temperatures as the season progresses is clearly demonstrated in Fig. 2 (p. 194), where the mean diurnal variation of temperature for successive sixteen day periods is plotted. The colder nights in the second period are probably the result of the clearer weather which followed a long period of snow from 17 to 31 June. It is also of interest to note that the time of the daily maximum temperature moves from about 15.30 hr. MST in the early summer, to 13.00 hr. MST at the end of the season. This may be due to the quicker warming of the air over local mountain slopes as these became free of snow.

Table I (p. 203) summarizes the main characteristics of the same periods.

3. Precipitation

Values for the total precipitation were obtained with a Canadian Meteorological Service standard rain gauge placed in the snow to the north of the meteorological station. Temperatures were normally high enough to prevent accumulation of solid precipitation in the funnel, but on a few occasions small quantities of snow remained there. These were melted and added to the rest of the precipitation before measurement. The routine ablation measurements (see Section 4·2 below) provided a rough value for snowfall when this was large, and in calculating the water equivalent an average value of the density was adopted from the periodic snow measurements (see Section 4·1 below).

The last ten days of June provided the period of greatest precipitation, of which about one half was in the form of snow. After 1 July, no significant quantities of snow fell, and the first falls of the 1957-58 accumulation had not yet taken place when the expedition withdrew on 16 August. Of the sixty-seven days during which records were kept, there were only twenty with no precipitation at all.

The total daily precipitations are plotted in Fig. 3 (p. 194). The day with the greatest snowfall was 30 June (8·1 cm. snow; 3·68 cm. total water), while the maximum total precipitation of 4·06 cm. was recorded on 23 June. The total for the whole period was 39·8 cm., about 18 per cent of the mean total annual precipitation as indicated by a twenty-two year mean from the nearest meteorological station at Premier, 18 km. to the south-east. Comparison with their mean monthly rainfalls indicates that the season was considerably wetter than usual, although this difference may in part result from the different situations of the two stations.

4. Snow Measurements

4·1 *Snow Density and Temperature*

On 7 and 8 June, soon after the occupation of the camp, a pit was dug 100 m. to the north for measurements of snow density and temperature at different depths. Digging was continued until a layer of dirty snow was reached at 4·7 m. This was believed to represent the transition

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to the previous season's snow. Temperatures taken with an alcohol thermometer showed the snow to be at freezing point throughout.

On 10 June samples were taken from freshly exposed snow on the south face of the pit. These measurements were made at 6 in. (15·2 cm.) intervals to a depth of 15 ft. 6 in. (4·7 m.). The densities showed very little variation with depth, giving a mean of a little over 0·53 gm. cm.$^{-3}$. A note was made of the position and nature of ice-bands. Throughout the season the observations were repeated periodically near the surface on freshly exposed snow. A steady increase of density amounting to about 15 per cent. was observed during the summer. The results are summarized in Tables II and III (pp. 203-4).

In the few days immediately preceding 27 June, considerable quantities of snow had fallen. This is the cause of the decrease of surface densities found on that day (Table III).

After the pit had been dug, a hole was drilled from the bottom to a total depth of 12 m. Two thermistors were buried here at depths of 12 and 7 m., and another was buried from the surface near by at a depth of 3 m. For the season these gave mean temperatures of −0·14, −0·06, −0·15° C. with maximum departures from the means of 0·06, 0·06, and 0·04° C. The variations were random and probably entirely experimental. It is therefore clear that there was no region of very cold snow remaining by the time the measurements began, and it may be concluded that the glacier is temperate.

4·2 *Ablation Measurements*

During the period of occupation of the meteorological camp daily measurements of the net ablation were made. For this purpose, four bamboo canes were driven into the snow to the north, east, south and west of the camp about 100 m. away. The distance from a marked point on each cane to the snow surface was measured at 09.00 hr. MST each morning. A method of measurement was adopted which avoided errors from the radiation hollows which formed around the stakes. Every few days the canes were reset.

During periods when no snow fell the ablation averaged about 4·5 cm. a day. As expected, there was no direct correlation with any of the other daily variables. These are all listed in Table VII (p. 206).

It was also possible during the earlier part of the season to set up a line of ablation stakes at half kilometre intervals from the camp to the bend of the glacier, and these were read occasionally until the advance of the firn line made travel difficult. The mean daily ablations for two periods in June are shown in Fig. 4 (p. 199). Although no great significance can be attached to individual values, it is clear that there is an upward trend of the ablation with decreasing altitude. The range covered is approximately from 1700 m. (camp) to 970 m. (bend) in which the ablation increases by about a half. As the exposure to radiation is similar throughout this part of the glacier, the difference must arise from the warming of the air during descent in the down-glacier winds.

4·3 *Percolation*

The percolation of water through the snow was measured directly. For this purpose a small pit, about 1·5 m. deep, was dug to the north of the camp. About 60 cm. below the surface on the south side a hole was dug 80 cm. into the wall. A 25 cm. funnel was forced up into the snow from inside the hole, which was then filled with snow. In this way the funnel was completely protected from radiation reflected from the pit and from warming by the air. The water collected flowed through a polythene tube to a vessel in the pit.

It was found that the daily percolation averaged about 2 cm. of water. Individual values frequently exceeded the water equivalent of the corresponding ablation. The condensation of water on the surface which can be inferred from this was confirmed by the detailed measurements of the heat balance of the surface (Section 7).

The values which were obtained for the daily percolation are given in Table VII.

5. The Temperature Profile

During the latter part of the season, detailed measurements were made of the temperature structure above the snow. An 8 m. aluminium mast (Fig. 5, p. 193) supported copper-constantan thermocouples on cross arms at heights of 46 cm. (1·5 ft.), 213 cm. (7 ft.) and 610 cm. (20 ft.). The junctions were soldered to small pieces of tin-plate approximately 1·5×2 cm., and by thus ensuring good thermal contact with the air the effect of any heat conducted along the leads from parts exposed to the sun was kept to a minimum. The junctions were screened by flat metal boxes, silvered on the outside and blackened on the inner surface (Fig. 6, p. 193). These were so mounted as to be open to the north and south, and therefore protected the elements from direct solar radiation at all times of the day. The cold junctions were maintained at 0° C. in a Dewar flask of melting snow.

Stable conditions were found to be most frequent at all levels although the layer of air between the lower two thermocouples had a markedly greater tendency to instability than the others. The relative frequency of occurrence of the different temperature gradients in the different layers is shown in Fig. 7 (p. 199). These are drawn from the results of over 75 hours of daytime observations.

Now it has been found[1] that the variation of the average potential temperature with height over a snow or ice surface can be expressed by the formula

$$\frac{\Theta}{\Theta_1} = \left(\frac{z}{z_1}\right)^{1/n_\theta}$$

where Θ and Θ_1 are the potential temperatures in ° C. at heights z and z_1, and n_θ is a roughness parameter for the particular snow surface. The values calculated for n_θ together with the average temperature gradients are given in Table IV, p. 204.

If the above equation holds over the range of our measurements, the gradient would be expected to decrease steadily with height. The values given above indicate a temperature higher than expected at 46 cm. This may in part be the result of warming of the air near the ground by the wooden base on which the mast rested. Prevailing winds would tend to carry such warm air towards the lowest thermocouple. In view of this uncertainty, when calculating the eddy conduction of heat to the surface (see Section 7 below) the use of the temperatures at 46 cm. was avoided. However, the values of n_θ are similar to those obtained by other workers (*e.g.* Orvig[2]).

At all times of day during these measurements the temperatures shown by the thermocouples were found to be subject to large fluctuations of about 30 per cent of the mean with typical periods of about half a minute. In order to obtain reliable data it was therefore decided to observe continuously during the detailed measurements.

6. Wind Measurements

During the latter part of the season detailed measurements were made of the wind profiles near the surface. Three remote-registering rotating cup anemometers (Bendix Aviation Corporation) were attached to the mast at heights of 46 cm., 213 cm. and 610 cm. Ten minute average values of the horizontal components of the wind were registered directly on counters in the hut.

When light winds came from the south-west it was often found that the speed near the surface was extremely small compared with that at 610 cm. Similarly, with light north winds the wind near the surface was sometimes greater than that above; and occasionally, the wind direction reversed from north at the surface to south or south-west at some higher level. All these effects were the result of the cold layer of air just above the snow flowing downhill to the camp from the upper snowfields to the north.

Most of the precipitation occurred with west or south-west winds (the prevailing wind direction); although during the long period of bad weather from 20 June to 1 July, there were strong easterly winds for a considerable proportion of the time.

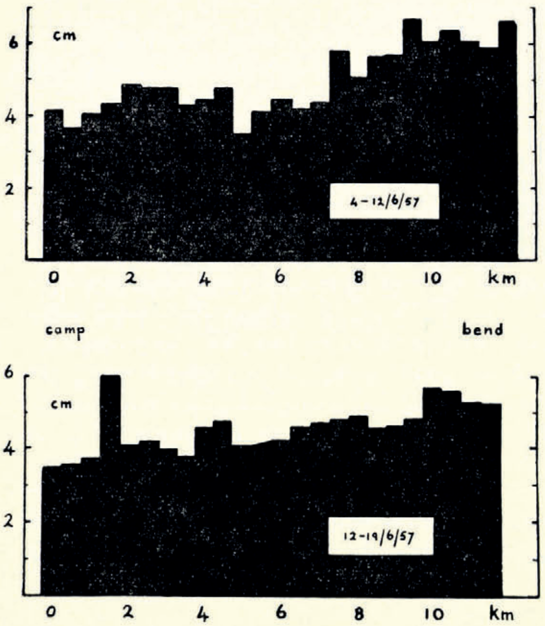

Fig. 4. The mean daily ablation at different points on the glacier for two periods in June

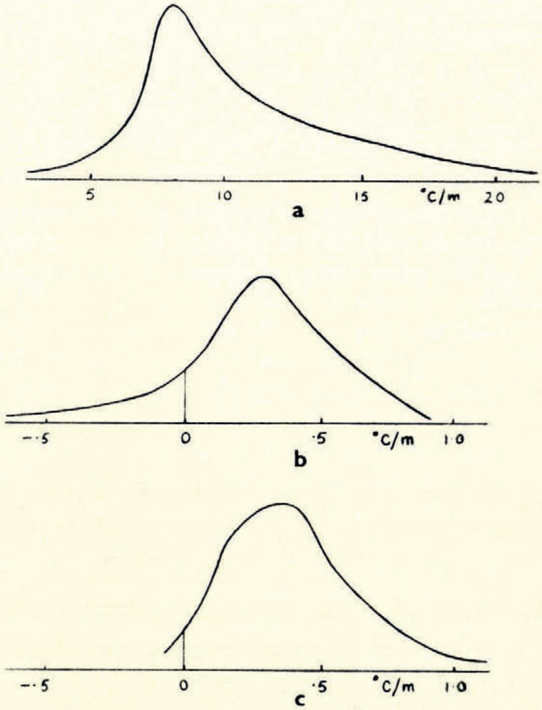

Fig. 7. The relative frequency of the different temperature gradients during the day in the three layers
(a) 0-46 cm. (b) 46-213 cm. (c) 213-610 cm.

Now it has been found [1, 3] that under stable conditions the variation of the average wind speed with height above a rough surface is best expressed by a power law. This may be written in the form

$$\frac{u}{u_1} = \left(\frac{z}{z_1}\right)^{1/n_u}$$

where u and u_1 are the average wind speeds at heights z and z_1, and n_u is a roughness parameter for the surface. Two values of n_u were calculated using wind speeds from the upper and lower pairs of anemometers. In these calculations all occasions with wind speeds below about 1 m./sec. were rejected to minimize errors due to the effect described in the second paragraph of this section. The values found for n_u were 4·0 and 3·8, which are similar to those obtained by other workers (*e.g.* Orvig[2]). They are included in Table IV for comparison with the values of n_θ.

7. The Heat Balance of the Surface

The heat balance of the surface may be summarized by the equation

$$80\ H = 600\ F + (\alpha I - R) + Q_a + Q_s$$

where H cm. sec.$^{-1}$ is the rate of ablation in terms of the water equivalent of the melting snow,

F cm. sec.$^{-1}$ is the rate of condensation on the surface,

$1-\alpha$ is the albedo of the snow surface,

I cal. cm.$^{-2}$ sec.$^{-1}$ is the total incoming radiation,

R cal. cm.$^{-2}$ sec.$^{-1}$ is the outgoing (long wave) radiation,

Q_a cal. cm.$^{-2}$ sec.$^{-1}$ is the heat brought to the surface by turbulent conduction, and

Q_s cal. cm.$^{-2}$ sec.$^{-1}$ is the heat arriving at the surface by conduction through the snow.

The latent heats of melting and evaporation of water at 0° C. are 80 and 600 cals. gm.$^{-1}$ respectively. As the Salmon Glacier is temperate (Section 4·4), $Q_s=0$. The evaluation of the other terms of the equation was performed as follows:

Ablation

The ablation was measured directly. For this study a method was adopted which gave greater accuracy than that of the routine observations. Three two-metre aluminium tubes were sunk into the snow about half a metre apart in a north-south line. The tops projected about 20 cm. above the surface, and between these a cotton thread was stretched tightly. The thread was knotted in the middle of each section, and a small plumb-line used to find the point on the snow vertically below. The distance between the snow and the thread was then measured with a short scale. In this way, it was possible to make the measurements to the nearest millimetre, although the particular values obtained were not strictly representative of the whole surface as at the time of these observations the snow had become heavily pitted. This was confirmed by significant differences in the two values obtained for the ablation.

Net Incoming Radiation

A net exchange radiometer (Beckmann and Whitley, N 188-07) was used to measure the net incoming radiation, $(\alpha I - R)$, directly. The instrument was supported on a box with the sensitive element projecting to the south about 50 cm. above the snow. Thermocouples embedded in the sensitive element gave an output proportional to the net incoming radiation. The e.m.f. was measured in the hut with the same potentiometer as was used for the temperature measurements. A Yaxley switch with silver-plated contacts was chosen to select the different e.m.fs for application to the potentiometer. There was no evidence of any spurious effects arising from the switching procedure.

The presence of the box supporting the radiometer effectively reduced the area of snow to which the lower face of the radiometer's sensitive element was exposed. A correction factor of 0·8 was calculated for this and applied to all the radiometer readings.

The highest observed values of the net incoming radiation were about 0·45 cal. cm.$^{-2}$ min.$^{-1}$ implying an albedo of about 0·77.

Eddy Conductivity

It has been shown[4] that the transport of heat to the ground by eddy conductivity is given by

$$Q_a = c_p . A . \frac{d\Theta}{dz}$$

where c_p cal. gm.$^{-1}$ °C.$^{-1}$ is the specific heat of air at constant pressure (=0·24),

A gm. cm.$^{-1}$ sec.$^{-1}$ is the eddy conductivity, and

$\frac{d\Theta}{dz}$ °C. cm.$^{-1}$ is the vertical gradient of potential temperature.

Over the range of heights involved in the present measurements the change from actual to potential temperatures involved corrections of a few per cent only. As the probable errors were at least this great, the actual temperatures were used in the calculations. Their measurement is described in Section 5 above.

Various expressions have been given for the eddy conductivity. That used by Wallén[5] is

$$A = k.\, u_z.\, z^{\left(\frac{n_\theta - 1}{n_\theta} - \frac{1}{n_u}\right)} .\ 10^{-2}$$

where k is an experimentally determined coefficient with a value of about 1·8,

u_z m. sec.$^{-1}$ is the wind velocity at a height z cm., and

n_θ and n_u are the roughness parameters as defined in Sections 5 and 6 above.

In the present study we take $n_\theta = n_u = 3{\cdot}9$ (see Table IV) so that the hourly transport of heat to the surface by eddy conductivity is

$$Q'_a = 0{\cdot}61\ (\Theta_{610} - \Theta_{213}).\ u_{213}$$

where the measured quantities are averages over the period concerned. The expression includes a factor to correct the mean wind at 213 cm. to that half way between the top two thermocouples.

Condensation

Calculation of the condensation on the surface requires knowledge of the gradient of water vapour pressure. The vapour pressure at the surface is fixed at 4·58 mm.Hg by the snow at 0° C. For measurement of the vapour pressure at 213 cm. a wet thermocouple was fixed beside the dry one (Fig. 6). The junction was essentially similar in construction to the others, but covered with gauze which was kept well wetted. Measured values of the humidity were found to agree well with those indicated by the hygrograph.

The downward flux of water vapour is given[1] by

$$F = A.\, \frac{df}{dz} = A.\frac{0{\cdot}623}{p}.\, \frac{de}{dz}$$

where f is the specific humidity,

e mm.Hg is the water vapour pressure,

p mm.Hg is the atmospheric pressure, and

A gm. cm.$^{-1}$ sec.$^{-1}$ is again the eddy conductivity as given above.

Hence the hourly condensation on the surface is given by

$$F' = 0{\cdot}00417.\ u_{213}.\ \left.\frac{de}{dz}\right|_{213}$$

or, assuming a power law profile for the humidity gradient similar to that for temperature or wind speed (see Sutton[6])

$$F' = 0{\cdot}0011\ .\ (e_{213} - e_0).\ u_{213}$$

where the variables are averages for the period of observation.

Choice of Periods for Observation

Short periods of about four hours were chosen in which the temperatures and radiation measurements were made according to a routine which made it possible to make at least five observations of each variable each half hour. As pointed out in Section 5, such frequent measurements were made necessary by the large fluctuations which were nearly always present in the temperatures. Measurements over the whole period were averaged and the mean hourly contribution of each term evaluated for each period. The observed values of the ablation were used as a check for the other observations. The results are given in Table VI (p. 205).

Unfortunately, the radiometers available would not work when wet, and therefore only a few observations of the other variables were made during rain. (Periods 1-4.) A few night periods were also chosen (Periods 5-8), but most of the observations were made during the day in periods with variable amounts of cloud, but no rain. The ablation values in the table are given in mm. of water. For the conversion from mm. of snow to mm. of water, a surface density of $0 \cdot 57$ gm. cm.$^{-3}$ is assumed. This is an average over the period of the observations of the density at a depth of 15 cm. (see Table III).

Little significance can be attached to the ablation measurements during the night, as they were extremely small, and in any case, the technique of measurement was not fully developed when they were made. No cause is known for the discrepancy between the calculated and observed values of the ablation for period 17. Excluding this occasion, the agreement is reasonably good, the calculated exceeding the observed ablation by an average of $11 \cdot 5$ per cent.

In Table V (p. 204), the relative importance of the different contributions to the melting are compared with those obtained on snow surfaces by other workers.

ACKNOWLEDGEMENTS

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TABLE I. TEMPERATURE ANALYSIS IN °C.

Period	1 *12-27 June*	2 *28 June-13 July*	3 *14-29 July*	4 *30 July-14 August*
Mean Daily Temperature	2·30	2·17	3·60	4·78
Mean Daily Maximum	4·60	5·05	6·42	8·00
Mean Daily Minimum	1·14	0·64	2·12	3·33
Absolute Maximum	9·45	12·22	12·22	12·22
Absolute Minimum	−1·11	−4·44	−1·39	1·39
Mean Daily Range	3·46	4·41	4·31	4·67

TABLE II. SNOW DENSITIES AND POSITION AND NATURE OF ICE BANDS

Date: 10 JUNE 1957

Depth ft.	in.	*Density* gm. cm.$^{-3}$	*Ice Bands*
	6	0·52	
1	0	0·50	
1	6	0·48	
2	0	0·49	
2	6	0·50	
3	0		CIB 0·1 in.
3	1		IB 0·2 in.
3	4	0·49	
3	5½		CIB 0·1 in.
3	11		FIB 0·1 in.
4	1		FIB 0·1 in.
4	2	0·54	
4	6	0·52	
5	0	0·54	
5	6	0·54	
5	6½		IB 0·5 in.
5	10		IB 0·2 in.
6	0	0·54	
6	3		IB 0·2 in.
6	4½		TIB
6	6	0·54	
7	0	0·53	
7	1-2½		IB 1·5 in.
7	6	0·54	
8	0	0·56	
8	2½-3		IB 0·5 in.
8	6	0·55	
9	0	0·53	
9	6	0·56	
9	10	0·56	
10	0		IB 0·2 in.
10	1-1½		TIBs
10	6	0·52	
10	7		IB 0·2 in.
11	0	0·53	
11	6	0·56	
12	0	0·56	
12	6	0·57	
13	0	0·58	
13	4½	0·58	
13	6-6¾		IB 0·7 in.
14	0	0·54	
14	0-6		IBs scattered
14	6	0·57	
15	0	0·56	
15	0-6	Believed transition zone	
15	6	0·53	

Explanation of abbreviations for ice bands: IB—ice band; CIB—composite ice band; FIB—faint ice band; TIB—thin ice band.

TABLE III. SURFACE SNOW DENSITIES

Depth ft.	in.	Date 10 June	27 June	7 July	19 July	2 August	7 August
	6	0·52	0·49	0·51	0·54	0·58	0·57
1	0	0·50	0·49	0·53	0·56	0·58	0·58
1	6	0·48	0·54	0·51	0·56	0·57	0·58
2	0	0·49	0·54	0·54	0·56	0·59	0·57
2	6	0·50	0·52	0·54	0·59		0·60
3	0		0·57		0·59		
3	6	(0·49)	0·56		0·59		
4	0	(0·54)	0·57		0·56		

TABLE IV

Height interval (cm.)	0–46	46–213	213–610
Average temperature gradient (° C./m.)	10·7	0·27	0·40
n_θ	—	9·7	4·0
n_u	—	4·0	3·8

TABLE V. THE RELATIVE IMPORTANCE OF THE DIFFERENT CONTRIBUTIONS TO THE MELTING OF SNOW SURFACES

Place	*Position and Elevation*	*Surface*	$(\alpha I - R)$ %	Q_a %	$600F$ %
Sveanor 30 June to 6 August 1931	79° 56′ N 18° 18′ E 5 m.	Isolated snowfield	23·9	58·5	17·6
Fröya Glacier 1 to 18 August 1939	74° 24′ N 20° 50′ W 453 m.	Snow	8·2	83·4	8·4
Barnes Ice Cap 25 June to 4 August 1950	69° 43′ N 72° 13′ W 866 m.	Snow 37 days Ice 4 days	67·7	32·3 (combined)	
Isachsen's Plateau 26 June to 15 August 1934	79° 09′ N 12° 56′ E 870 m.	Snow	55·9	29·4	14·7
Kårsa Glacier August 1942 to August 1948	>1100 m.	Snow	32	44	24
Salmon Glacier 30 July to 9 August 1957	56° 10′ N 130° 07′ W 1700 m.	Snow	74·7	15·4	9·9
Penny Ice Cap 13 to 26 July 1953	66° 59′ N 65° 28′ W 2050 m.	Snow	61·3	8·8	29·9

TABLE VI. SURFACE HEAT BALANCE

Period	Date	Time	*Precipitation* (mm. hr.$^{-1}$)	Q'_a (cal. cm.$^{-2}$ hr.$^{-1}$)	%	$\alpha I - R$ (cal. cm.$^{-2}$ hr.$^{-1}$)	%	600 F' (cal. cm.$^{-2}$ hr.$^{-1}$)	%	*Sum* (cal. cm.$^{-2}$ hr.$^{-1}$)	*Ablation* (mm. water hr.$^{-1}$) *Calculated*	*Observed*
Observations During Rain												
1	30 July	04.00-08.00	·012	1·33				1·03				0·71
2	30 July	08.00-12.00	·02	1·84				2·33				2·26
3	30 July	16.00-20.00	·54	2·67				1·39				1·48
4	31 July	12.00-15.30	·34	0·81				1·07				4·20
Observations During the Night												
5	30 July	00.00-04.00	0	1·96		−3·04		0·49		−0·59	freezing	0·00
6	30 July	20.00-00.00	0	0·49		−2·25		0·54		−1·22	freezing	0·62
7	31 July	00.00-04.00	0	0·25		−1·43		0·79		−0·39	freezing	0·34
8	31 July	04.00-08.00	0	0·10		−2·00		0·45		−1·45	freezing	0·24
Observations During the Day												
9	30 July	12.00-16.00	0	2·75	9	24·6	82	2·60	9	29·9	3·7	2·9
10	31 July	08.00-12.00	0	0·45	5	7·30	86	0·75	9	8·5	1·1	1·2
11	1 August	08.00-12.00	0	0·74	4	15·3	93	0·43	3	16·5	2·1	1·4
12	1 August	12.00-16.00	0	1·61	7	20·0	86	1·60	7	23·2	2·9	2·0
13	1 August	16.00-18.00	0	0·69	6	10·4	85	1·04	9	12·1	1·5	1·6
14	3 August	07.00-11.00	0	5·30	30	10·4	59	1·88	11	17·6	2·2	2·1
15	3 August	13.15-17.15	0	4·50	20	16·8	74	1·43	6	22·7	2·8	2·7
16	4 August	08.00-12.00	0	3·12	17	14·3	78	0·91	5	18·3	2·3	1·7
17	4 August	12.00-16.15	0	3·59	13	22·1	81	1·69	6	27·4	3·4	1·4
18	4 August	16.15-18.30	0	3·89	23	9·7	56	3·66	21	17·2	2·2	2·0
19	7 August	08.00-11.00	0	2·82	18	10·5	68	2·20	14	15·5	1·9	1·8
20	7 August	11.00-15.00	0	2·01	8	20·7	83	2·17	9	24·9	3·1	3·2
21	7 August	15.00-19.00	0	2·32	28	4·93	60	1·01	12	8·26	1·0	0·9
22	8 August	07.30-11.00	0	2·96	23	7·68	61	2·01	16	12·6	1·6	1·5
23	8 August	11.00-14.00	0	4·03	15	20·5	76	2·57	9	27·1	3·4	2·7
24	9 August	07.30-11.00	0	3·50	24	8·55	60	2·36	16	14·4	1·8	1·6
25	9 August	11.00-15.00	0	1·96	11	14·5	83	1·14	6	17·6	2·2	1·8
Mean Contributions					15·4		74·7		9·9			

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TABLE VII. DAILY VARIABLES

Date	*Net Ablation* (cm.) *Snow*	*Water Equivalent*	*Precipitation* (cm.)	*Percolation* (cm.)	*Maximum Temperature* (°C.)	*Minimum Temperature* (°C.)	*Range* (°C.)	*Mean* (°C.)
12 June	—	—	2·08	—	4·7	1·7	3·0	2·8
13 June	—	—	0·79	—	1·9	1·4	0·6	1·6
14 June	—	—	0·26	—	1·7	0·8	0·8	1·2
15 June	5·3	2·6	0·00	—	1·7	1·1	0·6	1·9
16 June	4·6	2·3	0·01	1·85	4·2	1·1	3·0	1·8
17 June	3·8	1·9	0·36	2·22	9·4	3·3	6·2	5·3
18 June	2·7	1·3	0·14	1·98	6·7	2·2	4·4	3·9
19 June	2·8	1·4	0·00	2·00	8·6	−1·1	9·7	3·0
20 June	2·5	1·2	0·02	1·65	7·2	1·9	5·3	3·3
21 June	−4·6		1·16	—	1·7	−0·6	2·2	0·5
22 June	−3·6		0·86	0·00	7·2	2·2	5·0	2·3
23 June	−3·6		4·07	0·46	3·9	1·7	2·2	2·0
24 June	0·1		0·41	0·86	5·8	−0·8	6·7	1·7
25 June	2·5		1·50	1·01	1·1	0·0	1·1	0·7
26 June	−7·6		2·39	0·84	1·7	0·6	1·1	1·0
27 June	3·6		1·45	—	6·1	2·8	3·3	3·7
28 June	−1·8		1·55	1·85	4·4	1·9	2·5	3·0
29 June	−1·3		1·07	2·00	1·9	1·7	0·3	1·8
30 June	−8·1		3·68	0·61	1·9	1·1	0·8	1·5
1 July	−0·5		0·46	0·00	2·2	−4·5	6·7	−0·2
2 July	6·3	3·0	0·00	1·16	7·2	1·7	5·5	3·3
3 July	7·9	3·8	0·00	0·79	3·9	2·5	1·4	3·2
4 July	3·6	1·7	1·07	2·84	10·0	1·1	8·9	3·7
5 July	1·5	0·8	1·04	2·54	5·8	0·6	5·3	2·5
6 July	2·8	1·4	0·05	—	4·4	0·6	3·9	1·4
7 July	3·6	1·8	0·28	2·16	1·1	−0·6	1·7	0·3
8 July	1·5	0·8	0·18	1·41	12·2	0·6	11·7	3·6
9 July	1·5	0·8	0·18	1·41	3·9	0·6	3·3	1·8
10 July	6·3	3·2	0·71	>1·73	3·1	0·8	2·2	1·6
11 July	3·6	1·9	0·00	0·74	7·2	2·2	5·0	3·2
12 July	0·3	1·6	1·20	1·42	3·3	0·3	3·0	1·8
13 July	4·3	2·3	0·38	1·29	8·1	−0·3	8·3	2·1
14 July	5·3	2·8	0·00	1·73	7·8	3·6	4·2	4·7
15 July	3·8	2·1	0·05	2·31	8·6	3·6	5·0	5·5
16 July	4·6	2·5	0·00	2·92	4·4	3·3	1·1	3·8
17 July	5·6	3·1	0·00	3·89	5·6	3·1	2·5	4·0
18 July	4·6	2·5	0·00	4·07	12·2	4·4	7·8	6·9
19 July	5·9	3·3	0·00	—	8·3	3·1	5·3	5·5
20 July	2·3	1·3	0·11	2·08	5·6	2·5	3·0	3·3
21 July	4·1	2·3	0·41	1·85	7·0	2·5	4·4	3·4
22 July	−1·5		2·10	2·39	2·5	1·1	1·4	2·0
23 July	1·3	0·7	2·06	2·33	7·2	1·1	6·1	2·9
24 July	1·3	0·7	1·09	1·04	4·2	1·1	3·0	2·4
25 July	1·8	1·2	0·46	0·77	3·3	1·9	1·4	2·5
26 July	1·8	1·2	0·46	0·77	9·1	1·1	8·1	3·1
27 July	1·8	1·2	0·00	0·94	1·7	1·1	0·6	1·3
28 July	2·5	1·4	0·00	1·12	9·7	−1·4	11·1	2·9
29 July	4·3	2·4	0·32	2·10	5·6	1·7	3·9	3·6
30 July	3·0	1·7	0·00	1·74	8·6	2·5	6·1	4·4
31 July	6·3	3·5	0·58	2·95	4·4	2·8	1·7	3·1
1 August	2·3	1·3	0·30	3·23	7·8	3·1	4·7	4·7
2 August	3·0	1·7	0·00	2·40	9·4	1·4	8·1	4·4
3 August	4·4	2·5	0·00	5·33	7·0	4·2	2·8	5·2
4 August	7·4	4·1	trace	2·90	9·1	4·7	4·4	6·2
5 August	6·8	3·8	1·15	4·57	12·2	3·6	8·6	5·8
6 August	2·7	1·5	1·22	2·30	4·2	2·8	1·4	3·6
7 August	3·2	1·8	0·74	2·00	8·3	2·5	5·8	3·9
8 August	5·7	3·2	0·00	2·90	5·6	3·6	1·9	4·2
9 August	5·6	3·1	0·00	3·93	6·1	4·4	1·7	5·2
10 August	6·0	3·4	0·13	2·52	10·0	4·4	5·5	5·8
11 August	5·0	2·8	0·41	3·49	10·0	3·9	6·1	5·0
12 August	5·0	2·8	0·41	3·49	9·7	3·9	5·8	5·7
13 August	6·3	3·5	0·03	—	3·9	3·6	0·3	3·8
14 August	3·3	1·9	0·00	1·98	11·7	3·1	8·6	5·2
15 August	4·8	2·7	0·00	1·08	6·1	4·2	1·9	4·7
16 August	2·8	1·6	0·00	1·73	10·8	4·7	6·2	5·2

Fig. 2. View of the right margin of Austerdalsbreen at the point L at which the velocity of the ice was measured. The small triangle had its moving mark on the small stone in front of the foot in the picture. Note the air gap between ice and rock in this region. (Photograph by J. Burgess)

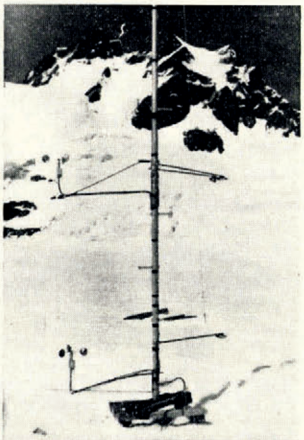


Fig. 5. The lower thermocouples and anemometers on the meteorological mast

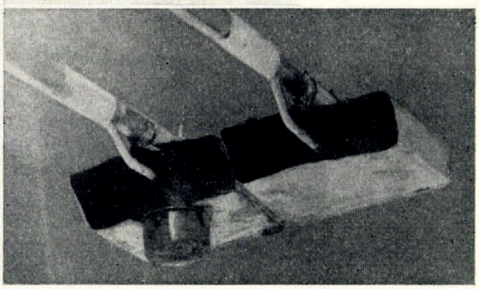
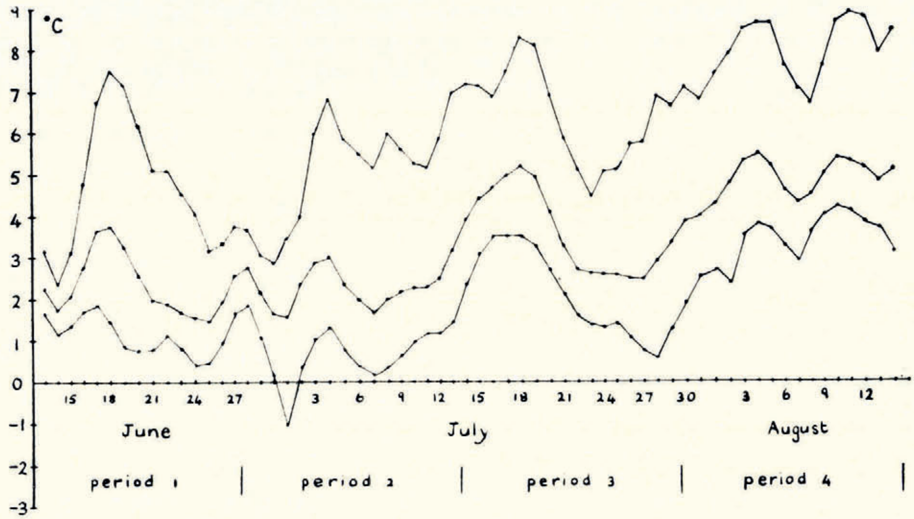
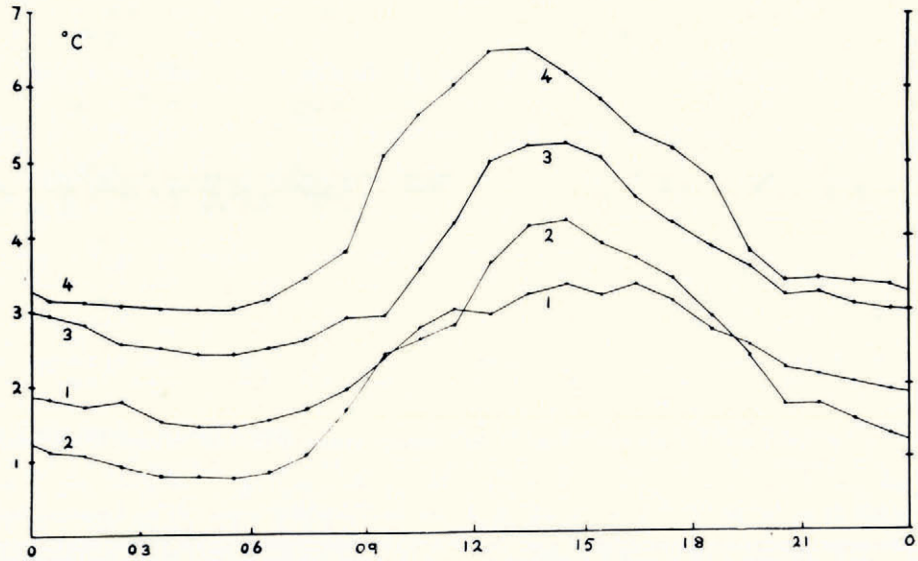
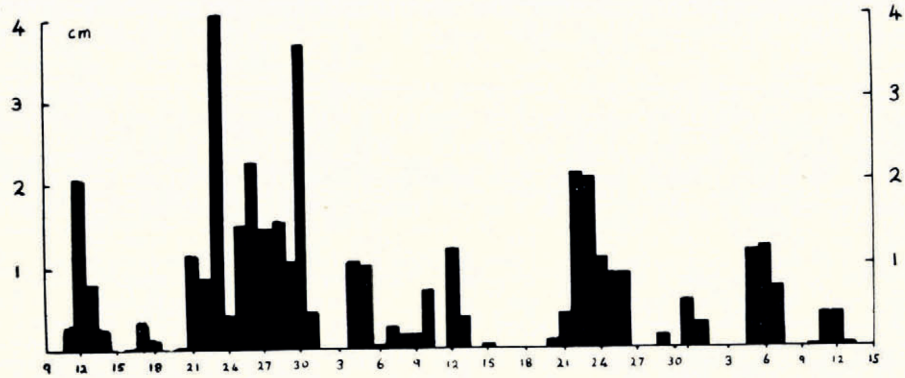


Fig. 6. The wet and dry thermocouples at 213 cm.

See C. J Adkins—The Summer Climate in the Accumulation Area of the Salmon Glacier, p. 195.







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