Summer and annual environmental variations of two polygons in the Indigirka-Kolyma lowland according to monitoring data

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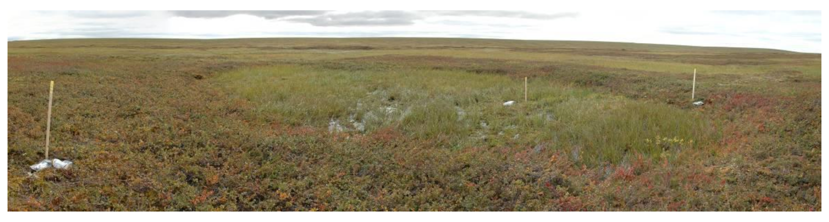
Kytalyk / Indigirka lowland



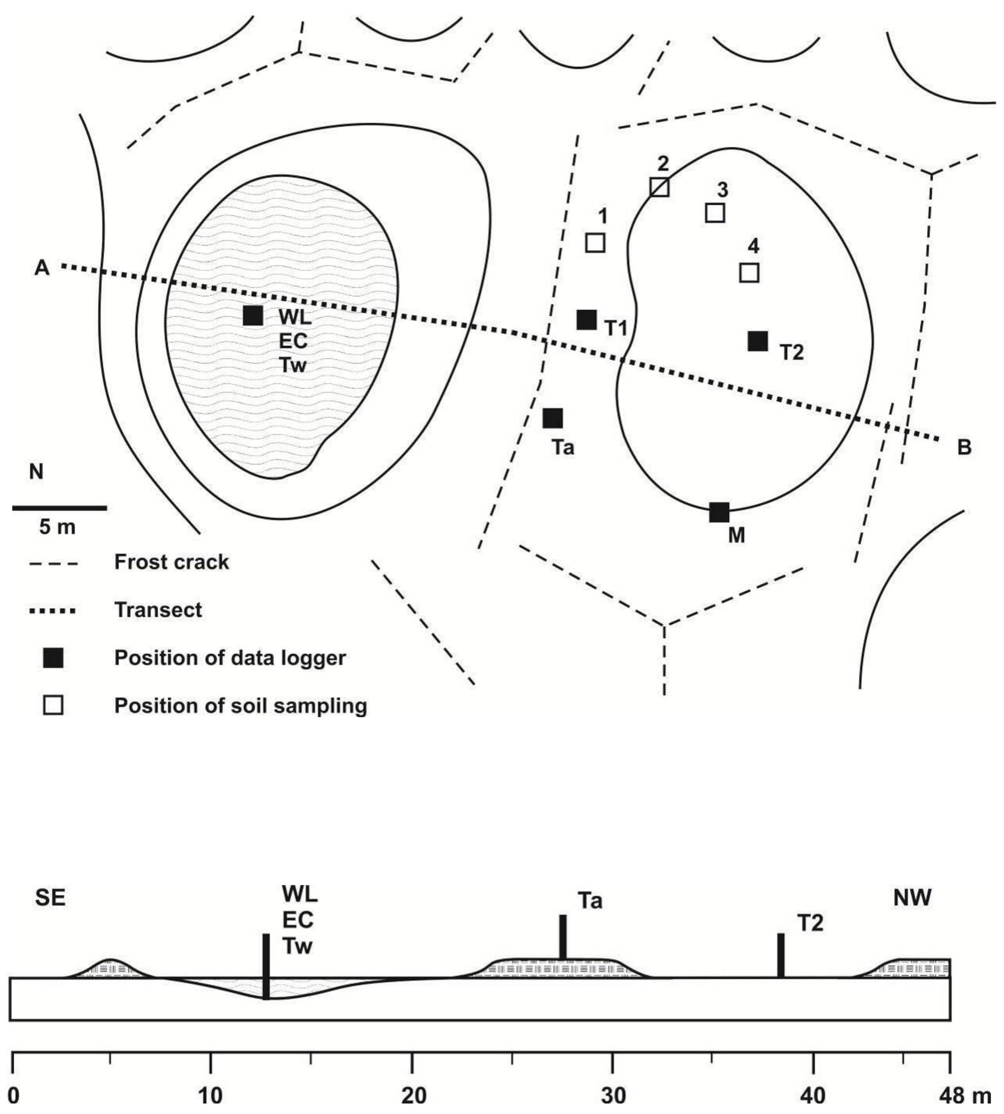


Figure 2 Photograph, site scheme, and location of all data loggers at the Kytalyk study site Kyt-01 (70° 83´12.1´´ N, 147° 48´29.9´´ E).

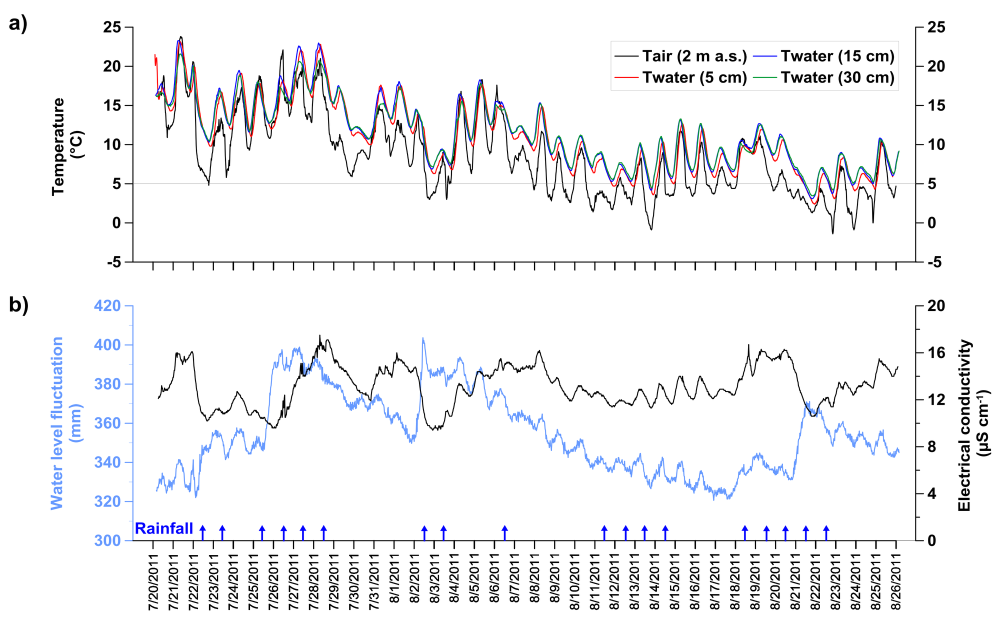


Figure 4 Monitoring data obtained from the site Kyt-01 from 29 July to 16 August 2011. (a) Air and water temperatures; (b) Electrical conductivity, water level, and rainfall.

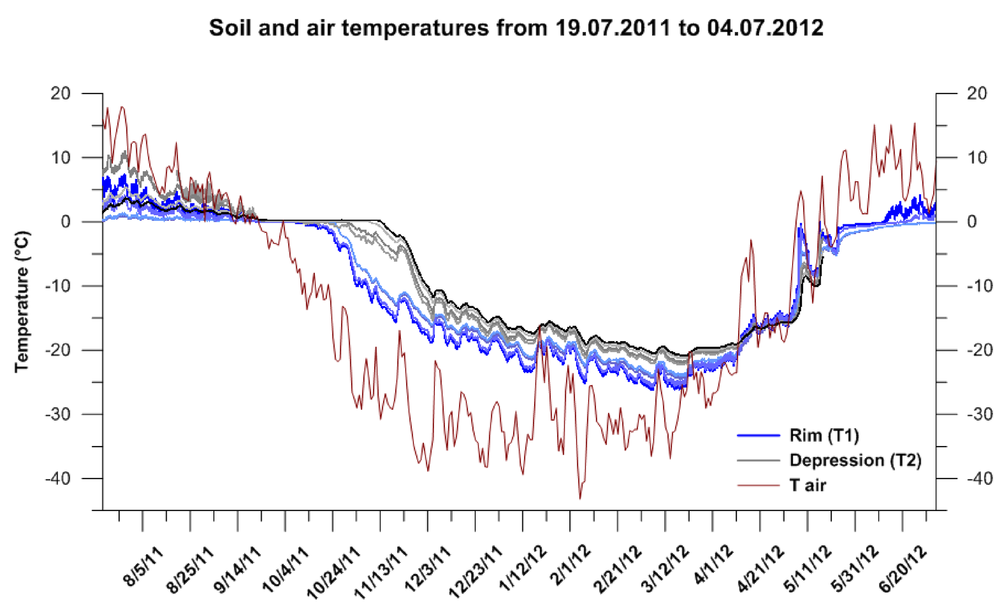


Figure 6 One year record from Kyt-01 (19 July 2011 to 04 July 2012) of soil temperature record from the polygon rim and depression. Air temperature data are daily averages provided by the online climate data base from NCDC/NOAA.

Air and water temperature

The records obtained from two sites in north-east Siberia demonstrate that environmental parameters of polygonal patterned ground are closely linked to local weather and climate variations.

The recorded air and water temperatures behave synchronous and show similar daily patterns during the monitored summer period (Figs. 4, 5). A generally cooling trend towards the end of the summer season is obvious. Both air and water temperatures seem to be in relation with water level changes and variations in electrical conductivity of the shallow pond water body.

Background and study sites

Patterned ground of the polygonal tundra yields sensitive indicators of environmental and climate change. Polygon ponds, mires and cryosoils are typical components of arctic Siberian wetlands underlain by permafrost.

Within the frame of the joint German-Russian DFG-RFBR project „Polygons in tundra wetlands: state and dynamics under climate variability in Polar Regions (POLYGON)" field studies of recent polygon dynamics were carried out in the Indigirka lowland in 2011/2012 and in the Kolyma lowland in 2012/2013 (Fig. 1). A monitoring program was carried out to measure changes in air, water and ground temperatures as well as water conductivity, water level and soil moisture (Tabs. 1, 2).

The study sites were located in the flood plain and the adjacent thermokarst affected lowland along the Berelekh River near the WWF-station Kytalyk (Kyt-01, Fig. 2), 28 km northwest of the settlement Chokurdakh (Indigirka lowland) and the southwestern boundary of the Kolyma Delta near the fishery village Pokhodsk (Pok-01, Fig. 3).

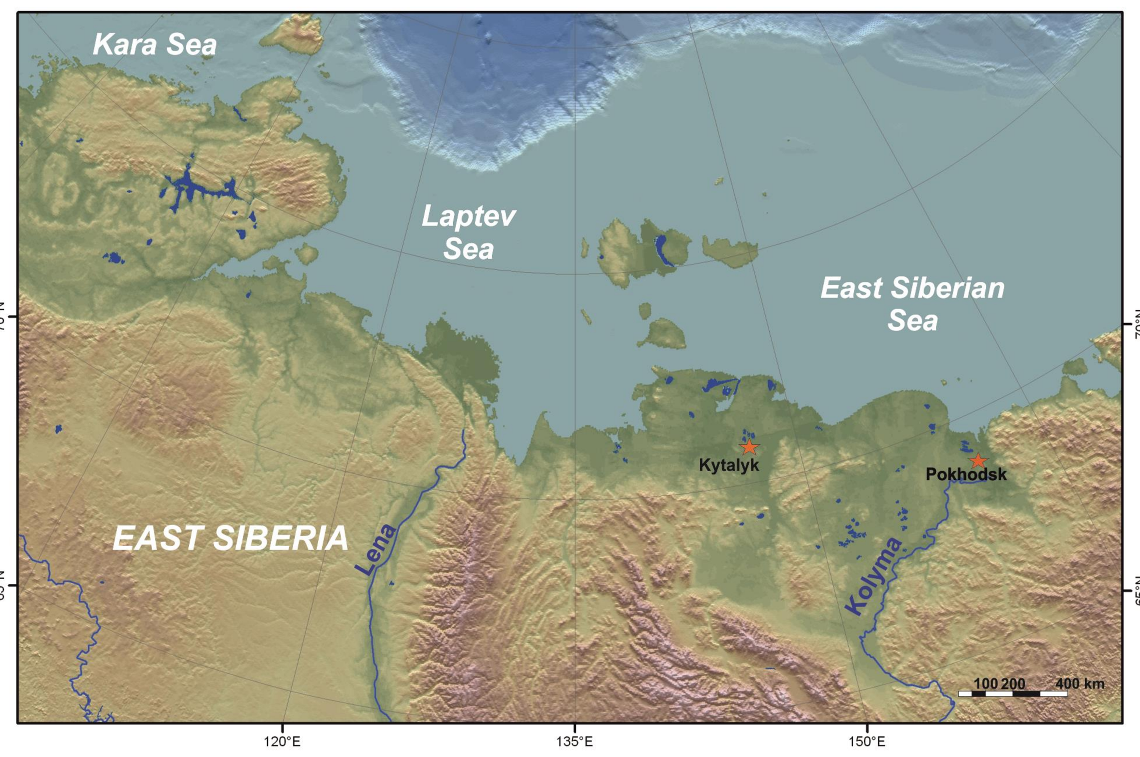


Figure 1 Location of the Kytalyk and Pokhodsk study sites in the northeastern Siberian lowland.

Name	Location	Logger type
Data sensor installed for meteorological conditions:		
Air temperature (Ta)	2 m above ground	MinidanTemp 0.1, ESYS
Data sensors installed for ground conditions:		
Ground temperature (T1)	Upper polygon rim, depth: 3; 15; 23; 31 cm	HOBO Micro Station; HOBO 12-Bit Temperature Smart Sensor
Ground temperature (T2)	Lower polygon rim, depth: 3; 13; 23; 33 cm	HOBO Micro Station, HOBO 12-Bit Temperature Smart Sensor
Ground temperature (T3)	Upper polygon rim, depth: 25; 50; 75; 95 cm	HOBO Micro Station, HOBO 12-Bit Temperature Smart Sensor
Soil moisture (M1)	Upper polygon rim, depth: 2; 14; 23; 28 cm	HOBO Micro Station, Soil Moisture Smart Sensor
Soil moisture (M2)	Lower polygon rim, depth: 5; 14; 23; 30 cm	HOBO Micro Station, Soil Moisture Smart Sensor
Data sensors installed in the pond centre for limnological conditions:		
Water temperature (Tw)	directly below water surface	MinidanTemp 0.1, ESYS
Water level (WL)	10 cm below water surface	HOBO Water Level/ Temp (U20-001-04)
Electrical Conductivity (EC)	20 cm below water surface	HOBO U24 Conductivity/Temp Logger
Water temperature (Tw)	60 cm below water surface	MinidanTemp 0.1, ESYS

Table 1 Overview about location and logger type of the installed data sensors at the Pokhodsk study site

Name	Location	Logger type
Data loggers installed at the dry low-centered polygon:		
Ground temperature (T1)	polygon wall, depth: 5; 10; 15; 20 cm	HOBO Micro Station; HOBO 12-Bit Temperature Smart Sensor
Ground temperature (T2)	polygon centre, depth: 10; 15, 20; 30 cm	HOBO Micro Station, HOBO 12-Bit Temperature Smart Sensor
Soil moisture (M)	inner polygon wall, depth: 12; 22; 27; 30 cm	HOBO Micro Station, Soil Moisture Smart Sensor
Data loggers installed in the polygonal pond:		
Electrical Conductivity (EC)	30 cm below water surface	HOBO U24 Conductivity Logger
Water level (WL)	30 cm below water surface	HOBO Water Level/ Temp (U20-001-04)
Water temperature (Tw)	5, 15, 30 cm below water surface	MinidanTemp 0.1, ESYS
Data logger installed on a pole between the two polygons:		
Air temperature (Ta)	2 m above ground	MinidanTemp 0.1, ESYS

Table 2 Overview about location and logger type of the installed data sensors at the Kytalyk study site

Ground temperature

The recorded ground temperature follows variations in air temperature. Furthermore, the active layer exhibits a thermal differentiation with depth that synchronizes with air temperature patterns, even in the lowest and coldest component of the active layer.

Soil temperature data show that freezing in polygon rim and depression occurred in late September and October several days after the air temperatures went well below 0°C. The rim was freezing earlier than the depression.
Even in winter the soil temperatures follow variations in air temperature despite being frozen solid. Soil temperatures in the rim were about 5°C lower than in the depression. The minimum temperature in the polygon rim was -26°C and -22°C in the polygon depression.

In April and May air temperatures reached ≥0°C. Ground thawing started in May and was faster than freezing while the polygon rim and depression thawed in the same period.

Pokhodsk / Kolyma lowland

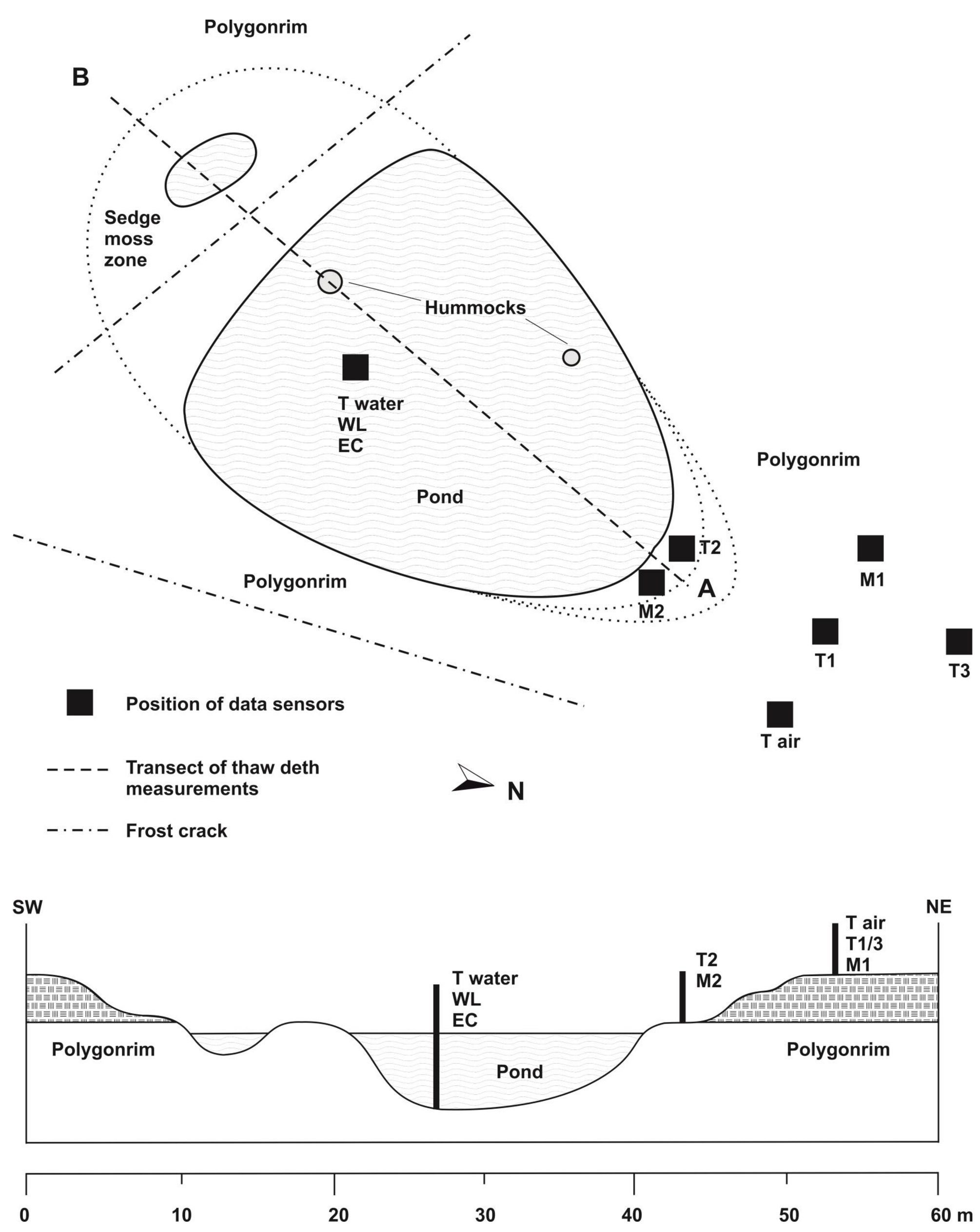


Figure 3 Photograph, site scheme, and location of data loggers at the Pokhodsk study site Pok-01 (69.09510° N, 160.93877° E).

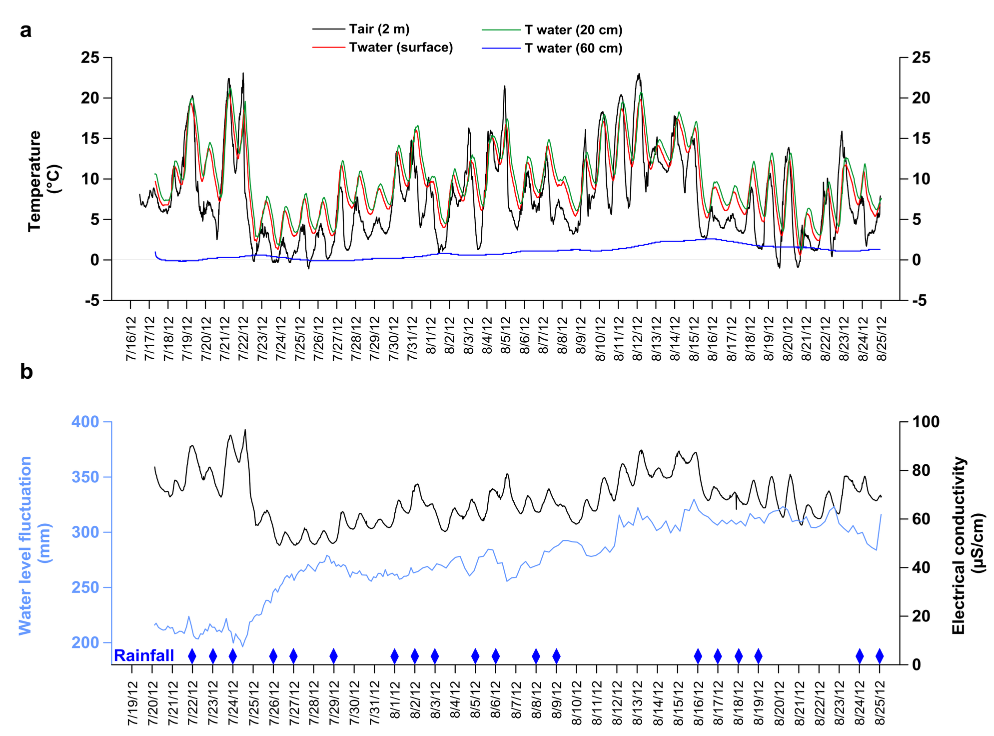


Figure 5 Monitoring data obtained from the site POK-01 from July 16 to August 25, 2012. (a) Air and water temperatures, (b) Electrical conductivity, water level, and rainfall.

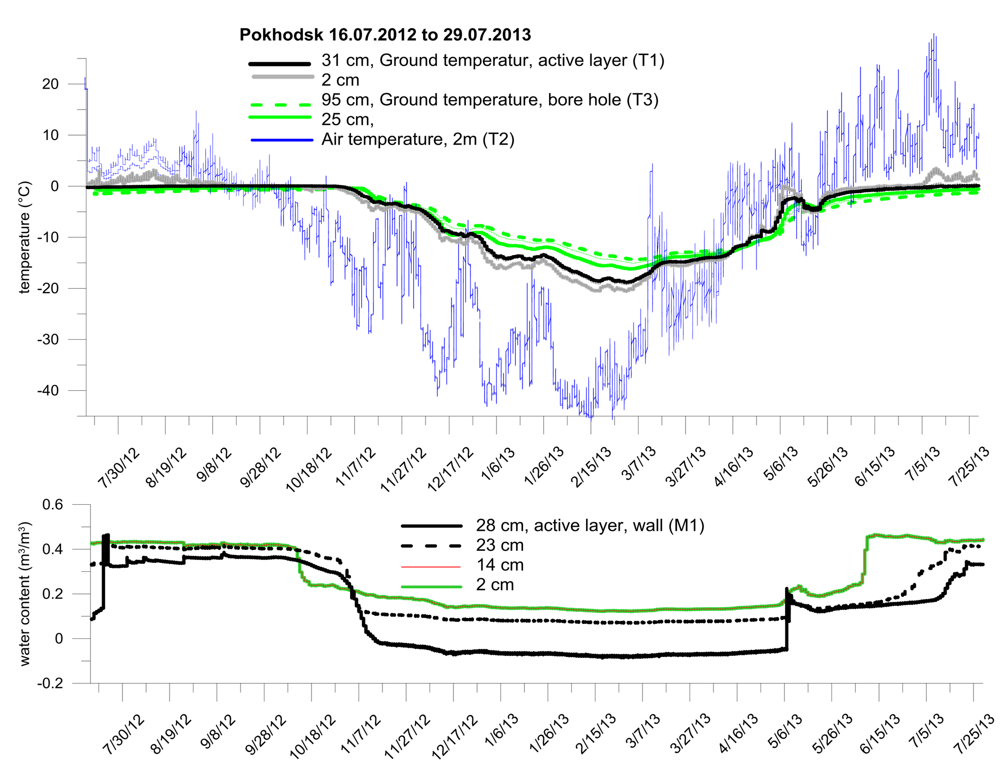


Figure 7 One-year record from Pok-01 (19 July 2012 to 29 July 2013) of soil temperature and soil moisture from the polygon rim.

Soil moisture regime

The data derived from the soil moisture sensors do not feature a significant pattern. They represent a largely constant moisture differentiation in the active layer during the summer season. Significant changes in moisture conditions were observed during the freezing and thawing periods in autumn and spring. The onset of freezing in autumn or spring-meltwater from sow and ice marks the periods of greatest soil moisture variations. During winter the sensors are frozen and did not measured any soil moisture

Support
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