In situ measurements of ice growth and melt in two lakes of eastern Canada to improve ice representation in the Canadian Small Lake Model

Thomas Brady[1,2], Antoine Thiboult[1,2], Tadros Ghobrial[1], Murray Mackay[3] and Daniel F. Nadeau[1,2]

1. Department of Civil and Water Engineering, Laval University, Quebec City, QC, Canada
2. Centre for Northern Studies, Quebec City, QC, Canada
3. Meteorological Research Division, Environment and Climate Change Canada, Toronto, ON, Canada

Abstract

Context & Objectives

In **cold regions**, lake ice and snow regulate lake-atmosphere interactions[1], yet **lake models** tend to be less accurate under ice-covered conditions due to a lack of observations[2]. **Costly and logistically challenging** measurements — often limited to safe-ice periods — highlight the need for improved observational methods[3].

The objectives of this study are to analyze the temporal evolution of the ice and snow cover in two northern lakes by :

① Developing and applying a custom-made temperature profiler called the Snow Ice Lake Temperature (SILT) device, to capture **high-resolution data** throughout the entire ice season.

② Evaluating the performance of the **Canadian Small Lake Model** (CSLM).

Study Area

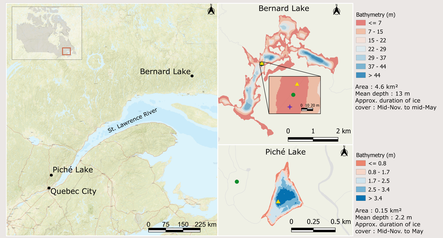


Figure 1: Study sites.

Methodology

Data Collection

Observation Methods
- Upward Looking Sonar (ASL IPS-5)*
- Manual measurement
- SILT device
- Snow pits
- Ice core & visual observations

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Variables
- Ice thickness
- Snow depth
- Snow temperature
- Snow density
- Ice type

*Bernard Lake only



Figure 2: Ice drilling (a), ice observation (b), IPS-5 deployment (c) and snow pit (d)

Data Analysis

① Processing of SILT data using an algorithm to estimate ice thickness and snow depth based on the detection of interface positions

② Validation of SILT-derived ice thickness and snow depth through comparison with manual and sonar measurements

③ Assessment of CSLM performance through comparison with multi-method observations of snow and ice data

How are interfaces detected?

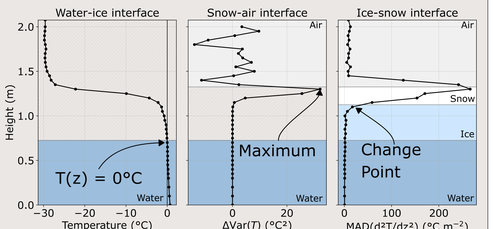
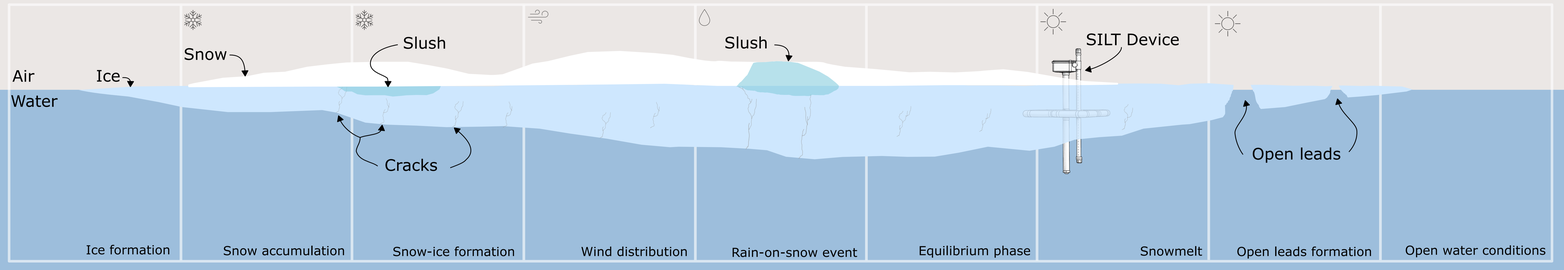


Figure 3: Interface detection

MAD : Mean Absolute Deviation

Lake Ice Evolution Diagram



How does the CSLM work?

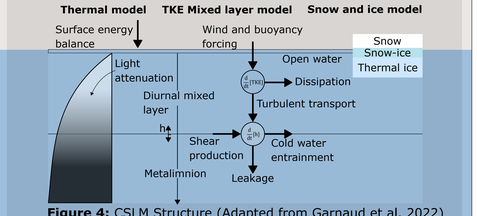


Figure 4: CSLM Structure (Adapted from Garnaud et al. 2022)

Preliminary Results

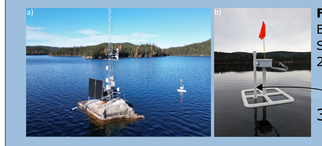
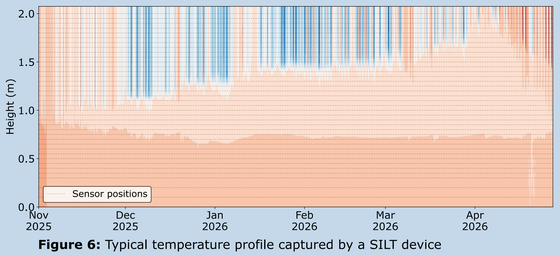


Figure 5: a) SILT device - Bernard lake 2024-25 b) SILT device - Piché lake 2025-26

39 NTC Thermistors

Piché Lake



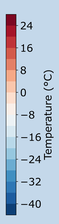


Figure 6: Typical temperature profile captured by a SILT device

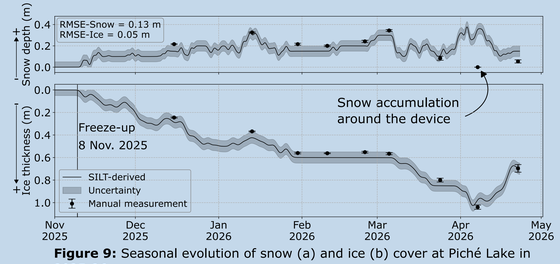
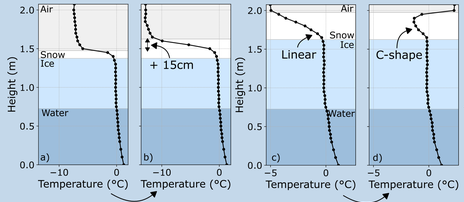


Figure 9: Seasonal evolution of snow (a) and ice (b) cover at Piché Lake in 2025-26



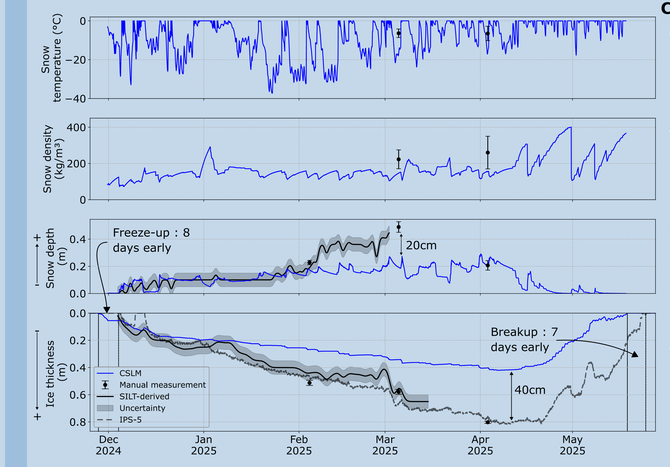
The SILT device provides insight into how ice and snow cover changes over time based on temperature.

Figure 7: Temperature profiles
a) and b) : Snow accumulation in March
c) and d) : Rising air temperature in April



Figure 8: Images captured by a camera on the bank

Bernard Lake



CSLM Evaluation:
- Biases in snow temperature
- Biases in snow density
- Underestimation of snow depth
- Snow properties influence snow-ice formation
- Underestimation of ice thickness
- Freeze-up and breakup dates earlier

Figure 10: Seasonal evolution of snow and ice cover at Bernard Lake in 2024-25

Conclusion

- SILT provides **high-resolution observations** of ice thickness throughout the ice season;
- Snow depth retrievals are more sensitive to localized snow accumulation;
- CSLM underestimates snow depth and ice thickness and predicts earlier freeze-up and breakup;
- Future work : A more **detailed analysis of the modules** will be conducted using the snow and ice type data.

References

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