PRELIMINARY RESULTS OF A STUDY ON SNOW AND GROUND THERMAL REGIMES
IN THE SCHEFFERVILLE AREA, NORTHERN QUEBEC

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ABSTRACT

Intensive monitoring of the thermal regime of the snow cover and the
near-surface layers of the ground were undertaken at a woodland site near
Schefferville from the period of December 1985 to May 1986. The monitoring
employed a datalogging system with multi-channel capacity for detailed
measurements of spatial and temporal variations in snow and ground
temperatures. The study was undertaken as a pilot project to an investigation
of snow and ground thermal regimes at an open woodland site and a lichen tundra
site in the 1986-87 field season.

INTRODUCTION

The influence of the seasonal snow cover on ground temperatures has long
been recognised (Bilello et al., 1970, 1972; Cary et al., 1978; Goodrich, 1978,
1982; Singh and Taillefer, 1984; Singh et al., 1984). However, the variations,
both in space and time, of snowpack properties and ground temperature
conditions at the boundary between the snow cover and the ground remain poorly
understood. This interface is the scene of much biological activity during the
winter. The temperature conditions at the interface are indicative of the
thermal regime of the root zone which is of crucial importance to the survival
of plant life.

This paper describes field measurements and preliminary results obtained
from a pilot study of snow and ground temperature measurements in a subarctic
woodland during the 1985-86 winter. The primary purpose of the data collection
was to field test a new datalogger installation and a multi-instrument
monitoring grid intended for more long-term operation during the 1986-87
winter.

FIELD MEASUREMENT

I. Site

The study was conducted in an open woodland on the McGill Subarctic
Research Station snow course near the town of Schefferville, Northern Quebec
(Figure 1). Vegetation characteristics at the site have been described by
Desrochers and Granberg (this volume).

Maximum and minimum air temperatures of +7.1 °C and -36.4 °C respectively,
and a maximum snow depth of 120 cm were recorded in the open woodland during
the period of December 1985 to May 1986. Prevailing northwesterly winds
modified the areal distribution of snow depth to the extent where snowdrifts
were, at times, greater than 1.5 m in open areas.

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II. Experimental Design

Data collection began in October 1985. Some start-up problems occurred and therefore the results presented in this paper are from December 1985 to May 1986 for two quadrants on a 10 m by 10 m grid. Measurements of 138 variables were undertaken on an hourly basis by a datalogging system with multi-channel capacity (Figure 2) and stored on cassette tape for later analysis. Figure 3 shows the instrumentation at the site.

Ground temperatures were measured at depths of 0.5, 2.5, 5.0, 10.0, 15.0, 20.0, 25.0, 50.0, 75.0 and 100.0 cm at six locations in the grid. Snow-ground interface temperatures were measured immediately below the moss and lichen layer at intervals of one metre along the six transects in the grid. Calibrated thermistors (Fenwal GB32P2) of +/- 0.001 °C nominal accuracy were used to obtain temperatures in the ground and at the snow-ground interface.

Snow temperatures were measured at levels of 0.5, 2.5, 5.0, 10.0, 15.0, 20.0, 30.0, 40.0, 50.0, 70.0, 80.0 and 90.0 cm above the ground surface at nine randomly located areas in the grid. The snow sensors that were used to measure temperatures in the snow cover were designed from 20 AWG, Type K, shielded, white PVC insulated thermocouple cables. Air temperature and relative humidity were measured with a Campbell Scientific Model 207 probe and monitored by the 21X datalogging system. Snow-air interface temperatures and snow depths were derived by comparing temperatures obtained from thermocouples nearest to the snow surface with the ambient air temperature in a Stevenson screen (1.5 m height).

Ground heat flux was measured at 3 cm below the ground surface using a Thornewaite Soil Heat Flux Disk and outward flux of vapour from unfrozen and frozen ground was determined using "vapour traps" placed on the ground surface. Soil moisture, wind speed, global radiation and albedo of the open woodland site were not measured during this particular time period, however they will be monitored during the 1986-87 field season. A Campbell Pacific Neutron Probe (503 Hydroprobe) will be used to measure the moisture content of ground material to a total depth of one metre at intervals of 5 to 10 cm. In addition, wind velocity will be obtained from a self-pulse generating AES anemometer and the radiation components will be obtained from two Eppley Precision Pyranometers (Model PSP). The instruments will be monitored by the 21X datalogging system at hourly intervals for the meteorological components and at four hour intervals for all remaining components.
PRELIMINARY RESULTS

I. General Climate

Snow depths on the McGill snow course for a stake five metres away from the study grid and for the area beneath a tree (SS1) and in the open (SS4) are recorded in Figure 4. The large differences in depth between stake # 10 and the two snow sensor devices are caused by interception. In addition to snowfall, a few rain showers and warm weather events took place during the study period, and winter temperatures, as well as snow depths were well below normal conditions. The normal yearly precipitation at Schefferville is approximately 785 mm of which 30 per cent falls between the months of December and May (Farr and Wright, 1981).

II. Ground Temperatures

Time-temperature profiles of the ground at both areas within the study grid are plotted in Figure 5. Freezing to a depth of 25 cm was not initiated until early January at both areas beneath a tree (GC1) and in the open (GC3). Ground frost reached a maximum depth of 50 cm in late April at GC1 and early March at GC3. Moisture content of soil layers were not obtained due to instrument failure, however soil pit observations indicated that soils beneath the tree were much drier than soils in the open area during very wet early winter conditions.

Snow depth had a major influence on ground temperatures. At GC1, ground temperatures were consistently colder between the depths of 0.5 to 25 cm than at GC3. Reasons for this may be associated with: (i) the very shallow snow cover beneath the tree at GC1 in comparison with the relatively deeper snow cover conditions in the open area at GC3, (ii) the available soil moisture
Figure 3. Map and instrumentation set-up at the snow course study site.
Figure 4. Snow depth at the study site from December 1, 1985 to May 15, 1986.

Figure 5. Ground temperature profiles from December 1, 1985 to May 15, 1986. (a) Beneath a tree at location GC1. (b) In an opening at location GC4. The top isotherm in each plot represents the 0.5 cm level in the ground and the bottom isotherm represents the 100.0 cm level at depth. Intervals are mentioned in the text.
present at the near-surface levels and/or depth to the water table, (iii) the effects induced by air temperatures and winds.

III. Snow Temperatures

Time-temperature profiles of the snow cover at both areas are plotted in Figures 6 and 7. Near-surface temperatures at SS1 were 4 to 5 °C cooler than at SS4. The effect of snow as an insulator is important, but such conditions as snow depth, air temperature and forest cover also control the thermal regime of a snowpack. The isotherms in Figures 6 and 7 were dependent on these conditions. Isothermal temperatures were reached intermittently in mid-April and snowmelt started in early May.

A major warming effect followed by a rain-on-snow event occurred in mid-January. This event was quickly monitored by the snow temperature sensors as shown by the arrow on Figures 5 and 6.

Figure 6. Time-temperature profile of the snow cover beneath a tree (SS1) from December 1, 1985 to May 15, 1986. The top isotherm represents the 0.5 cm level above the ground surface and the bottom isotherm represents the 90 cm level. Arrow points to a rain-on-snow event.

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Figure 7. Time-temperature profile of the snow cover in an opening (SS4) from December 1, 1985 to May 15, 1986. The top isotherm represents the 0.5 cm level above the ground surface and the bottom isotherm represents the 90 cm level. Arrow points to a rain-on-snow event.

CONCLUSIONS

The intensive monitoring techniques used in this pilot project have provided useful information in the spatial and temporal variations of temperatures in snow, ground and snow-ground interface. The preliminary results presented in this paper have shown that numerous measurements of snow and ground components can be obtained from data logging installations in extremely cold conditions. Detailed analysis of the data will aid in the understanding of interface conditions and its intervening heat transfer problems through the snow cover and the ground.

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