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ABSTRACT

Ground temperature data were acquired in August 2016 from 14 boreholes along the northwestern section of the Alaska Highway corridor between kilometre post (KP) 1559 and KP 1895 near the Alaska border. Mean annual ground temperatures, determined at or near the zero annual amplitude depth, indicate that permafrost temperature in this section of the corridor is generally above -1°C with colder conditions near the Alaska border where permafrost can be as cold as -3°C. Temperatures measured in the upper 1-2 m indicate that permafrost is present at some sites where surface temperatures are above 0°C and where a sufficient thermal offset exists. These new data have extended existing records so that time series for these sites are 3 to 5 years long. Although mean annual air temperatures in the corridor have increased over the last few years, there is no consistent trend in ground temperature apparent in the short records. The information obtained helps characterize regional permafrost conditions in the southern Yukon and informs climate change impact assessments and adaptation planning.

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INTRODUCTION

The Alaska Highway corridor traverses the discontinuous permafrost zone of the southern Yukon from the Alaska border to northern British Columbia. It is important to have information on current permafrost conditions in order to design new development projects or adapt existing infrastructure to a changing climate. Although a great deal of information on permafrost conditions including its thermal state was collected in the late 1970s to support a pipeline proposal (e.g. Burgess et al. 1982), until a few years ago there was limited information on current ground temperature conditions in the corridor. Changes in permafrost conditions have been documented in the corridor and elsewhere in northern Canada (James et al. 2013; Smith et al. 2010) so it is essential to have up to date information on ground thermal conditions for characterization of the terrain response to construction and operation of infrastructure and to ensure that the integrity of both the infrastructure and the environment is maintained under current and future climates.

Over the last decade, the Geological Survey of Canada (GSC) has collaborated with university and territorial partners to instrument boreholes and collect ground temperature information to enhance our knowledge of permafrost conditions in the corridor. In July 2013, eight cased boreholes, acquired from TransCanada Pipeline Ltd. (TCPL), were instrumented in collaboration with the Yukon Department of Highways and Public Works, Yukon Research Centre and Yukon Geological Survey (Smith and Ednie, 2013). These are located on the Alaska Highway easement between the Alaska border and kilometre post (KP) 1559 near Haines Junction (Figure 1). These boreholes complement a suite of boreholes instrumented in 2011-12 in the same section of the corridor in collaboration with the University of Ottawa (see Duguay, 2013, Smith et al. 2015), including boreholes in which the GSC previously made measurements in the late 1970s and early 1980s. This report provides a summary of the data acquired from 14 of these boreholes in August 2016.

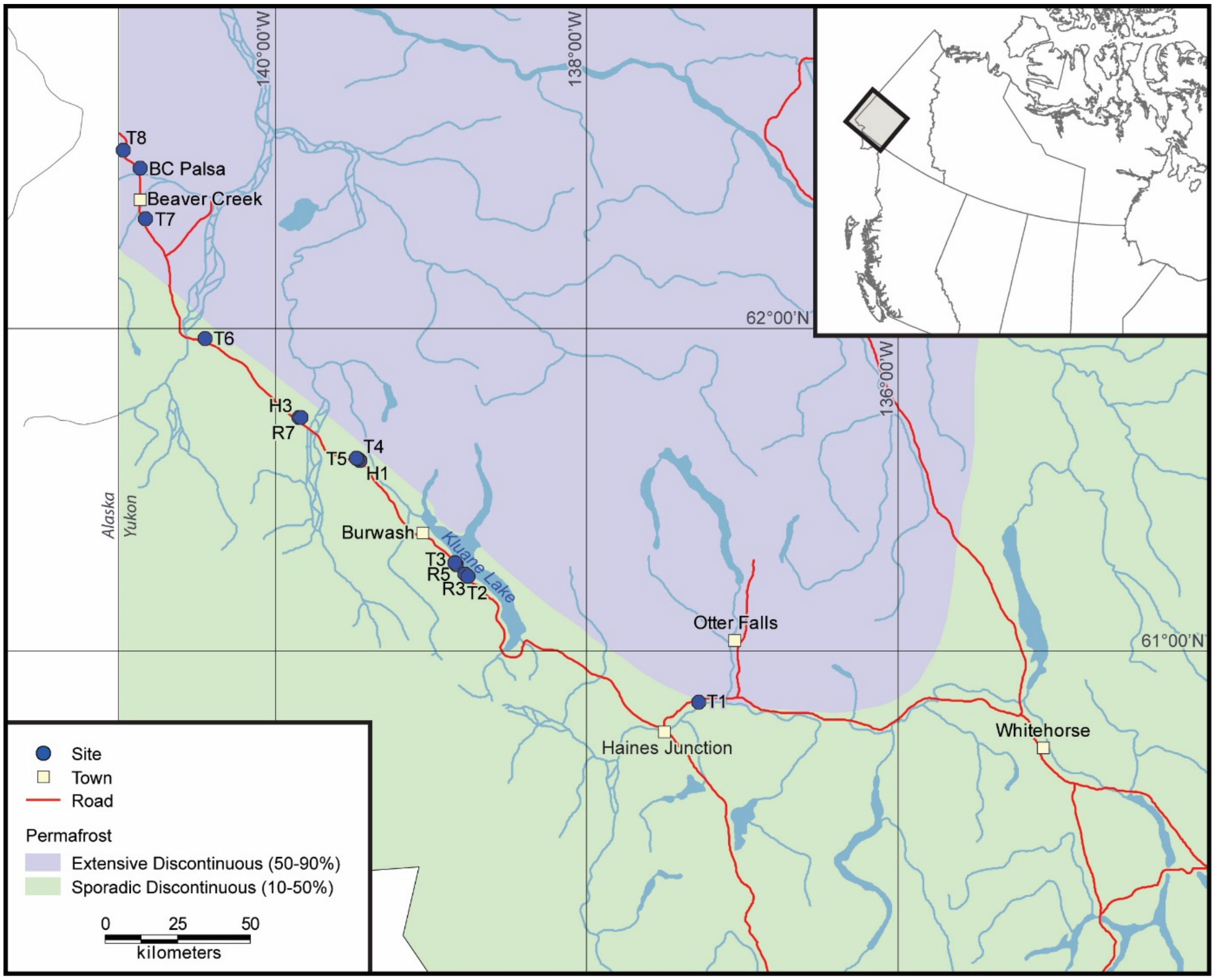

Figure 1. Location of boreholes along the Alaska Highway visited in August 2016, including ones on the easement instrumented in summer 2013 ("T" sites) and other boreholes instrumented in 2011-2012. Permafrost zones (from Heginbottom et al. 1995) are also shown.

STUDY SITES AND INSTRUMENTATION

The field sites are located along the Alaska Highway corridor (Figure 1) between KP1559 and KP1895. The study area is located within the Western Cordillera and the highway corridor crosses (east to west) the Teslin and Kluane Plateau over the Shakwak Trench and follows the Kluane Ranges (Mathews, 1986). Elevation in the region is variable reflecting the numerous mountains, valleys and plateaus. However the highway corridor itself is less variable in elevation than the surrounding area with elevation of the study sites ranging from approximately 600 to 850 m a.s.l. Most of the area has been glaciated although some areas around Beaver Creek remained ice free (Duk-Rodkin 1999; Rampton 1969, 1971). The glacial history of the region is described by Bond (2004), Duk-Rodkin (1999), Fulton (1989), Jackson et al., (1991), Rampton (1969, 1971) and summarized in Smith and Ednie (2013).

Surficial materials in the study area vary from coarse-grained sands, gravels and tills, associated largely with moraine and outwash deposits, to fine-grained silts and clays associated with alluvial and lacustrine deposits (Fuller and Jackson, 2009; Clague, 1989). Peat, generally less than 5 m thick is found in poorly drained areas (Clague, 1989; Foothills Pipe Lines, 1979). Sediment thickness generally exceeds 10 m in the section of the corridor where the boreholes are located (Foothills Pipe Lines, 1979). According to terrain analysis presented in the Environmental Impact Statement for the original pipeline application (Foothills Pipe Lines, 1979), peat was observed in about 35% of the terrain in the section of the corridor within 370 km of the Alaska border where the study sites are located.

The climate in the southern Yukon is subarctic continental, with cold winters and short mild summers (Jackson et al., 1991). Climate data are available from Environment Canada weather stations along the corridor between Whitehorse and the Alaska border (Whitehorse, Haines Junction, Burwash and Beaver Creek). Mean annual air temperature (based on 1981-2010 Normals) ranges from 0°C at Whitehorse to -4.9°C at Beaver Creek. Mean January air temperature ranges from -15.2°C at Whitehorse to -25.2°C at Beaver Creek. Mean July temperatures are lower at Haines Junction and Burwash (7.2°C and 13.1°C respectively) compared to Whitehorse and Beaver Creek where they are about 14°C. Mean total annual precipitation is greater in the western portion of the corridor, where it exceeds 400 mm, compared to Whitehorse which receives 262 mm. The proportion of total precipitation that falls as snow is 30-40%.

Monthly air temperature for August 2015 to July 2016 is shown for three Environment Canada weather stations in Figure 2. Overall, the mean air temperature for 2015-16 was higher than the 1981-2010 Normals and the previous two years. Warmer than normal conditions occurred during winter 2015-16. At Burwash Landing for example, the January 2016 air temperature was 7.6°C higher than the normal January temperature of -20.5°C. At Whitehorse, January 2016 temperature was 6.5°C warmer than the normal January temperature of -15.2°C. July 2016 temperatures for these sites were 1.3°C higher than normal.

The highway corridor is located largely within the sporadic discontinuous permafrost zone according to Heginbottom et al. (1995), except for a portion within about 50 km of the Alaska border that is in the extensive discontinuous zone (Figure 1). However, studies done in the 1970s (Foothills Pipelines, 1979) as well as modelling studies by Bonnaventure et al. (2012) indicate that permafrost is nearly continuous in the area north of Kluane Lake. South of Kluane Lake permafrost is less abundant, becoming patchy near Whitehorse where it is largely limited to organic terrain (James et al, 2013; Lewkowicz et al., 2011). Observations from geotechnical investigations and ground temperature measurements in the 1970s indicate that permafrost is generally less than 20 m thick throughout most of the corridor but the thickness exceeds 45 m near the Alaska border. (Burgess et al., 1982; Foothills Pipelines, 1979, Smith and Burgess, 2002). Recent electrical resistivity tomography surveys also indicate that permafrost is thicker than 20 m northwest of Burwash Landing (Duguay, 2013). Historical and recent ground temperature measurements in the northwest section of the corridor indicate that permafrost is generally warm with temperatures above -3°C (e.g. Burgess et al. 1982; Smith et al. 2015, 2016).

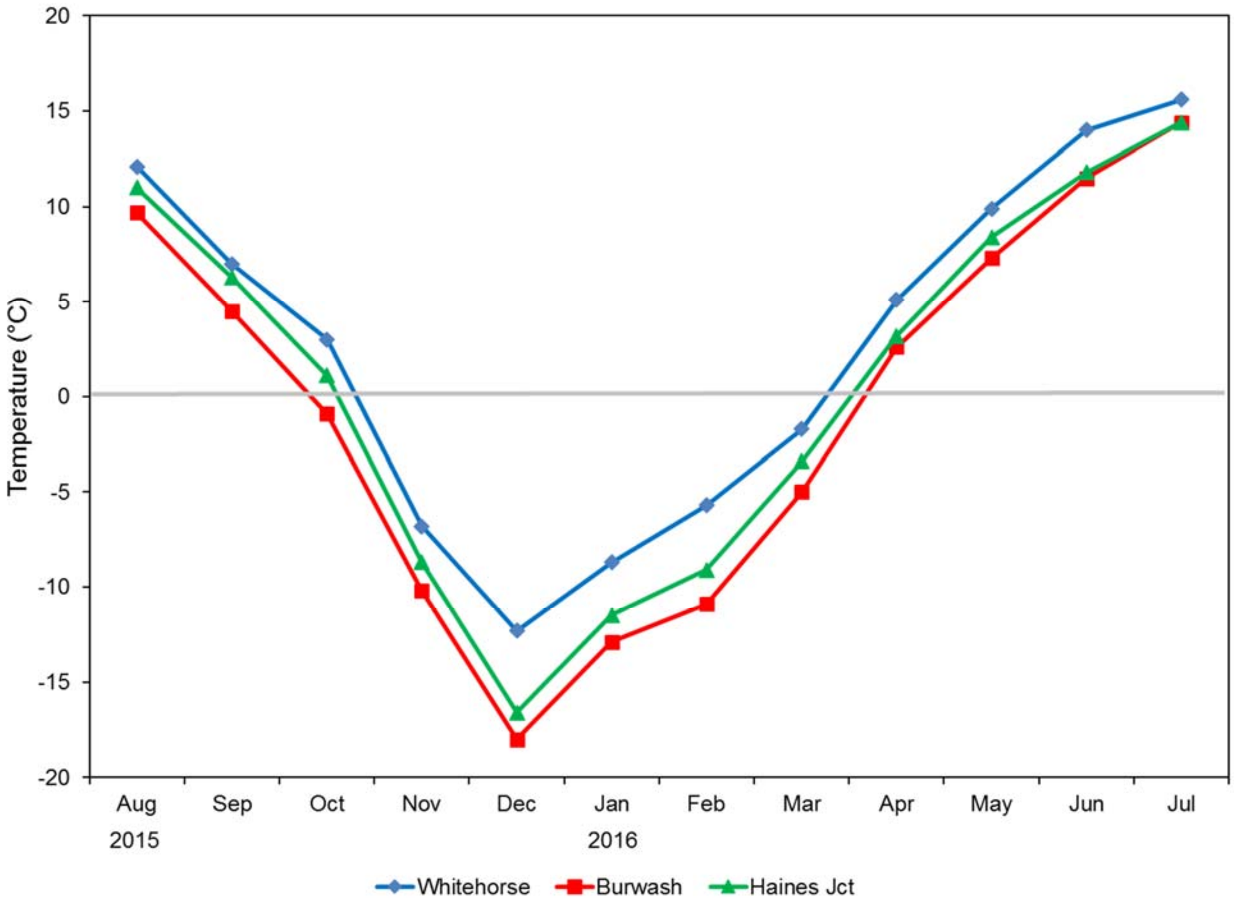

Figure 2. Air temperature for August 2015 to July 2016 for Environment Canada Weather Stations in the corridor.

The locations of the eight boreholes that were instrumented in 2013 ("T" Sites) are shown in Figure 1 and brief site descriptions are provided in Table 1. These boreholes are located on the highway easement, 10 to more than 30 m from the existing highway, with many located in or near previously disturbed areas. See Smith and Ednie (2013) for additional information including site photos. Six of the boreholes instrumented with University of Ottawa in 2011 and 12 (Figure 1, Table 1) are also included in this report. Five of these are boreholes ("R" and "H" sites) in which the GSC had made ground temperature measurements in the late 1970s and early 1980s (see Duguay, 2013, Smith et al. 2015) while one is located in a palsa ("BC Palsa" site) near Beaver Creek.

The cased boreholes were up to 10 m deep and were instrumented with multi sensor temperature cables. For most boreholes (Table 1) multi-thermistor cables (accuracy better than ±0.1°C) were attached to eight channel data loggers manufactured by RBR Ltd. (resolution better than ±0.01°C) that recorded temperature at 8 hour intervals. Some of the shallower boreholes (Table 1) were instrumented with 4-channel HOBO Microstation loggers (manufactured by Onset Corp.) connected to HOBO 12-bit temperature sensors to measure temperatures at four hour intervals. The accuracy and resolution of this system are better than ±0.2°C and ±0.03°C respectively.

Table 1. Location and description of sites visited in August 2016. Borehole location shown in Figure 1.

Site	Lat (°N)	Long (°W)	Approx. KP	Site Description	Soil description	Instrumentation
Easement sites established in 2013						
AH2013-T1	60.840	137.278	1559.6	Disturbed area between highway and old road	Silt (<1m) underlain by sand	HOBO logger with sensors installed to 4.95 m
AH2013-T2	61.232	138.762	1681.4	Open area with shrubs on edge of conifer forest	Organic silt (~1 m) over sandy till	RBR logger and multi-thermistor cable installed to 9.67 m
AH2013-T3	61.273	138.847	1687.7	10-15 m from embankment, open area with shrubs, ground cover, hummocky, edge of conifer (black spruce) forest	Organic silt (~1 m) underlain by silt	RBR logger and multi-thermistor cable installed to 7.43 m
AH2013-T4	61.595	139.468	1741.9	Shrub and grass covered area adjacent to open forest	Sand (some gravel) underlain by ice rich silt at 8.5 m depth	RBR logger and multi-thermistor cable installed to 8.36 m iButton (Snow depth measurement).
AH2013-T5	61.598	139.477	1742.6	Shrub and grass covered area on edge of forested area	Organic silt (~1 m) underlain by sand	HOBO logger with sensors installed to 4.85 m
AH2013-T6	61.970	140.452	1812.5	Open area with small conifers, shrubs (re-growth)	Surface organic layer (0.1m), ice-rich silt underlain by sand at 4 m depth	RBR logger and multi-thermistor cable installed to 8.82 m
AH2013-T7	62.340	140.833	1865.3	Open mixed forest	Surface organic layer (5 cm), organic silt to ~1 m depth, Ice-rich silt underlain by till at 6 m depth	RBR logger and multi-thermistor cable installed to 9 m iButton (Snow depth measurement)
AH2013-T8	62.554	140.974	1894.5	Hummocky with small spruce, shrub, willow	Organic layer (0.1 m), peat and ice-rich silt extends to borehole bottom	RBR logger and multi-thermistor cable installed to 9.94 m
Adjacent sites established in 2011 and 2012						
R3	61.238	138.783	1682.4	Small clearing in forested area, regrowth small spruce and shrubs	Thin peat layer underlain by clay and sand	RBR logger and multi-thermistor cable installed to 6.6 m
R5	61.268	138.842	1686.9	Hummocky, scattered spruce and shrubs	Organic silt (0.5 m) over ice-rich clay and silt	RBR logger and multi-thermistor cable installed to 8 m
R7	61.714	139.840	1767.9	Small clearing undergoing regrowth surrounded by spruce and birch trees with low lying shrubs	Ice-rich peat (~2 m), with volcanic ash layer, over ice-rich silt, peat and organic silt.	RBR logger and multi-thermistor cable installed to 7m
H1	61.594	139.463	1768.1	Open bog area (regrown cutline), scattered spruce and shrubs; grass and sedges	Thin peat over organic silt and volcanic ash underlain by sand and gravel	HOBO logger with sensors installed to 2.87 m
H3	61.715	139.843	1741.6	Wet area, low shrubs, sphagnum mosses, grasses, sedges	Peat (~1 m) with volcanic ash layer, underlain by clay (ice-rich)	HOBO logger with sensors installed to 2.39 m
Beaver Creek Palsa	62.498	140.861	1884.1	Forested palsa	Ice rich peat	RBR logger and multi-thermistor cable installed to 7.5 m

FIELD WORK CONDUCTED IN SUMMER 2016

The 14 borehole sites were visited August 25-31 2016. During the site visit a live reading of ground temperature was made at the RBR loggers and the HOBO Microstations in order to check the operation of sensors and loggers and supplement the logger readings (and ensure that at least one record is available if the logger failed). All data loggers were downloaded in the field and then programmed to resume logging.

DATA PROCESSING AND PRESENTATION

Data records acquired from the loggers were visually inspected and erroneous data (e.g. data spikes) were removed. Daily mean temperatures were calculated and utilized to determine the annual maximum, minimum and mean temperature for each depth for the August 1 2015 – July 31 2016 period. At sites where permafrost was present the maximum temperature profile was utilized to determine the maximum thaw depth (i.e. the active layer), while at non-permafrost sites, the minimum annual temperature profile was used to determine the depth of winter frost penetration. Since monitoring sites were visited in August 2016, active layer and frost depths presented in this report are for the 2015-2016 period. Thaw and frost depths were determined through extrapolation of the maximum (thaw) or minimum (frost) annual temperatures as described by Riseborough (2008). Monthly mean ground temperatures at each measurement depth were also determined for each borehole.

Detailed data summaries are provided for all sites in the Appendix. This includes graphical and tabular summaries of annual maximum and minimum temperature profiles, which defines the temperature envelope, and graphical presentation of monthly mean temperatures for 2015-16.

RESULTS

Ground temperatures measured at the time of the site visit indicate that permafrost is present at all borehole sites on the highway easement except for T1 and T2 (Figure 3A) and at all other sites adjacent to the easement (Figure 3B). Mean annual ground temperature (MAGT) profiles for the easement sites (Figure 4A) indicate that where permafrost exists it extends below the bottom of the borehole at all sites. At most of the sites adjacent to the easement, permafrost extends to depths greater than 8 m (Figures 4B).

MAGT profiles show a thermal offset in the upper metre at many of the sites, where the MAGT decreases with depth (Figure 4). The thermal offset (Burn and Smith, 1988) is defined as the difference between the ground surface temperature and temperature at the top of permafrost (TTOP). Although the ground surface temperature is not available for these boreholes (except for R7 where mean value is 1.5°C), the thermal offsets, based on the difference between the shallowest temperature measurement (~0.5 m or shallower) and the temperature at about 1 m depth (representative of TTOP), for example are at least -1.3°C at T3, -1.4°C at T5, -1.2°C at T6 and -1.7°C at T8. Ground temperature profiles for other sites in the northwest section of the corridor presented by Calmels et al. (2015) also show thermal offsets of a similar magnitude. Assuming equilibrium conditions exists, the thermal offset is due to differences between the thermal conductivity of frozen and unfrozen soils (Romanovksy and Osterkamp, 1995; Riseborough and Smith, 1998).

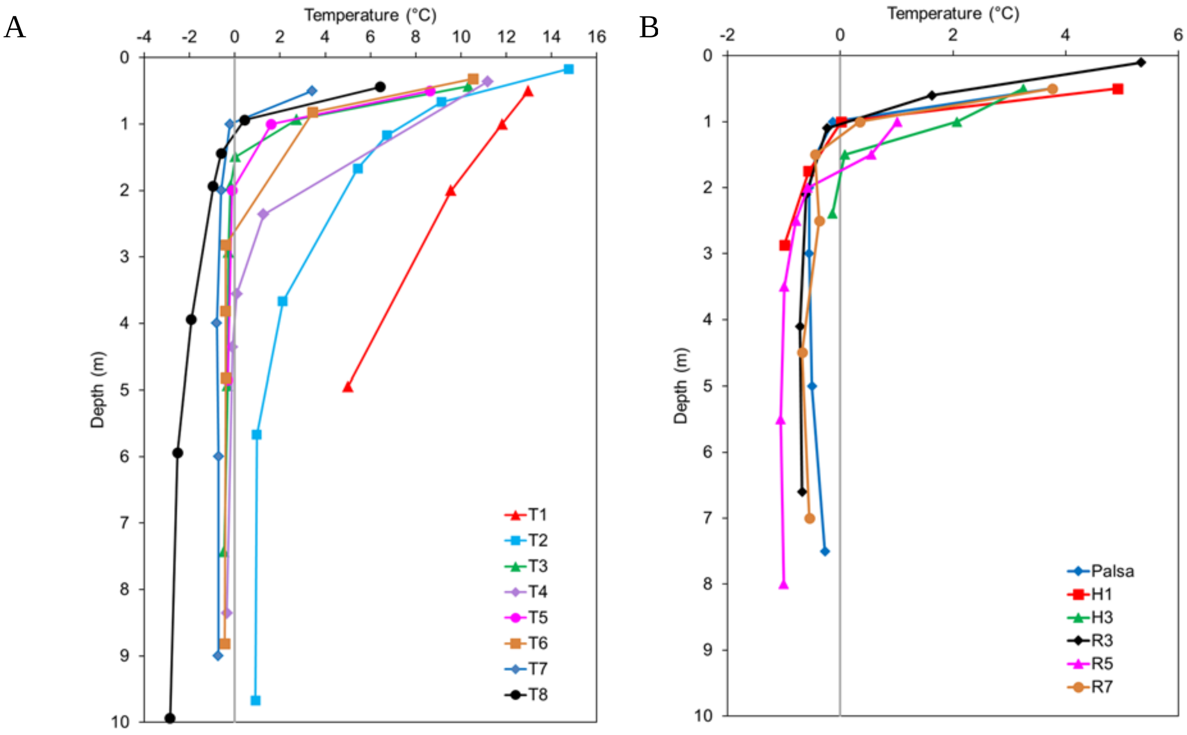

Figure 3. Ground temperatures measured during site visits in August 2016 at (A) the highway easement sites and (B) adjacent sites.

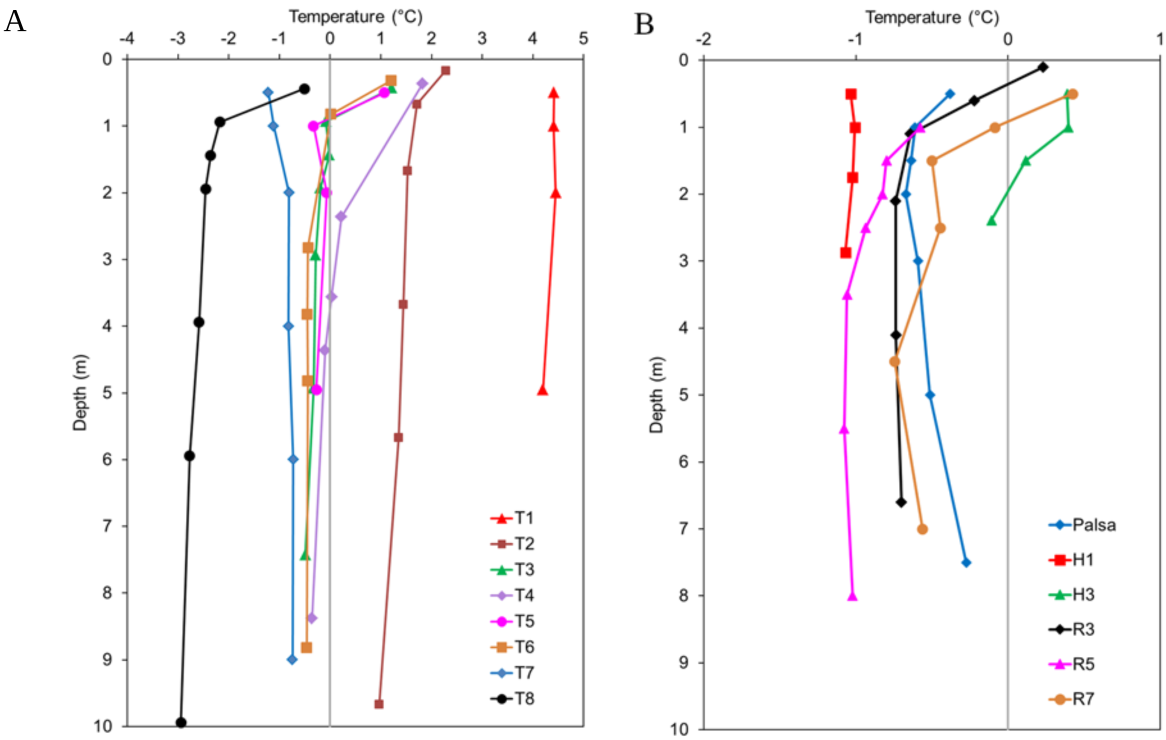

Figure 4. MAGT profiles for 2015-16 for (A) easement and (B) adjacent sites.

Table 2. Summary of ground thermal conditions for sites visited in August 2016. Mean annual ground temperature is near the depth of zero annual amplitude or at deepest measurement depth (indicated by "*" for measurement depth) if depth of ZAA is not reached. Maximum summer thaw depth for permafrost sites or depth of winter frost penetration for non-permafrost sites is also provided.

Borehole	Mean Annual ground Temperature (°C)	Measurement Depth (m)	Permafrost Y(es) or N(o)	Thaw (T) or Frost (F) Depth (m)
AH2013-T1	4.19	4.95 *	N	1.05 (F)
AH2013-T2	0.97	9.67 *	N	~1.88(F)
AH2013-T3	-0.02	1.43	Y	0.98 (T)
AH2013-T4	-0.10	4.36	Y	3.68 (T)
AH2013-T5	-0.27	4.95	Y	2.0 (T)
AH2013-T6	-0.46	8.82	Y	0.99 (T)
AH2013-T7	-0.73	6.0	Y	0.98 (T)
AH2013-T8	-2.94	9.94*	Y	0.96 (T)
R3	-0.70	6.6	Y	0.69 (T)
R5	-1.02	8 *	Y	1.46 (T)
R7	-0.56	7	Y	1.04 (T)
H1	-1.07	2.87 *	Y	1.33 (T)
H3	-0.11	2.39*	Y	1.58 (T)
BC Palsa	-0.27	7.5	Y	0.98 (T)

As discussed in Smith et al. (2016), the fine-grained or organic soils in the upper part of the ground (within the active layer) at T3, T5, T6 and T8 have high moisture contents and therefore likely a significant difference exists between frozen and unfrozen thermal conductivity. The difference between frozen and unfrozen thermal conductivity would appear to be sufficient to maintain permafrost (Riseborough and Smith, 1998) at these sites even though mean annual surface temperatures may be above 0°C. Similarly, at R3 and R7 where thermal offsets are about -1 and -1.6°C respectively (Figure 4B), permafrost is also likely maintained by the frozen/unfrozen thermal conductivity difference in the peat and fine grained sediment. Permafrost conditions at these sites appear to be dependent on the thermal offset and could be classified as ecosystem driven or ecosystem protected (Shur and Jorgenson, 2007). At other sites such as T4 where surface temperatures also appear to be above 0°C (Figure 4A), the coarse soils within the active layer have a low moisture content, so a significant difference between frozen and unfrozen thermal conductivity is unlikely. The thermal offset may therefore be due to a lag between warming at the surface, perhaps due to surface disturbance, and the offset is a result of the presence of permafrost rather than the reason for permafrost existence (James et al. 2013).

The ground temperature envelopes (provided in Appendix) can be utilized to determine the depth of zero annual amplitude (ZAA), which for practical purposes, is the depth at which the annual temperature range is less than 0.1°C (Williams and Smith, 1989). At the easement sites, ZAA depth could only be determined for T3, T4, T6 and T7, where it ranged from less than 1.5 m at T3 to 6 m at T7 (Table 2). The ZAA depth at the other easement boreholes was greater than the measurement depth and for T8 where the lowest ground temperatures were observed, ZAA depth exceeds 9.9 m. For the sites adjacent to the easement, borehole depth was not sufficient to determine ZAA depth except at R3, R7 and the palsa site (Table 2).

The MAGT for the 2015-16 period at the ZAA depth has been determined where measurements were made to sufficient depth. For other sites, the MAGT at the deepest measurement depth has been determined. MAGT at ZAA depth (or measurement depth closest to it) for permafrost sites ranges from about -3°C to -0.02°C (Table 2). MAGT at non-permafrost sites can be above 4°C. Generally the coldest permafrost is found closer to the Alaska border but very warm permafrost (>-0.5°C) can still be found within 50 km of the border (Figure 5). Calmels et al. (2015) also report MAGT of -3°C near the border in the vicinity of T8 with MAGT of -1 to -2°C for other nearby sites.

Thaw depths at the time of the site visits ranged from about 0.6 m to >2 m (Figure 3). Although site visits occurred in late August, these values are likely not representative of the maximum thaw penetration for summer 2016. Estimates of maximum summer thaw depth (or active layer thickness) for 2015 determined using maximum annual ground temperature profiles are summarized in Table 2 for permafrost sites. Maximum 2016 winter frost penetration estimated from minimum annual temperature profiles is also provided for non-permafrost sites. Thicker active layers are generally found along the easement compared to those observed at the adjacent sites which are located in undisturbed conditions with denser vegetation cover. Thaw depths along the northwestern section of the corridor range from 0.6 m to >3 m (Table 2). There is no apparent spatial pattern but within 100 km of the border, thaw depths are less than 1 m. Organic layers or peat likely limit thaw penetration at these sites.

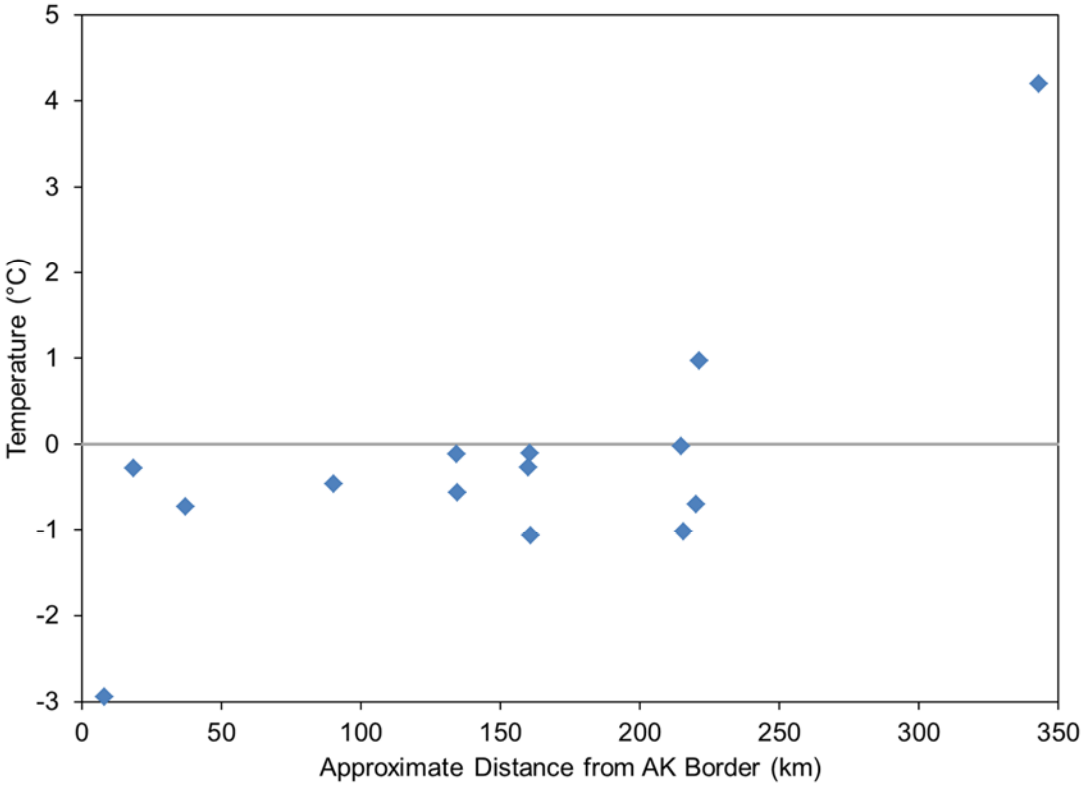

Figure 5. MAGT (2015-16) in the northwest section of the corridor at ZAA depth or measurement depth closest to it.

CHANGES IN GROUND TEMPERATURE OVER TIME

The ground temperature records for the northwestern corridor range from 3 to 5 years in length for the easement and adjacent sites respectively. Although data records are too short to assess any long-term trends in ground temperatures, they can be used to characterize recent temperature fluctuations in ground temperature that have occurred since installation.

For permafrost sites (Figure 6), the variation in MAGT over the period of record ranges from <0.05°C to 0.13°C. The largest fluctuation occurs at one of the colder permafrost sites at R5. Warmer permafrost sites generally show less variation, however at the warmest site (T3), the range (0.06°C) in MAGT over the 3 year record is as high as it is at the coldest site at T8 (Figure 6).

Data from Environment Canada weather stations along the corridor indicates that mean annual air temperatures have generally increased since 2012 (Figure 7). However, there does not appear to be a consistent increase in MAGT associated with this air temperature trend. Although MAGT has increased by a small amount recently, by 0.05 to 0.08°C over the last 3 years at T3, T5 and T8, MAGT at other sites have changed little or even decreased (Figure 6). Other factors will also be important in determining change and variability in MAGT including snow cover and the seasonal partitioning of changes in air temperature.

MAGT at the three deeper boreholes (R3, R5, R7) in which GSC previously measured ground temperatures in the late 1970s (Burgess et al. 1982), indicates that permafrost is still present at these sites. MAGT for 2015-16 at these three sites is still higher than those measured almost 4 decades ago (see also Duguay 2013; Smith et al. 2015) and this warming may be in response to increases in air temperatures since the 1970s (Figure 7).

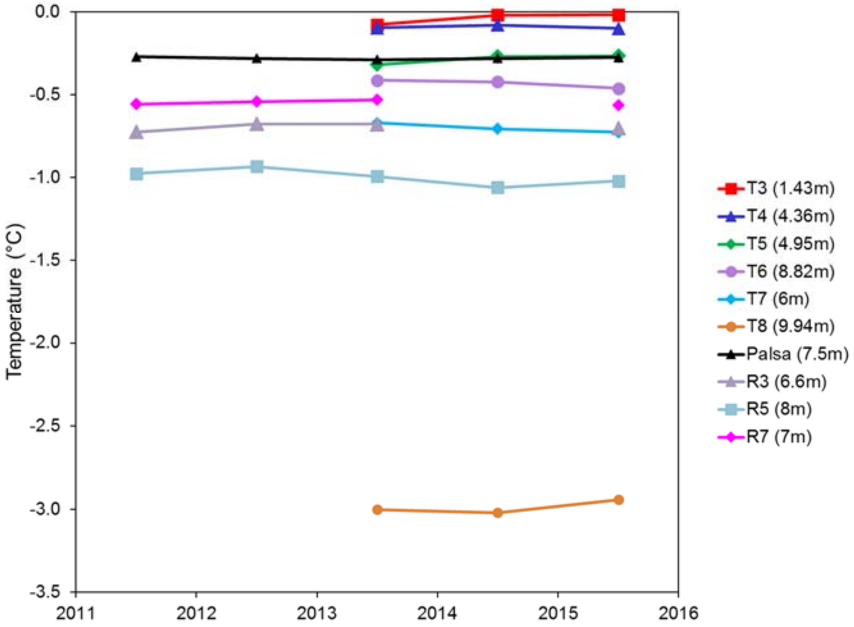

Figure 6. MAGT records for measurement depth closest to ZAA depth, in deeper boreholes at permafrost sites.

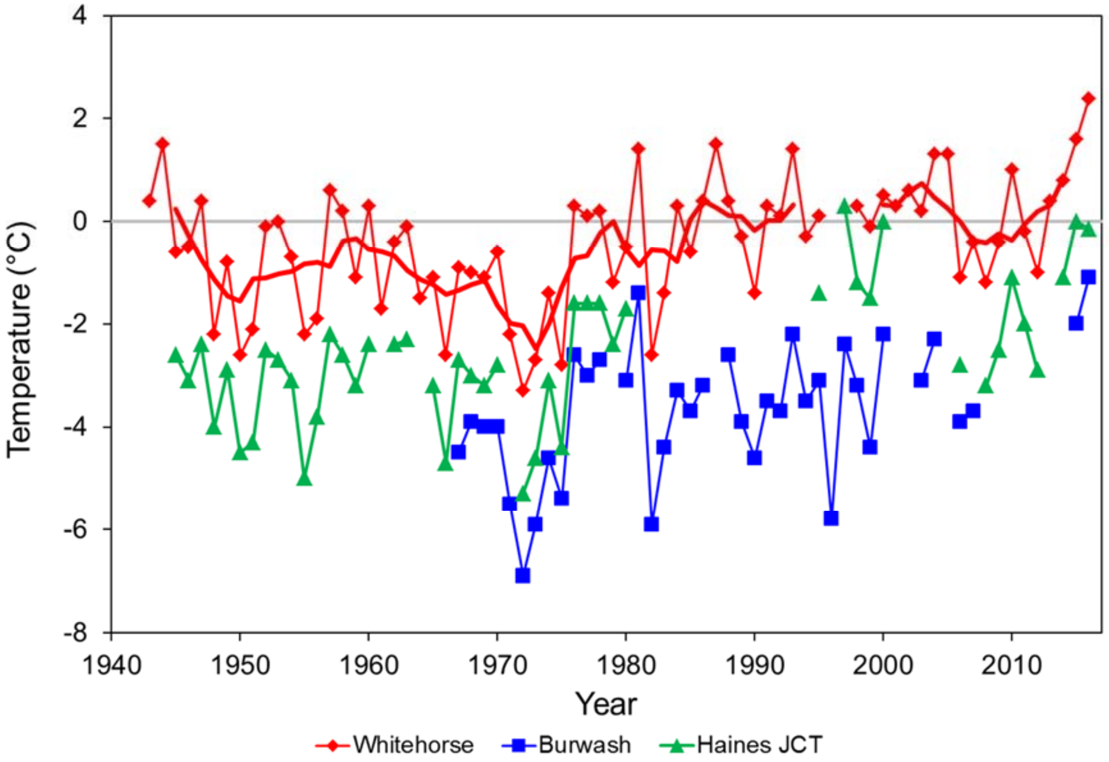

Figure 7. Mean annual air temperature records for Environment Canada stations in the corridor. The thick line represents the 5 year running mean for Whitehorse.

SUMMARY

Ground temperature data were acquired in August 2016 from fourteen boreholes in the northwestern portion of the Alaska Highway corridor. A continuous record of temperatures for the previous year was obtained at all of the sites. Permafrost is generally warm between highway kilometre post 1559 and the Alaska border with mean annual ground temperatures at most sites above -1°C. However, colder ground conditions exist at the site closest to the border with MAGT of about -3°C.

Shallow (upper 1-2 m) mean ground temperature profiles indicate that at some warm permafrost sites, ground surface temperatures are above 0°C. The difference in frozen and unfrozen thermal conductivity that is likely responsible for the thermal offset at many sites is sufficient to maintain permafrost. However permafrost can be considered ecosystem protected or ecosystem driven and may be vulnerable to thawing, especially if the surface is disturbed.

The ground temperature record for these boreholes is now 3 to 5 years long. There was no consistent trend in MAGT over time observed in the short records. Continued data collection is planned and this will facilitate documentation of fluctuations in ground temperatures and build up the time series which will support detection of trends in permafrost conditions in the southern Yukon. The public availability of these data can support climate change impact assessments and adaptation planning in the region.

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APPENDIX
Detailed data summaries for boreholes on the highway easement

For each site the following are provided:

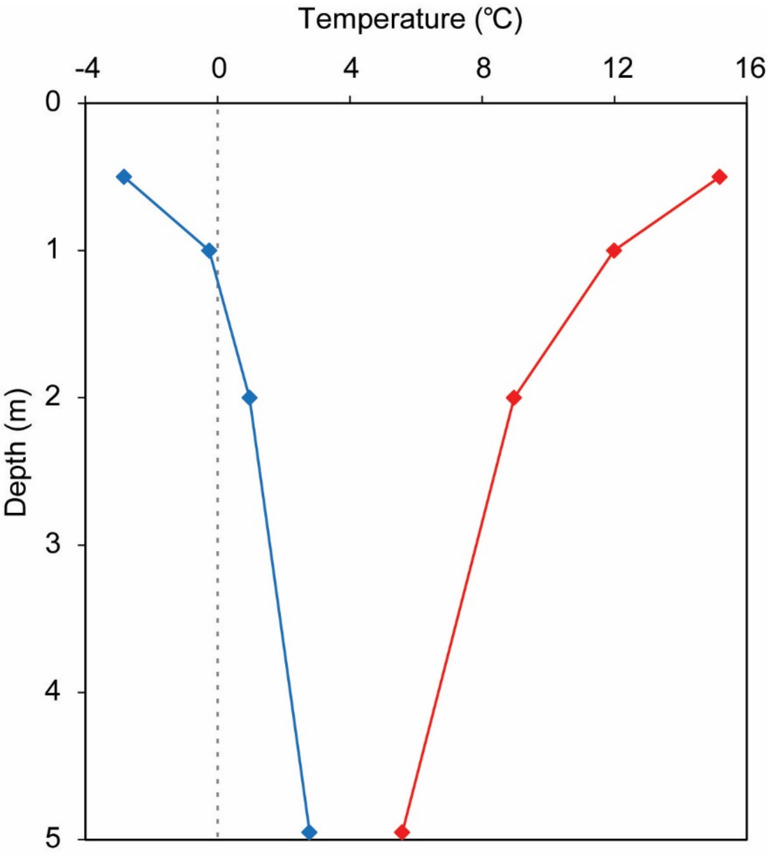
- Graphical and tabular presentation of ground temperature envelopes for the August 1 2015 – July 31 2016 period (annual maximum and minimum ground temperatures).
- Graphical presentation of monthly mean ground temperatures for 2015-16.

Thaw depths provided for permafrost sites are determined from shallow maximum annual ground temperatures. Seasonal frost depths at non-permafrost sites are determined from shallow annual minimum ground temperatures.

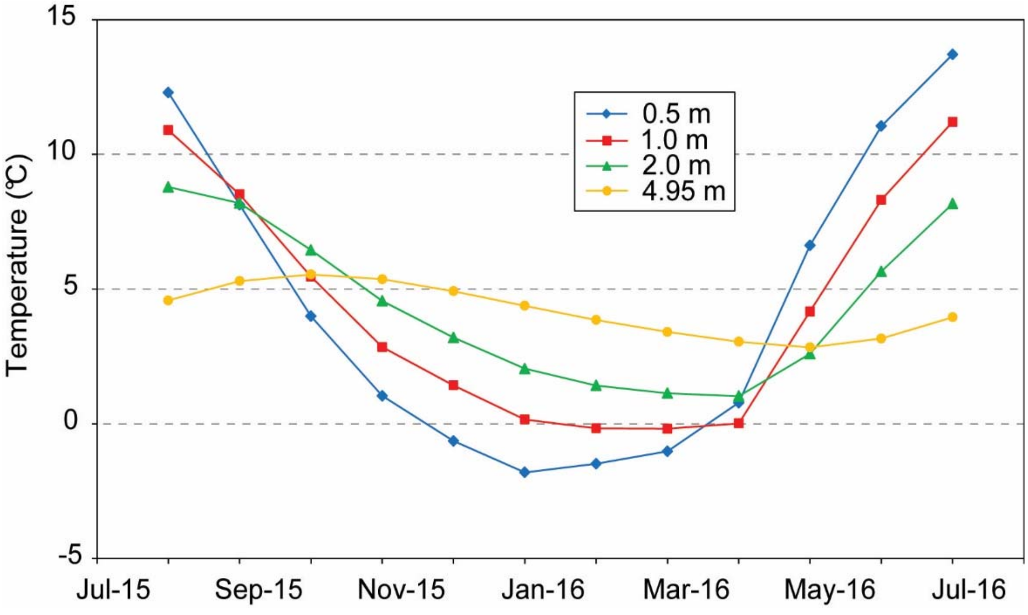
Information on terrain type was determined from:
Lipovsky, P.S. and Bond, J.B. 2014. Yukon digital surficial geology compilation, digital release 1, 08-Apr-2014. Yukon Geological Survey.
http://www.geology.gov.yk.ca/digital_surficial_data.html

AH2013-T1

Moraine, undulating
Latitude: 60.840 N Longitude: 137.278 W
Elevation: 686 m a.s.l.
Max Frost Depth: 1.05 m

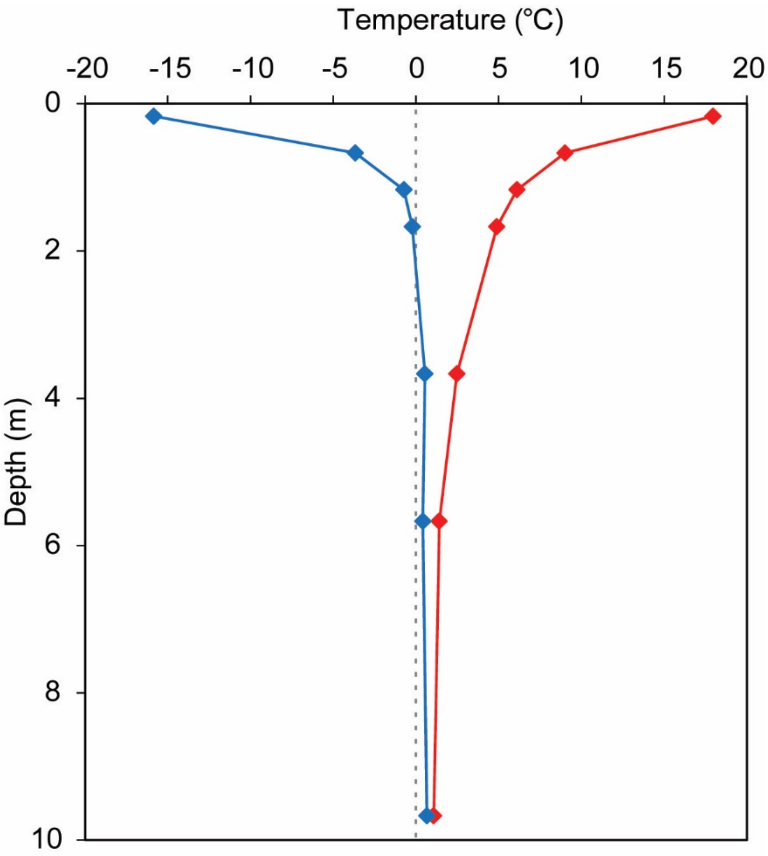


Depth (m)	Temperature (°C)	
	Max	Min
0.5	15.18	-2.83
1.0	11.99	-0.25
2.0	8.97	0.97
4.95	5.58	2.78

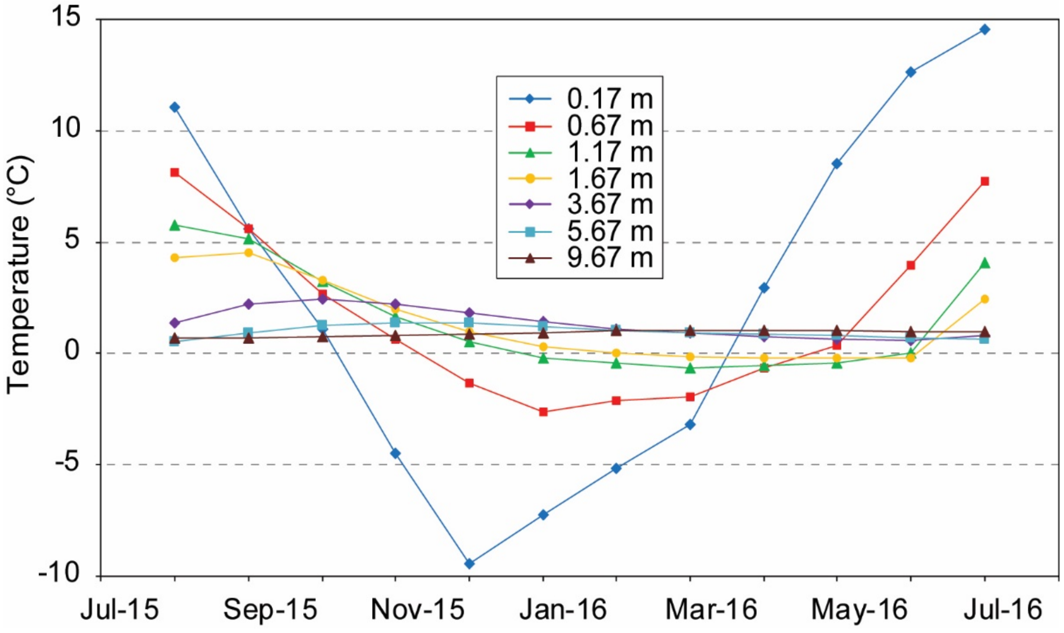


AH2013-T2

Moraine plain
Latitude: 61.232 N Longitude: 138.762 W
Elevation: 841 m a.s.l.
Max Frost Depth: 1.88 m

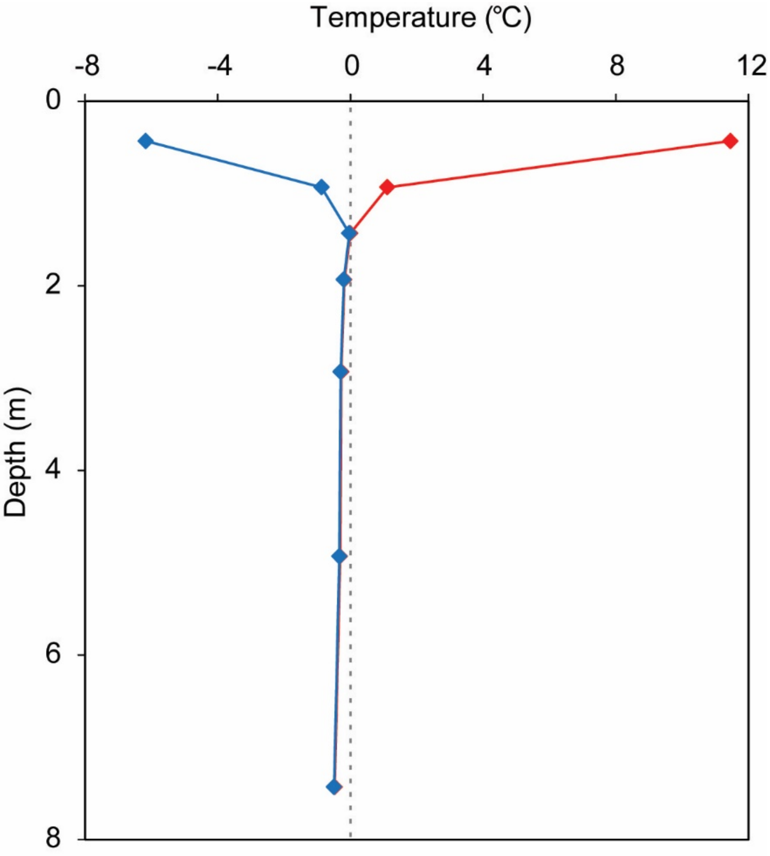


Depth (m)	Temperature (°C)	
	Max	Min
0.17	17.96	-15.83
0.67	9.01	-3.66
1.17	6.11	-0.73
1.67	4.89	-0.22
3.67	2.47	0.55
5.67	1.41	0.42
9.67	1.07	0.67

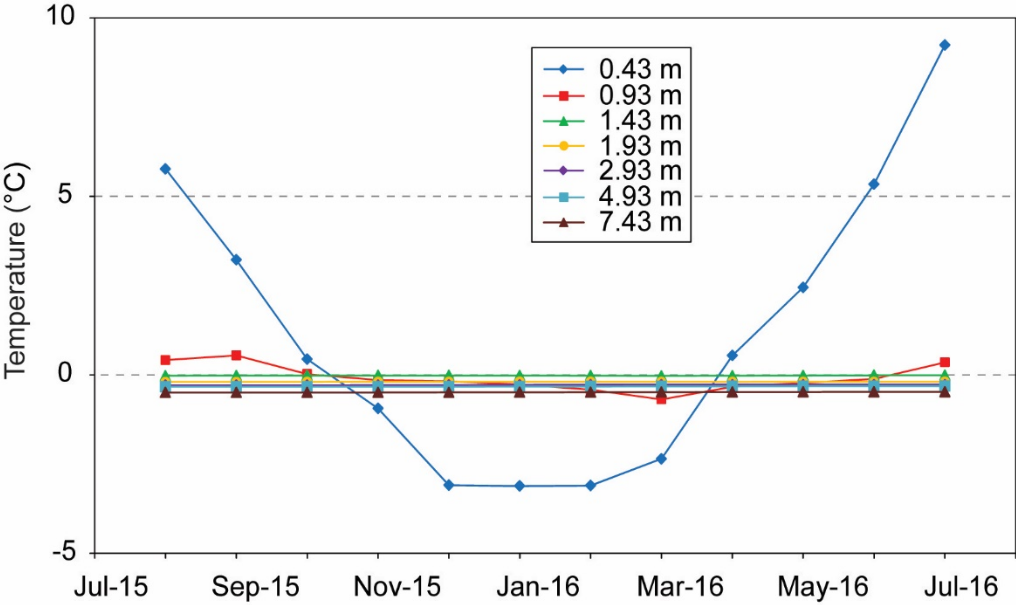


AH2013-T3

Alluvial fan
Latitude: 61.273 N Longitude: 138.847 W
Elevation: 833 m a.s.l.
Max Thaw Depth: 0.98 m

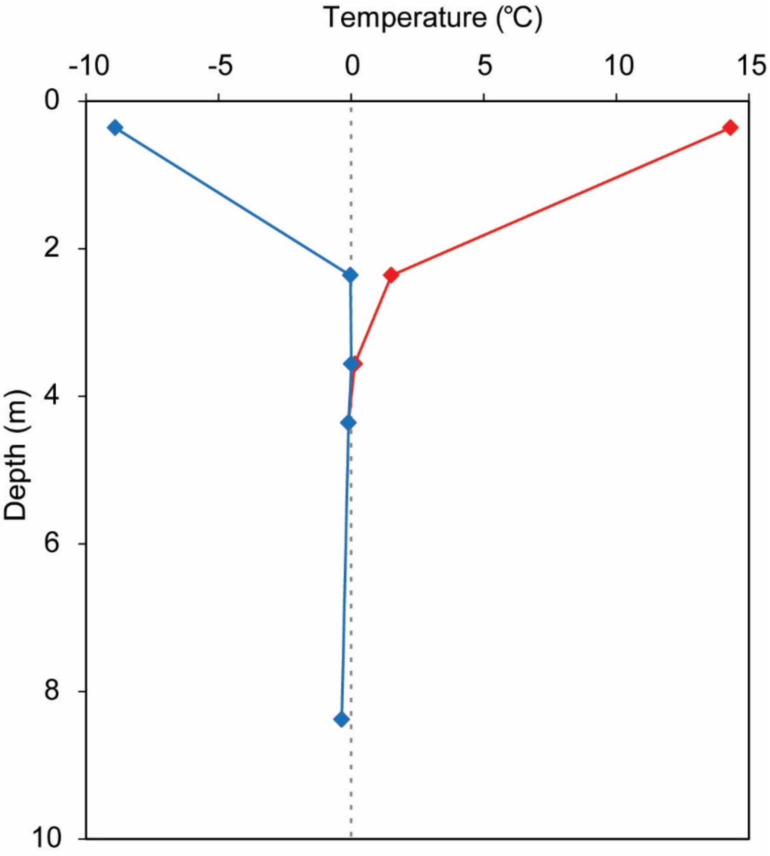


Depth (m)	Temperature (°C) Max	Min
0.43	11.46	-6.17
0.93	1.11	-0.87
1.43	-0.01	-0.03
1.93	-0.18	-0.20
2.93	-0.27	-0.29
4.93	-0.31	-0.33
7.43	-0.47	-0.49

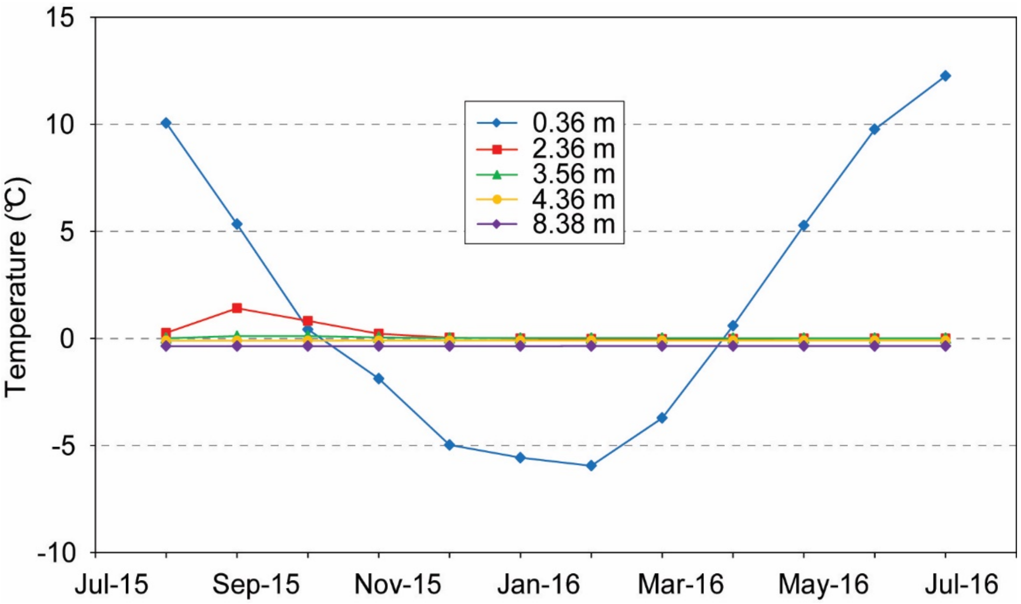


AH2013-T4

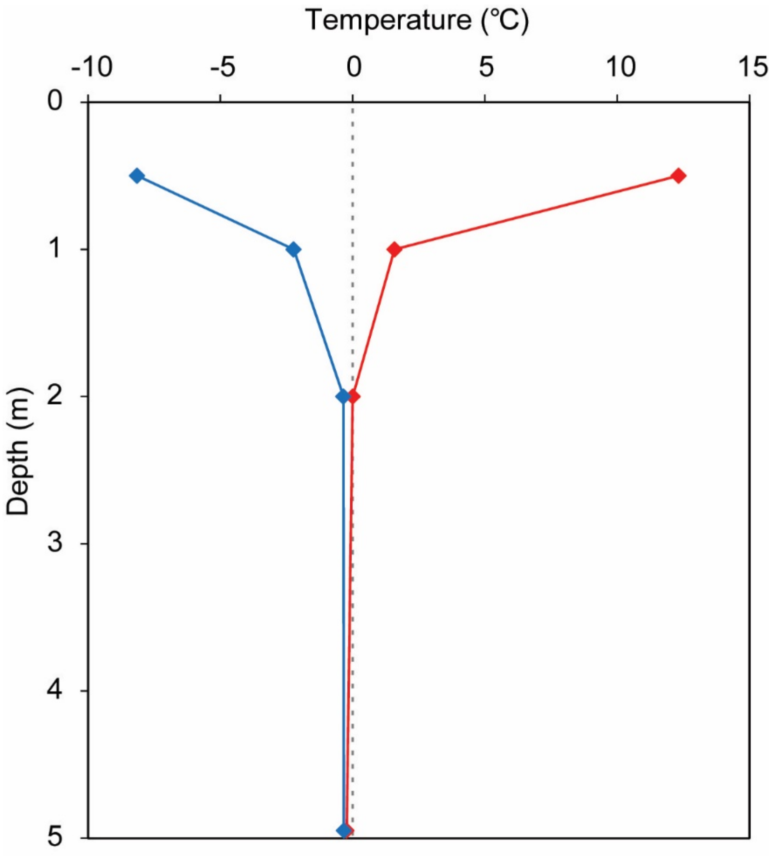
Moraine
Latitude: 61.595 N		Longitude: 139.468 W
Elevation: 783 m a.s.l.
Max Thaw Depth: 3.68 m



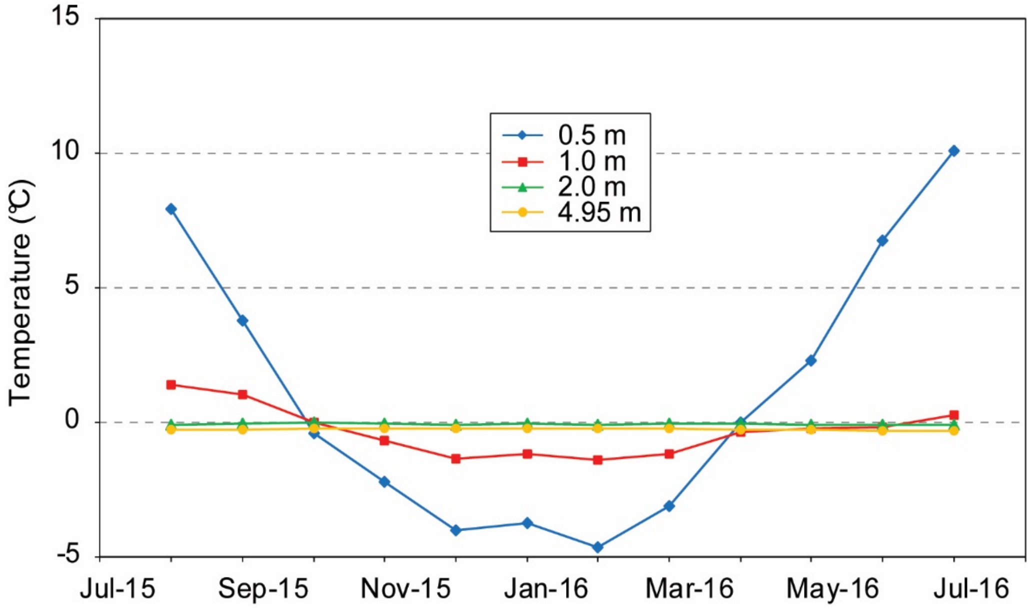
	Temperature (°C)	
Depth (m)	Max	Min
0.36	14.31	-8.90
2.36	1.51	-0.03
3.56	0.14	0.01
4.36	-0.10	-0.10
8.38	-0.35	-0.36



AH2013-T5
Moraine
Latitude: 61.598 N Longitude: 139.477 W
Elevation: 747 m a.s.l.
Max Thaw Depth: 2.0 m

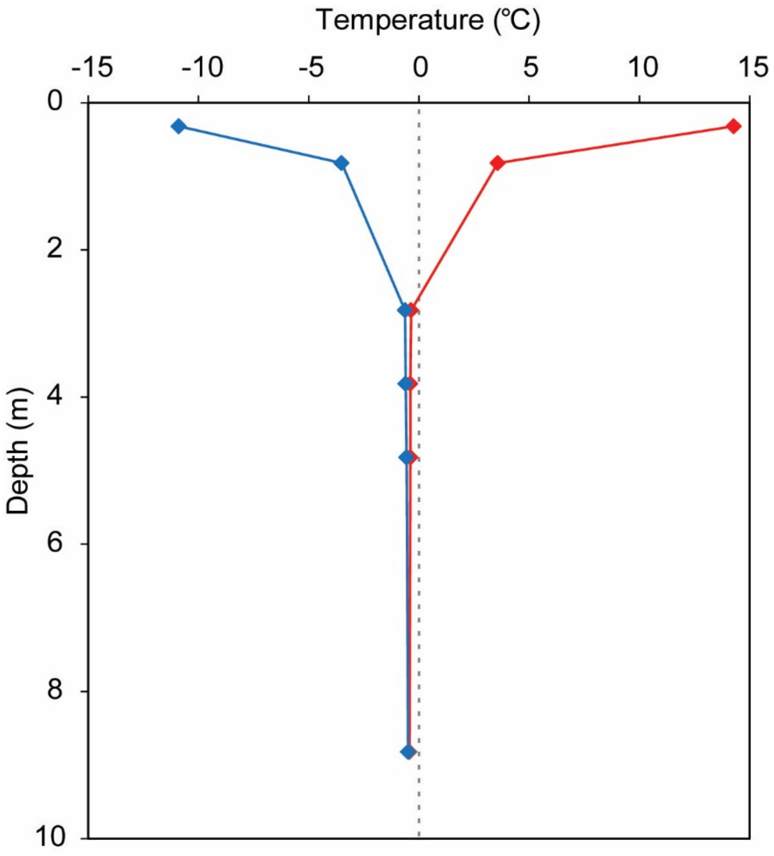


Depth (m)	Temperature (°C)	
	Max	Min
0.5	12.32	-8.14
1	1.58	-2.23
2	0.01	-0.35
4.95	-0.23	-0.33

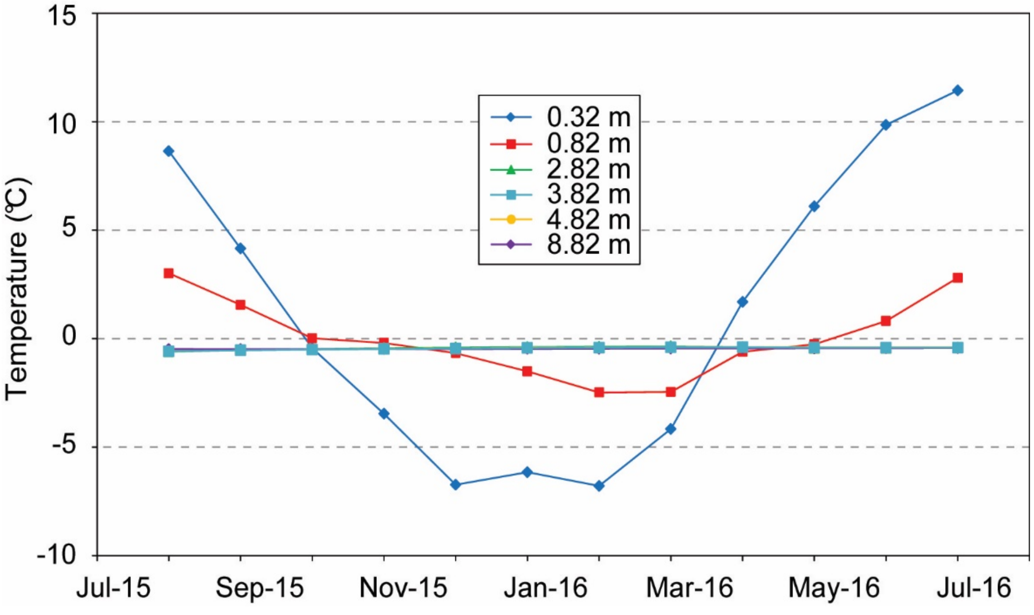


AH2013-T6

Alluvial terrace
Latitude: 61.970 N Longitude: 140.452 W
Elevation: 672 m a.s.l.
Max Thaw Depth: 0.99 m

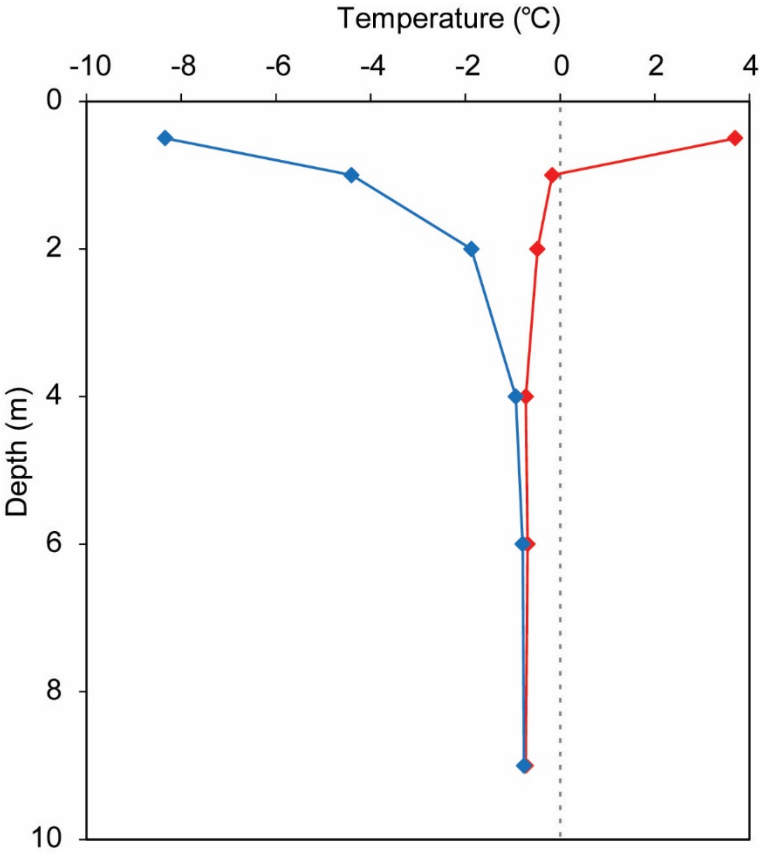


	Temperature (°C)	
Depth (m)	Max	Min
0.32	14.27	-10.89
0.82	3.58	-3.51
2.82	-0.35	-0.63
3.82	-0.39	-0.60
4.82	-0.39	-0.56
8.82	-0.44	-0.49

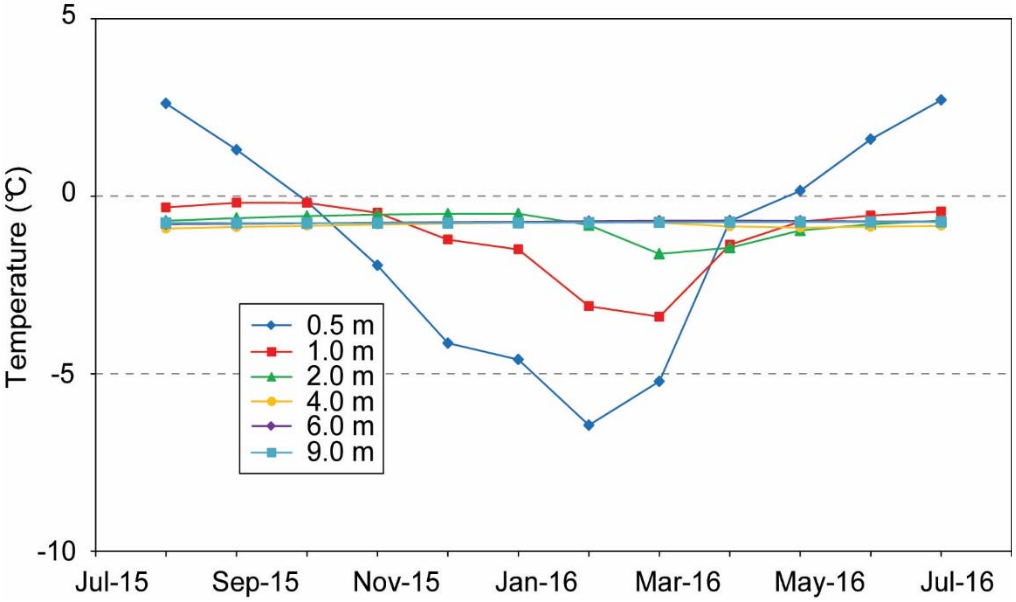


AH2013-T7

Moraine
Latitude: 62.340 N Longitude: 140.833 W
Elevation: 701 m a.s.l.
Max Thaw Depth: 0.98 m

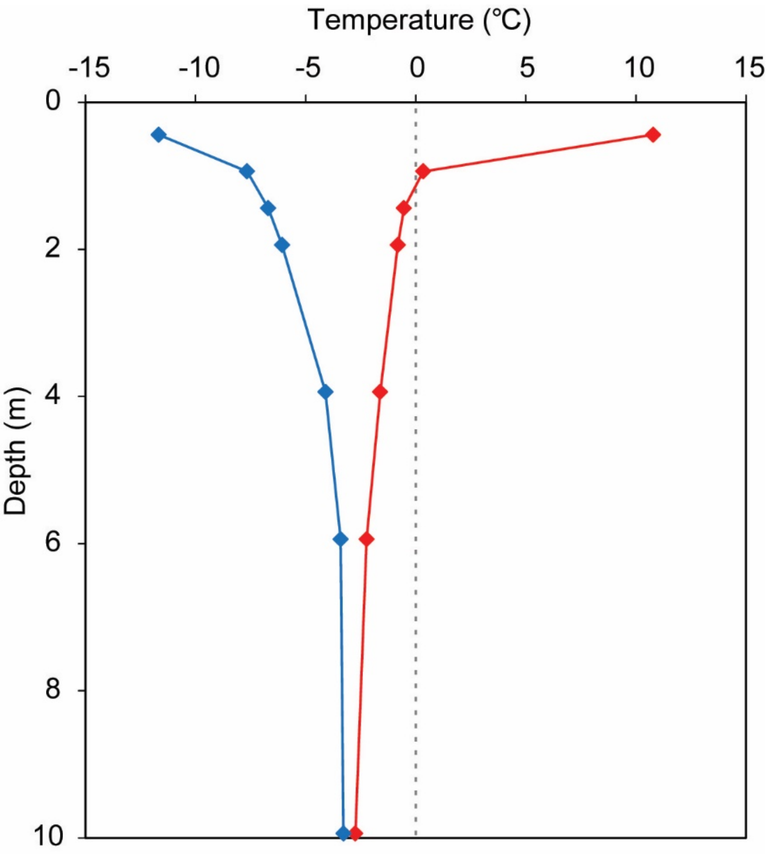


Depth (m)	Temperature (°C)	
	Max	Min
0.5	3.70	-8.34
1.0	-0.17	-4.40
2.0	-0.48	-1.87
4.0	-0.72	-0.93
6.0	-0.69	-0.79
9.0	-0.72	-0.76

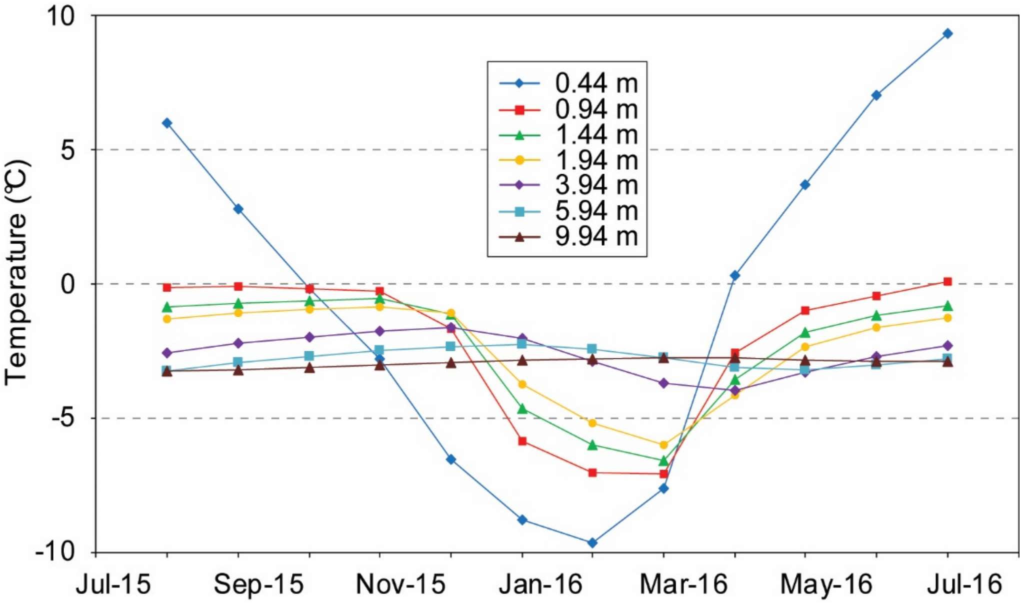


AH2013-T8

Alluvial plain
Latitude: 62.554 N Longitude: 140.974 W
Elevation: 610 m a.s.l.
Max Thaw Depth: 0.96 m

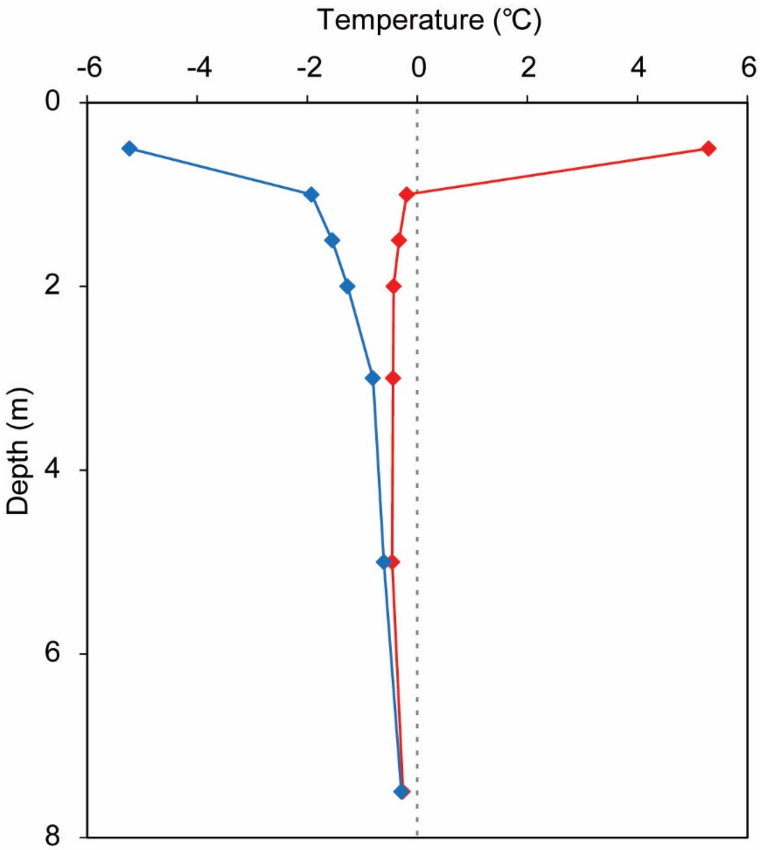


Depth (m)	Temperature (°C)	
	Max	Min
0.44	10.78	-11.67
0.94	0.34	-7.66
1.44	-0.54	-6.70
1.94	-0.82	-6.07
3.94	-1.61	-4.10
5.94	-2.23	-3.41
9.94	-2.74	-3.28

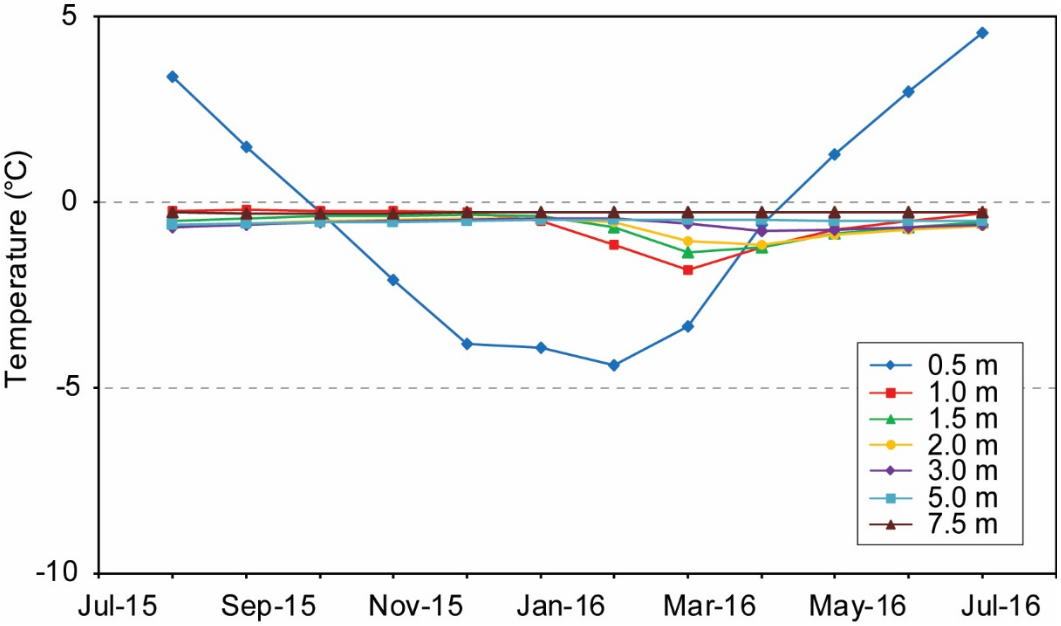


BC Palsa

Organic Plain (over alluvial plain)
Latitude: 62.498 N Longitude: 140.861 W
Elevation: N/A
Max Thaw Depth: 0.98 m

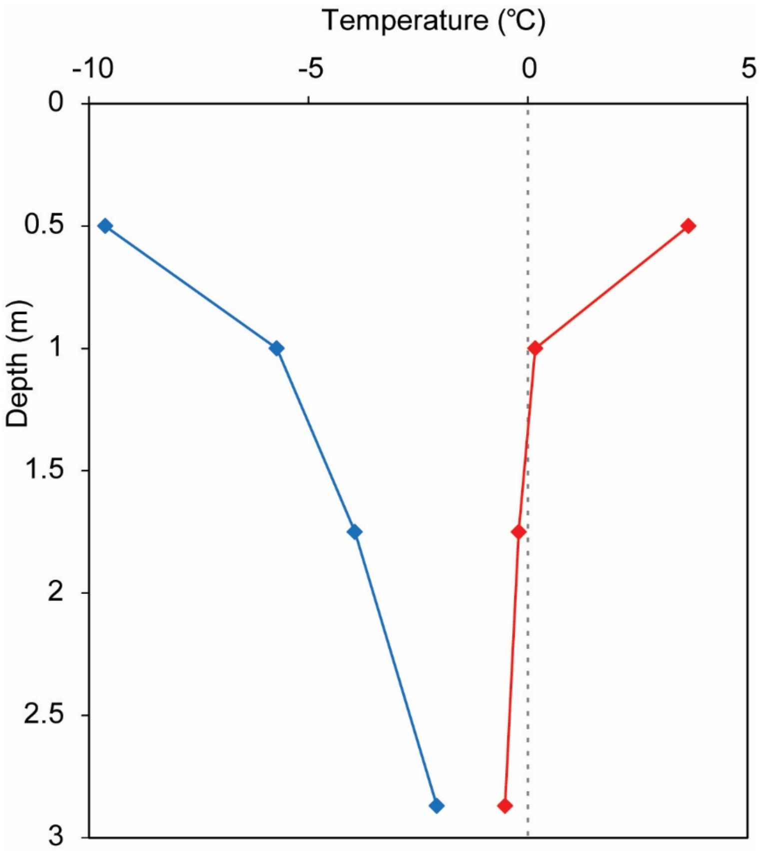


Depth (m)	Temperature (°C)	
	Max	Min
0.5	5.30	-5.23
1	-0.19	-1.92
1.5	-0.33	-1.54
2	-0.43	-1.27
3	-0.44	-0.81
5	-0.46	-0.60
7.5	-0.26	-0.29

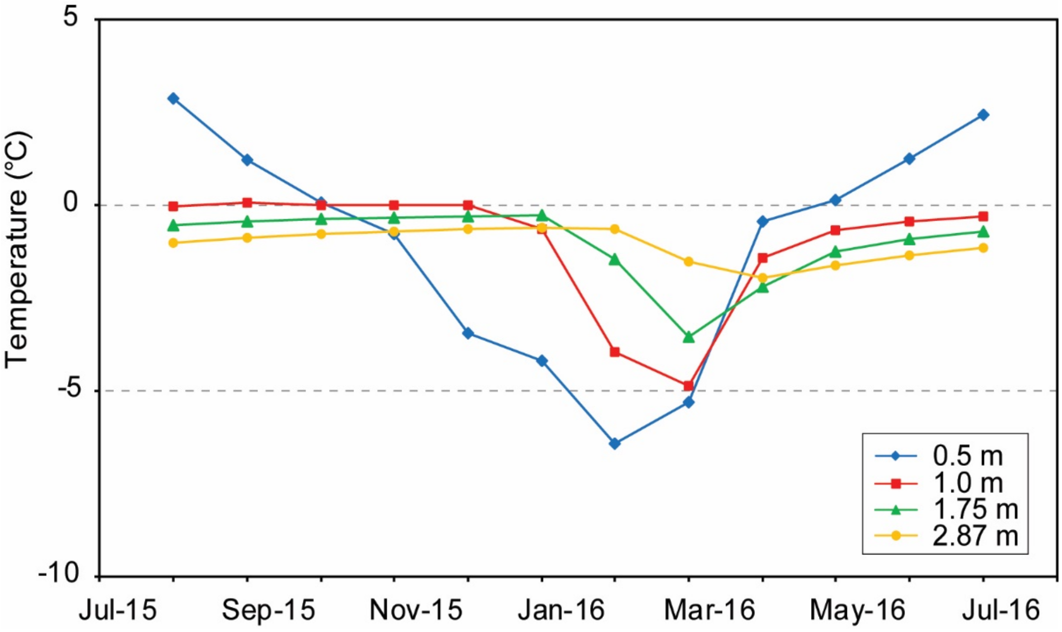


H1

Organic Plain (over moraine)
Latitude: 61.594 N Longitude: 139.463 W
Elevation: N/A
Max Thaw Depth: 1.33 m

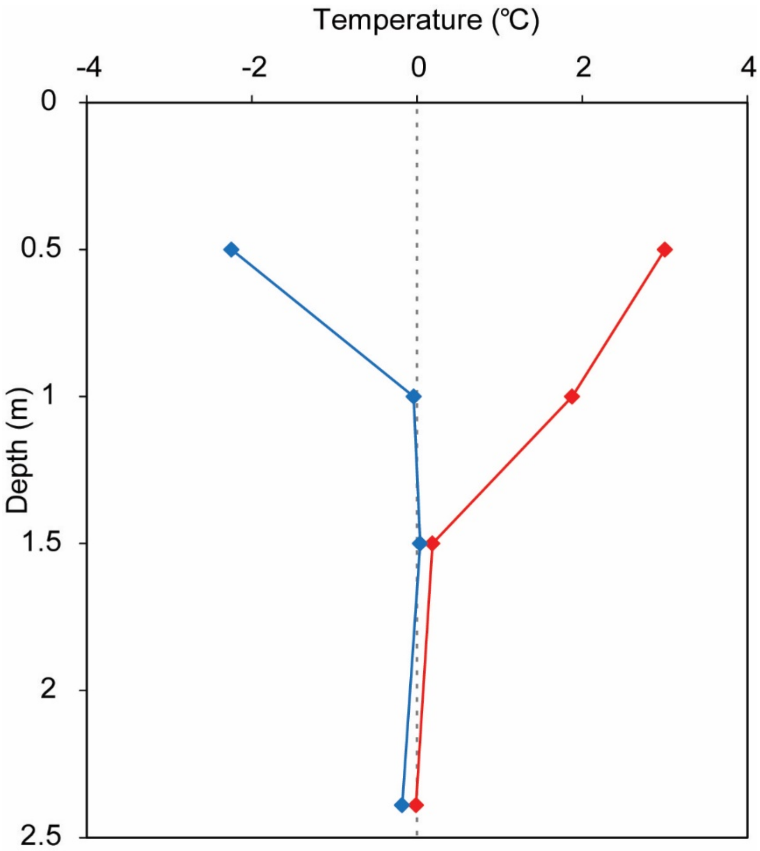


Depth (m)	Temperature (°C)	
	Max	Min
0.5	3.66	-9.63
1	0.17	-5.72
1.75	-0.21	-3.94
2.87	-0.52	-2.07

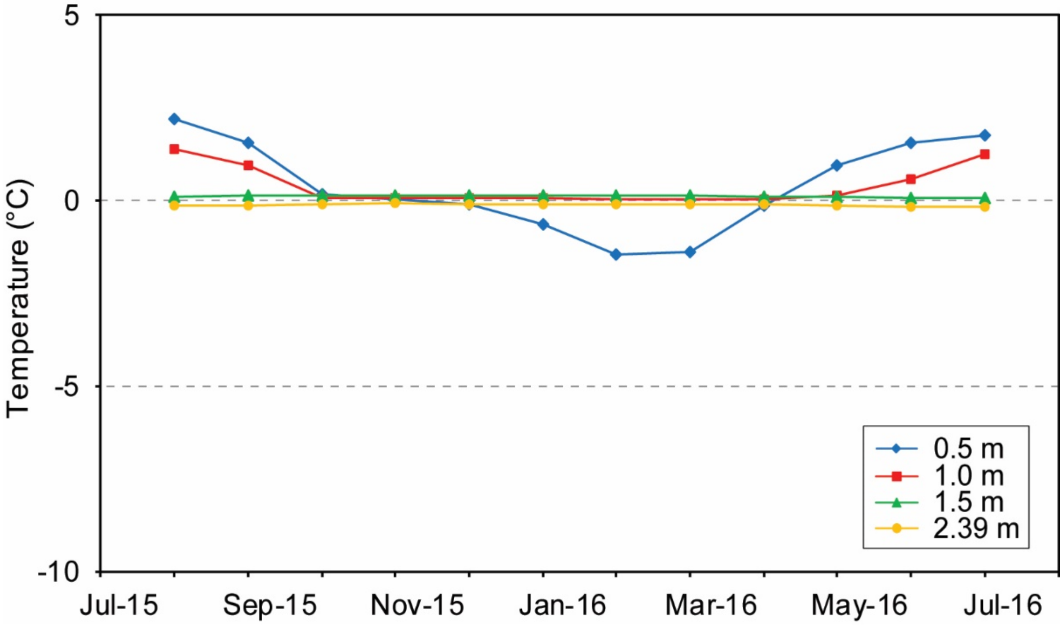


H3

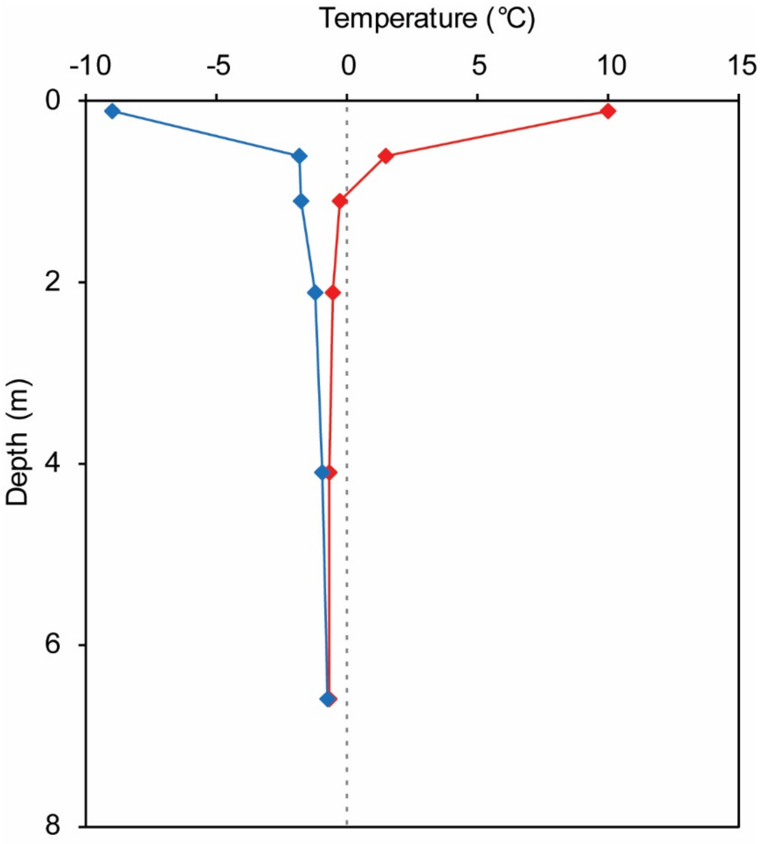
Eolian veneer over moraine
Latitude: 61.715 N Longitude: 139.843 W
Elevation: N/A
Max Thaw Depth: 2.33 m



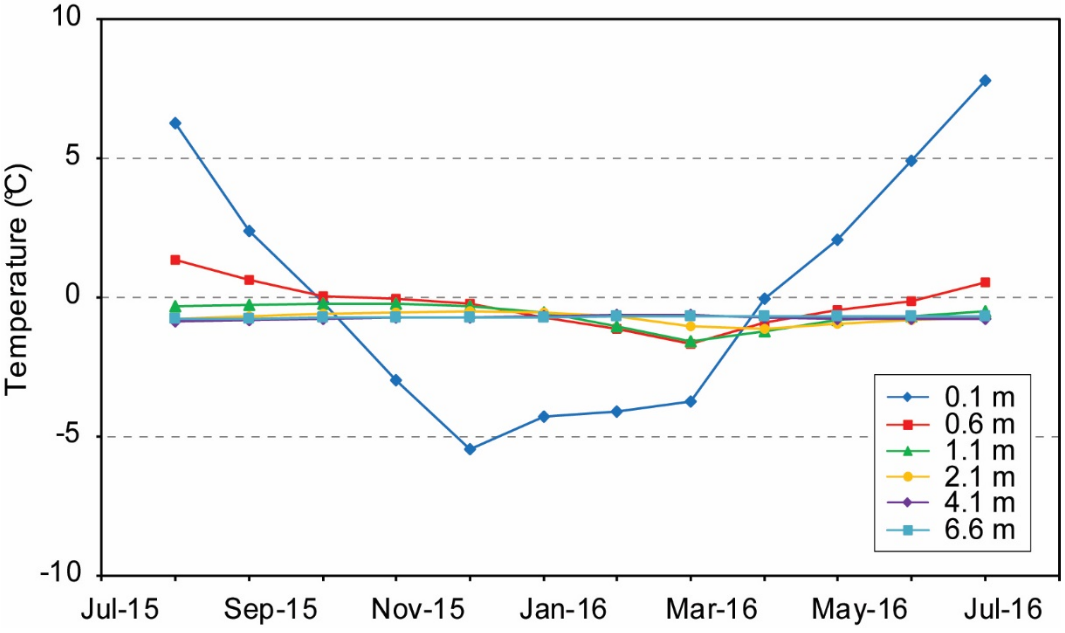
Depth (m)	Temperature (°C)	
	Max	Min
0.5	3.00	-2.25
1	1.88	-0.04
1.5	0.19	0.04
2.39	-0.01	-0.18



R3
Moraine
Latitude: 61.237 N Longitude: 138.781 W
Elevation: N/A
Max Thaw Depth: 0.69 m

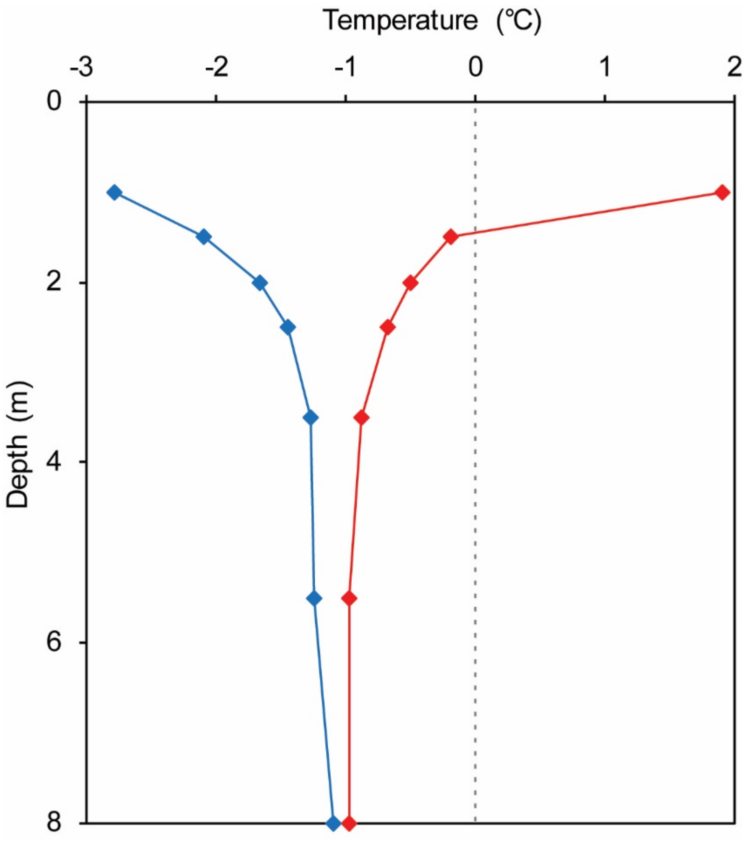


	Temperature (°C)	
Depth (m)	Max	Min
0.1	10.01	-8.94
0.6	1.50	-1.79
1.1	-0.23	-1.72
2.1	-0.50	-1.20
4.1	-0.64	-0.90
6.6	-0.66	-0.75

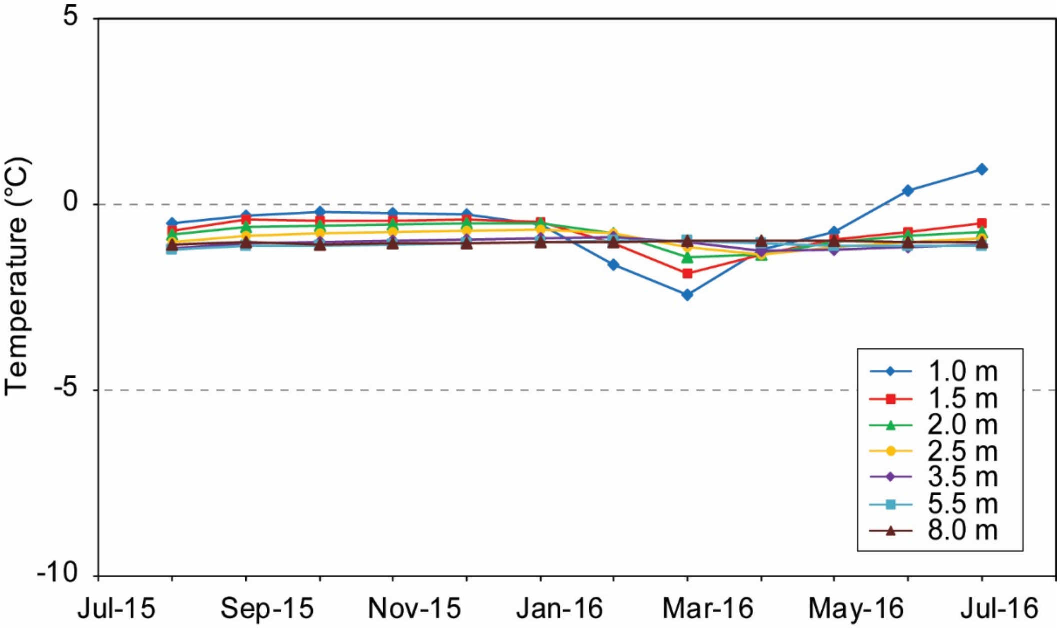


R5

Alluvial fan
Latitude: 61.266 N Longitude: 138.84 W
Elevation: N/A
Max Thaw Depth: 1.46 m

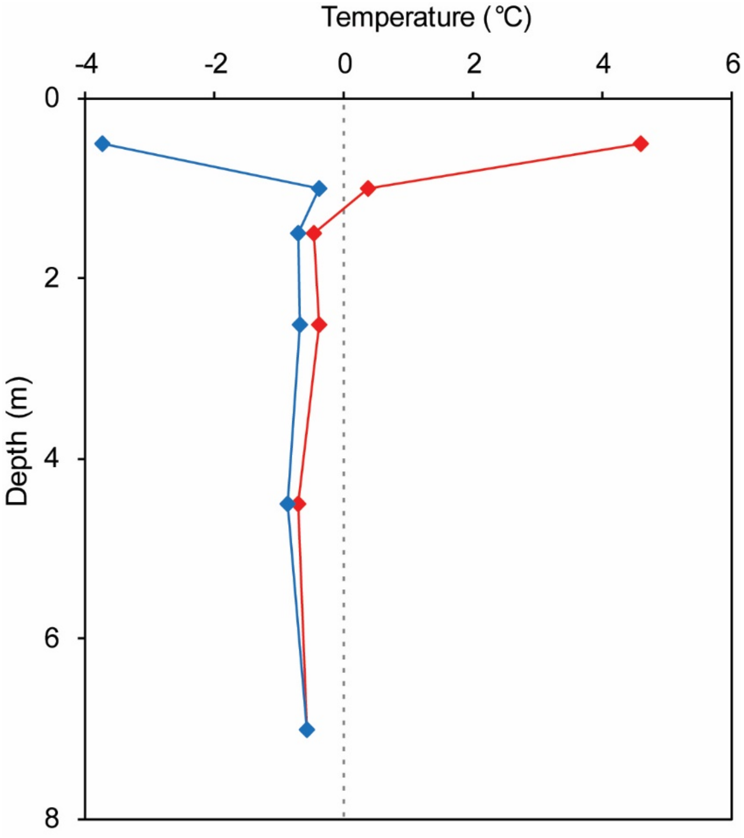


Depth (m)	Temperature (°C)	
	Max	Min
1	1.91	-2.78
1.5	-0.18	-2.10
2	-0.50	-1.66
2.5	-0.68	-1.44
3.5	-0.88	-1.26
5.5	-0.97	-1.24
8	-0.97	-1.09



R7

Eolian veneer over moraine
Latitude: 61.715 N   Longitude: 139.84 W
Elevation: N/A
Max Thaw Depth: 1.04 m



Depth (m)	Temperature (°C)	
	Max	Min
0.5	4.61	-3.73
1	0.38	-0.37
1.5	-0.46	-0.70
2.5	-0.38	-0.67
4.5	-0.68	-0.86
7	-0.55	-0.57