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The ISP-CNR Ice Core Drilling System: Addressing Firn Aquifers from Arctic to High-Altitude Glaciers

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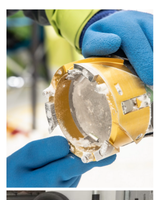
Since spring 2023, during two field campaigns of the **Ice Memory project,** the ISP-CNR team, in collaboration with Ca' Foscari University of Venice, has faced major challenges in recovering shallow ice cores from wet, water-saturated firn, despite below-freezing surface temperatures.

The two field campaigns were:

- **Holtedalfonna** (**HDF2023**, Svalbard, Norway) – late spring 2023, **Arctic** environment, **1150 m a.s.l**. 0.98 m w.e. yr^{-1} (van Pelt et al., 2019)
- **Corbassière glacier** – Grand Combin (**GC2025**, Switzerland) – spring 2025, **Alps, 4050 m a.s.l.** 1.02 m w.e. yr^{-1} (GLAMOS, 2025)

The ISP-CNR drilling system is based on the **light series rig** from Cryosphere Research Solutions LLC, with a 300 m plastic winch cable and powered by a 3 kW generator.



Electromechanical drill
(**EM100**, HDF2023, GC2025)
Core barrel length: 110 cm
Core diameter: 100 mm

Electrothermal drill
(**ET85**, GC2025)
Core barrel length: 200 cm
Max core diameter: 85 mm

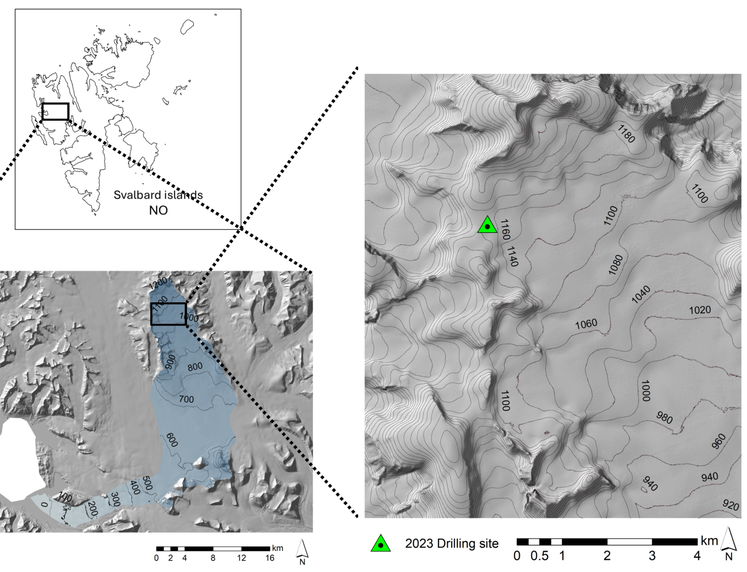
Results with **EM100** (HDF2023 and GC2025)
Average recovered core length: **83 ± 20 cm**
Average recovered core Ø: **101 ± 1 mm**
Feed rate: **3 - 8 mm s^{-1}**
Production rate: **6 ± 2 m h^{-1}**

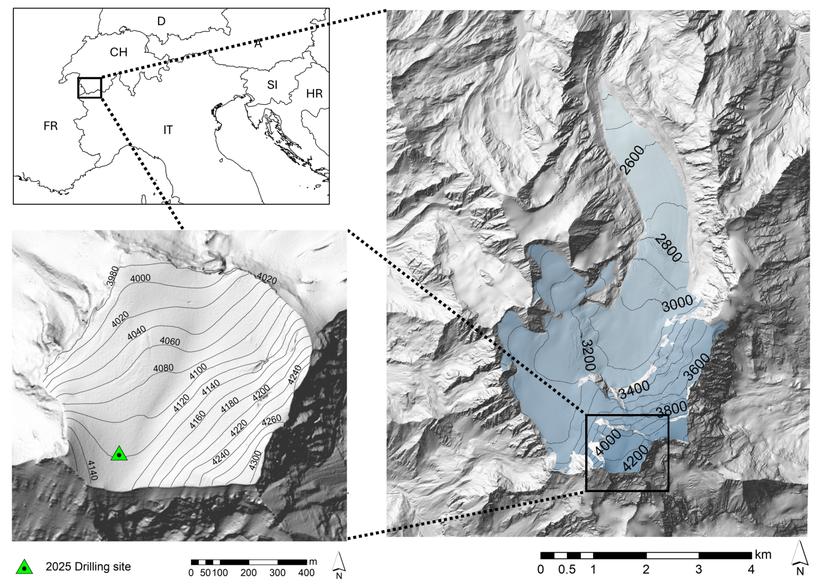
Results with **ET85** (GC2025 only)
Average recovered core length: **148 ± 44 cm**
Average recovered core Ø: **84 ± 4 mm**
Feed rate: **0.8 - 3 mm s^{-1}**
Production rate: **1.7 ± 0.9 m h^{-1}**

Dealing with partially water-filled boreholes
Both the EM100 and ET85 drilling systems can work underwater. However, due to the relatively low weight of the drill body (~7 kg), **additional weight** (5–10 kg) was mounted above the drill **to reduce buoyancy** (and to increase bit pressure)**.**

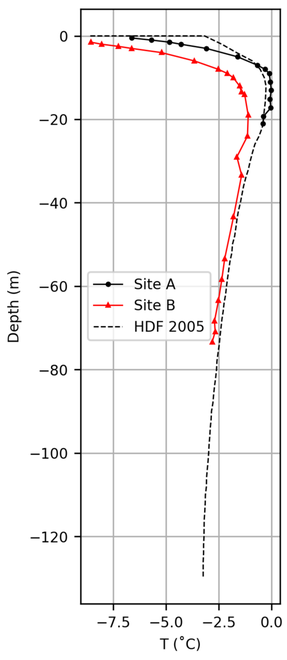
During HDF2023, a normal motor section with brushed DC motor was used (brushes were replaced frequently). During GC2025 a dedicated submersible motor section was used.

In addition, a bailer was employed **to remove meltwater** from the borehole (BH) and, when necessary, **to deploy ethanol** into the borehole kerf as an antifreeze measure (and subsequently recover it).



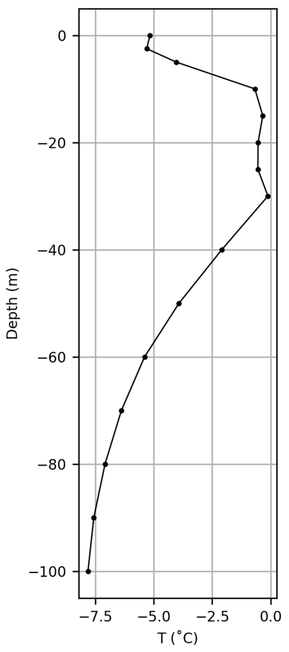


HDF2023



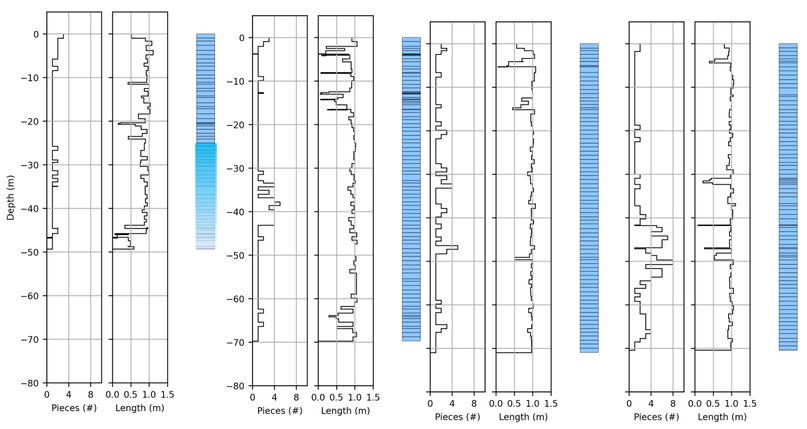
- Previously drilled in 2005 (bedrock not reached). **Polythermal** glacier.
- A **large aquifer** was encountered at the firn–ice transition at **23.5 m** depth on **Site A** (bedrock not reached).
- **Aquifer recharging rate ~2L/min.**
- Working with **submersed EM100 drill for 25.6 m.**
- No aquifer observed at **Site B**, located 140 m uphill, where **bedrock was reached at 73 m**

GC2025

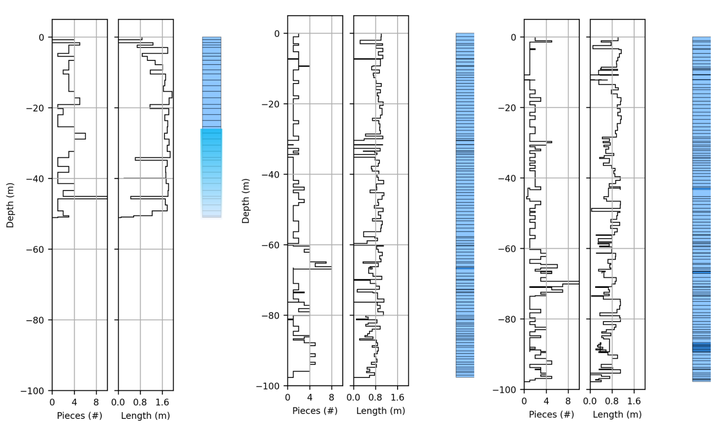


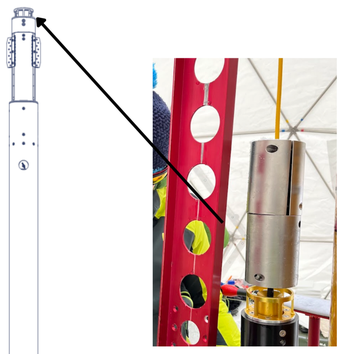
- First drilling attempt in 2020 (no bedrock). Glacier with **polythermal** regime.
- **Aquifer** found at firn-ice transition at **28.8 m** depth.
- Working with **submersed ET85 drill for 22.4 m** (bedrock not reached).
- **80 - 90 litres of water removed** (per borehole) with bailer when working with ET100 drill
- **Bedrock reached at 100 m**.

Site A — Site B

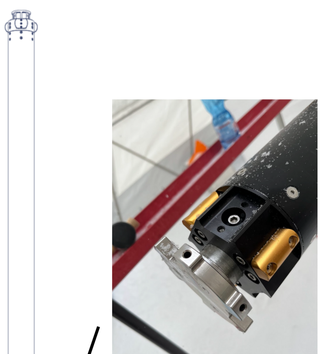


ET85 — EM100





Both the EM100 and ET85 were equipped with additional weights when working underwater. In the picture, each weight module is 5 kg. To extend the cable life, weights were removed if not necessary.



Details on the bailing system

The bailer was employed in its standard configuration during HDF2023 and GC2025 to remove water from the BH. In this setup, **each bailer run was capable of extracting up to 14 liters** of fluid from the borehole.

During GC2025, **the bailer valve system was modified to allow ethanol deployment** into the BH kerf and to **promote mixing** between ethanol and water during recovery. Specifically, the ball valve was adapted in the field with a removable latching device that prevented valve closure during the lifting phase.

Once at the surface, **the valve state could be reset** to its default configuration allowing more ethanol deployment or ethanol+water mixture recovery.

Next steps:

- Improve weight modules, improve bailer latch valve, include gyro in drill.
- Automatic ethanol dispenser for ET drill needs more testing → tests scheduled on next season 2026
- Drilling equipment is expected to be tested on south Asia (Karakoram) in 2027

Acknowledgments:
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References:
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GLAMOS data 1997 - 2024, available at https://glamos.ch/it/factsheet#/B83-03

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