Cahiers de géographie du Québec

Net radiation during cloudy, damp conditions in the snow-free season at Poste-de-la-Baleine (Great Whale), Québec

Cynthia Wilson

Volume 16, numéro 39, 1972

URI : https://id.erudit.org/iderudit/021080ar
DOI : https://doi.org/10.7202/021080ar

Aller au sommaire du numéro

Éditeur(s)

Département de géographie de l'Université Laval

ISSN

0007-9766 (imprimé)
1708-8968 (numérique)

Découvrir la revue

Citer cet article

Wilson, C. (1972). Net radiation during cloudy, damp conditions in the snow-free season at Poste-de-la-Baleine (Great Whale), Québec. *Cahiers de géographie du Québec*, *16*(39), 411–418. https://doi.org/10.7202/021080ar

Résumé de l'article

Dans une étude antérieure, on a trouvé une bonne corrélation linéaire entre le bilan du rayonnement et le rayonnement global à Poste-de-la-Baleine, en mai/juin, pour des surfaces humides de divers types par temps frais, humide et nuageux. On essaie ici de déterminer à partir des données météorologiques horaires de 1969 pour la station du AES jusqu'à quel degré cette corrélation caractérise entièrement la saison sans neige.

Les résultats indiquent que presque la moitié des heures diurnes se conforme à ces conditions, et que la courbe du rayonnement est typique du temps associé aux vents provenant de la mer. On signale quelques implications écologiques de cette conclusion.

NET RADIATION DURING CLOUDY, DAMP CONDITIONS IN THE SNOW-FREE SEASON AT POSTE-DE-LA-BALEINE (GREAT WHALE), QUÉBEC *

by

Cynthia WILSON

Centre d'Études nordiques, université Laval, Québec

INTRODUCTION

One of the long-term aims of the surface energy exchange study being undertaken by the Centre d'Études nordiques at Poste-de-la-Baleine is to try to determine for each season characteristic values associated with the different weather conditions and surface types. This station is situated at latitude 55°17' N. on the east coast of Hudson Bay, near the northern limit of tree growth along the Bay (figure 1). During the snow-free season, the radiation climate is strongly influenced by the high frequency of depressions, and until late in the season, by the relative cold of the ice and surface waters of the Bay.

THE PROBLEM

In a preliminary study from May 30 to June 1, 1970, point measurements of total insolation and net radiation were made over a variety of surface types with portable Dirmhirn and Dirmhirn-Sauberer instruments. The surfaces sampled included areas of sand, rock, rock pools, residual snow and ice partially or completely covered with sand, sparse coarse grass, scrub, lichens, dwarf spruce, mosses and peat. For the cool, humid, cloudy conditions (from fog to cirrus) and damp surfaces which prevailed during this period, the results indicated a close linear relationship between the net radiation (R) and total insolation (Q + q) for all surface types combined, where $R = 0.724\ (Q + q) - 0.002$ lys / min, and the standard error of estimate 0.019 ($N = 32$) ; the correlation coefficient, 0.998, was highly significant at the 1% level (Wilson and MacFarlane, 1971). These results are reproduced in figure 2.

The lack of significant differentiation in the net radiation from one type of surface to another was apparently the result of the equalizing effects

* *Mélanges* du Centre d'Études nordiques nº 59 (Hud-25).

Figure 1

THE LOCATION OF POSTE-DE-LA-BALEINE

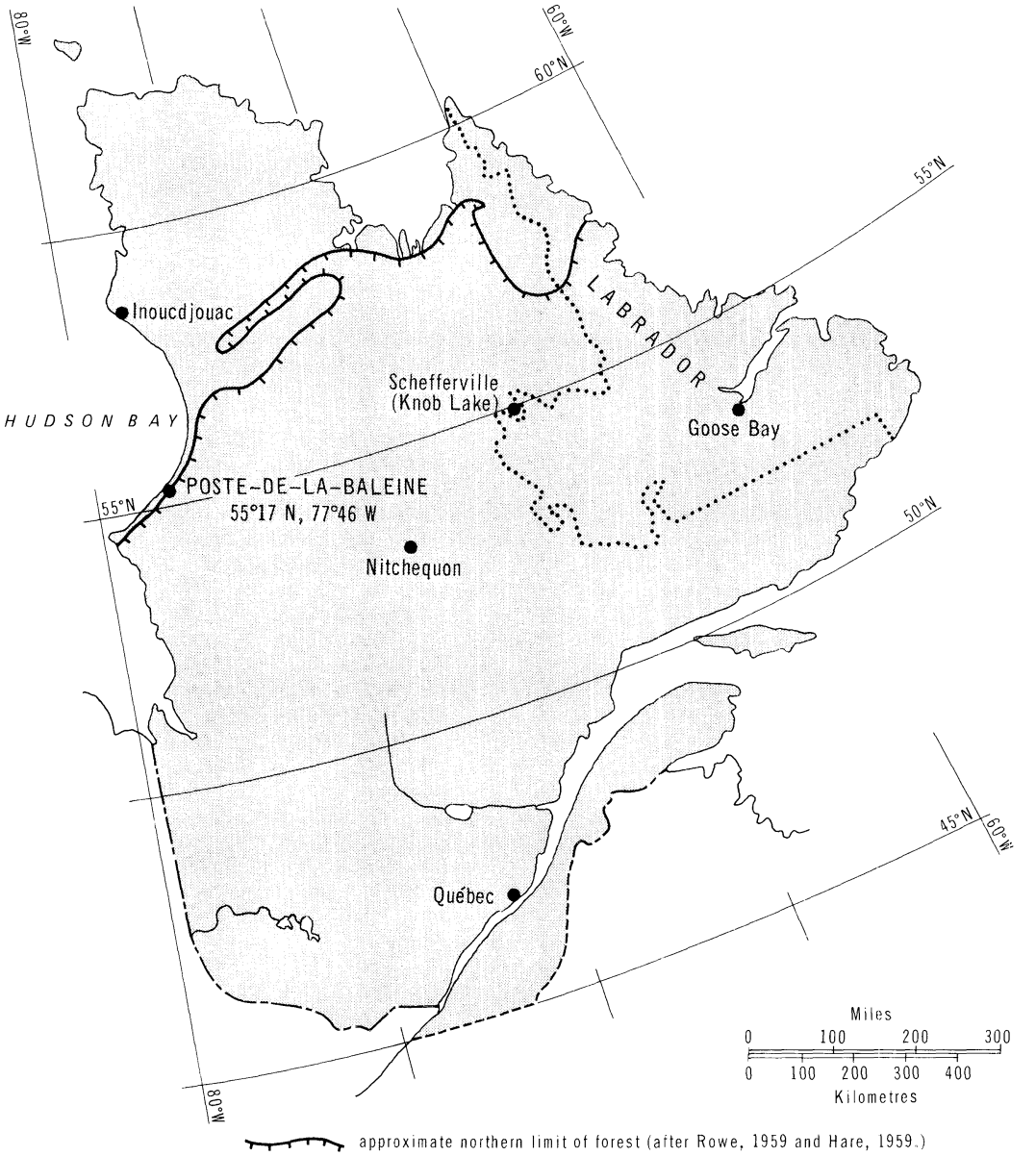
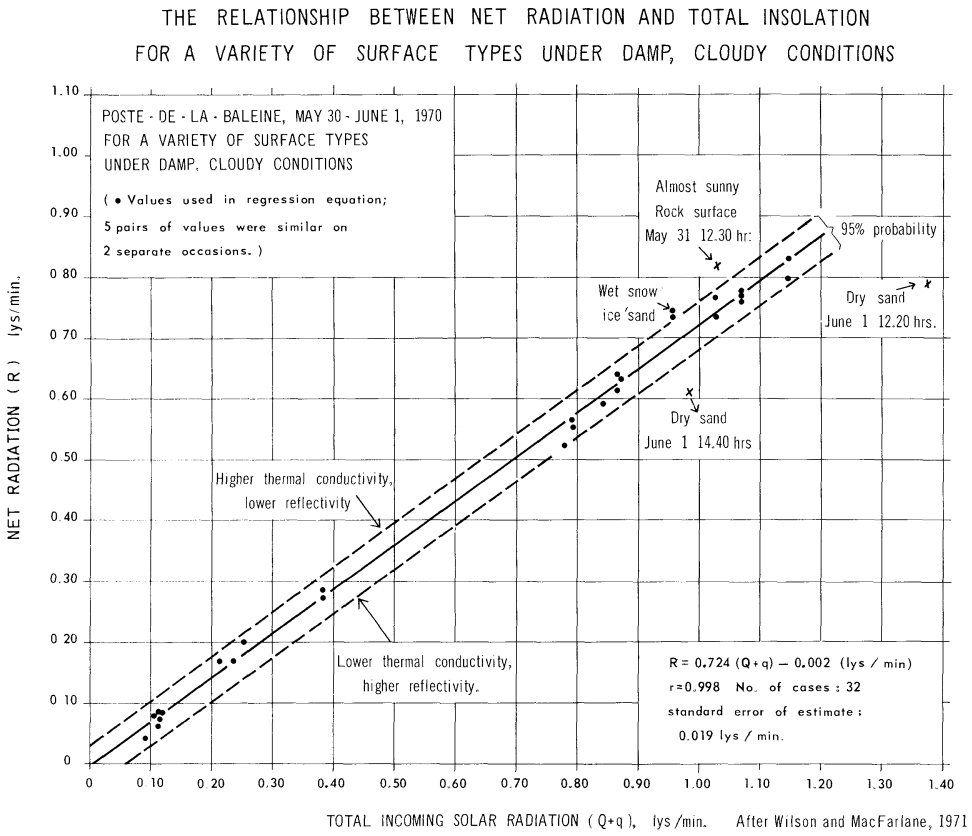


Figure 2



of the cloud cover and surface wetness : while the high proportion of diffuse radiation minimized the influence of surface roughness and texture on insolation, the wetness if the various surfaces minimized their differences in reflectivity and thermal conductivity. Three further pairs of measurements (excluded from the regression calculation) suggested that a considerable scatter of points might be introduced by the inclusion of dry surfaces even below cloud. A second point of interest is that although the insolation was often much reduced by the cloud cover, a relatively high percentage (~72%) of the energy received was available at the surface for physical, chemical and biological processes.

The question now arises as to what extent this curve is characteristic of the snow-free season at Poste-de-la-Baleine.

DATA AND ANALYSIS

An attempt was made to define the significant surface and atmospheric conditions at the time of the radiation measurements in terms of the

standard hourly observations of weather elements at the local AES station. The combined hourly frequencies of these selected elements were then obtained for the daylight hours of the snow-free season, May 16 to October 15, in 1969 [1].

1. *Surface conditions*

The determination of the period when the surface can be assumed damp involves both wetting and drying criteria. A « wet » hour was defined as one of observed precipitation, or fog, or the relative humidity at 1.5 m greater than 90%. The latter was included to allow for the presence of dew (cf. Monteith, 1957), and for the direct removal of water vapour from the atmosphere by some hygroscopic plant surfaces, for example lichens and mosses (Fraser, 1956, Brown, 1966).

The vapour pressure deficit and the air temperature at 1.5 m have been used to define an approximate limit to the duration of the period of dampness. The rate of evaporation depends on the temperature of the evaporating surface, the temperature and humidity gradients between the wet surface and the atmosphere, and the degree of mechanical turbulence. During the original observation period, the winds were from the Bay, with characteristic speeds from 5 to 9 m/s. Given overcast skies, and the moderate wind speeds generally associated with cold air advection at Poste-de-la-Baleine, it seems reasonable to assume that the surface temperature is similar to the air temperature at this level. In this case, the vapour pressure deficit at 1.5 m is closely related to the rate of drying of the surface. During the period of field measurements (with air temperatures ranging from 0° to 10° C), even sand and lichen surfaces remained damp when the vapour pressure deficit was equal to or below 1 mb. All daylight hours with temperatures $\leq$ 10° C and VPD $\leq$ 1 mb have therefore been considered as having damp surface conditions. Possible error related to the ignoring of the necessary time sequence — of the initial requirement of wetting of the surface — is believed to be small, owing to the very high frequency of light precipitation and fog (73% and 50% respectively of all days in the snow-free season, 1969), and the prevalent high relative humidities.

2. *Atmospheric conditions*

The restriction to air temperatures equal to or below 10°C was extended to all hours to set an upper limit to the absolute humidity at 1.5 m. The final required characteristic was a 9 to 10 tenths cloud cover.

The regional synoptic situations giving rise to the set of weather conditions under study had included both the passage of a depression and an anticyclonic interlude. The unifying factor appeared to be the prevailing

[1] The hourly data were kindly made available by the Atmospheric Environment Service of Canada.

winds off the Bay during both situations, owing to the general orientation and local curvature of the coast line. The combined hourly frequencies were therefore scanned to note the number of cases where the winds were in fact from these directions (from southwest to north, inclusive).

Table 1 summarizes these hourly weather criteria.

Table 1. ***Poste-de-la-Baleine : Hourly weather criteria.***

1. Hours with observed precipitation or fog or relative humidity $>$ 90%, + hours with vapour pressure deficit $\leq$ 1 mb.
2. Restricted to air temperatures $\leq$ 10°C.
3. Further restricted to cloud cover $\geq$ 9/10.

Final scanning of combined frequencies to note the number of cases where the winds were from Hudson Bay (southwest to north).

RESULTS AND DISCUSSION

The results of the analysis are illustrated in figure 3 [2]. During the snow-free season 1969, 44% of all daylight hours conformed to these conditions. In 87% of these cases, the winds were from the Bay (or, rarely, calm) ; in the remainder, the flow was principally from the south to southeast, associated with light showers or high relative humidity.

Dividing the season into half-monthly periods, the highest relative frequencies occurred in late May, early June and early October (64, 58 and 54% of the possible daylight hours, respectively), with values ranging from 33 to 38% during July and August. The autumn rise in relative frequency was interrupted in the second half of September, when the lowest value of the season, 29%, occurred. While the reduction in the frequency during the summer periods July 16 to August 31 was largely due to the upper temperature limit of 10°C, in September there was an abrupt decline both in the number of days with surface wetting and with overcast. For the individual semi-monthly periods, the percentage of cases with winds from the Bay only dropped significantly below the seasonal fraction in late September (to 66%) and early October (to 72%).

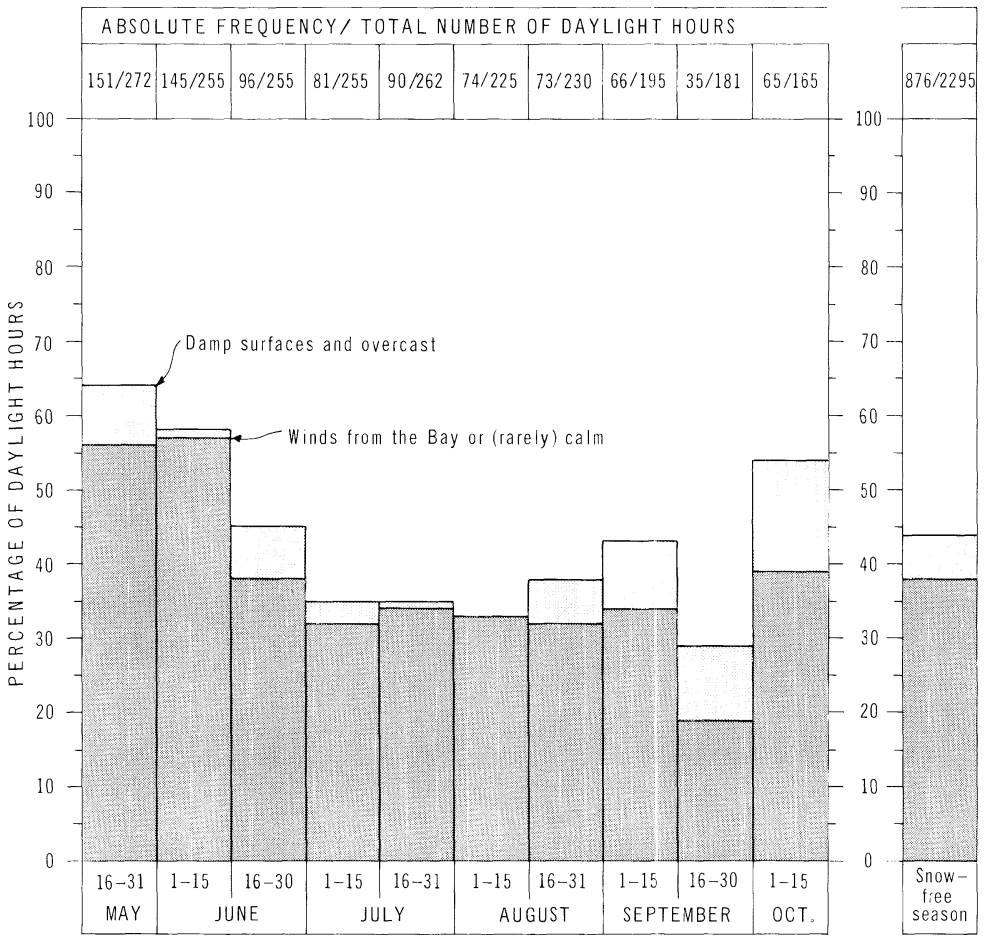
Although further radiation data are required to check the validity of the basic curve, these results suggest that the measured net radiation characteristics are representative, seasonally, of weather conditions associated with onshore winds. On a synoptic scale these are related both to depressions and to certain anticyclonic situations ; on a local scale there is a sea-breeze component and possibly topographic channeling along the coast. Normally an ice concentration of 2 to 3 tenths can be expected off the east coast of the Bay near Poste-de-la-Baleine in July, with clearing by early August, and maximum surface water temperatures of about 7°C in

[2] The absolute frequencies given in figure 3 refer to those cases where the winds were from the Bay. The corresponding values for all cases of damp surface conditions and overcast are 175, 147, 114, 89, 92, 74, 88, 84, 53, 89 and 1005, respectively.

Figure 3

POSTE-DE-LA-BALEINE : SNOW-FREE SEASON, 1969

RELATIVE FREQUENCY OF DAYLIGHT HOURS, WHEN IT IS PROBABLE THAT:
NET RADIATION = 0.724 (INSOLATION) − 0.002LYS/MIN, ±0.038,
WITH MINIMAL DIFFERENTIATION BETWEEN SURFACE TYPES.



September (Danielson, 1969). Until late in the snow-free season, the Bay as a cooling agent is especially effective in increasing the relative humidity and the coastal frequency of fog, drizzle and low cloud in the warmer, more humid southwesterly to westerly flow. In September and early October, the air/water temperature differences are frequently small, and towards the end of the season, the Bay begins to act as a source of heat and moisture with respect to cold, dry northwesterly flow. In 1969, the ice concentration remained greater than 7 tenths on July 23, and there was still ice offshore in mid-August, suggesting that the surface waters were also colder than normal in September.

A check on the climate at this station in 1969 against long-period means indicated in May and June an abnormal dominance of westerly flow over northerly, associated in turn with a higher average percentage of cloud cover, more days with precipitation and lower mean temperatures. Mid-summer conditions closely resembled the normal, although July received 25 mm less rain and August 43 mm more than usual. The incidence of fog, an important factor in surface wetting in the summer months, normally decreases sharply in September ; at the same time, there is a significant increase in the percentage of hourly winds from the land towards the Bay (cf. Powe, 1968). This was the case in 1969, although the month was exceptional (especially during the latter half) in the predominance of northerly rather than westerly flow. It was a period characterized by persistent and recurring anticyclonic situations over Keewatin and Hudson Bay. The mean monthly temperature was 4.2°C, 3.3°C lower than normal and probably similar to that of the offshore waters, and there were considerably fewer days with precipitation and reduced cloud cover. Powe has shown that in September there is a decrease in the relatively high frequencies of low cloud and poor visibility normally associated with north winds in late spring and summer. In general, it is believed that the 1969 seasonal frequency of the weather conditions under study is probably a representative climatological value, although there may be a small overestimate in the late spring and a similar underestimate in the fall.

CONCLUSION

This energy regime, related principally to cold air advection, would appear to be a basic component in the seasonal climate of the exposed coastal district. The following ecological implications are worth noting :

1) Although the total amount of the radiation input at the surface may be greatly reduced by atmospheric conditions, the surface wetness compensates to some extent by ensuring a higher efficiency in the absorption of radiation and in heat storage ;

2) The quality of solar radiation reaching the surface is considerably modified ;

3) Evaporation and evapotranspiration are minimal ;

4) The bulk of the surface energy is transferred to the atmosphere as sensible heat. However, winds from the Bay during this regime in 1969 were over 3.5 m/s (8 mph) on 96% of the occasions and generally above 5 m/s (11 mph), so that although cold advection favours the heat transfer, the heat would be diffused by turbulence and advected out of the area. The air temperatures associated with these conditions ($\leq$ 10°C) remain low with respect to plant requirements ;

5) The degree of exposure may give rise to important small-scale spatial differences along the coastal zone, with less exposed sites profiting

from this exchange of sensible heat to enjoy a warmer microclimate in the layer near the ground. On a larger scale, there is the question as to how far inland the influence of the Bay extends. This has yet to be explored, but preliminary ecological evidence suggests that it may be a relatively short distance in some areas.

REFERENCES

BROWN, R.J.E. (1966) *Influence of vegetation on permafrost.* Ottawa, National Research Council, 6 p. NRC 9274.

CANADA, ATMOSPHERIC ENVIRONMENT SERVICE (1971) *Ice, summary and analysis, 1969, Hudson Bay and Approaches.* Toronto. 47 p.

DANIELSON, E.W. (1969) *The surface heat budget of Hudson Bay.* Montréal, Marine Sciences Centre, McGill University. 196 p. Marine Sciences Manuscript Report no 9.

FRASER, E.M. (1956) *The lichen woodlands of the Knob Lake area of Québec-Labrador.* Montréal, McGill University. 28 p. McGill Sub-Arctic Research Papers no 1.

HARE, F.K. (1959) *A photo-reconnaissance survey of Labrador-Ungava.* Ottawa, Geographical Branch, Mines and Technical Surveys. 83 p.

MONTEITH, J.L. (1957) Dew. *Quarterley Journal, Royal Meteorological Society,* 83 : 322-341.

POWE, N.N. (1968) *The weather for Poste-de-la-Baleine airport.* Toronto, Atmospheric Environment Service, unpublished manuscript.

ROWE, J.S. (1959) *Forest regions of Canada.* Ottawa Department of Northern Affairs and National Resources, Forestry Branch. 71 p. Bulletin 123.

WILSON, C,. and M.A. MacFARLANE (1971) The radiation balance of snow-free surfaces at Poste-de-la-Baleine, Québec, May 30 — June 1, 1970. *Cahiers de géographie de Québec,* 15 (36) : 495-508.

ABSTRACT

Net radiation during cloudy, damp conditions in the snow-free season at Poste-de-la-Baleine (Great Whale), Québec.

In a previous study, a close linear relationship was indicated between net radiation and incoming solar radiation at Poste-de-la-Baleine, in late May/early June, for damp surfaces of many types, under cool, humid, cloudy conditions. Using the standard hourly weather observations at the AES station for 1969, an attempt is now made to determine to what extent this relationship may be typical of the entire snow-free season.

The results suggest that nearly one half of all daylight hours conformed to these conditions, and that the radiation curve is characteristic of weather associated with onshore winds. Certain ecological implications of this conclusion are noted.

KEY WORDS : Climate, Radiation
New Québec

RÉSUMÉ

Le bilan du rayonnement de la saison sans neige pour des conditions nuageuses et humides à Poste-de-la-Baleine (Great Whale), Québec.

Dans une étude antérieure, on a trouvé une bonne corrélation linéaire entre le bilan du rayonnement et le rayonnement global à Poste-de-la-Baleine, en mai/juin, pour des surfaces humides de divers types par temps frais, humide et nuageux. On essaie ici de déterminer à partir des données météorologiques horaires de 1969 pour la station du AES jusqu'à quel degré cette corrélation caractérise entièrement la saison sans neige.

Les résultats indiquent que presque la moitié des heures diurnes se conforme à ces conditions, et que la courbe du rayonnement est typique du temps associé aux vents provenant de la mer. On signale quelques implications écologiques de cette conclusion.

MOTS-CLÉS : Climat, rayonnement
Nouveau-Québec