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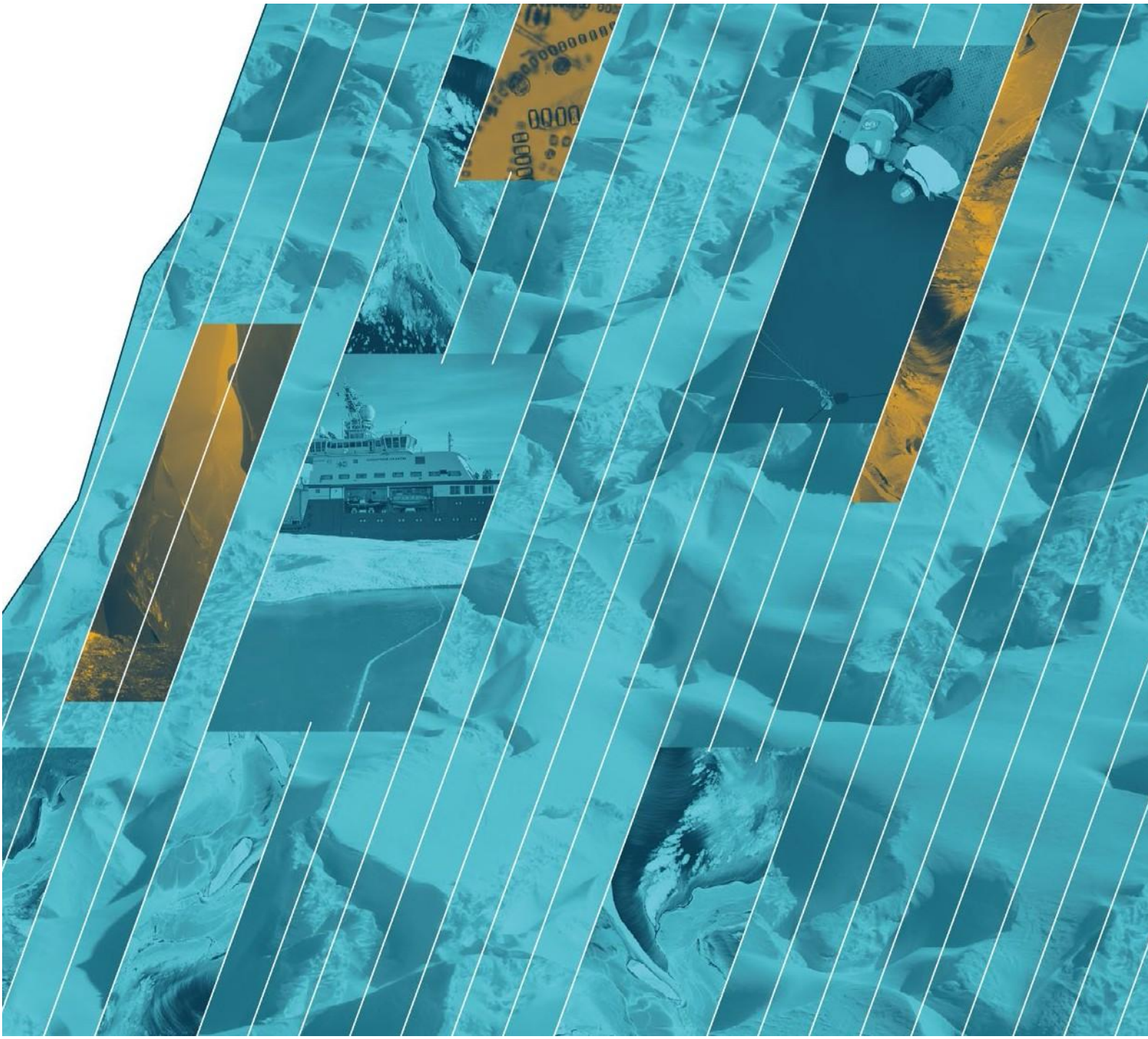
iC3-25-01

Field trip Report



iC3 Report Series, Volume 02 (2026)

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Title of the report: Field Report iC3-25-01 - Methane emissions from glacial-fed lakes, Kangerlussuaq, southwest Greenland

Year: 2026

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Keywords: Greenland, Greenland Ice Sheet, methane, greenhouse gases, climate change, carbon cycling, proglacial lakes, ice-marginal lakes, lake sediments, sediment cores, biogeochemistry, Kangerlussuaq.

Photo credit: Joost van Genuchten

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To be cited as: Lamarche-Gagnon, G. et al. (2026). iC3-25-01 Field report - Methane emissions from glacial-fed lakes, Kangerlussuaq, southwest Greenland. *iC3 Report Series*, *Volume 02*. https://doi.org/10.7557/30.8516

ISSN: 2704-2065
Publisher: Septentrio Academic Publishing Tromsø Norway

Version	0 (02.2026)
Comments	First version

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1 Preface

This report details fieldwork activities and corresponding research plans associated with the iC3-25-01 land-based research expedition to the Kangerlussuaq area, southwest Greenland, in April 2025. The fieldwork joined participants from iC3: Centre for ice, Cryosphere, Carbon and Climate, UiT-The Arctic University of Norway, the Cryoeco group at Charles University in Prague (CU), as well as the University of Alaska Fairbanks. The work falls under the general iC3 research theme on carbon cycling in ice sheet environments and was fully supported via the centre's main research activity funds, with additional financial and in-kind support from the Cryoeco group to its participant member.

2 Participant list

All participants contributed equally to all fieldwork activities.

- *Lamarche-Gagnon, Guillaume (iC3/UiT – researcher), field leader* [GLG]
- *van Genuchten, Joost Martijn (iC3/UiT, PhD candidate)* [JvG]
- *Bulínová, Marie (UiT, PhD candidate)* [MB]
- *Brosius, Laura (Full Plate Farm, MI, USA – previously University of Alaska Fairbanks, PhD)* [LB]
- *Fouillé, Arthur (Charles University in Prague, PhD candidate*) [AF]

3 Introduction and objectives

Mounting evidence indicates that glacial melt and ice-sheet retreat can be accompanied by emissions of the greenhouse gas methane to the atmosphere (e.g. Christiansen & Jørgensen, 2018[2]; Dieser et al., 2014[3]; Lamarche-Gagnon et al., 2019[4]). How important these glacial emissions are and what trajectory they might take following future accelerating rates in ice retreat is not well understood and impossible to forecast with the data and knowledge at hand. Directly accessing the subglacial environments, where carbon transformations and greenhouse gas production occurs, is very logistically challenging. But the recently deglaciated margins of ice sheets are more readily accessible and might hold clues to better understand these processes.

This fieldwork centred around monitoring and sampling of glacial-fed ice-marginal lakes previously identified as hotspots of methane emissions in the sector of Kangerlussuaq, Southwest Greenland (Brosius et al., 2024[1]; Walter Anthony et al., 2012[6]). Broadly, this work aims at better understanding the environmental drivers behind those methane hotspots and potential connections to the subglacial ice-sheet environment. Samples

and data collected during the fieldwork will help address uncertainties regarding methane emissions in (pro)glacial environments, inform on carbon cycling in subglacial and glacially influenced freshwater systems (lakes and ice-marginal zones), as well as on lake development and ecological transition following deglaciation in polar regions.

Field objectives consisted in collecting lake sediment, water and gas samples for biogeochemical analyses. These include the characterisation of methane gas (concentrations and stable isotopic composition), organic carbon and macronutrients, as well as lake sediment properties. Samples destined for microbial community characterisation (DNA) and incubation experiments (methanotrophy and methanogenesis) were also collected.

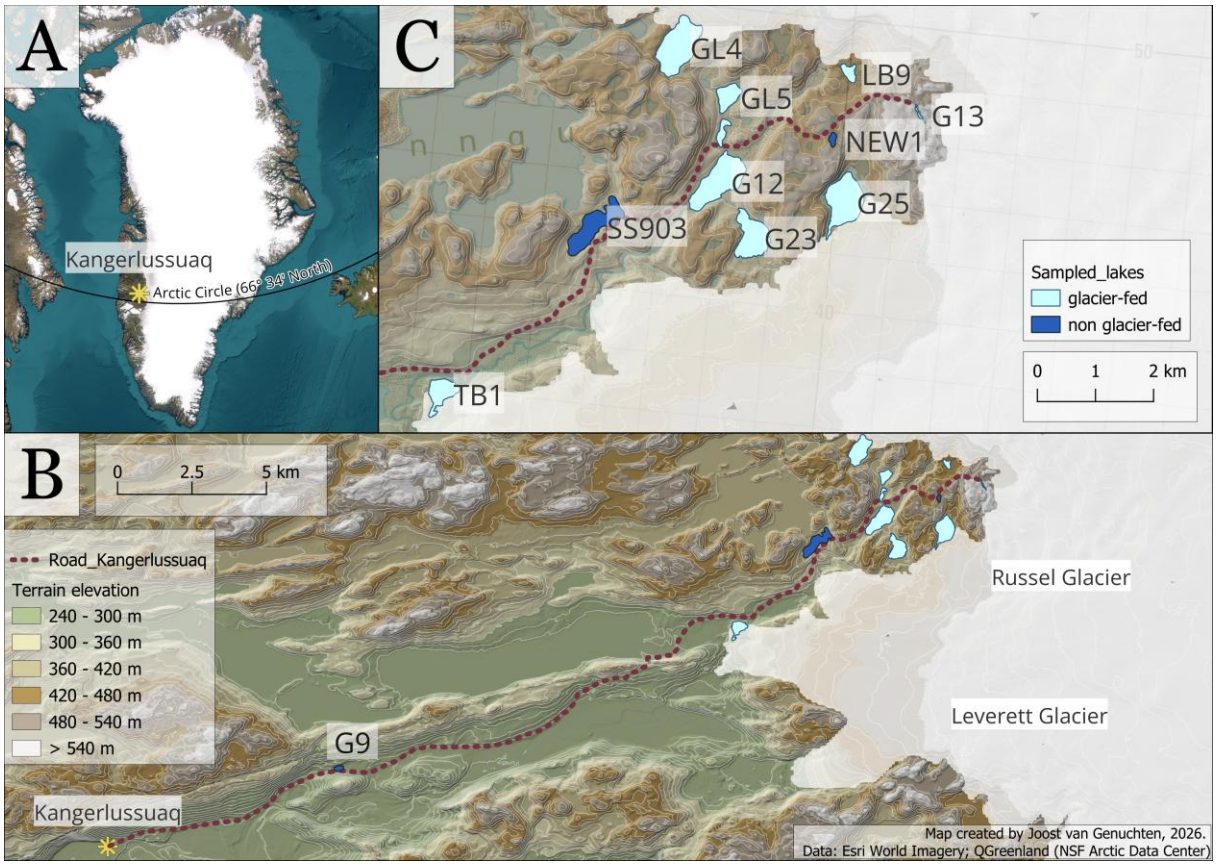

Figure 1. Map of sampling locations near the settlement of Kangerlussuaq, Southwest Greenland. A. Greenland with location of Kangerlussuaq highlight. B. Overview map of all sampling locations visiting during the fieldwork. The different lakes samples are highlighted in blue, and the dashed red line corresponds to the road connecting the town of Kangerlussuaq to the ice sheet. C. A zoomed-in version of the map in B, highlighting most sampling sites located closer to the ice sheet margin.
Image credit: Joost van Genuchten.

4 Study Area

The settlement of Kangerlussuaq was originally built to serve as a US military base during the Second World War (Søndrestrom) but has since transitioned to full Greenlandic settlement status during the 1990s. Kangerlussuaq served as Greenland's main international air transport hub until 2024 but remains the main

destination for US Air National Guard flights serving the NSF's Greenland research program. Due to easy access and proximity to the Greenland Ice Sheet, Kangerlussuaq has been one of the main destinations for scientific research in Greenland and on the Greenland Ice Sheet. Kangerlussuaq is also located next to the UNESCO World Heritage Site Aasivissuit – Nipissat, a protected area that spans the entire land sector between Sisimiut and the ice sheet, used for hunting and foraging for > 4000 years and comprising several archaeological sites. (https://whc.unesco.org/en/list/1557/).

Online resource information on Kangerlussuaq: https://scienceservices.gl/

Figure 2. View of Kangerlussuaq 2025.04.24.
Photo credit: Arthur Fouillé

The study area between Kangerlussuaq and the Greenland Ice Sheet (GrIS) consists of continuous permafrost, with a geology dominated by granitic and gneissic rocks with basic intrusions (e.g. Yde et al., 2018[8]). Geographical features in the area include floodplains with dunes, meandering river systems, moraine ridges, numerous glacial lakes, low mountains, tundra vegetation, and a dry Arctic climate. All fieldwork was terrestrial and took place during the month of April 2025 under late-winter conditions; i.e. sub-zero temperatures and snow-covered terrain, although snow-depth rarely exceeded a few 10s of cm,

typical of the low annual precipitations and cold semi-arid climate of the region (https://weatherandclimate.com/greenland/qeqqata/kangerlussuaq#t2).

5 Activity Report

Fieldwork was operated in April 2025 from the settlement of Kangerlussuaq, with members staying at the Kangerlussuaq International Science Support (KISS) facility (Fig. 2). Most field sites were located within 30 km of Kangerlussuaq and required up to 2-hour drive followed by typically < 30 min walk in shallow snow and on lake ice – the shallow snow conditions did not require the use of skis or snowshoes, but sleds were used to transport equipment to the more distant lake locations (e.g. Fig. 3). Site access was by vehicle (pickup truck) on a road that connects Kangerlussuaq to the ice sheet margin (a.k.a. Point 660), and then by foot to sampling locations, which mostly consisted of lakes receiving glacial meltwaters during the summer months (glacial-fed lakes, GF) or hydrologically separated from glacial meltwaters (non-glacial fed, NGF) (see Fig. 1).

Figure 3. Entrance of the Kangerlussuaq International Science Support (KISS) station (back). Team offloading gear from pickup truck (front).
Photo credit: Marie Bulínová

Figure 4. Example of lab space inside KISS.
Photo credit: Arthur Fouillé

Figure 5. Pickup truck used during fieldwork on the road towards field sites, with group of tourist and tourist bus in the background - pickup truck rental JMM Gruppen (top left). Also field team walking on lake ice (bottom left) or partially snow-covered tundra (right), carrying field gear in backpacks and snow sled. Bottom left: lake G12. Right: ice-dam lake G25 in the background with part of Russell Glacier.
Photo credit: top left, Arthur Fouillé; bottom left and right Joost van Genuchten.

The bulk of sampling activities consisted in collecting lake hydrochemical and biogeochemical data and samples from the water column and short (<1m) sediment cores. Follow-up biogeochemical analyses include the characterisations of methane gas (concentrations and stable isotopic composition), organic carbon and macronutrients, as well as lake sediment properties. Samples destined for microbial community characterisation (DNA) and incubation experiments (methanotrophy and methanogenesis) were also collected.

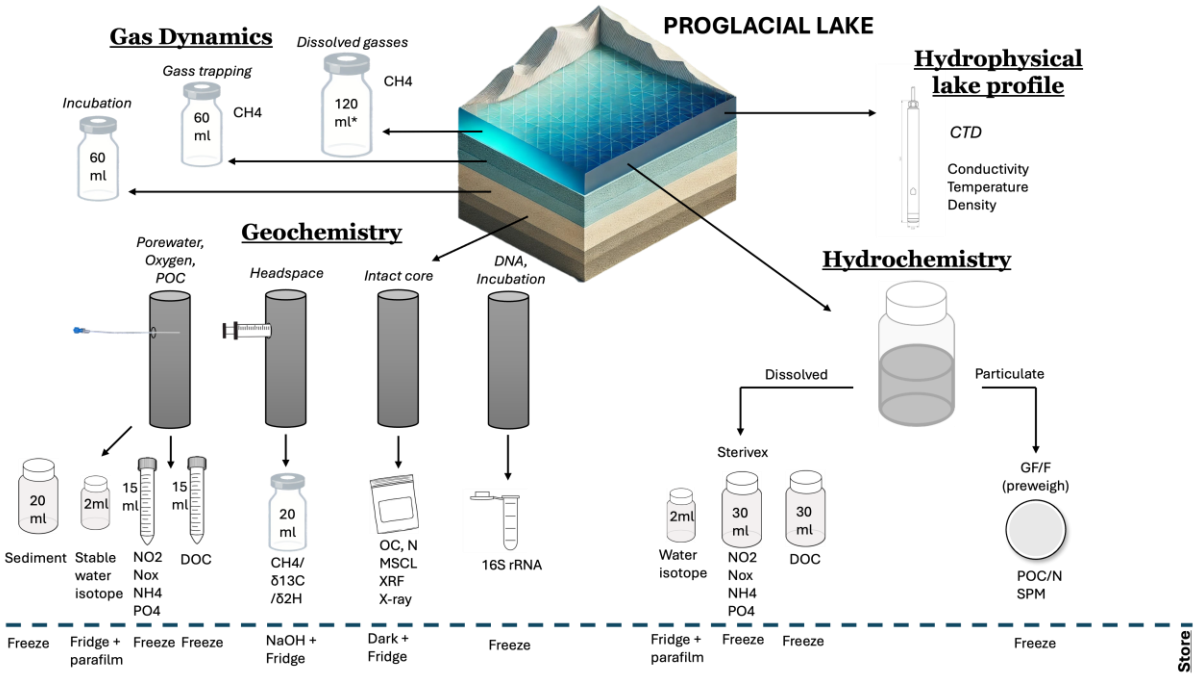

Figure 6. Summary diagram of sampling activities.
Image credit: Joost van Genuchten

Lake samples were accessed via boreholes through the lake ice (ice thickness ~70 – 130 cm) using hand or electrical augers and ice picks. On-site sub-sampling was normally performed inside a "science" tent whenever possible, or back at the KISS facilities. Borehole location was based on previously determined lake bathymetry, geography (e.g. middle of lake), or visible presence of ice-bubble clusters (likely indicative of methane ebullition hotspot). Lake hydrological profiles were determined using a depth sonder and CTD (see sections below). The first core (replicate core #1) was normally destined for methane porewater subsampling, followed by a core for porewater extraction (replicate core #2), for microbial community characterisation (replicate core #3) and finally for sedimentology characterisation and archiving (replicate core #4). Lake water samples were collected in parallel. No more than 2 cores were collected from the same borehole to prevent the collection of disturbed material; water samples were collected from undisturbed water column (either prior to commencing coring or from a separate borehole). Whenever possible, activities were performed in parallel in sub-groups to minimise sampling time. A handful (3) of groundwater icings (Fig. 1) were also sampled for hydrochemistry, and tentative and partial methane ice-bubble surveys performed on 3 lakes where field and ice conditions allowed.

Figure 7. Aerial view of field site G23 and lake coring activities on 2025.04.09. Clear lake ice and snow-free conditions due to warmer temperatures and light rain during the past 24 hours.
Photo credit: Joost van Genuchten

The following sections details sampling activities in typical order. Some activities were performed in parallel whenever possible. The full list of sampling locations is reported in Appendix A

5.1 Sediment core retrieval

5.1.1 Description and methods

Lake sediment cores were collected using a universal piston percussion corer deployed through an ice borehole using hand or electrical augers and ice picks, with a target of four cores per lake. Core liners consisted of 120 cm long (internal diameter 68mm) transparent polycarbonate tubes. Lake water depth was first measured using a depth sonder (Hondex PS-7) and the percussion corer then lowered to the lake sediment-water interface. Percussion coring was performed using a bronze weight connected to a separate rope, which enabled to be lifted and let down for hammering.

5.1.2 Methods

Sediment cores were retrieved as followed: First, drill a hole in the ice and remove any ice slush, so this will not disturb the piston to create the vacuum. Measure the water depth with a portable depth sounder to determine the appropriate setup. Prepare the percussion corer by attaching the necessary ropes (premeasured) core liner and hammer setup, following manufacturer's instructions. Lower the corer and hammer into the water, ideally with two people. Each person is responsible for one of the two ropes (i.e. corer and hammer).

Ensure a vacuum is created inside the liner and that the piston or valve closes properly. If the vacuum is not achieved, remove any remaining ice using hot water or manually remove ice and close the valve with a knife. Continue lowering the corer until it reaches the lakebed. Mark the rope at a point 120 cm above the water table. Hammer the liner into the sediment until the mark on the rope is reached if possible. Carefully pull the corer up with continuous speed, minimizing shocks, with the assistance of two persons. While the liner is still submerged, cap its bottom to prevent sediment loss, then tape the capped liner securely. Mark the sediment-water interface (SWI) and the top of the core. Photograph the core for documentation. Detach the barrel from the coring device. Then, drain the headwater from the liner through either a predrilled hole or a hole that is created on the spot with a knife. Finally, proceed with subsampling or prepare core for storage and transport following the methods below.

5.1.3 Equipment

Ice auger, universal percussion corer (Aquatic Research Instruments), rope 2x, knife/screwdriver flat, screwdriver, core liner (predrilled and taped), liner cap, tape, gloves, hot water thermos, Hondex PS-7 portable depth sounder.

Figure 8. Left: Ice borehole created using hand auger and ice pick on lake G23 and installation of science tent; surface of Russell Glacier visible in the background (2025.04.09). Top-right: Borehole created using an electrically powered auger (IonIce Fishing instrument – courtesy of Dr. Jasmine Saros) on lake TB1 (2025.04.13) – ice margin of Russell Glacier visible in the background. Bottom-right: Sediment corer with liner deployment into a borehole on lake G13 (2025.04.04) – also visible is ice-auger connected to electrical drill used to create the borehole and glacier moraines in the background.
Photo credits: left, Arthur Fouillé; top and bottom right, Guillaume Lamarche-Gagnon

5.2 Lake water dissolved methane concentrations

5.2.1 Description and methods

Dissolved methane concentrations were collected directly from the ice boreholes (surface water samples). Surface water samples for dissolved methane concentrations were taken before core retrieval to prevent any chemical disturbance to the lake surface water collected water samples. Bottom water samples were collected from above the water-sediment interface within the retrieved core liners (see section 5.4).

5.2.2 Methods

Water samples were collected inside pre-labelled 120 ml borosilicate serum vials, completely filled while submerged to avoid trapping air, capped with grey butyl stoppers and then crimped. A waterfilled needle inserted through the stopper was sometimes used to help push the butyl stopper and displacing water without incorporated air bubbles before capping. Sampled were fixed with 1 ml of 10M NaOH to the vial to preserve the sample whilst simultaneously removing 1 mL of sample (using 2 syringes). Vials were stored refrigerated at 4°C in an upside-down position. Water samples were normally collected in duplicate.

5.2.3 Equipment

Borosilicate vial 120ml, grey butyl stopper, aluminium crimp caps, crimper, 10M NaOH solution, syringe, needles

Figure 9. Example of surface (clear) and bottom (turbid due to sediment disturbance) samples collected for dissolved methane analyses.
Photo credit: Arthur Fouillé

5.3 Hydrochemical and microbiological sampling of lake water

5.3.1 Description

Both surface and bottom lake waters were collected for downstream hydrochemical analyses (e.g. dissolved organic carbon (DOC), major nutrients), suspended particulate matter (SPM) concentrations and organic

carbon (POC), as well as for downstream microbial community characterisation (16S rRNA and metagenomics). For the collection of bottom lake waters, see section *5.4*. Surface water samples for hydrochemistry were taken before core retrieval or from a separate borehole to prevent any chemical disturbance to the lake surface water during coring.

5.3.2 Methods

Surface waters were normally collected directly from the ice borehole whenever possible using a 60 mL syringe or immediately subsampled from waters collected inside 1000 ml HDPE plastic bottle after rinsing it six times with lake water (dedicated bottles for glacier-fed and non-glacier fed lakes were used). The syringe was first rinsed 3 times with sample water and then filtered through a Sterivex syringe filter (PES membrane, 0.22 µm poresize). The first 60 mL of filtered samples were discarded to flush and rinse the filter. Filtered water samples were collected into dedicated storage bottles, pre-rinsed 3 times with filtered water. Samples destined for DOC and major nutrient analyses were collected into acid-washed 30 ml HDPE plastic bottle (leaving headspace for water expansion during freezing) and 2 ml glass vials for stable water isotopes filled without headspace and sealed with parafilm. DOC and nutrient samples were stored frozen. Field blanks consisting of deionised (MilliQ) water were also collected as above.

Following water filtration, Sterivex filters were flushed with air and kept frozen for downstream microbiological analysis.

5.3.3 Equipment

1000ml HDPE bottle, Syringe 60ml, syringe filter (Sterivex PES, 0.22 µm), 30ml HDPE bottle, 2ml glass vial + cap, MilliQ, parafilm

Figure 10. MB sampling for dissolved methane and hydrochemistry directly from ice borehole on lake LB9 (2025.04.19). Also visible is JvG and AF creating a second borehole using hand auger; lateral glacial margin of Insunnguata Sermia visible in the background.
Photo credit: Guillaume Lamarche-Gagnon

5.4 Methane gas in sediment core (subsampling core #1)

5.4.1 Description

Subsampling of lake sediment core for downstream analyses of dissolved gases (methane) in porewaters.

5.4.2 Methods

Lake sediment core (replicate core #1) was collected using a pre-drilled core liner (1.5 cm hole diameter) to allow for sediment subsampling using 5 mL cutoff syringes - sediment plugs (~5 cm^3). Pre-drilled holes were kept closed with electrical tape during sampling. Special attention was made to keep the core vertical during the entire duration of sampling (e.g. secured onto a camera tripod or tent pole). Samples were taken from predefined intervals and transferred into 20 mL serum vials containing 5 mL of 1M NaOH (to stop microbial activity) and a glass bead (to help mixing), immediately capped with a butyl-rubber septum and aluminium crimp and vigorously shaken to ensure mixing of the preservative. Samples were stored refrigerated. The gas samples are to be analysed by gas chromatography using the headspace equilibration method.

N.B. Sampling of gases in porewaters was always performed in the field.

5.4.3 Equipment

Pre-drilled liner, cutoff syringe (5ml), glass serum vial 20ml, glass beads, butyl stoppers, aluminium crimp cap, 1M NaOH, pipet, pipet tips 5ml, knife, crimper, safety goggles

N.B. Always use gloves, goggles when handling the NaOH and cap the bottle immediately after using.

5.5 Sediment porewater hydrochemistry (subsampling core #2)

5.5.1 Description

Sediment porewaters (replicate core #2) were extracted using micro rhizon samplers and destined to downstream analyses for carbon and nutrient analyses (e.g. DOC, TN, etc).

5.5.2 Methods

The sediment core was mounted vertically on an installation setup as above (section 5.4). Rhizon samplers were inserted into the core barrel through predrilled holes (3mm diameter). Vacuum was created using 20 mL syringes kept propped open using wooder retainers. It is advised to hang the propped open syringes in a stabilizing rack (see Fig. 11). Porewaters destined for organic carbon and nutrient analyses were transferred into HDPE centrifuge tubes (15 ml) and stored frozen. Porewaters destined for stable water isotope analysed were stored headspace-free as above (section 5.3).

N.B. When temperatures allowed, the work was performed in the field inside the field tent (if air temperature inside the tent remained high enough to prevent freezing of the rhizon lines during sampling). Otherwise, the samples were extracted back at KISS (< 4 hours following core retrieval).

5.5.3 Equipment

Rhizon samplers (19.21.23F), 20 mL syringes, wooden syringe retainers, HDPE centrifuge tubes 15ml, 2ml vial + cap, parafilm, syringe stabilizing rack.

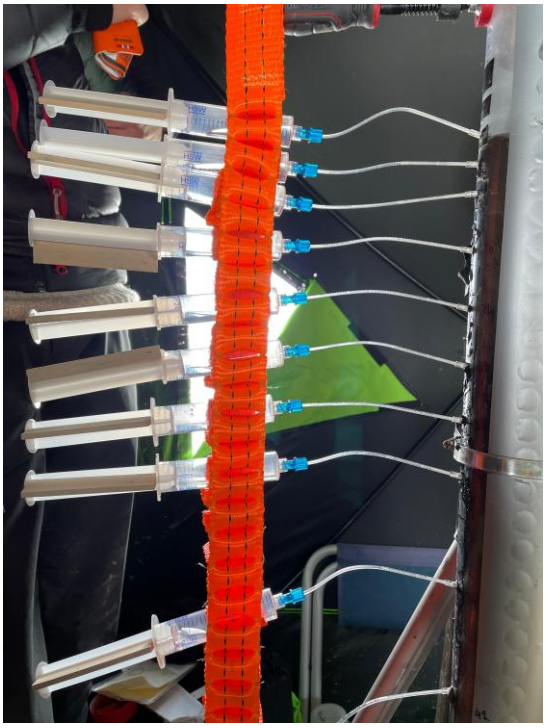

Figure 11. Example of porewater extraction inside the field tent.
Photo credit: Joost van Genuchten

5.6 Collection of lake bottom water

5.6.1 Description

Bottom lake waters destined for dissolved gases, hydrochemical, and microbial analyses described above were collected from the water layer overlaying sediments inside the core liner. Ideally, water layers overlaying undisturbed or minimally disturbed sediments were collected but this was not always possible (e.g. fig. 8).

5.6.2 Methods

Water inside the core liner was extracted using a tube inserted through pre-drilled holes. The tube was rinsed by flushing it with sample water for a few seconds prior to sampling. Sampling was conducted sequentially to minimize gas exchange with the atmosphere and to ensure thorough rinsing of the tube with sample water. Initially, water for dissolved gas analyses was collected. The tube directed the collected water directly into 120 mL glass serum vials. Once the vial was full, additional water was allowed to overflow for a few seconds to prevent air contamination. The serum vials were then capped and fixed following the procedure outlined in Section 5.2.

Subsequently, the remaining water was transferred into a 1 L HDPE bottle. The bottle was pre-rinsed three times with lake surface water and three times with a small volume of bottom water before collection. This water was used for hydrochemical sub-sampling and processed as described in Section 5.3.

5.6.3 Equipment

Glass vial 120ml, grey butyl stopper, crimp caps, crimper, NaOH solution, syringe, needles, tubing. Also see section 5.3 for hydrochemical samples.

Figure 12. Example of sampling of bottom lake water from above the sediment/water interface inside a core liner and destined for dissolved gas analyses.
Photo credit: Joost van Genuchten

5.7 Sampling for microbial community profiling (Subsampling core #3)

5.7.1 Description

Sterile samples of lake sediments (core replicate #3) were collected for downstream microbial community (DNA; 16S rRNA/metagenomics) analyses. Some sites were also selected for parallel microbial incubation experiments – see section 5.12.

5.7.2 Methods

Lake sediment cores (core replicate #3) were collected inside pre-sterilised (70% ethanol) and pre-drilled (1.5 cm diameter) core liners. Back at KISS, sediment was collected using sterile spatulas and/or new cut-off syringes at pre-defined depth intervals into sterile cryovials and stored frozen (<-20°C).

5.7.3 Equipment

Stainless steel spatula (flame sterilised), 5ml cryovial (sterile), nitrile gloves

5.8 Core collection for sedimentology analyses (core #4)

5.8.1 Description

The last replicate core (replicate #4) was destined for downstream sedimentology analyses (e.g. scanning and imaging) back at the home laboratory. This core was left unprocessed for the duration of the fieldwork.

5.8.2 Methods

The sediment core was extracted using an intact core liner without pre-drilled holes. Excess bottom water was drained from the core barrel by puncturing the liner with a knife. Once drained, the plastic liner was shortened with a saw to just above the sediment-water interface. Foam was cut and inserted to fill the empty space above the sediment core, ensuring stable transport with minimal disturbance. The liner was then securely sealed to preserve the core. The sealed core was stored in a dark, cold environment until further laboratory procedures were performed back at the home institution.

5.8.3 Equipment

Metal saw, tarp (to maintain dark environment), flower foam

Figure 13. Sediment cores from a GF lake (GL4, left) and NGF lake (NEW1, middle), and corer with empty core liner prior to deployment (right).
Photo credit: left, middle, Joost van Genuchten; right, Guillaume Lamarche-Gagnon

5.9 Lake water column profiling

5.9.1 Description

Hydrological profiling of lake water-column using a CTD (conductivity, temperature, depth) sensor. Lake depth was also first measured using a hand-held depth sounder (see section 5.1).

N.B. The CTD available during this field campaign (Keller-Druck DCX-22-CTD) was unfortunately not rated for depth greater than ~ 20 meters. Pressure records for deeper lakes were therefore limited to the top ~20 m – however electrical conductivity and temperature data for these deeper water layers were still accurately recorded.

5.9.2 Methods

The logger was activated beforehand using a laptop to ensure it was ready for data collection. The rope was securely attached to the CTD device. The CTD was lowered into the water at a rate appropriate for the measurement interval to ensure accurate data collection. Once the CTD reached the bottom, it was left in place to record approximately 5–10 logs. The CTD was then carefully retrieved by reeling it in at the same steady pace used during lowering. Finally, the logger was deactivated to stop data recording. Detailed handling and procedures followed the manufacturer's instructions.

5.9.3 Equipment

Keller-Druck DCX-22-CTD, laptop, rope.

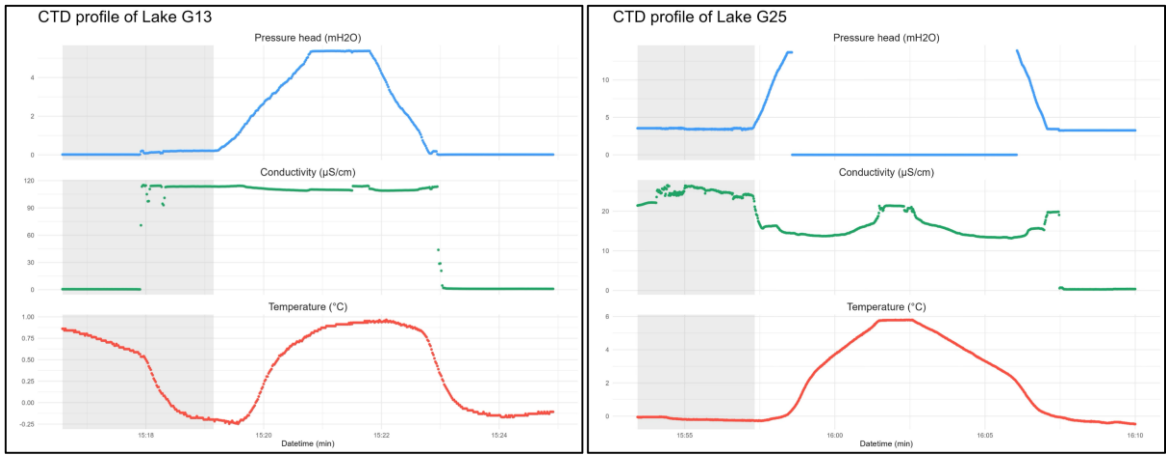

Figure 14. Example of CTD profiles of a shallow lake (G13, left) with a complete profile and deeper lake (G25, right) with a pressure profile cut at ~20 m.
Image credit: Joost van Genuchten

5.10 Bubble capturing

5.10.1 Description

Gas (methane) bubbles liberated during coring were also trapped using an inverted funnel gas trap in shallower lakes.

5.10.2 Method

The funnel setup was filled with lake water ensuring all air was carefully extruded using a three-way or two-way valve connected to a 60mL syringe. Gas bubbles would then displace water inside the funnel. Once an adequate volume of gas was captured, the syringe was retracted to extract the gas, and the syringe valve was securely closed. The gas sample was then injected into a pre-capped 60 mL serum vial pre-filled with a near-saturated NaCl solution (30%). The two-syringe method was employed to allow the displaced NaCl solution to exit the vial, ensuring accurate gas transfer. The high salinity of the NaCl solution prevented the dissolution of the gas sample into the liquid phase. To preserve the gas sample, 1 mL of 10M NaOH was added to each vial. Replicate samples were prepared by repeating the same procedure, where feasible. Finally, all samples were stored refrigerated until further analysis.

5.10.3 Equipment

Inverted funnel setup (funnel, electrical tape, tubing, three/two-way valve), pre-capped and saltwater (30%) filled 60ml serum vials, blue stopper, aluminium crimp caps, crimper, 60 ml 3 piece syringe, needles, NaOH solution

Figure 15. Photo of an inverted funnel inside a lake borehole. Visible is only the funnel and tubing without the syringe and valve attachments.
Photo credit: Joost van Genuchten

5.11 Microbial incubations (subsampling core #3)

5.11.1 Description

Sterile sub-samples of lake sediments (core replicate #3) from 3 different depths were collected back at the KISS facilities to ensure cleaner conditions in the aim to start CH_4 production monitoring long-term incubation

experiments. All incubations were conducted as close to in situ conditions as possible and in triplicate at 4°C, in the dark.

5.11.2 Methods

Bottom water was first extracted from above the lake sediments in the core liner through pre-drilled holes and inserting a tube (pre-sterilised with 70% ethanol) to allow the water to flow out. The tube was rinsed by flushing it with sample water for a few seconds (as described in Section 5.4) before collecting the water into a Whirl-Pak® bag for subsequent incubation. Simultaneously, lake sediments were also collected for microbial community analysis. Sediments were sampled from three specific depth ranges: the top 5 cm, the bottom 5 cm, and an intermediary depth (spanning 5 cm). Sediments were extracted using a sterile, pre-cut 5 mL syringe and transferred into a 200 mL Whirl-Pak® bag. The collected sediment layers were homogenized by shaking the Whirl-Pak® bag thoroughly. Approximately 5 cm^3 of sediment from each depth was then extracted using the same pre-cut syringe and transferred into a sterile 33 mL glass vial containing a glass bead. Subsequently, 20 mL of lake water, collected from the core using a 50 mL sterile syringe, was added to each vial.

For control vials, an additional 50 µL of 10% sodium azide (NaN_3) solution was added to stop methanogenic activity. Each vial was sealed with a blue septum stopper and secured with an aluminium crimp cap.

To create anoxic conditions, a long needle connected to an N_2 gas canister was inserted through the septum, reaching the bottom of the vial (input), while a smaller free needle was inserted at the surface of the septum (outlet). Nitrogen gas (N_2) was injected into the vials for several minutes to expel O_2 and CH_4 present in the sediment and bottom water. Care was taken to avoid over-pressurizing the vial by removing the long needle first. The prepared vials were stored in at 4°C in the dark until further measurements of headspace gas concentrations were conducted. Headspace samples were measured using a portable gas analyser (ABB).

Figure 16. 3 incubation vials from different depth of the same core.
Photo credit: Arthur Fouillé

5.11.3 Equipment

33mL vials, glass beads, NaN_3 10 % solution, 1L and 200mL Whirl-Pak®, 5mL pre-cut syringe, 50mL syringe, needle (long and small), 10-100µL micropipette, tubbing, blue stopper, aluminium crimp caps, crimper, N_2 cannister.

5.12 Video imaging of lake environments

5.12.1 Description

Video imaging of lake water columns beneath the lake ice was attempted using a remotely operated vehicle (ROV, BlueEye Pro). Unfortunately, the high suspended-sediment concentration content (high turbidity/low visibility) of glacial-fed lakes prevented acquiring any useable video footage.

5.12.2 Methods

Ice boreholes were widen using 1m long ice-saws to allow the deployment of the BlueEye ROV. The ROV was operated directly from the side of the lake boreholes.

N.B. Widened boreholes used to deploy the ROV were plugged shut after deployment using the cut-off ice blocks, as well as marked to prevent accidents around the borehole before re-freezing (usually <1day).

5.12.3 Equipment

Blue-Eye ROV, ice-saw

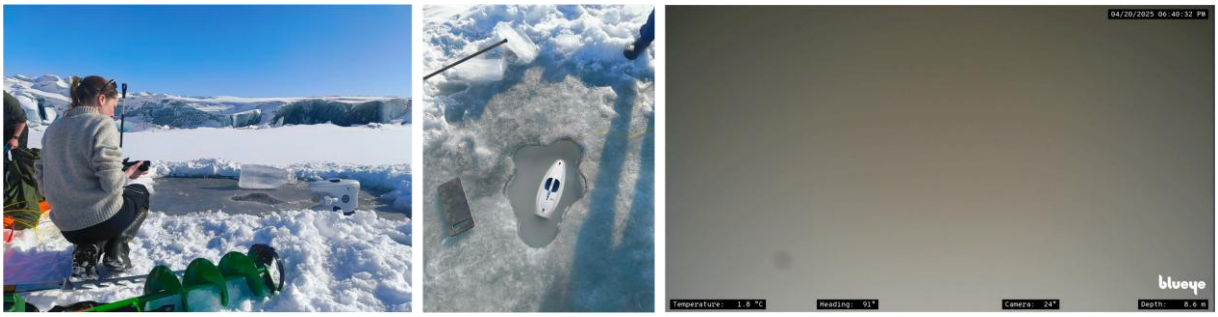

Figure 17. Deployment attempt of the BlueEye ROV on lake TB1. Left: Team next to deployment borehole – Russell Glacier visible in the background. Middle: Deployment borehole with the top of the BlueEye ROV visible. Right: Screenshot of (absence of) visibility in lake water column (TB1 lake, 2025.04.20).
Photo credits: left and middle, Guillaume Lamarche-Gagnon.

5.13 Ice bubble survey

5.13.1 Description

Quick and partial ice-bubble surveys (IBS) were performed on 3 lakes (G13, TB1, and GL6) to generate rough estimates of methane ebullition fluxes when and where time and ice-conditions allowed. IBS are a quick tool

to estimate methane ebullition on seasonally frozen lakes by counting and measuring the size of methane bubbles trapped within lake ice Walter Anthony et al., 2010[7]. IBS are normally performed during early winter over thin ice and require several measurements transects for more accurate flux measurements. The IBS performed here therefore consist of very rough first-order estimates of methane ebullition.

5.13.2 Methods

IBS were performed as per Walter Anthony et al., 2010[7]. Briefly, a transect of lake ice was cleared from snow using a plow shovel to expose lake ice and entrapped methane bubbles. Bubble numbers and types (shape, size, cluster) were tallied and converted to ebullition fluxes as per Walter Anthony et al., 2010[7]. and quality controlled at the University of Alaska Fairbanks (special thanks to Dr. Katey Walter-Anthony). Again, the IBS performed here were only carried on very small lake areas and over late-winter ice conditions which are not ideal for accurate methane ebullition flux measurements.

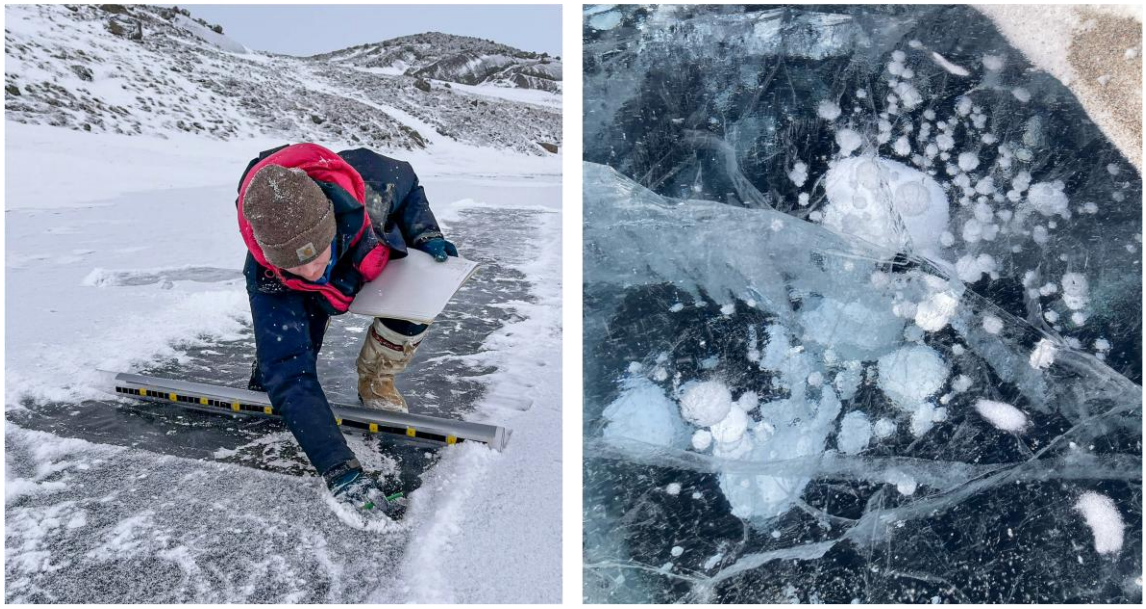

Figure 18. Left: LB performing methane ice-bubble survey on lake G13. Right: Cluster of methane bubbles trapped in lake ice. Photo credit: left, Marie Bulínová; right; Arthur Fouillé

6 Activity permits

All fieldwork activities and collected samples fall under the Non-Exclusive Licence No. G25-001 for Utilization of Greenland Genetic Resources and corresponding Greenland Mineral Export Permit 352025.

7 Data Management

A dedicated data management plan was prepared prior to the expedition, following the iC3 Data Management Plan (Sarti, F. et al., 2025[5]) and utilizing the FAIR Wizard Norway tool, which provides an essential and lightweight structure while ensuring compliance with FAIR principles. The plan has been shared and discussed with the field trip participants. It is not included in this report but can be made available upon request.

8 Dissemination and communication

During the expedition

Visit from Mittarfeqarfiit (Greenland airport) representative

Diana Kristensen, a Mittarfeqarfiit (Greenland airport) representative from the Nuuk office visited Kangerlussuaq and KISS on April 9-10, 2025. During her visit, Diana joined us in the field and the lab where we discussed scientific activities, the importance of Kangerlussuaq as a hub for research on Greenland and the Greenland Ice Sheet and heard on why this might also be of interest to people living in Greenland.

Figure 19. Visit of Diana Kristensen, Mittarfeqarfiit representative, to discuss and demonstrate science activities in the field (2025.04.10). Left: Team photo on lake GL5, from left to right: Joost van Genuchten and Laura Brosius (inside the science tent), Guillaume Lamarche-Gagnon, Diana Kristensen, Marie Bulínová, and Arthur Fouillé standing on lake ice next to science tent. Right: Diana and Guillaume deploying the sediment corer down a lake borehole.
Photo credits: Diana Kristensen

Linking up with CLIMET scientists

An unexpected extended stay in Kangerlussuaq due to flight cancellations allowed us to link up with scientists Suzanne McGowan and Tom Berben for a couple of days during the initial phase of their CLIMET project on methane cycling in Arctic lakes. You can learn more about the CLIMET project here: https://climet.nl/en.

Figure 20. Dust sampling on Arctic lakes on clean (left) and dirty (right) snow.
Photo credit: Guillaume Lamarche-Gagnon

Online mentions

Isaaffik Arctic Gateway - Methane emissions from glacial-fed lakes, Guillaume Lamarche-Gagnon, March 14th 2025; https://isaaffik.org/projects/view/methane-emissions-from-glacial-fed-lakes

EGU Cryosphere blog - The Proglacial Puzzle: Sampling of Glacier-fed Lakes in Greenland, Joost van Genuchten, July 11th, 2025 Cryo Adventures, Fieldwork. https://blogs.egu.eu/divisions/cr/2025/07/11/the-proglacial-puzzle-glacier-fed-lakes-in-greenland/

9 Health & safety

A risk assessment to identify, evaluate, document and mitigate hazardous situations and processes during the field trip has been conducted prior to the expedition following UiT's recommendations and guidelines. The fieldwork also ensured to follow UiT's JEDi (Justice, Equity, Diversity and Inclusion) Field of Conduct. The final document has been shared with the participants and signed prior to the expedition. It is not included in this report but can be made available upon request.

9.1 Recommendations for future expeditions

Ideally, science activities should be reported well in advance to the Qeqqata Municipality office, as well as in person upon arrival. Discussion with the Qeqqata Municipality office can also facilitate potential research outreach activities depending on the needs and interests of the Qeqqata municipality.

Qeqqata Municipality contact: kangerlussuaq@qeqqata.gl. More practical information and resources can also be found here: https://scienceservices.gl/research/

Early communication with relevant Greenland authorities regarding permits and science activities should also be considered and special recommendations followed. For example, fieldwork activities should be communicated and coordinated with local tourism and hunting concessionaires to minimise potential disturbances – initial communications via The Ministry of Business, Trade, Mineral Resources, Justice and Gender Equality.

10 Acknowledgments

The authors acknowledge past and present people of Greenland as stewards of the land where this research took place. We also would like to thank to Dr. Jasmine Saros (University of Maine), as well as Dr. Suzanne McGowan (NIOO-KNAW) for support with fieldwork planning as well as for providing equipment replacement during fieldwork operations. Thanks also to Dr. Clay Prater for help in the field (Loughborough University). Equipment was also kindly provided by Dr. Jemma Wadham (iC3, UiT), Daniel Ludwig Vogedes (UiT) and the Norwegian Polar Institute. We acknowledge the Drone Technology Group at the Institute of Technology and Safety, UiT for both training to JvG and drone usage, as well as to Emily Joanne Venables (UiT) for training and providing the team with the BlueEye underwater ROV. Thank you to Dr. Anders Schomacker (UiT) for assistance with pre-fieldwork training and sampling advice. Thank you to Dr. Gabrielle Kleber for help with the identification of groundwater icings. Thanks also go out to Chris Sørensen from the Kangerlussuaq International Science Support Center (KISS) for the logistical support. Importantly, this fieldwork would not have been possible without key scientific discussions with Dr. Katey Walter-Anthony (University of Alaska Fairbanks), whose previous work in the sector served as foundation for this study. Finally, I (GLG) would like to personally acknowledge and thank the unfaltering and exceptional team spirit and efforts of all participants, without which the success of the fieldwork would have been impossible.

This research is a part of iC3: Centre for ice, Cryosphere, Carbon and Climate and was supported by the Research Council of Norway through its Centres of Excellence funding scheme, project number 332635.

Support to AF also by the Johannes Amos Comenius Programme (P JAC), project No. CZ.02.01.01/00/22_008/0004605, Natural and anthropogenic georisks.

Appendix A. Full list of sampling locations

lake	latitude	longitude	date	Ice thickness (cm)	lake depth (m)	Length of sediment core (cm)
G9	N 67.048133	W 50.523467	2025.04.02	70	2.4	75
GL6	N 67.146841	W 50.124005	2025.04.03	114	3.4	110
G13	N 67.150480	W 50.047001	2025.04.04	106	8.5	36
TB1	N 67.101317	W 50.222953	2025.04.06	86	15.6	NA
G25	N 67.137228	W 50.072198	2025.04.07	133	41.5	32.8
G23	N 67.130683	W 50.111396	2025.04.09	110	7.2	58.5
GL5	N 67.150628	W 50.126007	2025.04.10	105	15.3	113
GL4	N 67.158866	W50.144368	2025.04.12	104	55	40.5
S5903	N 67.127730	W 50.175226	2025.04.14	105	30	112
NEW1	N 67.145692	W 50.080730	2025.04.16	120	2.5	97.5
G12	N 67.136683	W 50.126088	2025.04.17	95	22.7	96
LB9	N 67.156521	W 50.077672	2025.04.19	113	7	100.5

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