Short Papers and Notes

NET RADIATION STUDIES IN THE SCHEFFERVILLE AREA

Introduction

A paper by Orvig[1] describes micrometeorological research undertaken by workers from McGill University in the Labrador-Ungava Peninsula. It presents results of measurements of net radiation flux made in 1958 over subarctic surfaces within a 30-mile radius of the McGill Sub-Arctic Research Laboratory at Schefferville. In the summer of 1961 further measurements were carried out by the writer.

Net radiation, the energy available at the ground, is measured as the difference between total downward and total upward flux:

$$R_{net} = R_{si} + R_{li} - R_{sr} - R_{lr},$$

where R_s = short-wave radiation from sun and sky,
R_{si} = incoming,
R_{sr} = reflected;
R_l = long-wave radiation,
R_{li} = incoming,
R_{lr} = outgoing;
modified from ref. 2.

Although several meteorological stations in the Canadian North record incoming short-wave radiation continuously, net radiation, the important parameter in heat and water balance, is rarely measured. Hence, to determine the latter, approximate values have to be sought by means of regression analysis. Shaw[3] has shown correlation coefficients of 0.98 and 0.97 between net and incoming short-wave radiation under completely cloudless or overcast conditions respectively. His study, in more southerly latitudes, was based on continuous records of both parameters. However, Orvig established a correlation of 0.777 between non-continuous daily measurements of net radiation from a portable net radiometer and continuous actinograph measurements at the McGill Sub-Arctic Research Laboratory at Schefferville. The net radiometer data for the calculations were obtained by using the mean of several hours' measurements as the daily mean.

It was the purpose of the study in 1961 to provide further net radiation data from a variety of sites in the vicinity of Schefferville, which would be correlated with incoming short-wave data at the laboratory to test the correlation found in 1958.

Instrumentation

A continuous record of incoming short-wave radiation is provided by a MSC type G bi-metal actinograph. Net radiation was measured by a Suomi-Kuhn "Economical" Net Radiometer, an instrument of "moderate accuracy"[4]. Its simplicity, low cost, and transportability make it well suited to studies in areas where rough terrain has to be traversed and where a power supply is not available. Net radiation is determined (with the use of tables and correction factors) from the difference between temperatures of an upper and lower black absorbing surface. The conversion of temperatures into radiation terms is based on the principle that a black body radiates as a function of the fourth power of its temperature (σT^4) (the Stefan-Boltzmann law). By using insulating material between the two surfaces, losses due to conduction are small. Suomi and Kuhn estimate losses of 10 per cent of the energy exchange. For rapid determination of its value a conductivity correction nomogram is consulted where the conduction factor is plotted against the difference between the temperatures of the two absorbing surfaces.

The formula for calculating net radiation is:

$$R_{net} = 1.25(\sigma T_t^4 - T_b^4) + 0.0025(T_t - T_b),$$

where T_t and T_b are the temperatures

(°C.) of the upper and lower surfaces respectively. Two Weston dial thermometers were used as sensors.

A further correction must be applied to R_{net} to counteract the poor cosine response of the instrument at low sun angles. According to Suomi and Kuhn the instrument measures approximately 90 per cent of the net flux at a zenith angle of 25°, and 83 per cent at 65°. According to Orvig, the zenith angle at Schefferville (54°48′N.) changed between June 21 and September 7 from 31°20′ to 48°40′ and the instrument should therefore measure 88 to 85 per cent of the net radiation. For calculating purposes it was assumed that 86 per cent was measured during the whole summer and a correction factor of 1.16 was applied to R_{net} (calculated from the formula above). The same correction was applied to the data collected in 1961.

Table 1. Distribution of measurements during the summers of 1958 and 1961.

1958	*1961*
June (9-28) 299	June (1-28) 181
July (6-29) 378	July (8-31) 131
Aug. (4-27) 303	Aug. (2- 9) 259
Sept. (3- 7) 14	Sept. (—) —
Total 994	Total 571

Table 2. Mean net radiation for each hour, 1958 and 1961 in ly./min.

Atlantic St. Time	*Corrected mean R_{net}*		*No. of observations*	
	1958	*1961*	*1958*	*1961*
0000-0100	—0.07	—	4	0
0100-0200	—0.04	—0.05	4	3
0200-0300	—0.05	—0.04	4	1
0300-0400	—	—0.04	0	1
0400-0500	—0.05	—0.05	16	6
0500-0600	0.00	—0.05	37	4
0600-0700	0.07	0.04	55	6
0700-0800	0.07	0.20	10	9
0800-0900	0.24	0.49	6	13
0900-1000	0.42	0.61	40	28
1000-1100	0.50	0.62	170	50
1100-1200	0.50	0.57	124	95
1200-1300	0.71	0.65	25	74
1300-1400	0.45	0.63	37	53
1400-1500	0.52	0.54	112	56
1500-1600	0.48	0.52	126	75
1600-1700	0.27	0.33	57	68
1700-1800	0.46	0.36	3	18
1800-1900	0.02	0.21	15	3
1900-2000	—0.01	0.03	76	6
2000-2100	—0.05	—0.05	57	1
2100-2200	—0.05	—0.02	12	1
2200-2300	—0.10	—	4	0
2300-2400	—	—	0	0
			Totals 994	571

The net radiometer was set up at a height of 6 feet over as many vegetation and ground-surface types as possible, which were easily accessible. Woodland lichen, dwarf shrubs, and bare ground constituted the drier surfaces over which net radiation was measured, and mosses and the fringes of waterlogged sedge meadows represented the wetter surfaces. As the instrument depends on the insertion of a 12-inch spear into the ground for stability, a soil depth of at least 1 foot was required. Consequently, few measurements could be conducted on the higher tundra ridges in the area, and the bulk of the studies was confined to the lower lands, but even there an adequate depth of soil was sometimes hard to find.

Although rather precariously poised the net radiometer was remarkably stable in strong winds, which were at times accompanied by gusts up to 45 mi./hr. This was attributed to the directly downwind orientation of the instrument.

Results

Table 1 shows that there were fewer net radiation measurements in 1961 than in 1958 (571 against 994), with a marked maximum in August. A comparison of the hourly distribution of the measurements in the two years is shown in Table 2. In 1958 the main concentration of measurements was between 0400 and 2200, whereas in 1961 the distribution is compressed between 0800 and 1800. However, the data appear more evenly distributed in 1961, and furthermore, they are as representative of the period of daily net radiation flux as those from 1958. Consequently the plots of the two sets of hourly daytime net radiation data in Fig. 1 are very similar, although the 1961 curve is slightly smoother. In both years there was an average of 14 hours of positive net flux per day for the summer months.

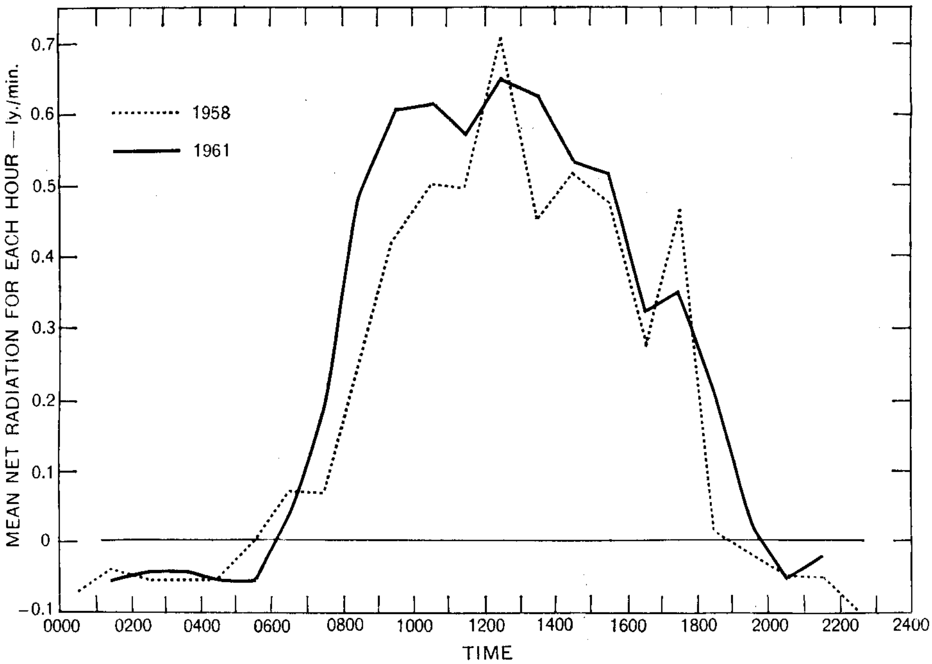

Fig. 1. Mean net radiation for each hour.

Times of the beginning and ending of positive radiation were 0530 and shortly after 1900 in 1958 and 0600 and 2000 in 1961.

The incoming and net radiation data from which the regression equations for the two years have been calculated are listed in Table 3. The times of the net radiation measurements from which the mean value was calculated are included.

A plot of the data is shown in Fig. 2.

(a) In 1958: Y = 0.121 + 0.00084 X. the method of least squares for the 1958 data is characterized by the formula:

$$Y = 0.121 + 0.00084 X,$$

where X is the daily total short-wave radiation and Y the mean daytime net flux.

For the 1961 data in Fig. 2 (b) the formula is:

$$Y = 0.152 + 0.00077 X.$$

In Fig. 2 (b) the curve for the 1958 data is also plotted to show the great similarity between the regressions. The correlation coefficients of 0.777 and 0.736 respectively also show this similarity.

From the regression formulae the mean solar radiation for the summer

Table 3. Radiation observations at Schefferville and vicinity in 1958 and 1961 that were used for regression analysis.

Date		*Mean daytime R_{net} ly./min.*	*Total daily incoming radiation ly./24hr.*	*Time of observation Atlantic St. Time*
1958	June 9	0.647	326	1010-1110
	10	0.643	605	0935-1620
	11	0.456	215	0935-2250
	12	0.768	550	1210-1345
	13	0.545	471	1100-1530
	18	0.462	375	0935-1635
	19	0.587	531	0940-1015
	21	0.900	771	0955-1550
	26	0.696	713	1200-1710
	27	0.206	407	0520-1200
	28	0.510	410	1130-1240
	July 6	0.747	768	0935-1415
	12	0.161	185	0550-1855
	13	0.282	493	1340-1355
	14	0.470	617	0955-1435
	21	0.227	275	0530-1125
	22	0.138	116	1045-1155
	27	0.294	193	1025-1610
	August 4	0.478	465	1005-2245
	5	0.507	239	1100-1545
	7	0.349	192	1010-1130
	8	0.417	278	1030-1605
	12	0.512	291	1415-1615
	21	0.319	308	0945-1615
	23	0.143	148	0930-1130
	26	0.247	248	1010-1130
1961	June 1	0.352	488	1550-2005
	4	0.563	513	1425-1710
	6	0.296	311	0930-1710
	9	0.611	653	0835-1705
	10	0.553	487	0805-1010
	12	0.827	780	0755-1825
	17	0.815	805	0925-1625
	28	0.579	503	0900-1530
	29	0.559	302	0950-1200
	July 20	0.314	547	0630-0940
	22	0.683	635	1025-1700
	23	0.255	209	1100-1425
	31	0.544	345	1325-1705
	August 2	0.684	635	1040-1625
	4	0.453	474	1025-1905
	5	0.450	283	0925-1415
	7	0.369	330	1050-1645
	8	0.576	387	1510-1645
	9	0.474	495	1455-1750

months can be calculated approximately by setting incoming solar and sky radiation equal to zero.

(a) In 1958: Y = 0.121 + 0.00084 X.

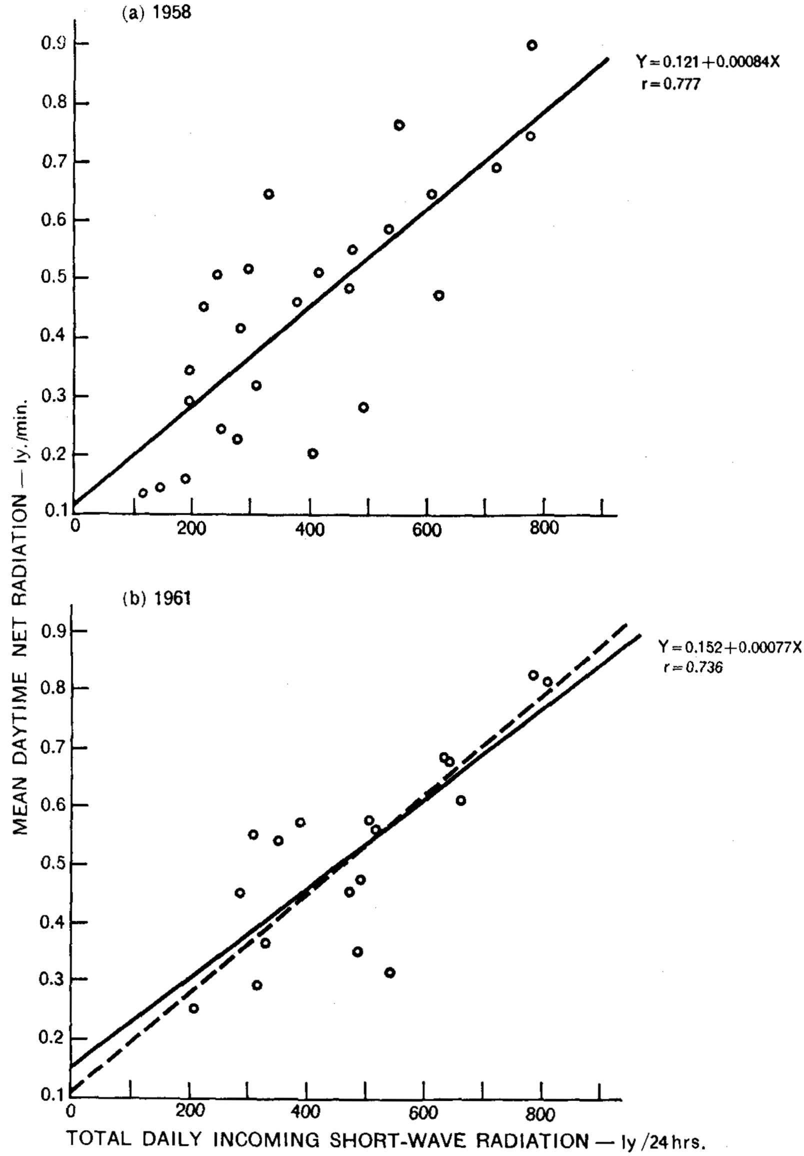

Fig. 2. Mean daytime net radiation.

Setting X as 0, Y becomes 0.121 ly./min. However, the average of the observed mean daytime net flux was 0.450 ly./min. and the mean solar radiation should thus be 0.329 ly./min.

(b) In 1961: Y = 0.152 + 0.00077 X. Setting X as 0, Y becomes 0.152 ly./min. However, the average of the observed mean daytime net flux was 0.524 ly./min. and the mean solar radiation should thus be 0.372 ly./min.

From the actinograph records the mean solar radiation for June, July, and August was 0.330 ly./min. in 1958 and 0.396 ly./min. in 1961. These values compare favourably with the mean solar radiation derived from the formulae.

Thus, from the data collected during

two different summers' field work, using a Suomi-Kuhn "Economical" Net Radiometer, it seems that either of the two regression equations can be used as a general, regional characteristic from which one may obtain approximate mean daytime net flux values from observations of total daily solar radiation.

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[1]Orvig, S. 1961. Net radiation flux over subarctic surfaces. J. Met. 18:199-203.

[2]Dutton, J. A. 1962. Space and time responses of airborne radiation sensors for the measurement of ground variables. J. Geophys. Res. 67:195-205.

[3]Shaw, R. H. 1956. A comparison of solar radiation and net radiation. Bull. Am. Met. Soc. 37:205-7.

[4]Suomi, V. E., and P. M. Kuhn. 1958. An economical net radiometer. Tellus 10:160-3.

N. S. F. Information Office

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A. P. CRARY

UNIVERSITY OF ALASKA GULKANA GLACIER PROJECT, 1962

Studies in glaciology and glacial geology on the Gulkana Glacier of the Central Alaska Range that were begun in 1960 (Arctic 14:74, 236) were continued during the summer of 1962 by members of the Department of Geology. The program is supported by a grant from the National Science Foundation to Dr. Troy L. Péwé, Head, Geology Department, University of Alaska. The U.S. Army, Ft. Greely, Alaska again generously supplied helicopter support to establish the base camps, and the U.S. Geological Survey kindly lent some equipment.

Gulkana Glacier lies on the south side of the Alaska Range about 4 miles east of the Richardson highway and 135 miles southeast of Fairbanks.

During the 1962 season two groups concentrated on special aspects of this project: (1) the re-formation of foliation at the base of the ice fall, and (2) the Recent history of Gulkana and East Gulkana glaciers.

The firn limit lies above the main ice fall of Gulkana Glacier (Gabriel Ice Fall) and thus the internal ice structures are exposed for about 1 to 2 months of the ablation season. To study these structures, particularly the reformation of the foliation following disruption in the fall, Dr. Donal M. Ragan, Assistant Professor of Geology, with one assistant, Walter Phillips, re-established a base camp at about 5000 feet. A closely spaced net of thirty stakes was set up in and immediately below the ice fall. This net, in combination with stakes surviving from 1961, was used for motion measurements, as a base for plane-table mapping, and for ablation measurements. Internal structures were mapped in detail; these included possible stratification that survived the ice fall, and various secondary planar structures that develop at the very base of the ice fall and that are progressively modified down-glacier into the typical nested-arc pattern. Proposed work on ice fabric was not done this summer because of an early onset of winter snow accumulation.

The Recent glacial history of Gulkana Glacier was studied by Richard D. Reger, graduate student in geology at the University of Alaska; he was assisted by Gerard Bond, also a graduate