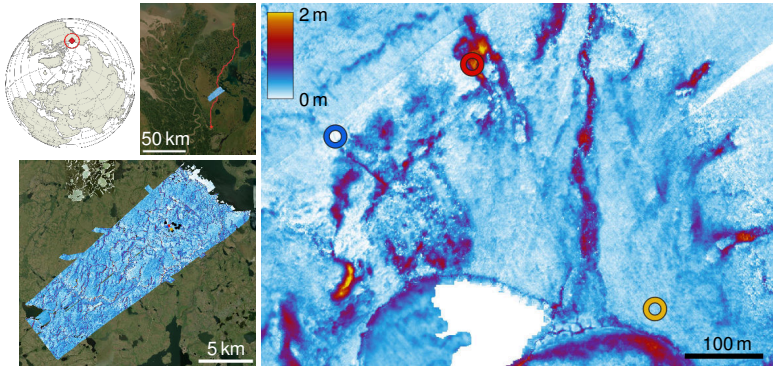
Snow on permafrost: the effect of spatial snow variability on soil temperature in Trail Valley Creek, NWT, Canada

I. Grünberg[1], D. Hollenbach Borges[1,2], J. Hammar[1], N. Rutter[3], P. Marsh[4], and J. Boike[1,2]

1 AWI 2 Humboldt-Universität zu Berlin 3 Northumbria University Newcastle 4 Laurier Inspiring Lives.

How does the snow variability affect soil temperature and permafrost thaw?

- Treeline ecosystem
- Continuous permafrost
- 140 km^2 snow depth map (April 02, 2023)
- 13 loggers for temperature profiles at 13, 0, and −8 cm



Background: ESRI satellite

inge.gruenberg@awi.de

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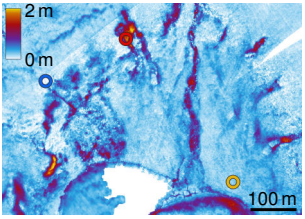
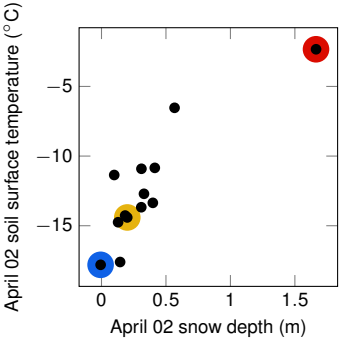
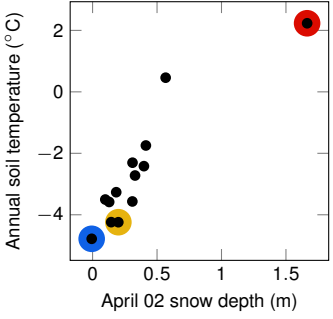


Thick snow keeps the soil warm all year

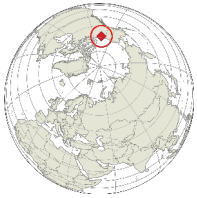
- Winter and annual soil temperature highly correlated with April snow depth
- Snow depth related with topography and vegetation type: today 10:54, EGU24-16806, HS6.4, PICO spot 3

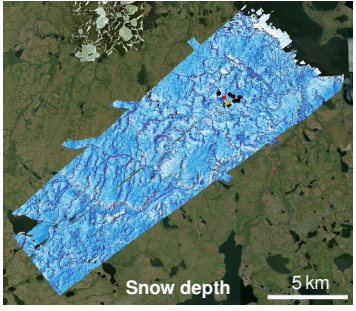


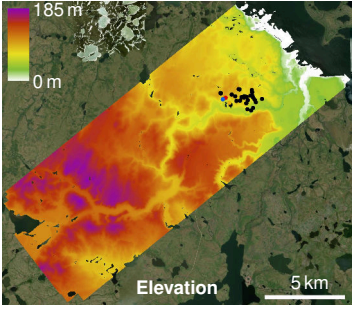


inge.gruenberg@awi.de

- Trail Valley Creek
- 42 km north of Inuvik
- North-West Territories, Canada
- 68.74 °N,133.50 °W
- Research station by Phil Marsh, Wilfrid Laurier University
- Continuous permafrost
- Treeline ecosystem with mostly tundra vegetation and sparse spruce forest in favourable locations
- Mean annual air temperature: −4.2 °C







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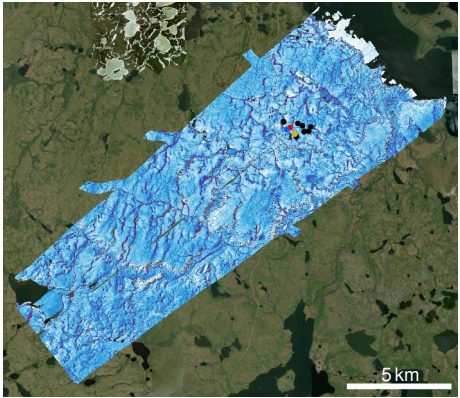
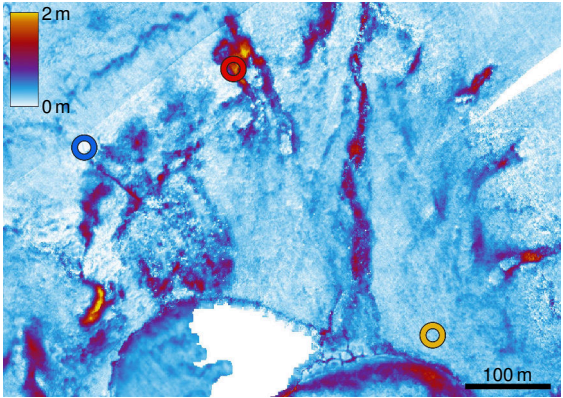
- Airborne laser scanning surveys: April 2 and July 10, 2023
- Winter DSM: Riegl VQ-580, summer DTM: Riegl LMS-Q680i (full waveform)
- 1 m^2 spatial resolution for 140 km^2 (winter) and 170 km^2 (summer)
- Underestimation of snow depth at dense vegetation where the terrain model does not represent the ground





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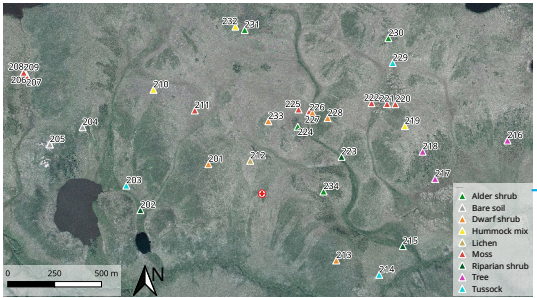
- 34 loggers since August 2022
- Only 13 could be read out in August 2023 (wildfires)
- The complete data cover 9 vegetation types with 2–3 replicates
- Each logger measures a temperature profile in air/snow (13 cm above the surface), at the soil surface and in the soil (8 cm depth)
- Tomst TMS-4



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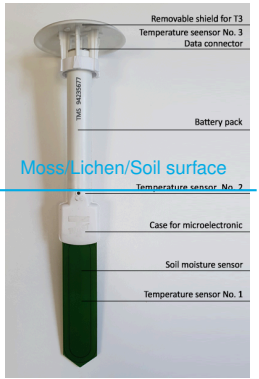

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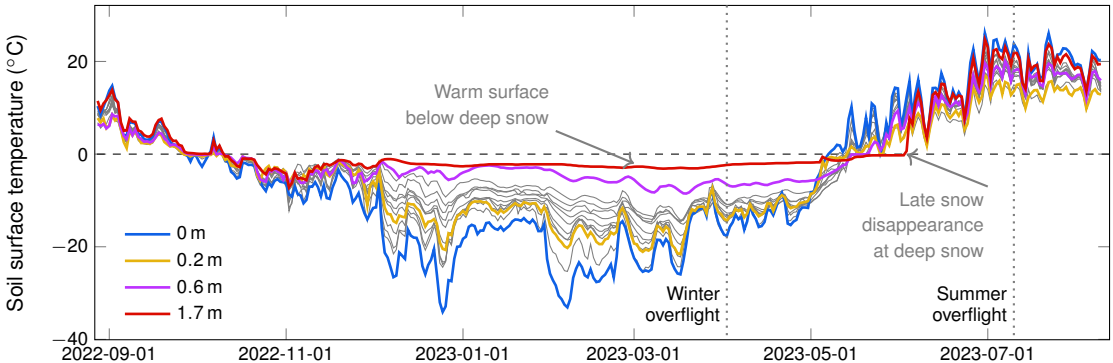
- Daily mean values of 13 soil surface temperature sensors: bottom of the snow pack
- Four sensors with different April 02 snow depth highlighted (see legend)



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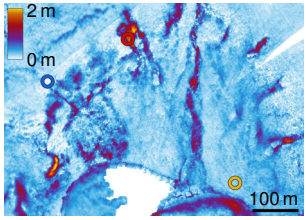
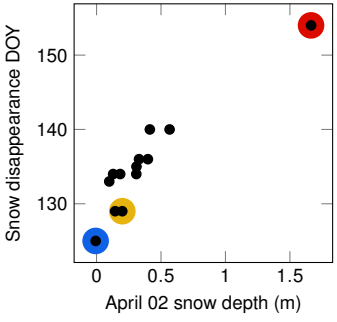
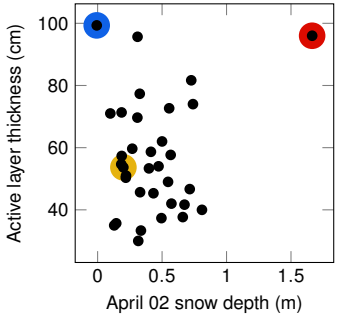
Thick snow leads to late melt

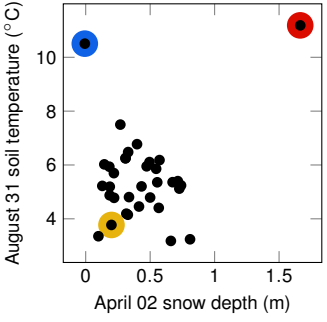
Relationship April snow depth – summer conditions unclear: vegetation and soil properties

- All 34 points can be used for snow depth and summer conditions









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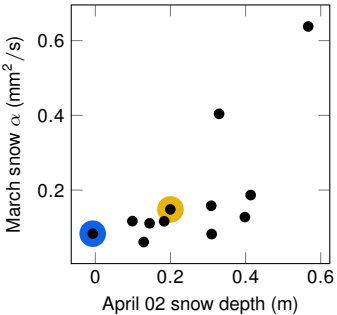
Snow depth and/or vegetation influence snow thermal properties (which are hard to measure)

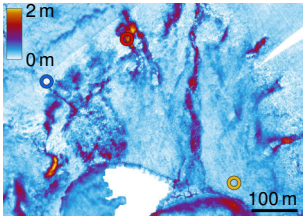


$\alpha = \frac{k}{\rho c_p}$ with

- α thermal diffusivity
- k thermal conductivity
- ρ density
- c_p specific heat capacity

Estimated from the daily temperature amplitudes in the lowest snow layer (0 cm–13 cm) using the approach by

- An et al., 2016: Estimation from Soil Temperature of Soil Thermal Diffusivity and Heat Flux in Sub-surface Layers Boundary-Layer Meteorology, 158, 473-488

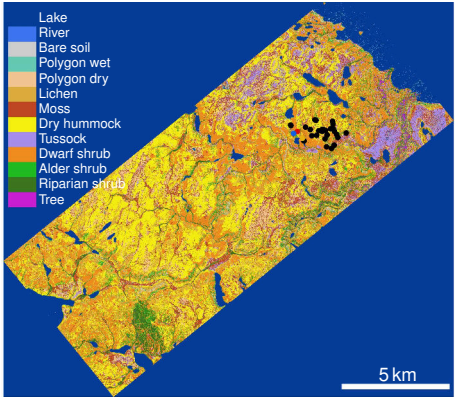


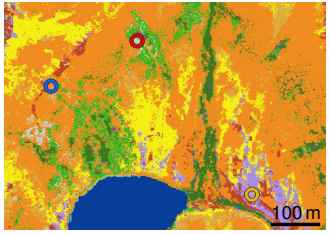
More research needed to be confident about the absolute values

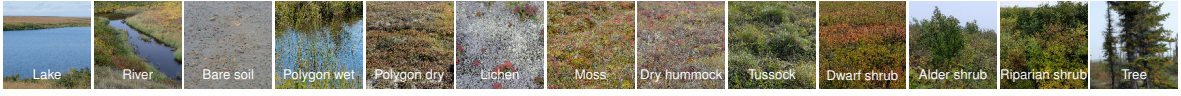
inge.gruenberg@awi.de

This summer, we will collect data of all 34 sensors covering 2 years. Last year, wild fires did not allow us to collect all data but only 13 loggers.

- The complete data cover 9 vegetation types (excluding 2 water & 2 polygon types) with 2–3 replicates
- We will look at the interaction of vegetation type – snow characteristics – snow, surface, and soil temperature variation







inge.gruenberg@awi.de

Thank you for your attention!

I would love to get your feedback and discuss further: inge.gruenberg@awi.de

Thanks to

- Thomas Krumpen and the IceBird Winter 2023 Campaign crew
- Guido Grosse and the Perma-X Summer 2023 Campaign crew
- Nick Rutter, Branden Walker and their teams for detailed snow measurements in the field
- Anselm Köhler and Rolf Sander for the pico beamer template