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Permafrost Ground Temperature Report: Scotty Creek Research Station, Northwest Territories

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NORTHWEST TERRITORIES
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Northwest Territories

Cover photo caption:
Forested peat plateaus and wetland terrain, the typical landscape around the Scotty Creek Research Station, on 20 August 2018.

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Introduction

Project description

This report includes a compilation of ground temperature data recorded at the Scotty Creek Research Station, Northwest Territories (NWT) since the inception of the research site in 2001. Meteorological data (four components: radiation, air temperature, relative humidity, and wind speed) can be provided by the author (William Quinton). Ground heat flux, soil moisture, soil thaw, precipitation and snow survey data have been collected at the site continuously since 2001.

Location

The Scotty Creek Research Station (61°18'N; 121°18'W) is located in the peatland headwaters of Scotty Creek, approximately 50 km south of Fort Simpson, NWT. Scotty Creek drains into the Liard River, about 40 km south of where the Liard River meets with the Mackenzie River.

Principal investigator and partners

Ryan Connon: Project Manager, Wilfrid Laurier University
William Quinton: Data Ownership, Wilfrid Laurier University

Data usage policy

Complete metadata and data associated with this summary are available with this report. The use of the published data will not carry restrictions. Full citation of referenced publications and reports by users is required.

Table 1. Summary of the ground temperature data included in this report.

Northwest Territories Region	Dehcho
Number of Sites	14
Maximum Sensor Depth (m)	9.28
Minimum Sensor Depth (m)	0.5 above ground
Record Start Date (YYYY-MM-DD)	2001-08-20
Record End Date (YYYY-MM-DD)	2017-01-29
Raw Data Included (Y/N)	Y

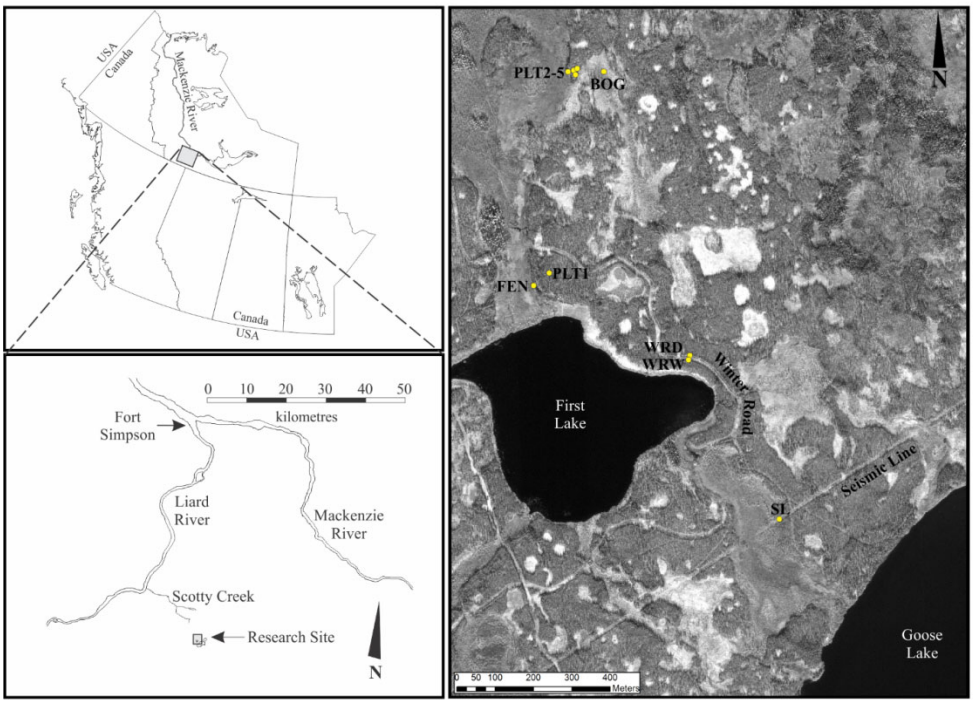

Figure 1. Map showing the location of sites with an inset map of the Northwest Territories showing the location of the study area.

Data collection approach

Research Design

The ground temperatures in this report are a combination of deep (permafrost) and shallow (suprapermafrost) thermistor strings. Permafrost around Scotty Creek is thawing rapidly, and as such, some thermistor strings initially installed in permafrost are no longer in permafrost. Thermistors have been installed in different terrain types. Each installation is named by site and the depth of the thermistors (deep or shallow). The prefix of the name describes the land cover type, and the suffix describes the depth.

Prefix:
SL: Seismic Line
WRW: Winter Road Wet
WRD: Winter Road Dry
PLT: Plateau
BOG: Bog
FEN: Fen

Suffix:
DP: Deep
SHLW: Shallow

For example, SL_DP refers to the deep thermistors on the seismic line. Note that there are five different plateau installations, labelled PLT1, PLT2, PLT3, *etc*.

Installation

Deep thermistors were installed into the permafrost using a water jet drill. These thermistors were installed in 2010. At each deep thermistor site, there is also a set of shallow thermistors (0.05 m, 0.2 m, 0.4 m, and 1.0 m below the ground surface). The shallow thermistors were installed in a pit that was hand-excavated. Additional sites at Scotty Creek have shallow thermistors in the suprapermafrost layer. Pits were excavated with a shovel and sensors were inserted horizontally into the face of the soil pit. Pits were backfilled with effort made to retain original stratigraphy. The only exception is the installation in a bog, where thermistors were attached to a wooden dowling which was inserted into the ground.

Instrumentation

The sensors on the deep thermistor strings are RBR XR-420. The shallow thermistors at the same locations are Hobo TMC-HD sensors connected to a Hobo U12-008 logger. The other shallow thermistors are Campbell Scientific 107B thermistors connected to a CR10X data logger.

Calibration

Calibration is currently unknown and assumed to be the standard factory calibration provided by either RBR, Hobo or Campbell Scientific Canada.

Special circumstances or conditions

Shallow thermistor pits equipped with Campbell Scientific 107B thermistors were excavated to the permafrost table at the time of installation. Vertical permafrost thaw has substantially increased the thickness of the suprapermafrost layer (thickness of ground above permafrost) and has created a talik between the active layer and permafrost. Depth to permafrost at the shallow thermistor installation was about 0.7 m, whereas depth (in 2016) is about 2.0 m. Note that there is no permafrost beneath the sensors at the bog and fen sites.

Ground temperature record

Period of the record

Deep RBR Thermistors:
July 26, 2011 – 2016 (SL_DP, WRW_DP, WRD_DP, PLT1_DP, FEN_DP)

Shallow Hobo Thermistors:
July 31, 2012 – 2016 (SL_SHLW, WRW_SHLW, WRD_SHLW, PLT1_SHLW, FEN_SHLW)

Shallow Campbell Thermistors:
August 20, 2001 – 2016 (PLT2_SHLW)
April 14, 2004 – 2016 (PLT3_SHLW)
May 14, 2004 – 2016 (BOG_SHLW Original Thermistors)
May 18, 2004 – 2016 (PLT4_SHLW, PLT5, SHLW)
August 24, 2008 – 2016 (BOG_SHLW New Thermistors)

Measurement interval

The RBR and Hobo thermistors read and record the temperature at the logging interval indicated below. The shallow Campbell thermistors read a value every minute and record the average value over the measurement interval (*i.e.,* if the logging interval is 1 hour, the average of 60 values is recorded).

Deep RBR Thermistors:
1-hour intervals

Shallow Hobo Thermistors:
2-hour intervals

Shallow Campbell Thermistors:
20 August 2001 – 17 September 2004: 1-hour intervals
17 September 2004 – present: 0.5-hour intervals

Care and maintenance

All thermistors have remained in the ground since installation. There has been no maintenance to the sensors. However, batteries are checked periodically throughout the summer season. Data loggers are typically downloaded at least once per year.

Missing data

Missing data occurs due to either insufficient battery power or lack of memory in the datalogger, which may result in periods of missing data.

Special notes:

PLT1_DP: After July 31, 2012, the data appears to be erroneous. Constant temperatures are reported at 0.0043°C at all depths. Realistic trends (not values) become detectable at about the 9th decimal place; hence, there may be a problem with the logger and that this data may be correctable. It is unadvisable to use the data.

FEN_DP: The sensor at 0.4 m below the ground surface produces data that is not realistic for this depth. The values appear to be more closely related to air temperatures than the subsurface. Although the sensor was installed at 0.4 m below the ground surface, it appears the sensor is now closer to 0.05 m or 0.1 m below the ground surface.

BOG_SHLW: Two thermistors (0.1 m and 0.3 m below ground surface) were installed in May 2004. An additional eight thermistors (0.1 m, 0.2 m, 0.3 m, 0.4 m, 0.5 m, 0.6 m, 0.8 m, and 1.0 m below ground surface) were installed in August 2008. The original two remained installed; however, there is a noticeable drift in the data of the original thermistor 0.3 m below the ground. These absolute values should not be used.

Changes to measurement interval or measurement depth

A change to the measurement interval of the shallow Campbell thermistors was made on 17 September 2004. The logging interval was changed from 1 hour to 0.5 hours. No changes to the measurement depths have been made since the sensors have been installed.

Site conditions

For a complete site description, the reader is referred to the study site section Quinton *et al*. (2003) and Hayashi *et al.* (2007). Hayashi *et al.* (2007) provides a detailed description of the shallow Campbell thermistors installed in 2001.

Special site conditions

Permafrost at Scotty Creek only exists on forested peat plateaus. Wetland sites (bogs and fens) are devoid of permafrost. Permafrost still exists underneath linear disturbances (seismic lines and old winter roads), but is degrading rapidly in response to the removal of the forest canopy.

Disturbance

Disturbances at Scotty Creek are limited to seismic lines and old winter roads. These linear disturbances involved the removal of the forest canopy and compaction of near-surface peat and are typically 5 m to 10 m wide. A complete description of disturbances can be found in Williams *et al.* (2013). Three of the deep RBR thermistor strings and three of the shallow Hobo thermistor strings are located on linear disturbances (WRW, WRD, and SL sites).

Expected temporal variability

Northwestern Canada is one of the most rapidly warming regions in the world. There has been a rapid loss of permafrost at the study site, and a concomitant change to basin hydrology (Quinton *et al.* 2011; Connon *et al.* 2014). The effects of the thawing permafrost are evident in the ground temperature dataset.

Expected changes

None

Available supplementary data (see Appendix)

Snow survey data is provided for different transects from 2006 to 2014. Each land cover type (lake, fen, bog, peat plateau) has different snow accumulation and retention characteristics. Snow depth, density, and snow water equivalent (SWE) measurements were made. There is a map illustrating the locations of each transect. Meteorological data has been provided to Environment and Natural Resources. Measurements are taken in a bog; metadata file contains sensor names and measurement heights.

Related publications

Connon, R.F., Quinton, W.L., Craig, J.R., and Hayashi, M., 2014. Changing hydrologic connectivity due to permafrost thaw in the lower Liard River valley, NWT, Canada; *Hydrological Processes*, 28, 4163-4178, doi:10.1002/hyp.10206.

Hayashi, M., Goeller, N., Quinton, W.L., and Wright, N., 2007. A simple heat-conduction method for simulating the frost-table depth in hydrological models; *Hydrological Processes*, 21, 2610-2622, doi:10.1002/hyp.6792.

Quinton, W.L., Hayashi, M., and Chasmer, L.E., 2011. Permafrost-thaw-induced land-cover change in the Canadian subarctic: implications for water resources; *Hydrological Processes,* 25, 152-158, doi:10.1002/hyp.7894.

Quinton, W.L., Hayashi, M., and Pietroniro, A., 2003. Connectivity and storage functions of channel fens and flat bogs in northern basins; *Hydrological Processes,* 17, 3665-3684, doi:10.1002/hyp.1369.

Williams, T.J., Quinton, W.L., and Baltzer, J.L., 2013. Linear disturbances on discontinuous permafrost: implications for thaw-induced changes to land cover and drainage patterns; *Environment Research Letters.* 8, 12 pages, doi:10.1088/1748-9326/8/2/025006.

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Terms of use

References

Connon, R.F., Quinton, W.L., Craig, J.R., and Hayashi, M., 2014. Changing hydrologic connectivity due to permafrost thaw in the lower Liard River valley, NWT, Canada; Hydrolological Processes, 28, 4163-4178, doi:10.1002/hyp.10206.

Ecosystem Classification Group, 2012. Ecological Regions of the Northwest Territories – Southern Arctic; Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. x + 170 pp. + insert map.

Fulton, R.J., 1995. Surficial materials of Canada; Geological Survey of Canada, "A" Series Map no. 1880A

Hayashi, M., Goeller, N., Quinton, W.L., and Wright, N., 2007. A simple heat-conduction method for simulating the frost-table depth in hydrological models; Hydrological Processes, 21, 2610-2622, doi:10.1002/hyp.6792.

Quinton, W.L., Hayashi, M., and Chasmer, L.E., 2011. Permafrost-thaw-induced land-cover change in the Canadian subarctic: implications for water resources; Hydrological Processes, 25, 152-158, doi:10.1002/hyp.7894.

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Williams, T.J., Quinton, W.L., and Baltzer, J.L., 2013. Linear disturbances on discontinuous permafrost: implications for thaw-induced changes to land cover and drainage patterns; Environment Research Letters. 8, 12 pages, doi:10.1088/1748-9326/8/2/025006.