Prolonged and profound changes of retrogressive thaw slumps (Herschel Island - Qikiqtaruk, Yukon, Canada)

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Introduction

Along Arctic coastlines retrogressive thaw slumps (RTS) are a common thermokarst landform (Lantuit & Pollard 2005, Ramage et al. 2018) and an indictor of climate warming and permafrost degradation (Segal et al. 2016). They deliver a large amount of material rich in organic carbon to the nearshore zone (Tanski et al, 2017, Lantuit et al. 2012). In the last century the number of RTS has strongly increased in the Canadian Arctic (Lantuit & Pollard 2008, Ramage et al. 2018). Mainly characterized by rapidly changing topographical and internal structures (such as mud flow deposits, thaw bulbs, warm permafrost bodies or seawater-affected sediments) RTS are strongly incluenced by increasing gullies. We propose that due to thermal and mechanical disturbances, especially large RTS are likely to develop a polycyclic behavior.

Study site

Located in the canadian Beaufort Sea on **Herschel Island** - Qikiqtaruk the examinated RTS "Slump D" is the largest along the Yucon coast (Ramage et al. 2017). This area is predicted to experience the greatest warming in the Canadian Arctic (Lantuit & Pollard 2008).

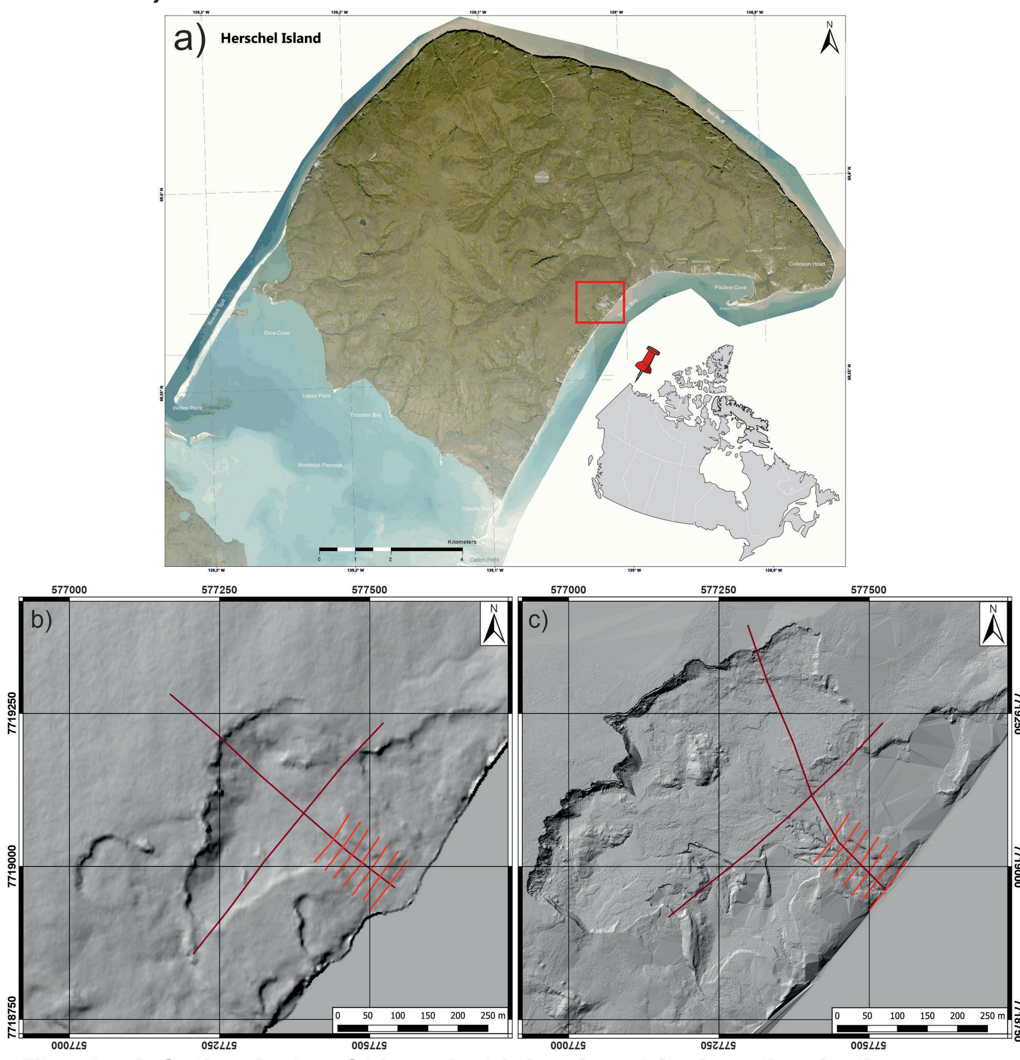
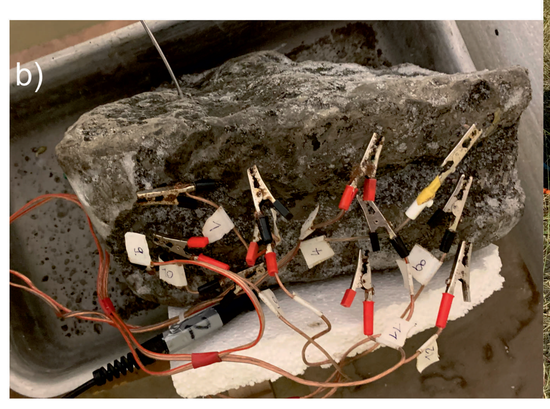


Fig. 1: a) Orthophoto of Herschel Island and its location in the Canadian Beaufort Sea (Orthophoto by AWI); b) DEM (airborne, by AWI) of Slump D from 2012 including the measured ERT-profiles; c) DEM (terrestrial) form 2019 including the measured ERT-profiles

Methods

- 2D and 3D electrical resistivity tomography (ERT): 9 transects 2011, 2012 & 2019
- **2D surveys**: 500 m from coastline to undisturbed tundra
- **3D survey**: sequence of 7 parallel 100 m long transects.
- **calibration** in the field: frost probing to detect the unfozen-frozen transition
- **calibration** in the lab: bulk sediment resistivity measured vs. temperature curves

Fig. 2: a) headwall Slump D in 2019, height aprox. 25 m; foreground: ERT measuring equipment.
b) laboratory calibration on a frozen sample from Herschel Island



Results

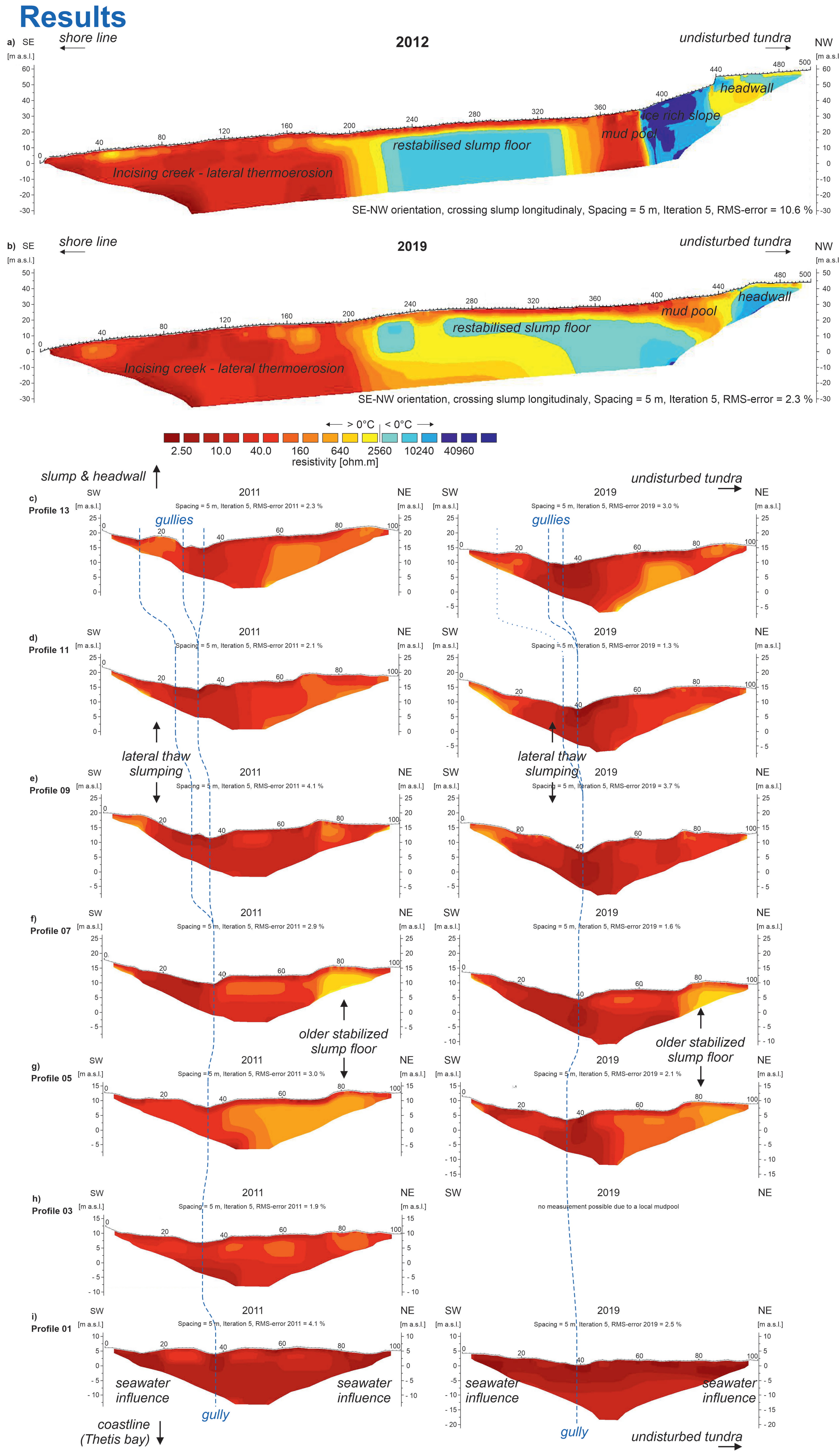


Fig. 3: Electrical Resistivity Tomography (ERT)-Profiles; a) longitudinally crossing Slump D (2012); b) repeated transekt (2019); c-i) 3D-transects measured in 2011 and repeated in 2019 with profile 01 (i) measured at the shoreline and profile 13 (c) closest to the headwall; interpretation based on mapping and geophysical laboratory calibration (Fig. 4).

Discussion

- **RTS can generate** strong and deep **thermal perturbations** (> 10 m) rendering them more susceptible to polycyclic activity
- Underlying gullies, low resistivities show permafrost warming accelerated by **heat transfer from flowing water** (de Grandpré et al. 2012)
- Slump D showes some effects of **seawater intrusion** several meters inward from the shoreline (drop of resistivity)
- Fig. 3 a&b show low resistivities beneath the headwall: result of heat input by mud pools & an exaggerating artefact of the robust inversion
- **ERT calibration** (Fig. 4): temperature of aprox. 0°C at a bulk sediment resistivity of ca. 2.5 kΩm

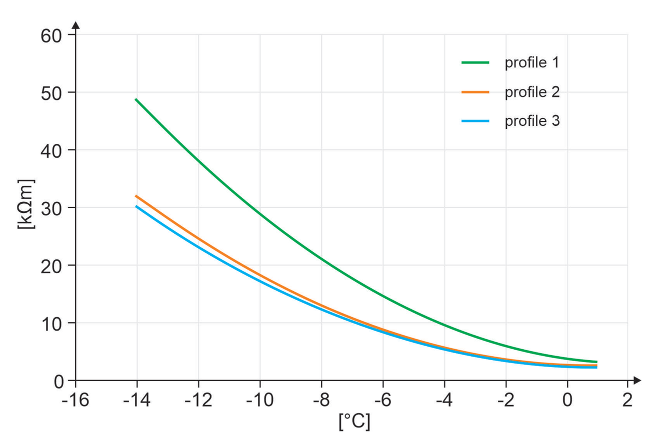


Fig. 4: calibration of ERT - bulk sediment resistivity vs. temperature curves, using setup as in Fig. 2a. Profile 1 (green) located on a very ice rich layer in the sediment sample, leading to an offset of resistivity for cooler temperatures.

Conclusion

- Strong **thermal and topographical disturbances** by gullies, mud pools and other processes → long recovery rates for disturbed permafrost (decades to centuries)
- transport of massive amounts of sediment & organic matter to the shoreline by gullis → **gullies are a major heat source affecting the underlying permafrost**
- Geophysical methods: sutable to be used for determination long-lasting **thermal and mechanical disturbances predefining susceptibility of RTS to a polycyclic reactivation**

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