In-situ measurements of sediment temperature under shallow water bodies in Arctic environments

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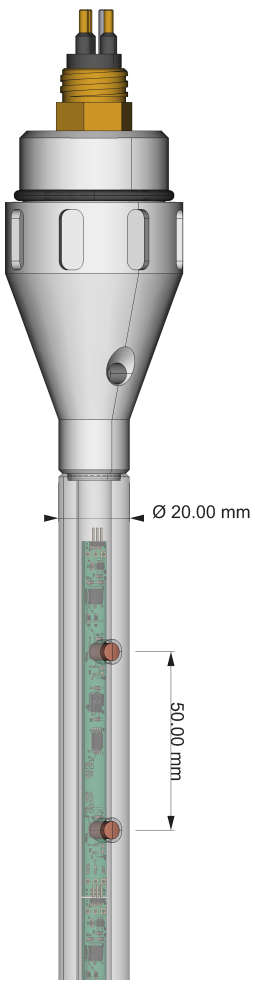
Background and Aims

Information regarding the thermal regime of sediments below Arctic lakes and the near-shore marine environment is scarce but could potentially inform us about the presence of and depth to permafrost. To address this need, we developed a robust temperature lance capable of withstanding these harsh environments while delivering high accuracy temperature depth profiles.

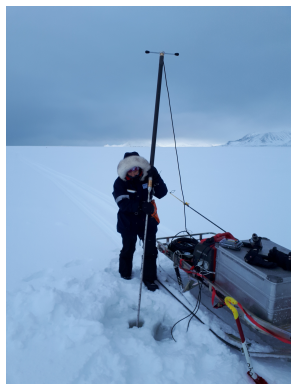
Technical Overview

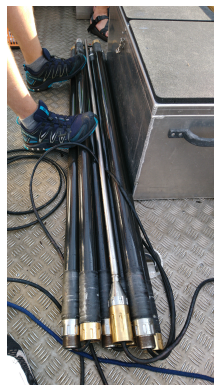


The temperature lance is constructed from stainless steal, 1.5m long, and 20mm in diameter:

- 15 digital nodes, 30 temperature sensors, with $5\,\mathrm{cm}$ spacing
- 2 nodes with an accelerometer to measure probe angle (tilt)
- accuracy $\pm\ 0.10\,^{\circ}\mathrm{C}$
- resolution $0.01\,^{\circ}\mathrm{C}$
- ice-bath calibration to increase accuracy at $0\,^{\circ}\mathrm{C}$ to near $\pm\ 0.01\,^{\circ}\mathrm{C}$
- Arduino based logger with GNSS to record measurements and position (below)
- Extendable with $1.5\,\mathrm{m}$ extensions up to $9\,\mathrm{m}$ (right, center)

Deployment Methods

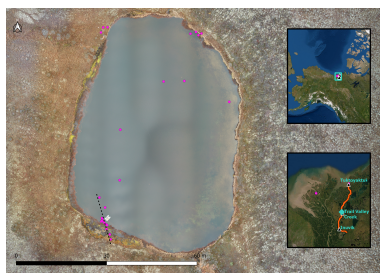


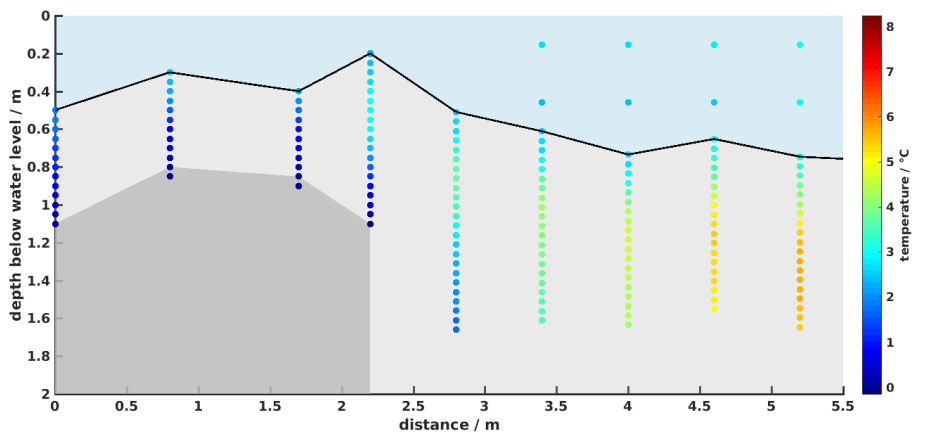


Designed to be deployed through a hole in the ice during winter (left), it can also be deployed from a small boat or wadding in shallow water (right). It can either be pushed into soft sediments or hammered in hard sediments.

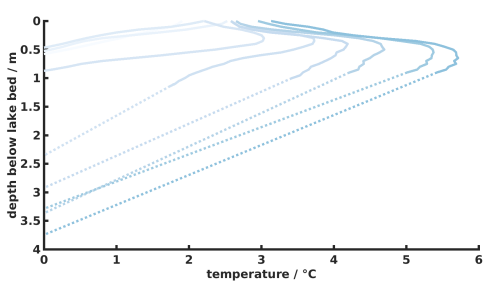
Example Data from NW Canada

This data set was collected in September 2022 in NW Canada beneath a thermokarst lake near the Inuvik-Tuktoyaktuk-Highway just north of Trail-Valley-Creek research station.



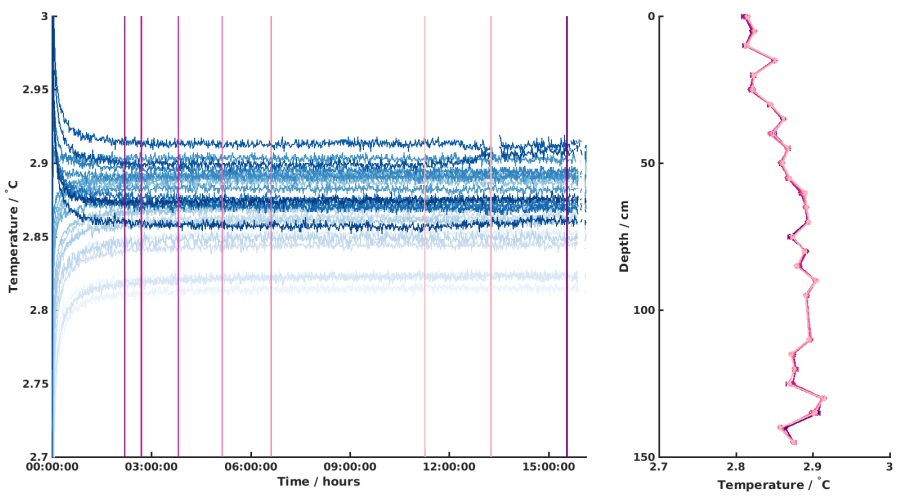


In the shallow and swampy part of the lake, the ground was only thawed to about 70cm and we could detect it with the temperature lance.



Modeling can possibly be used to approximate the depth of the permafrost table (left; solid lines, measured; dashed lines, modeled). Comparisons with other (geophysical) methods is ongoing.

Data Post-Processing



Measurements over 12 hours (left) show that the sensors equilibrate quickly and are stable. The temperature profiles at different times are shown on the right.

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