

The Future of Arctic Water: Lake Ice & Snow Cover

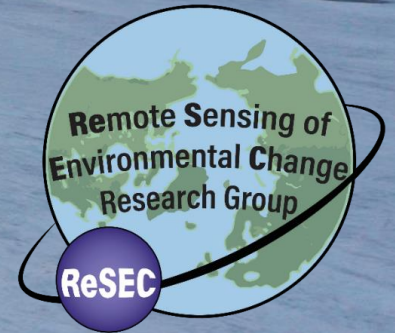
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Canada Research Chair in Remote Sensing of Environmental Change

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Department of Geography & Environmental Studies

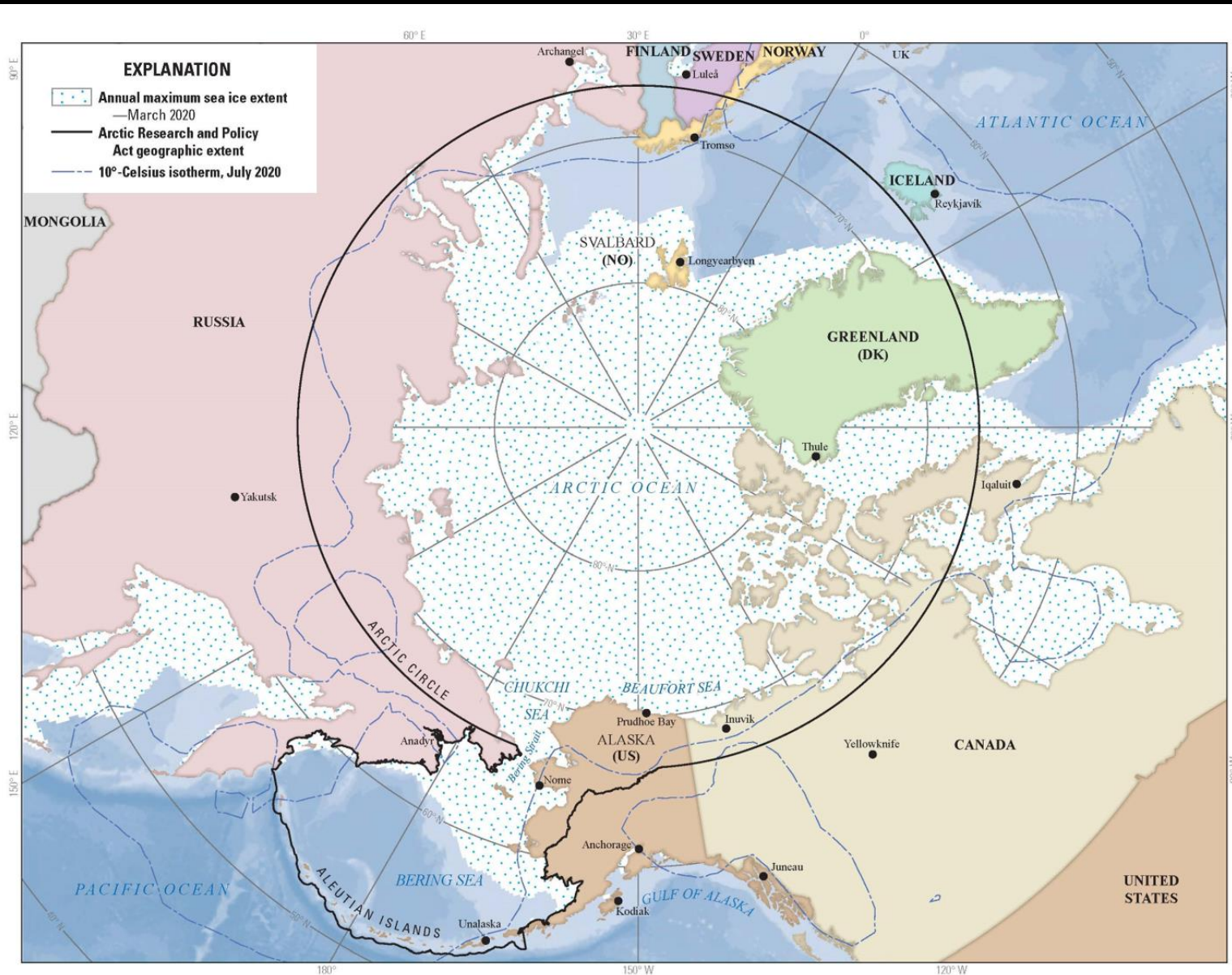
Cold Region Research Centre



Tuesday, Mar 04, 2025

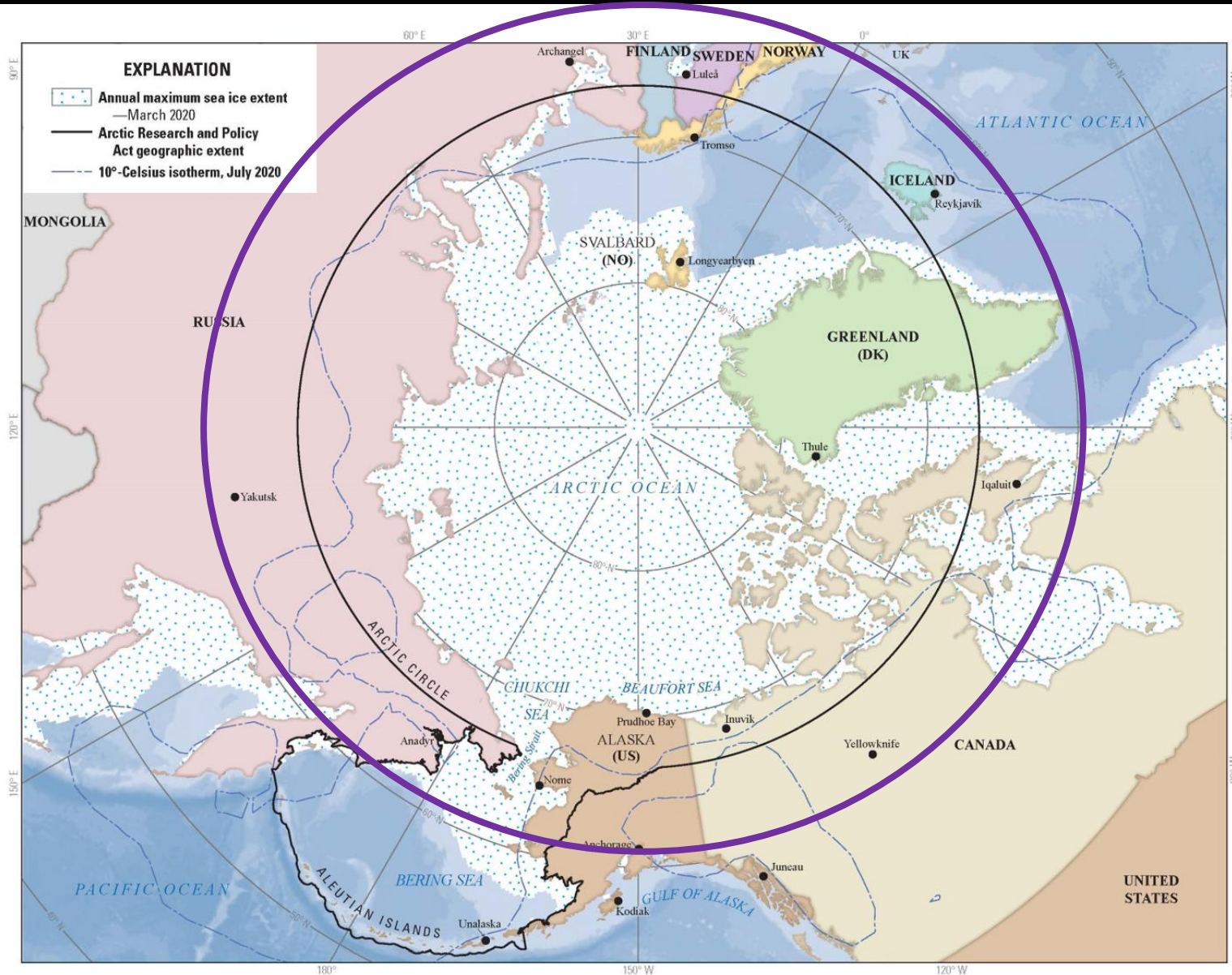


Arctic Circle (66-90° N)



The Arctic can be defined as all the lands and waters above the black line

Arctic & Subarctic (60-90° N)

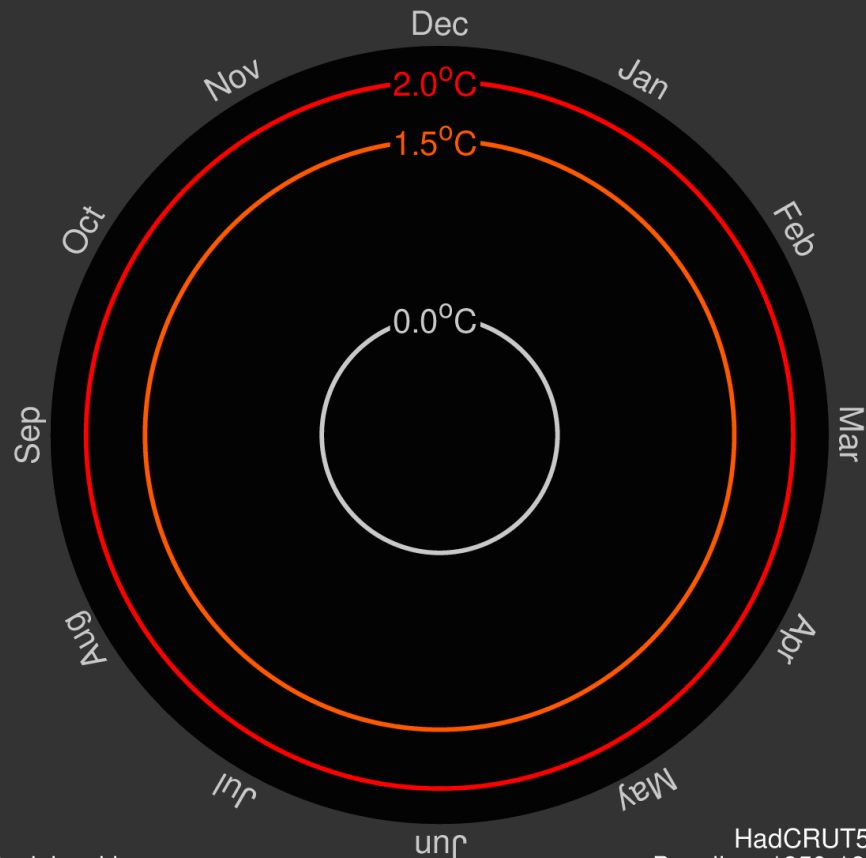


The Subarctic is the region immediately south of the Arctic. the purple line

Global Climate Warming

Combined land and ocean, global temperature **has increased** at an average rate of **0.08 °C/decade** since 1850s

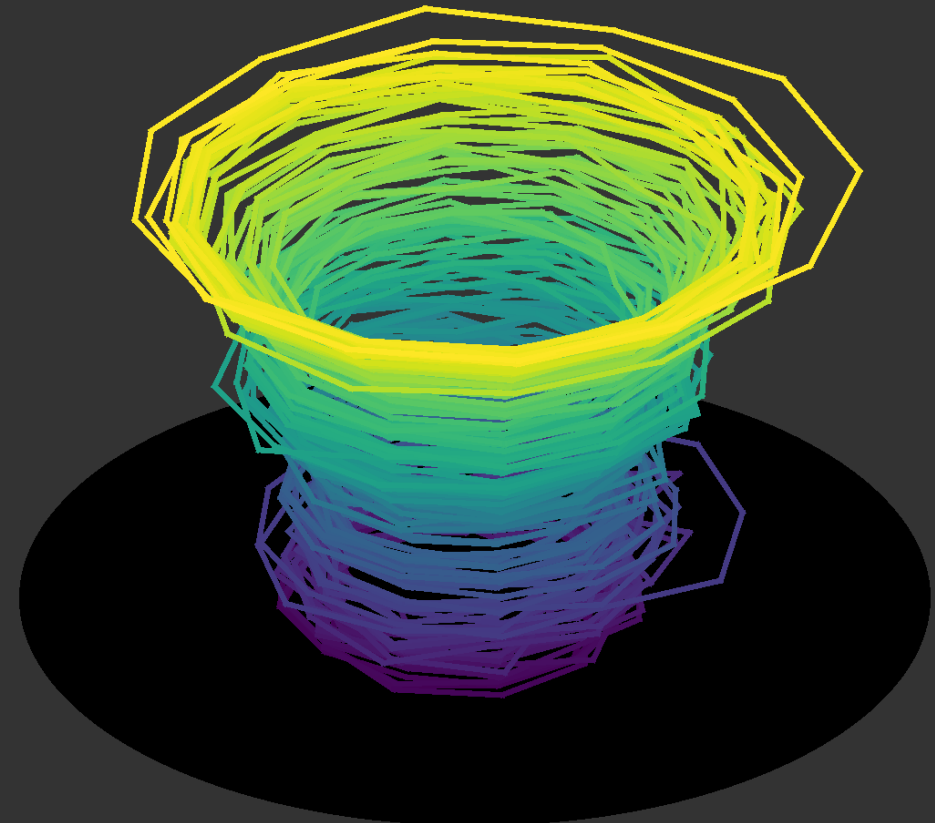
Global temperature change (1850-2024)



@ed_hawkins

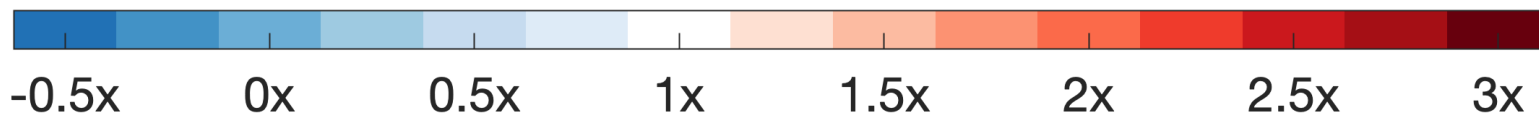
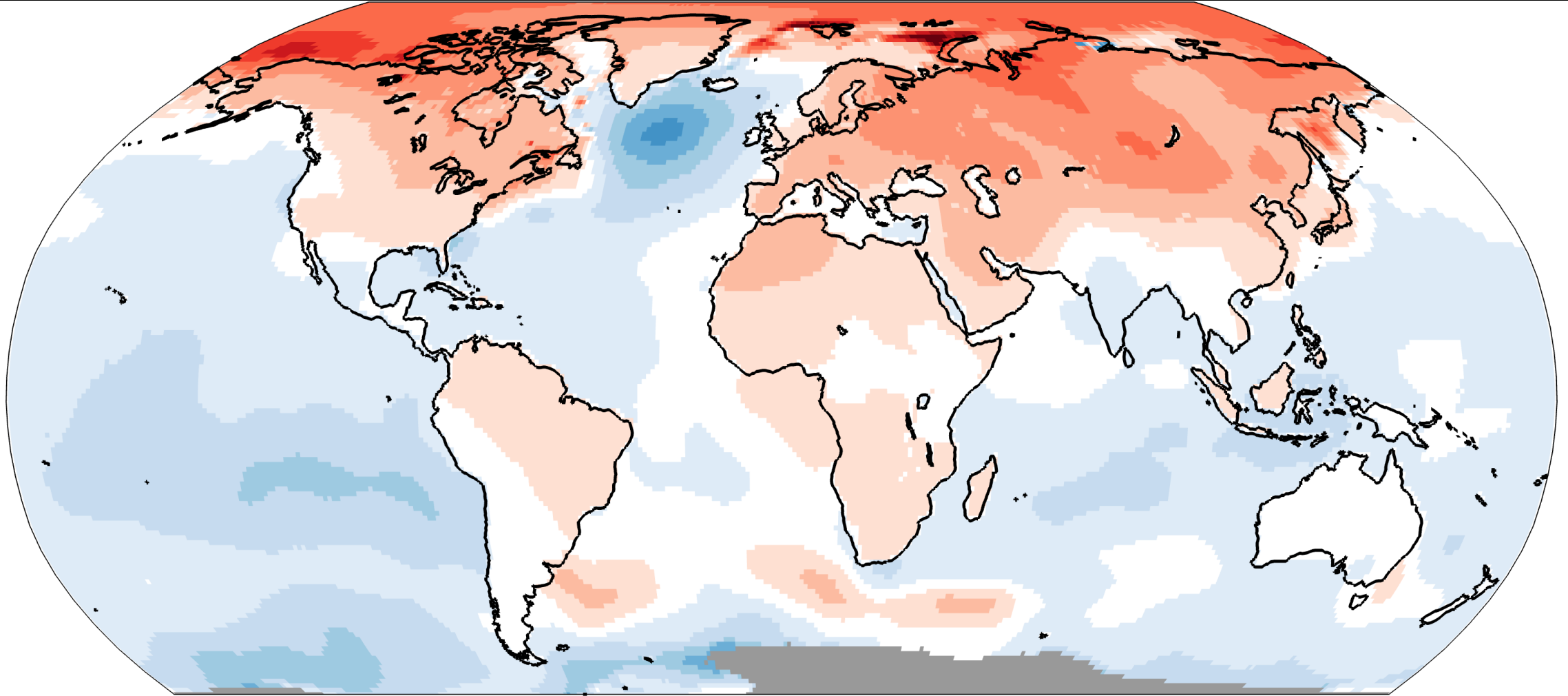
HadCRUT5.0
Baseline: 1850-1900

Global temperatures since 1850: an artistic representation



@ed_hawkins

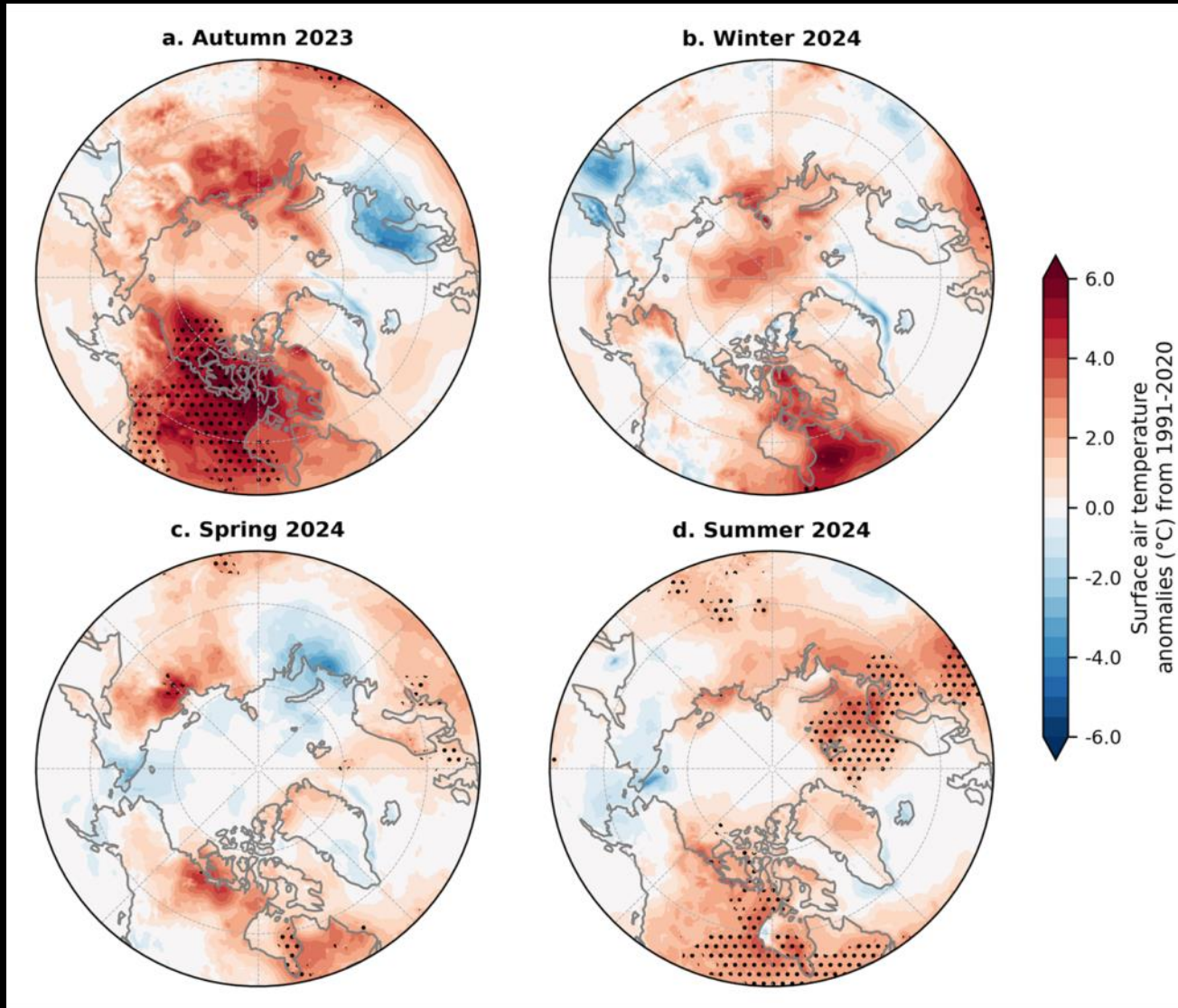
Warming Faster or Slower than Global Average



Arctic Surface Air Temperature

- Arctic annual 2023-2024 surface air temperatures ranked 2nd warmest since 1900
- Autumn 2023 and summer 2024 were especially warm across the Arctic with temperatures ranking 2nd and 3rd warmest, respectively
- An early August 2024 heatwave produced record daily temperature maxima in several northern Alaska and Canada communities

Arctic Surface Air Temperature

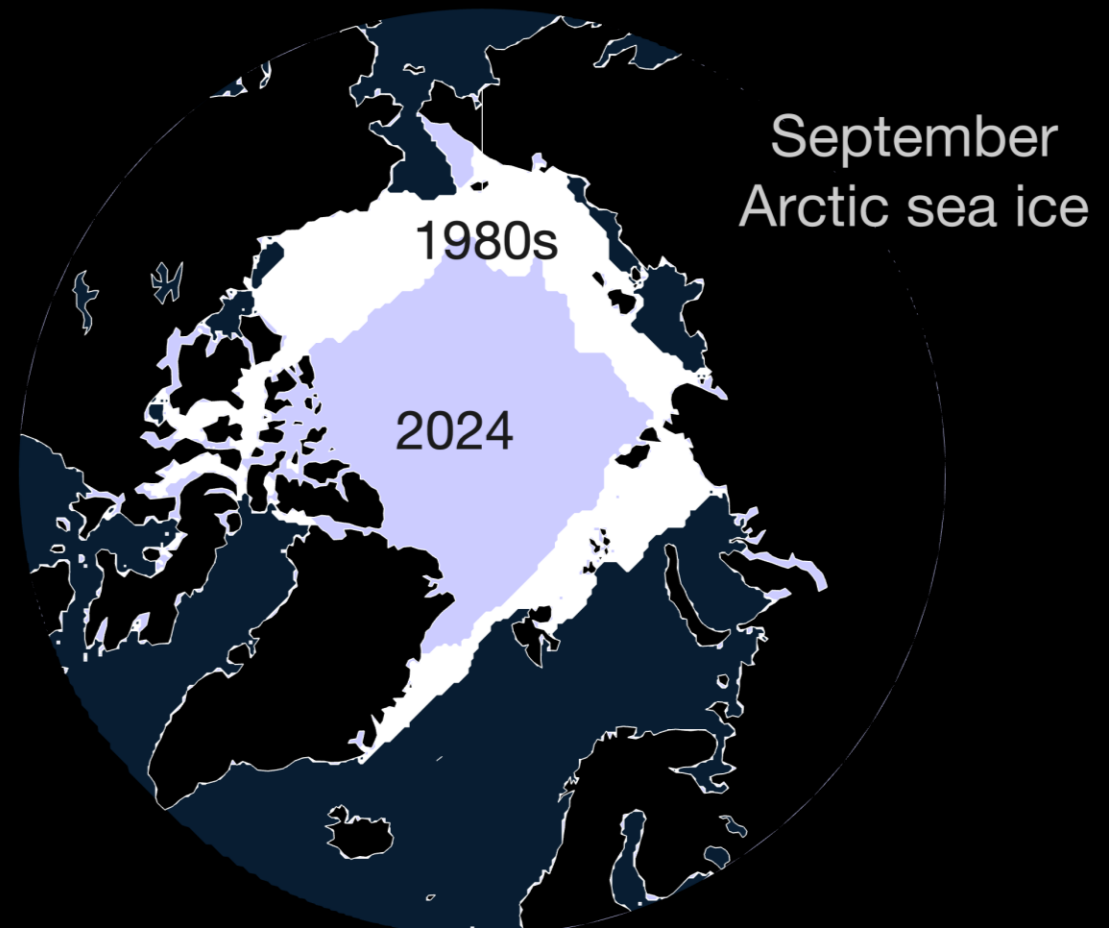
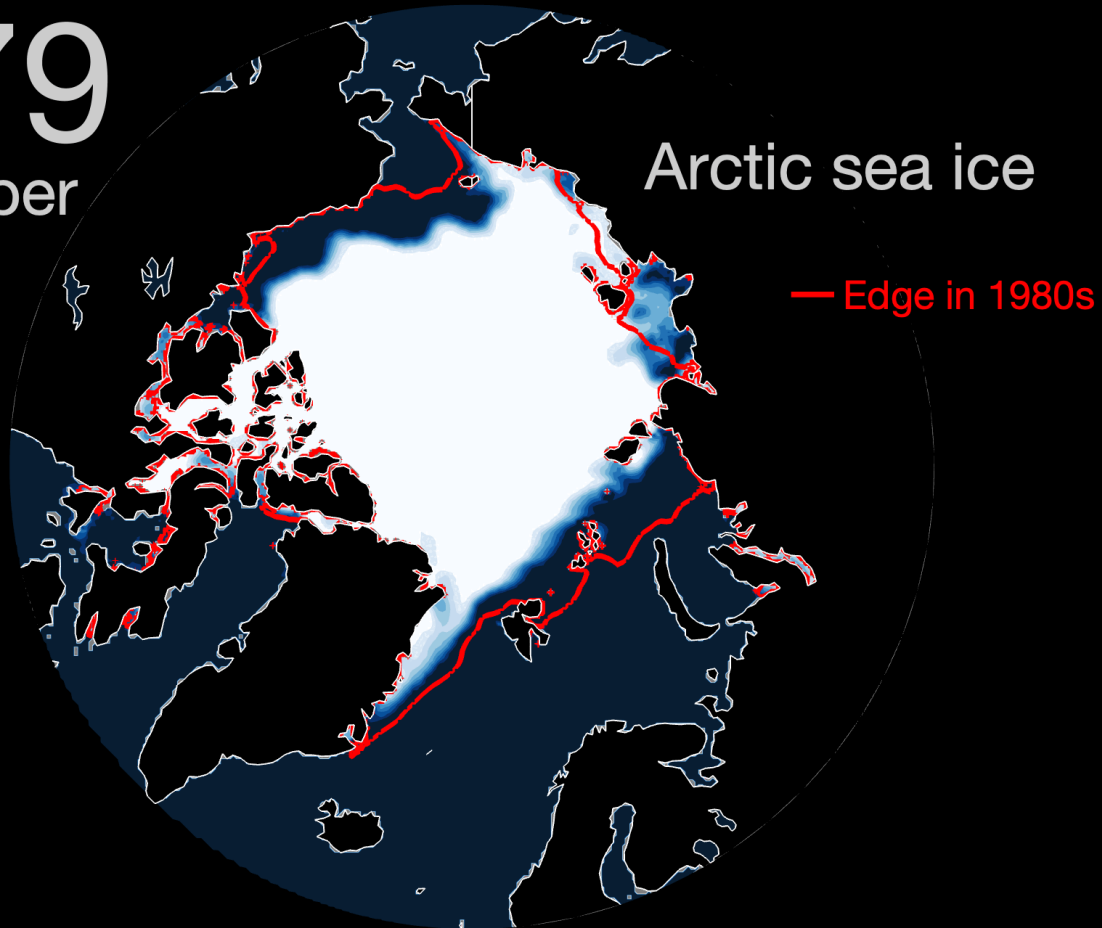


Seasonal surface air temperature anomalies (°C) for

- (a) autumn 2023**
- (b) winter 2024**
- (c) spring 2024**
- (d) summer 2024**

Change in Arctic Summer Sea Ice Concentration

1979
September



Lakes in Canada

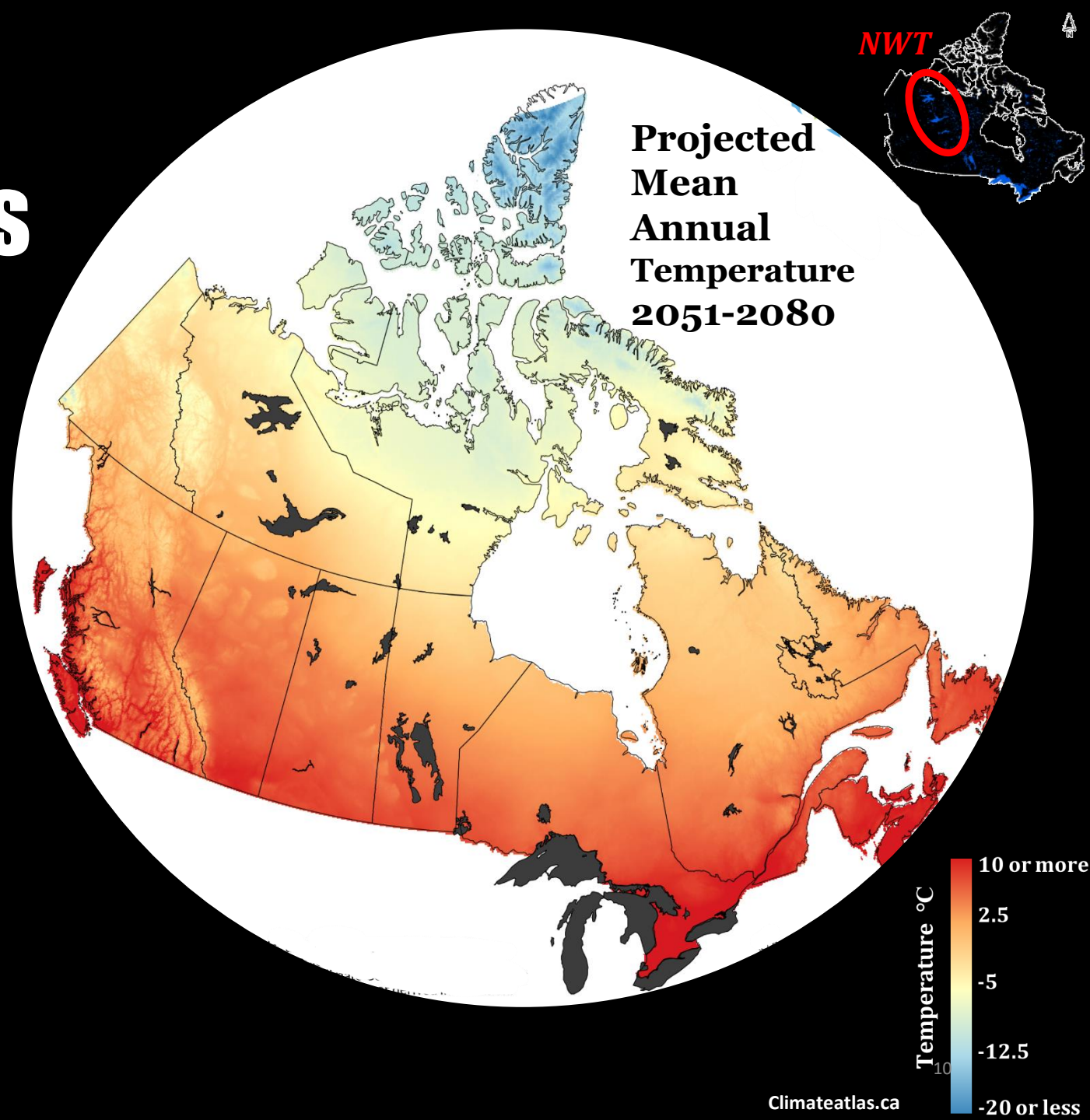


~2 million Lakes in Canada
>160,000 Lakes in NWT
> 8% of Canadian Lakes

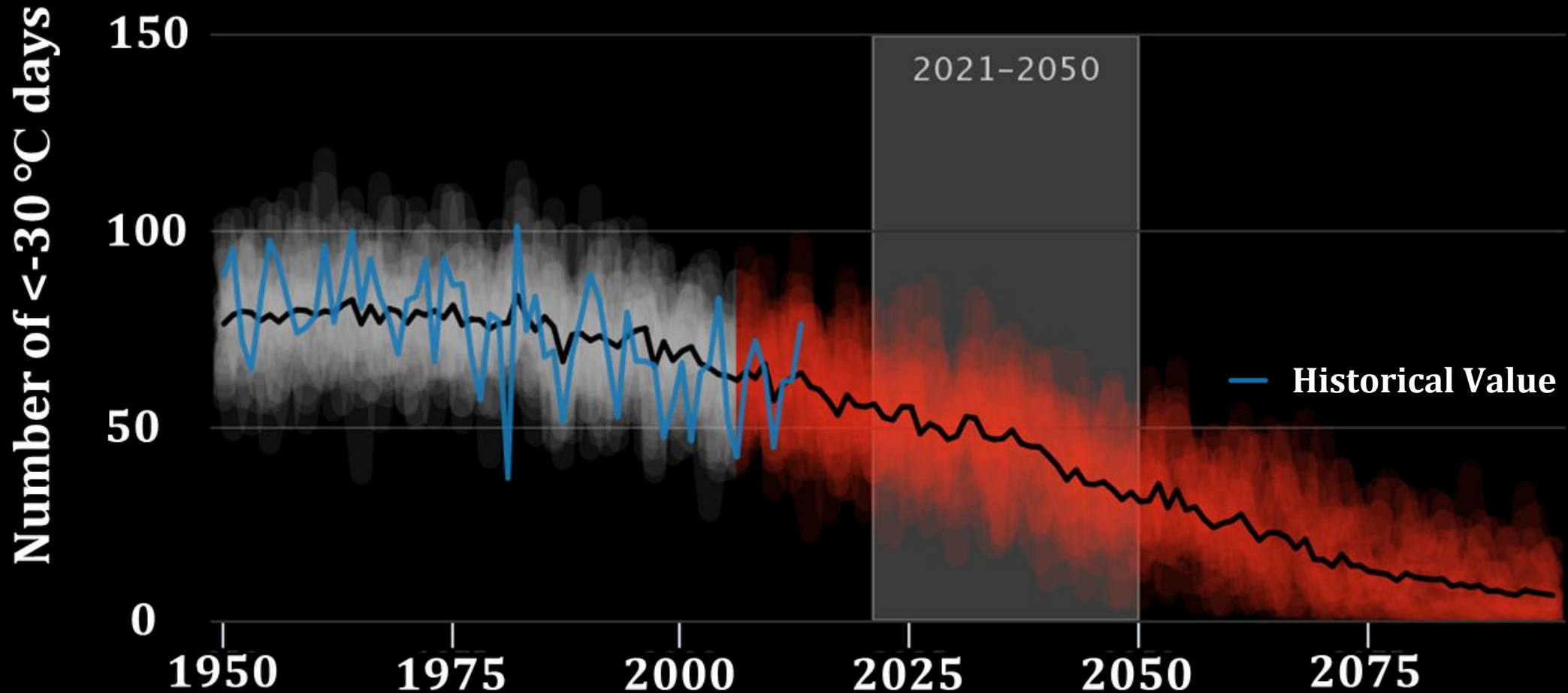
Climate Warming – Northwest Territories

NWT by 2080

- Annual Mean Temperature can increase by **+5.6°C**
- **Winter** Mean Temperature can increase by **+7.8°C**
- **Winter Min** Temperature can increase by **+8.2°C**



Climate Warming – Northwest Territories



< -30 °C days can decrease 28 days by 2050
< -30 °C days can decrease 51 days by 2080

Lake Processes

Physical

- Water temperature
- Ice cover duration and thickness
- Break up/freeze up date
- Open water duration
- Solar radiation exposure
- Precipitation/Evaporation
- Water level and volume
- Thermal regime and mixing

Geochemical

- Chlorophyll-*a*
- Nutrient availability
- Dissolved oxygen level
- Dissolved organic matter
- Nitrogen and phosphorus

Biological

- Extinction
- Blooming or migration of various biological species
- Biodiversity
- Biomass and production

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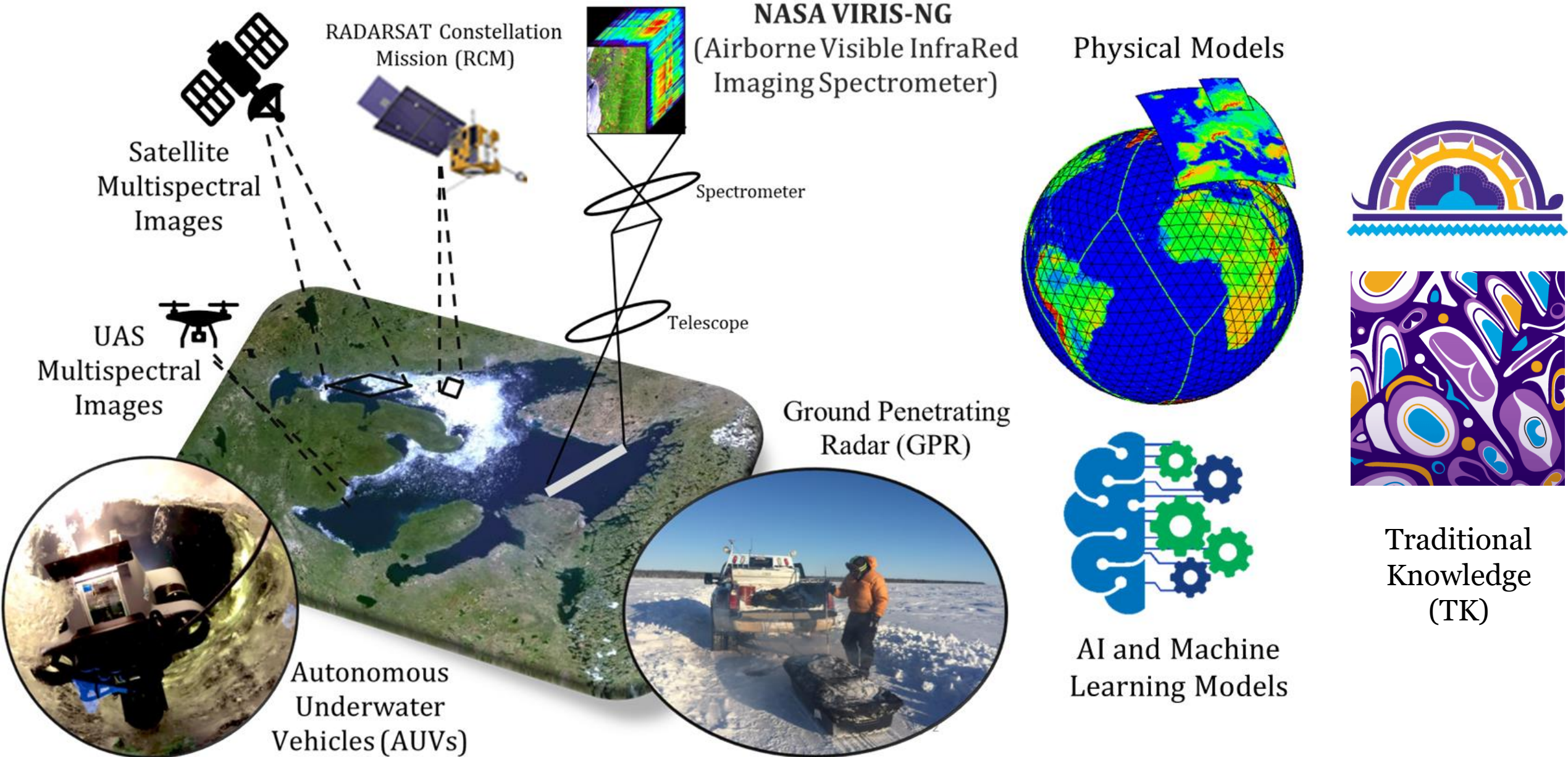
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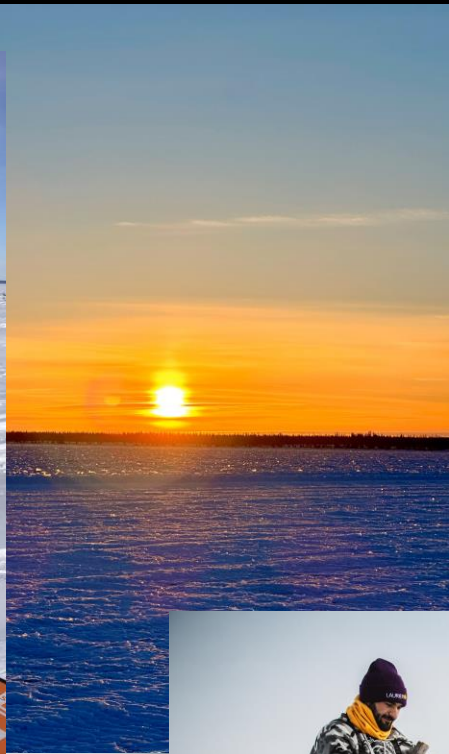
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Multi-method Approach



Multi-method Approach

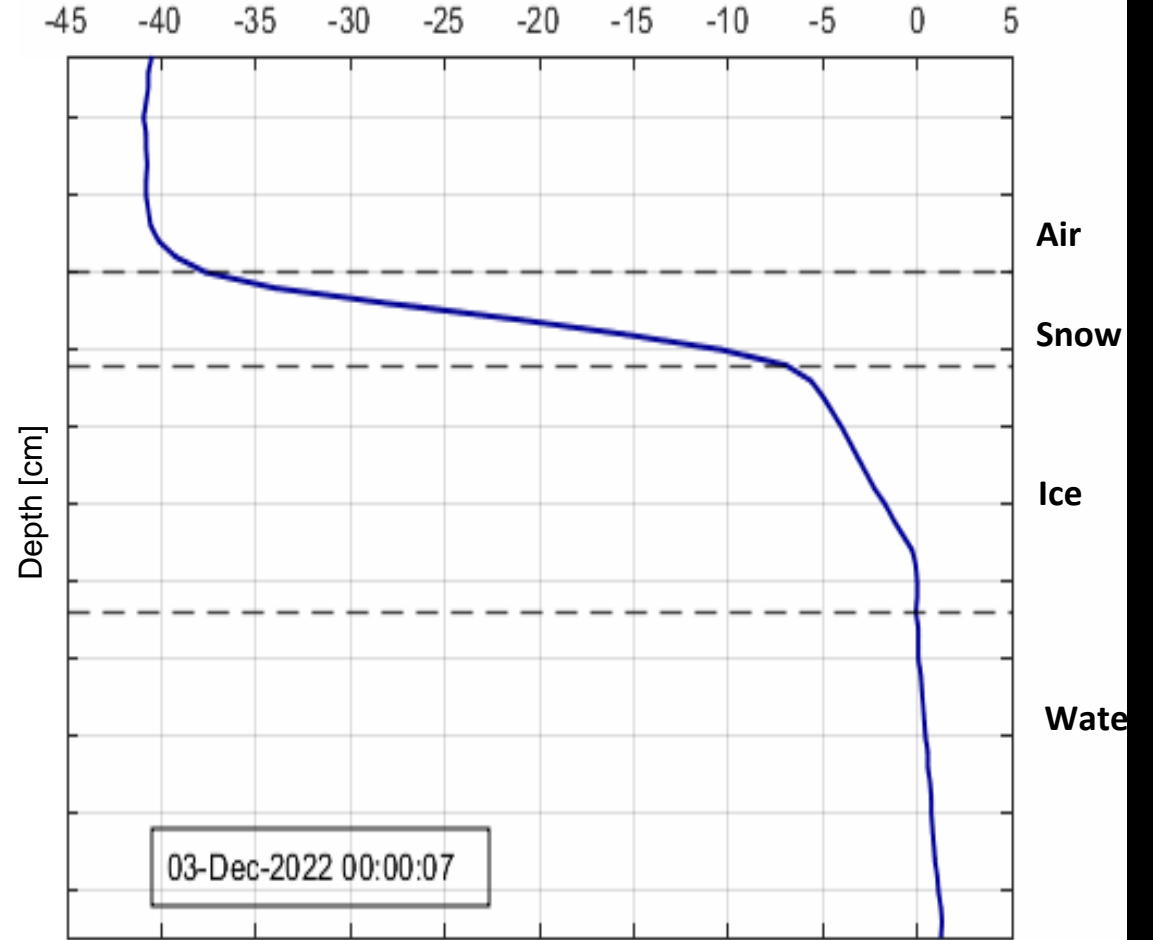
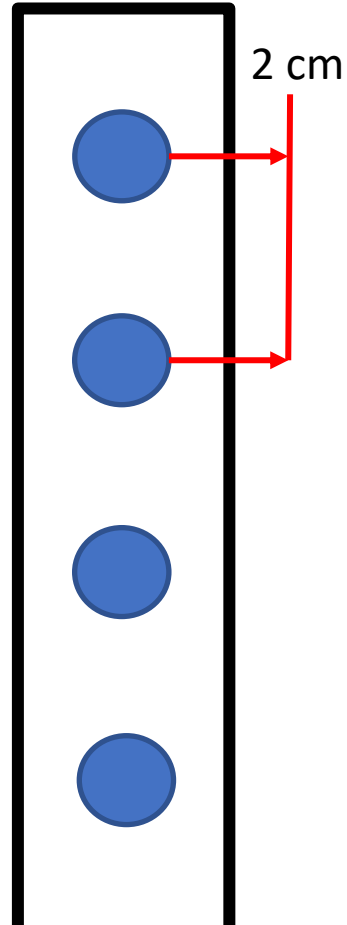
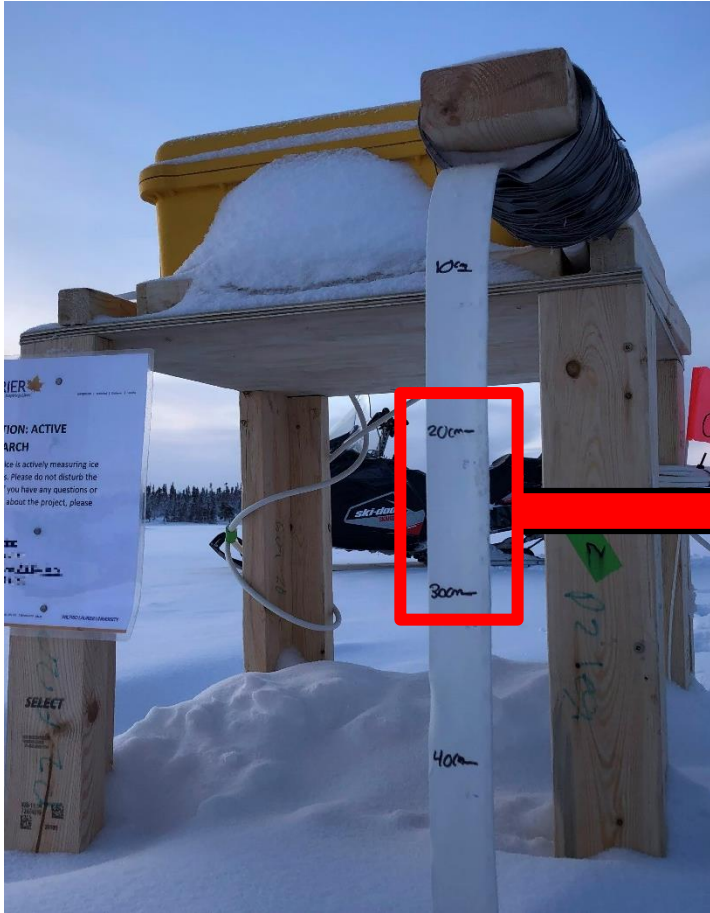


Ice Thickness



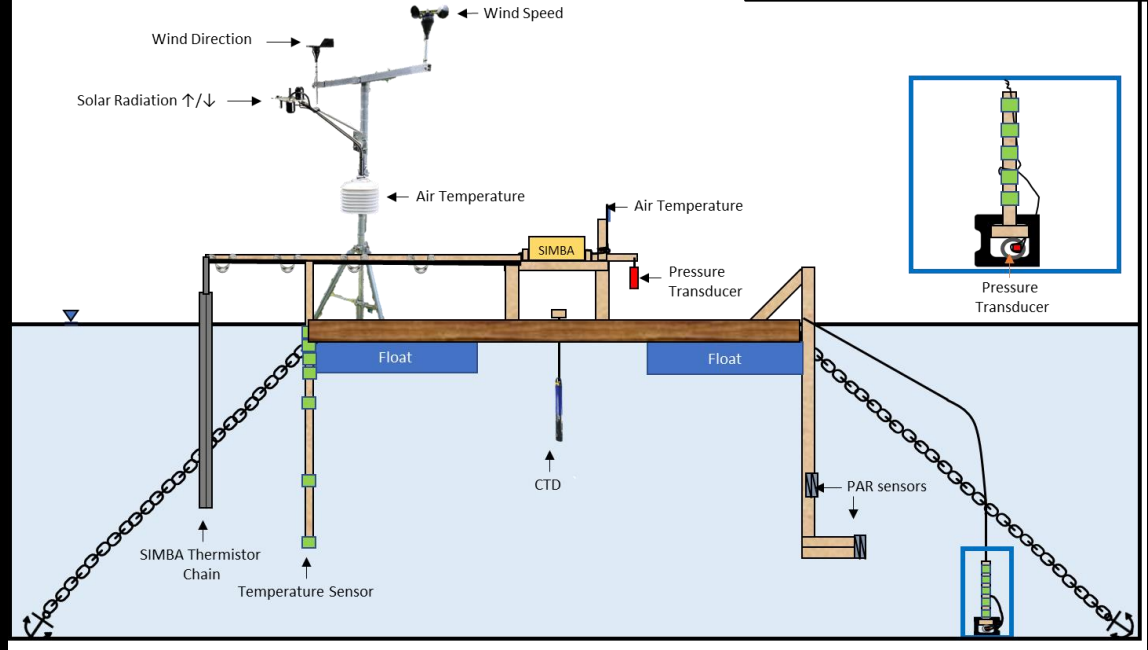
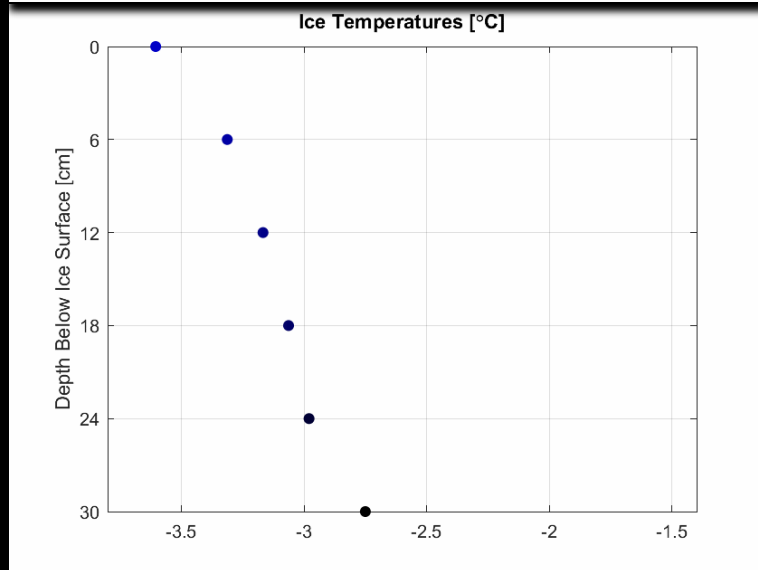
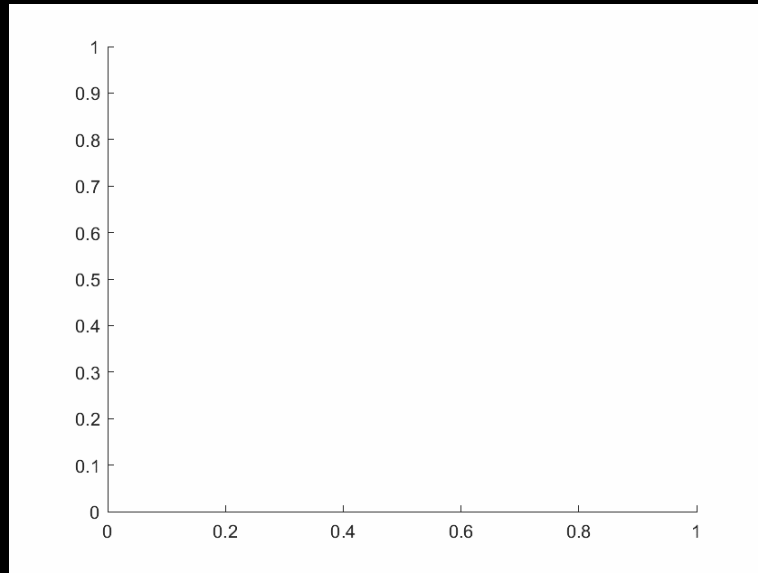
Great Bear Lake (April 2022)

Real-time Lake Ice Monitoring

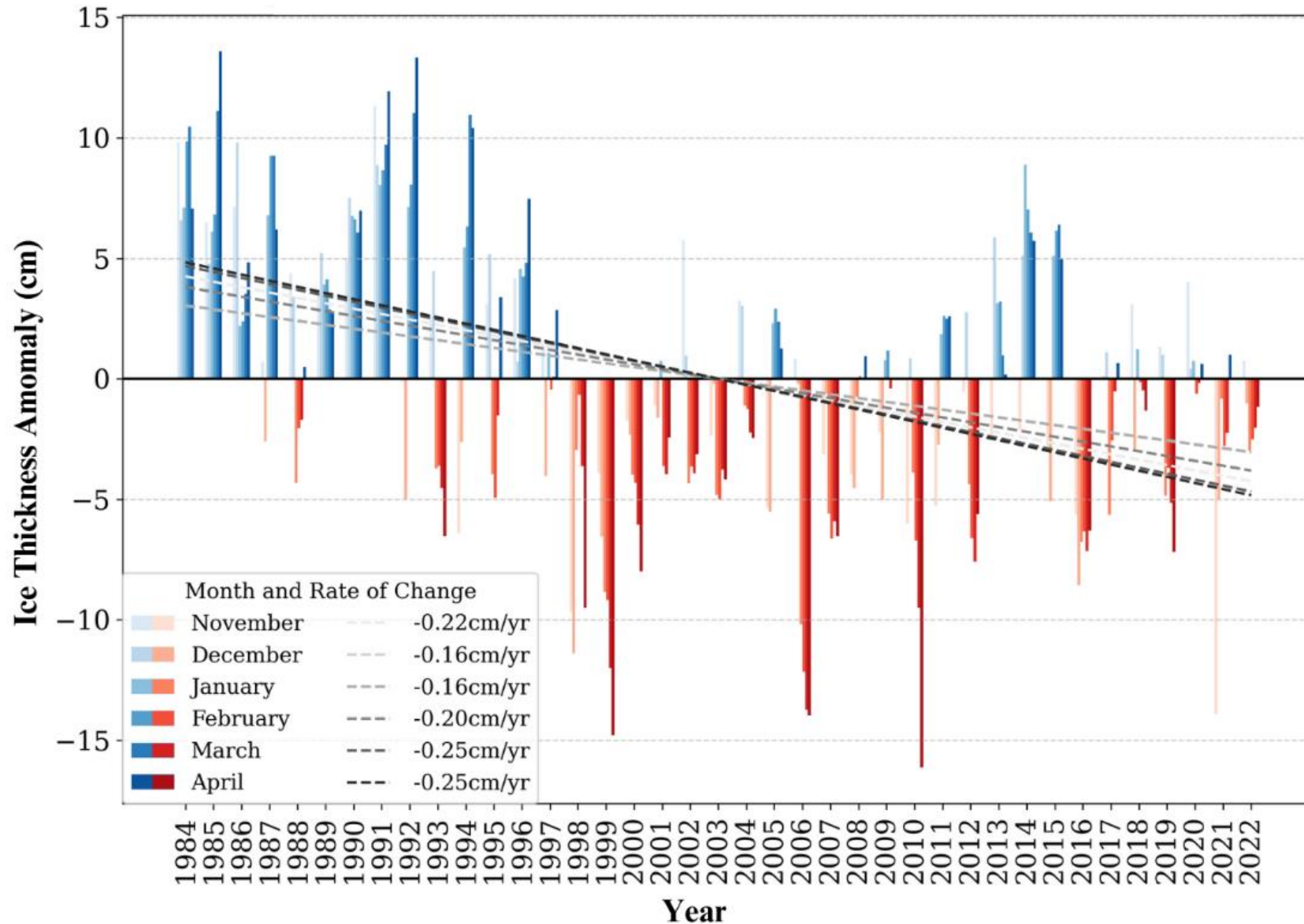


Thermistor chain system (2 or 5 cm with 15 min frequency)

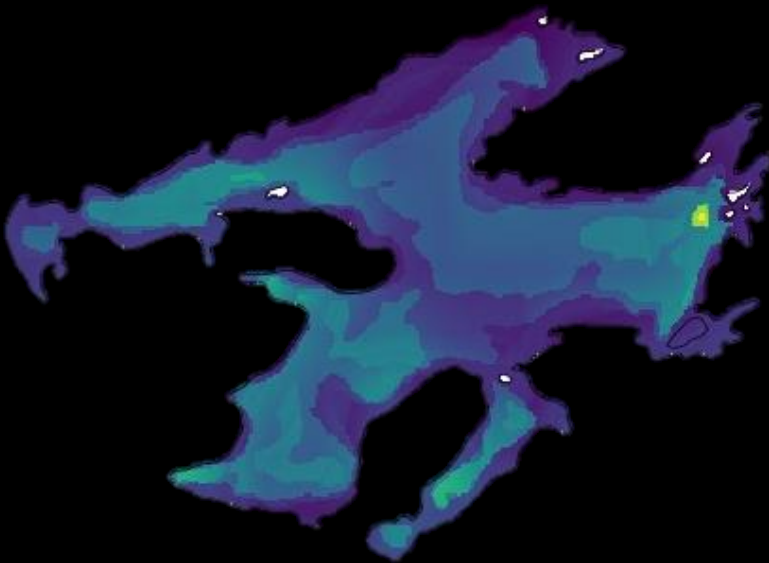
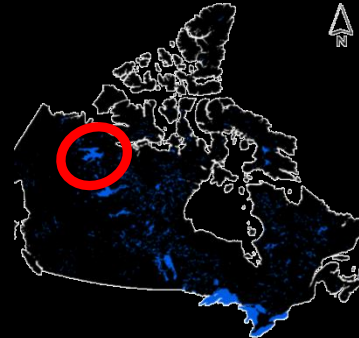
Real-time Year-Round Lake Monitoring



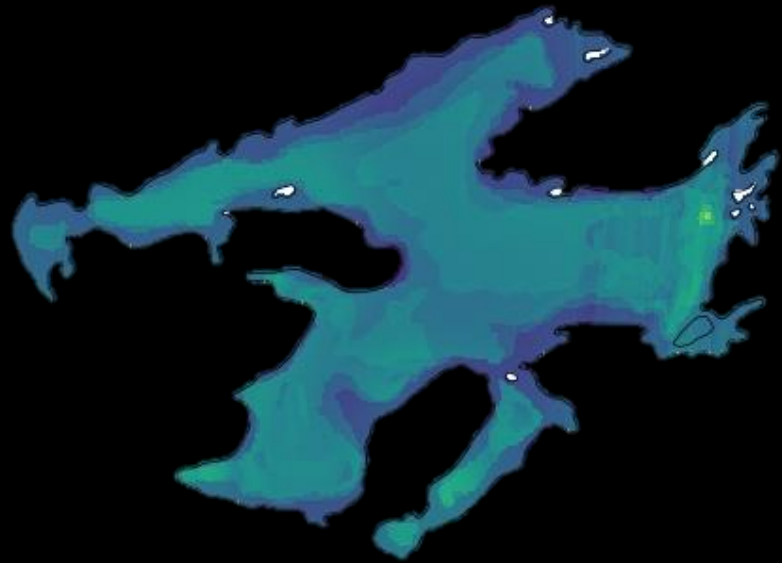
Ice Thickness



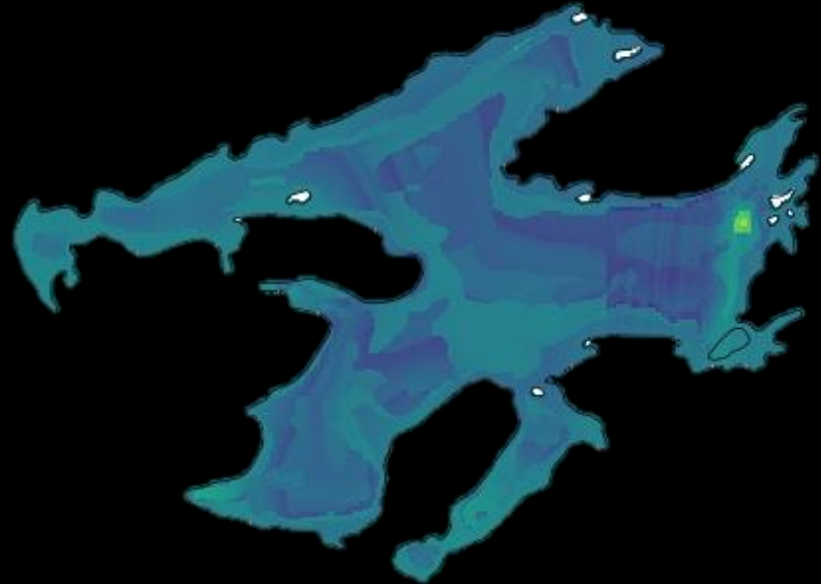
Daily Ice Thickness - Great Bear Lake



December 01, 2003



December 01, 2006



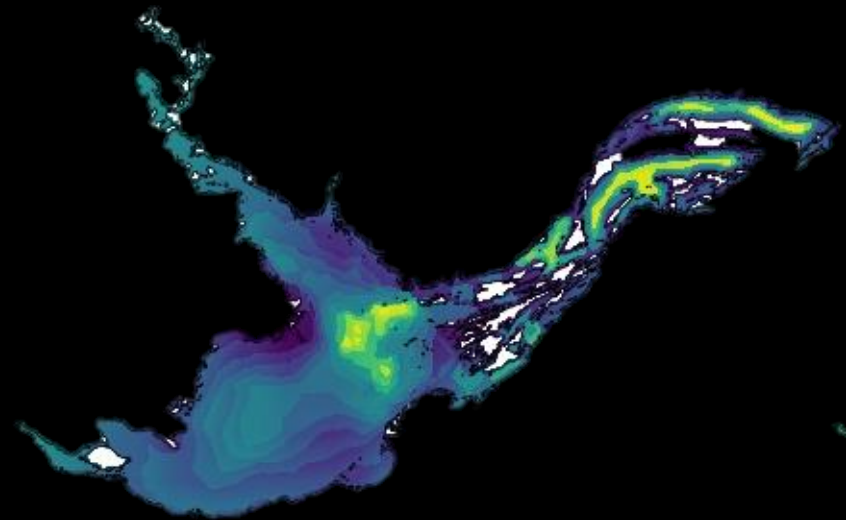
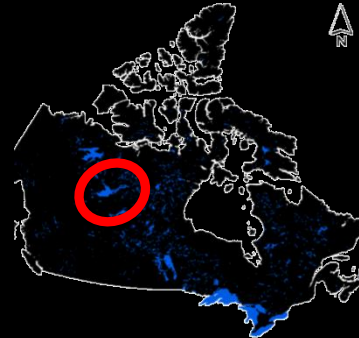
December 01, 2020



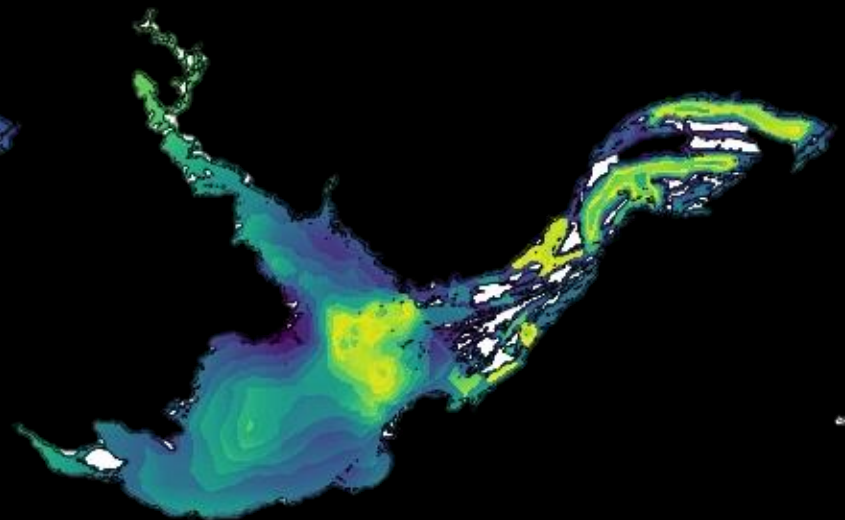
0.3 0.7

Ice Thickness (m)

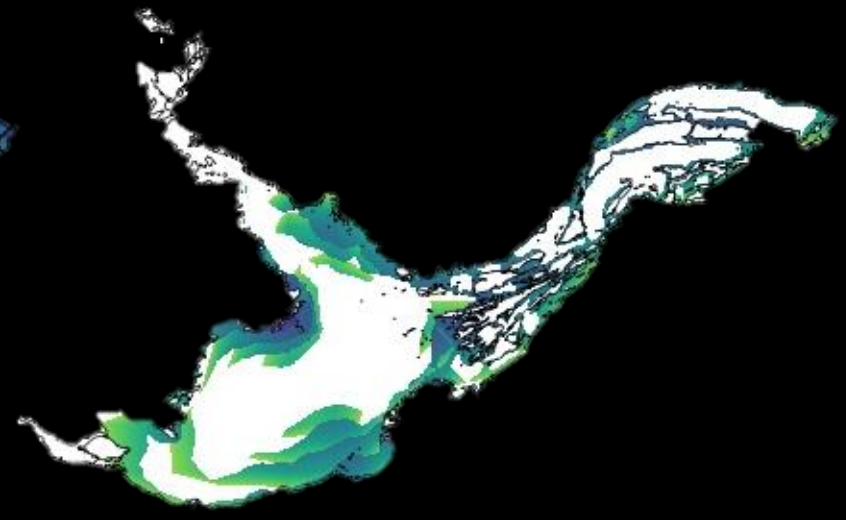
Daily Ice Thickness - Great Slave Lake



December 01, 2003



December 01, 2006



December 01, 2020



0.4 0.6

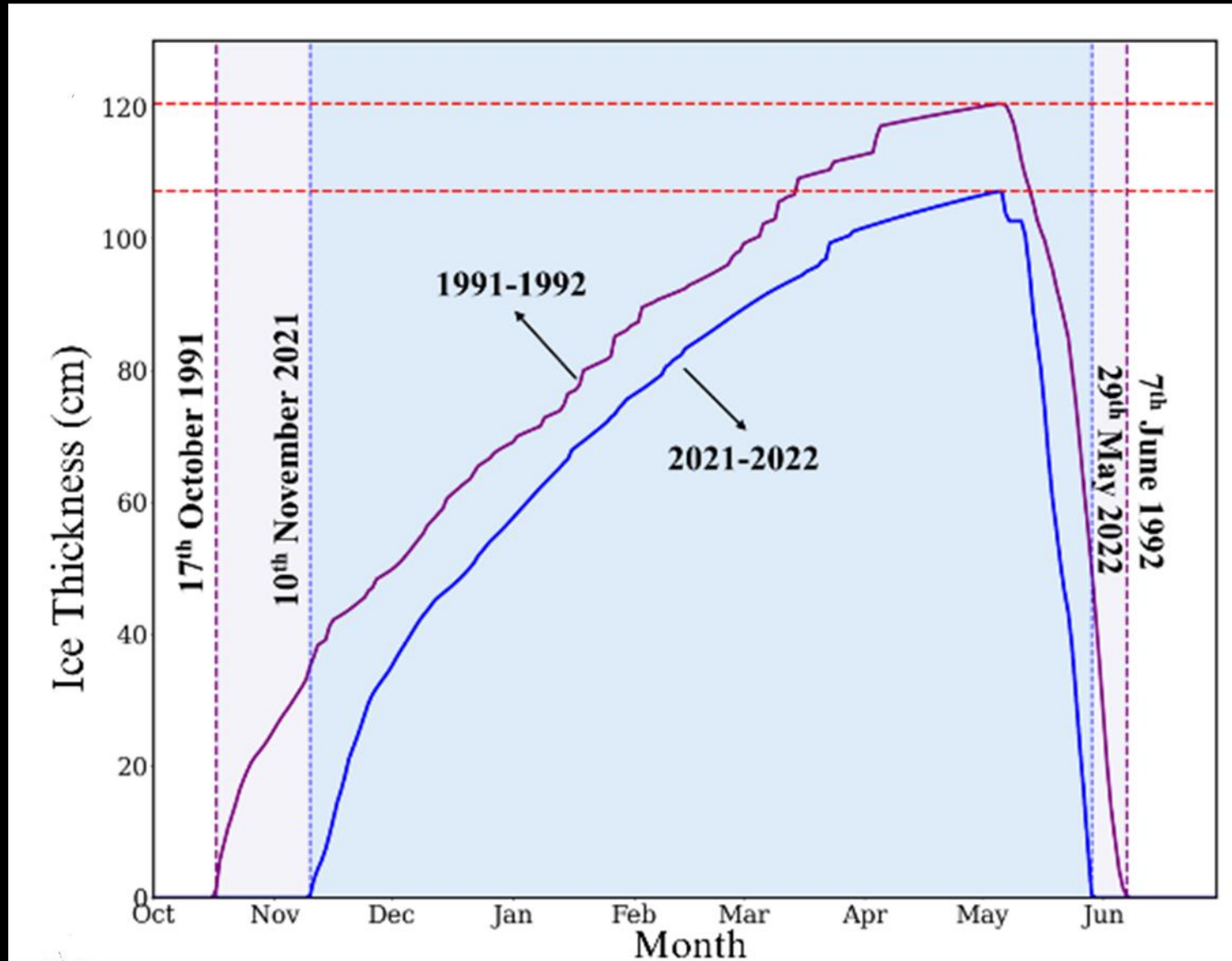
Ice Thickness (m)

Freeze up/Break up Dates

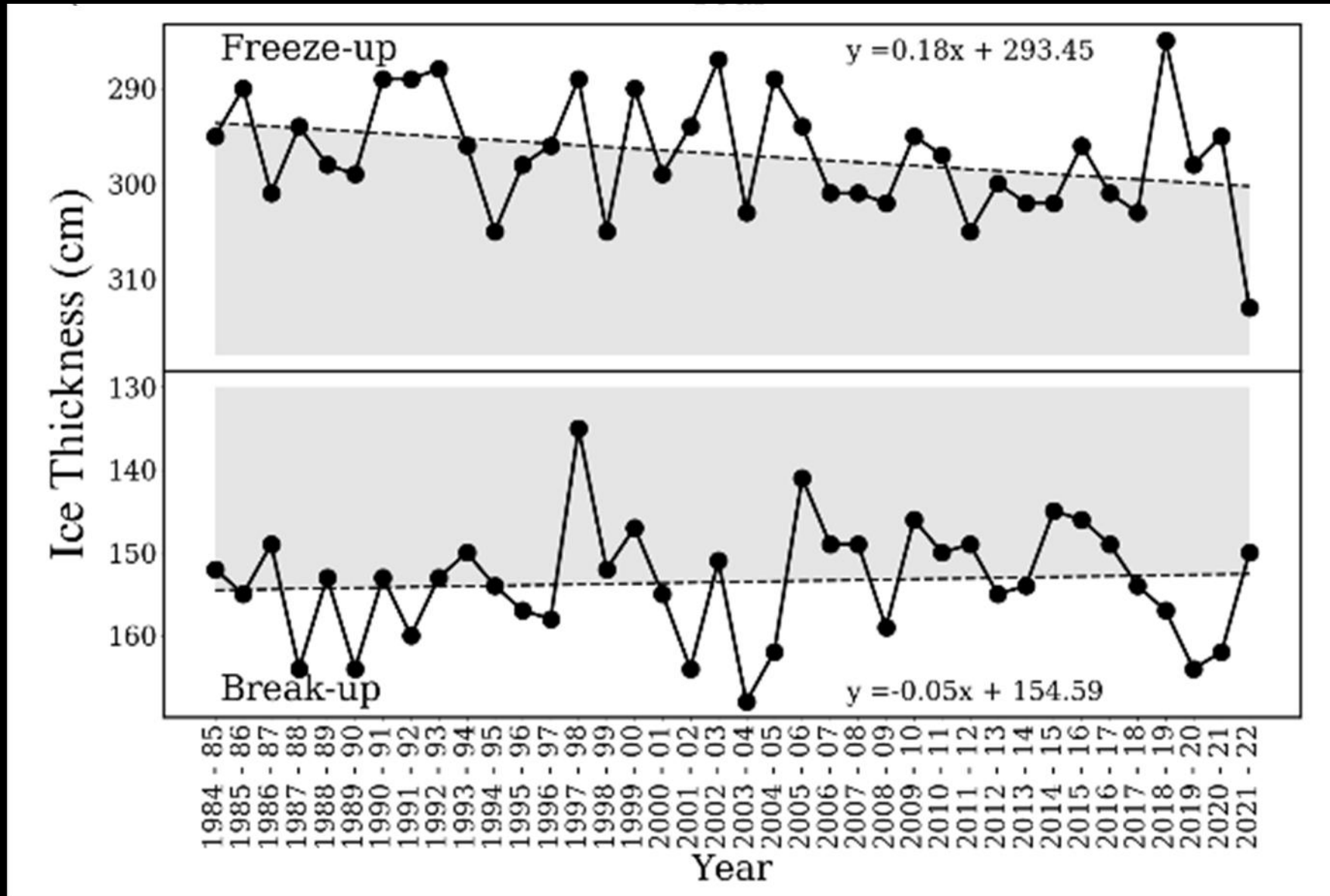


Great Bear Lake (June²³ 2023)

Freeze up/Break up Dates



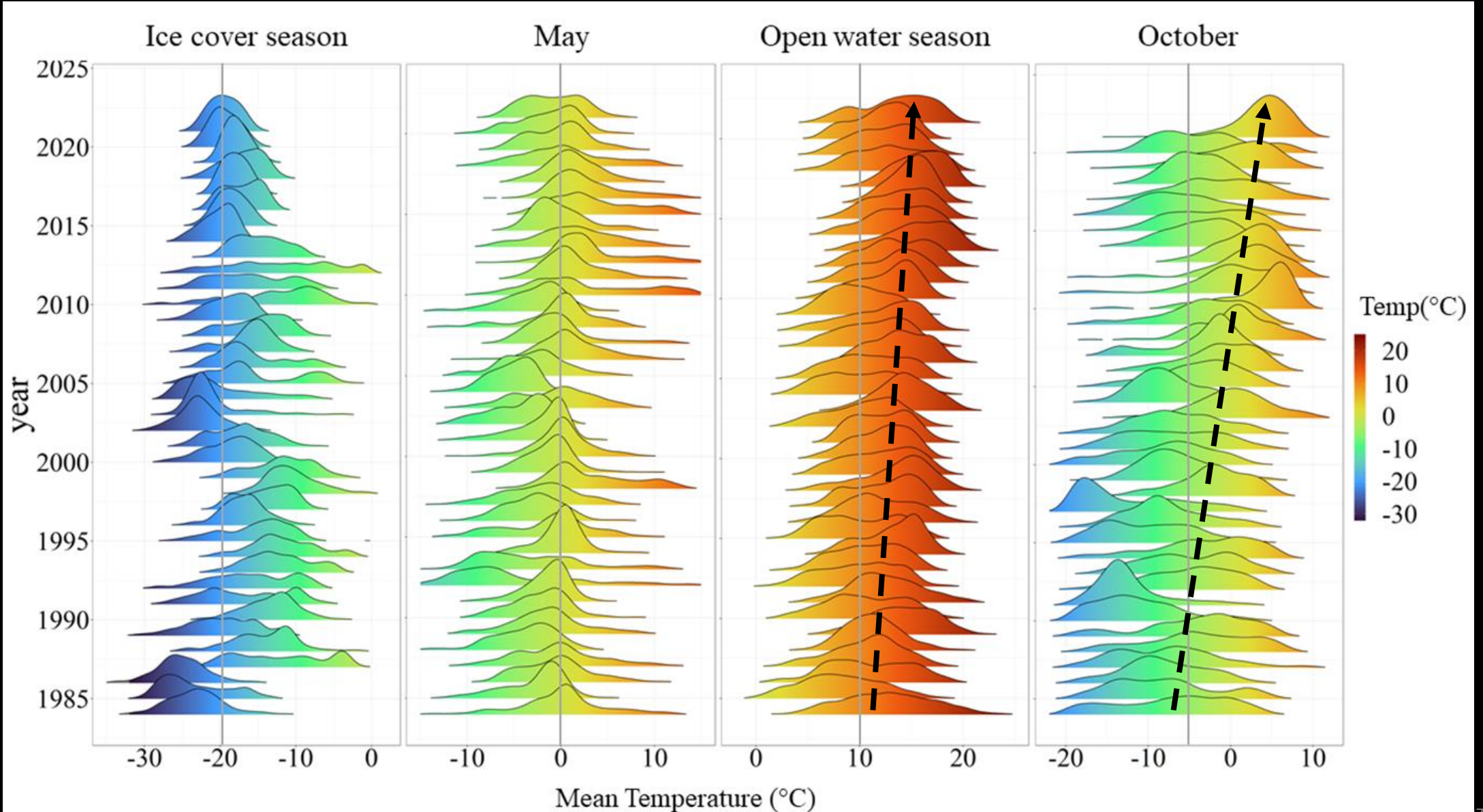
Freeze up/Break up Dates



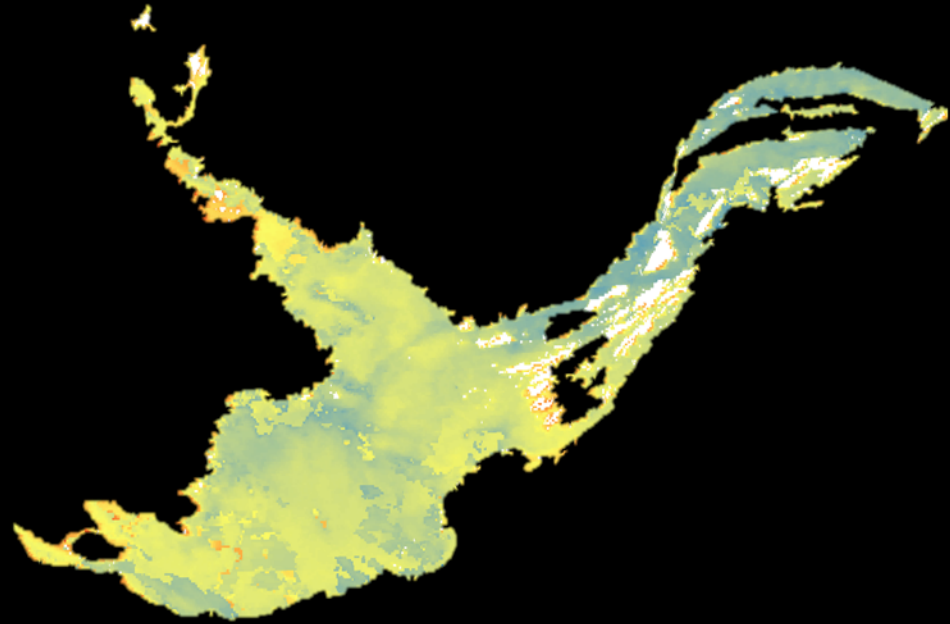
Lake Surface Temperature



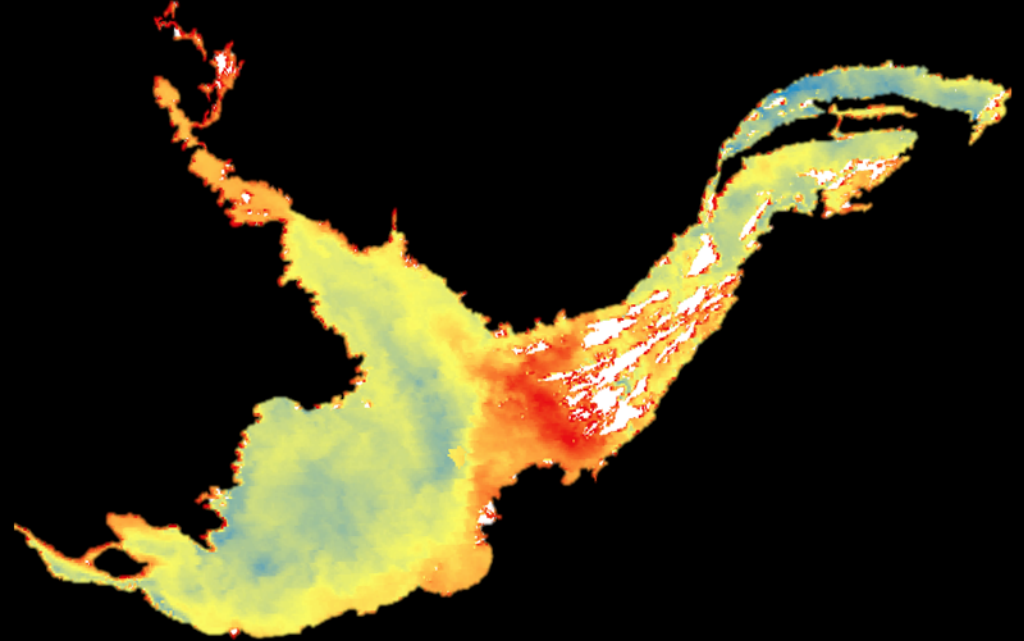
Lake Surface Temperature



Lake Surface Temperature



July 26, 2012



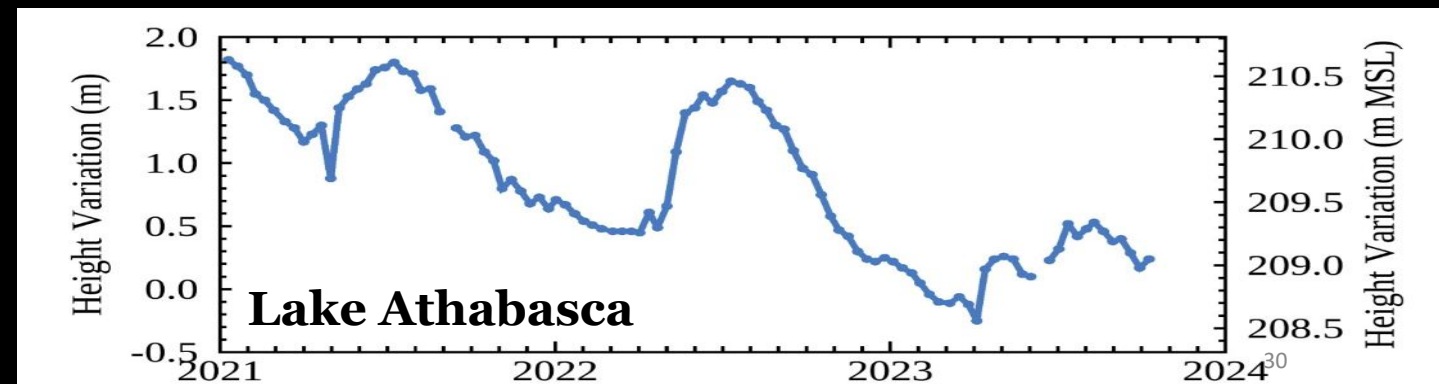
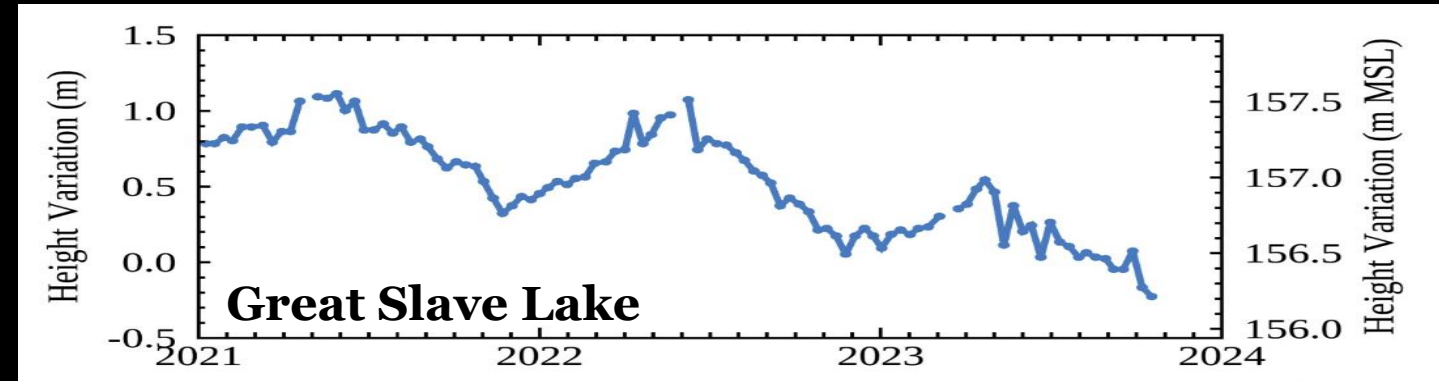
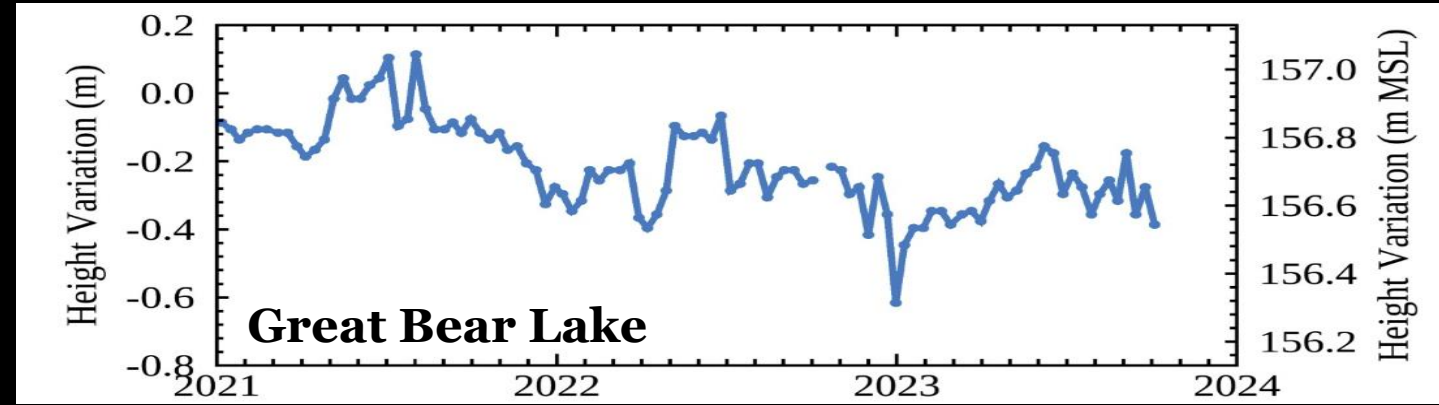
July 26, 2022



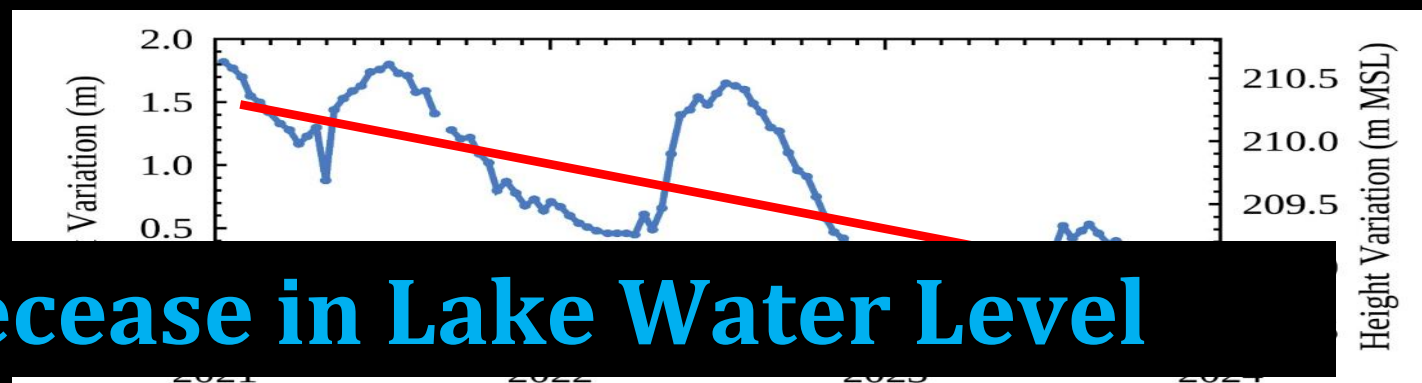
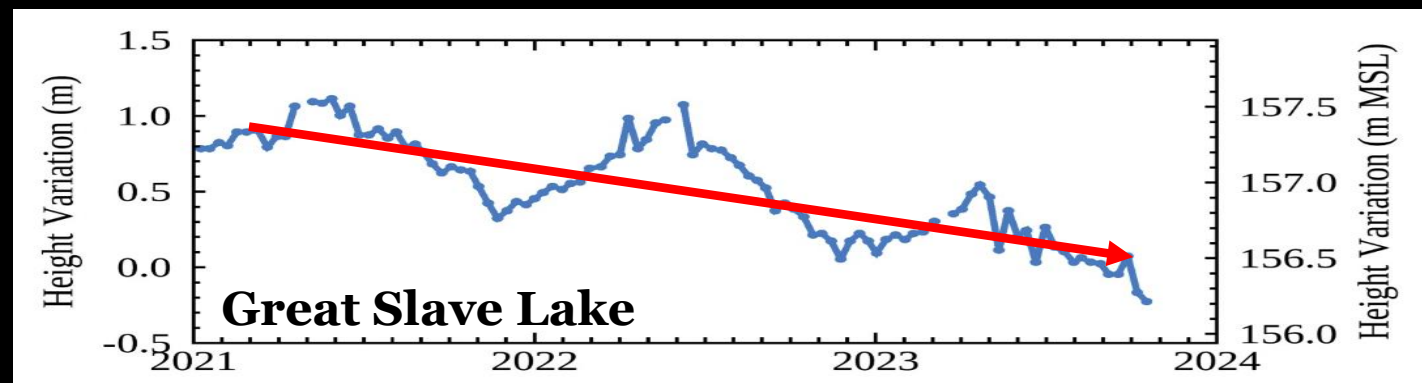
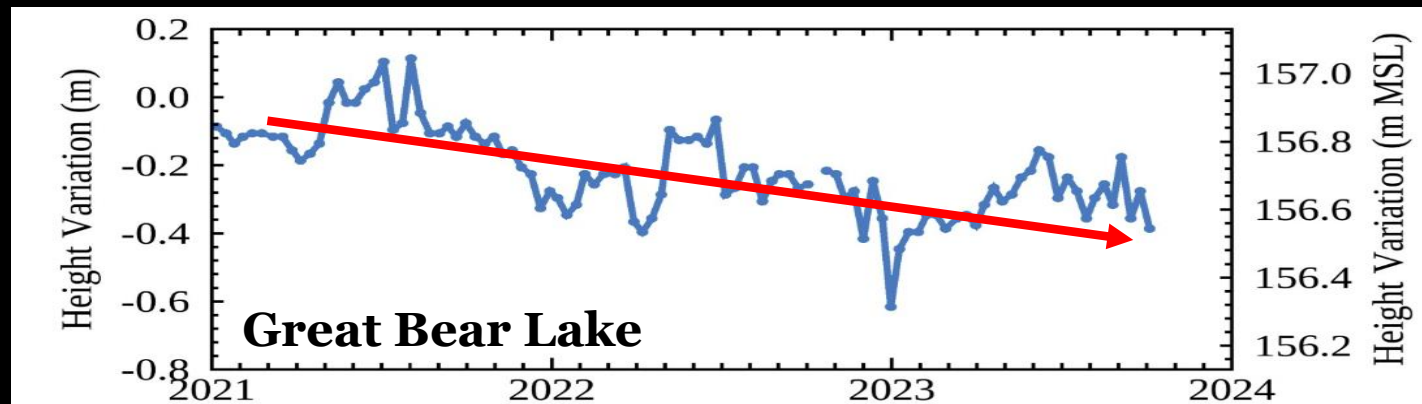
Water Level



Water Level Monitoring



Water Level Monitoring



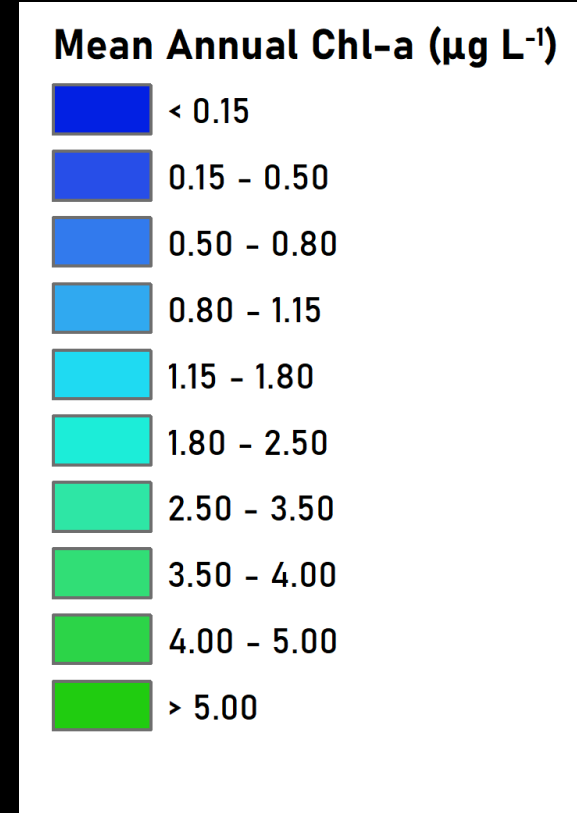
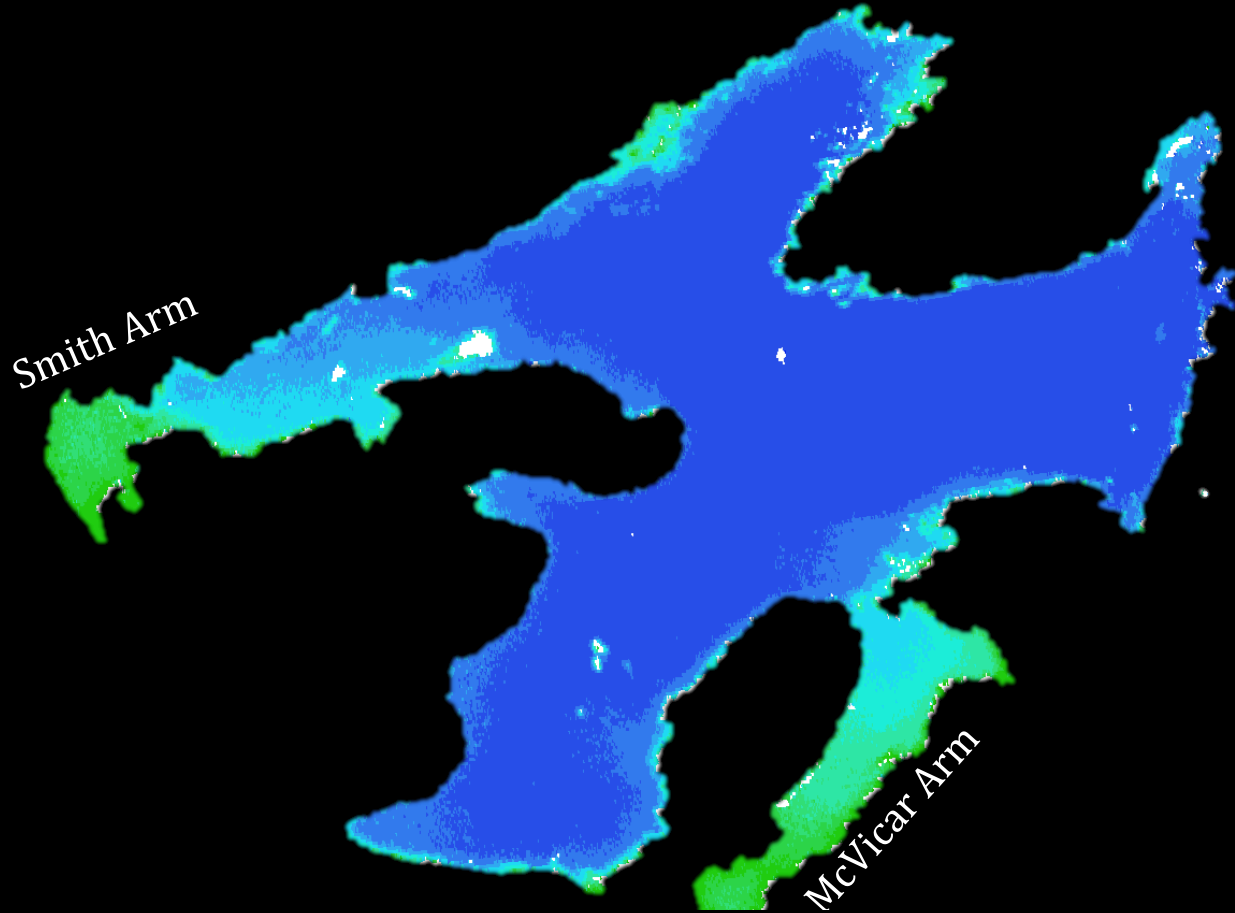
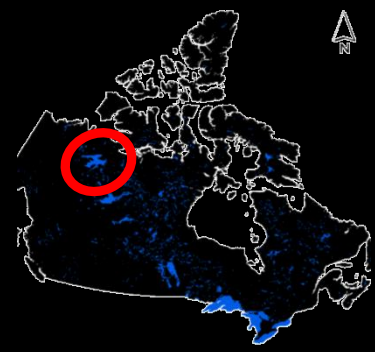
Significant Decrease in Lake Water Level

Water Quality



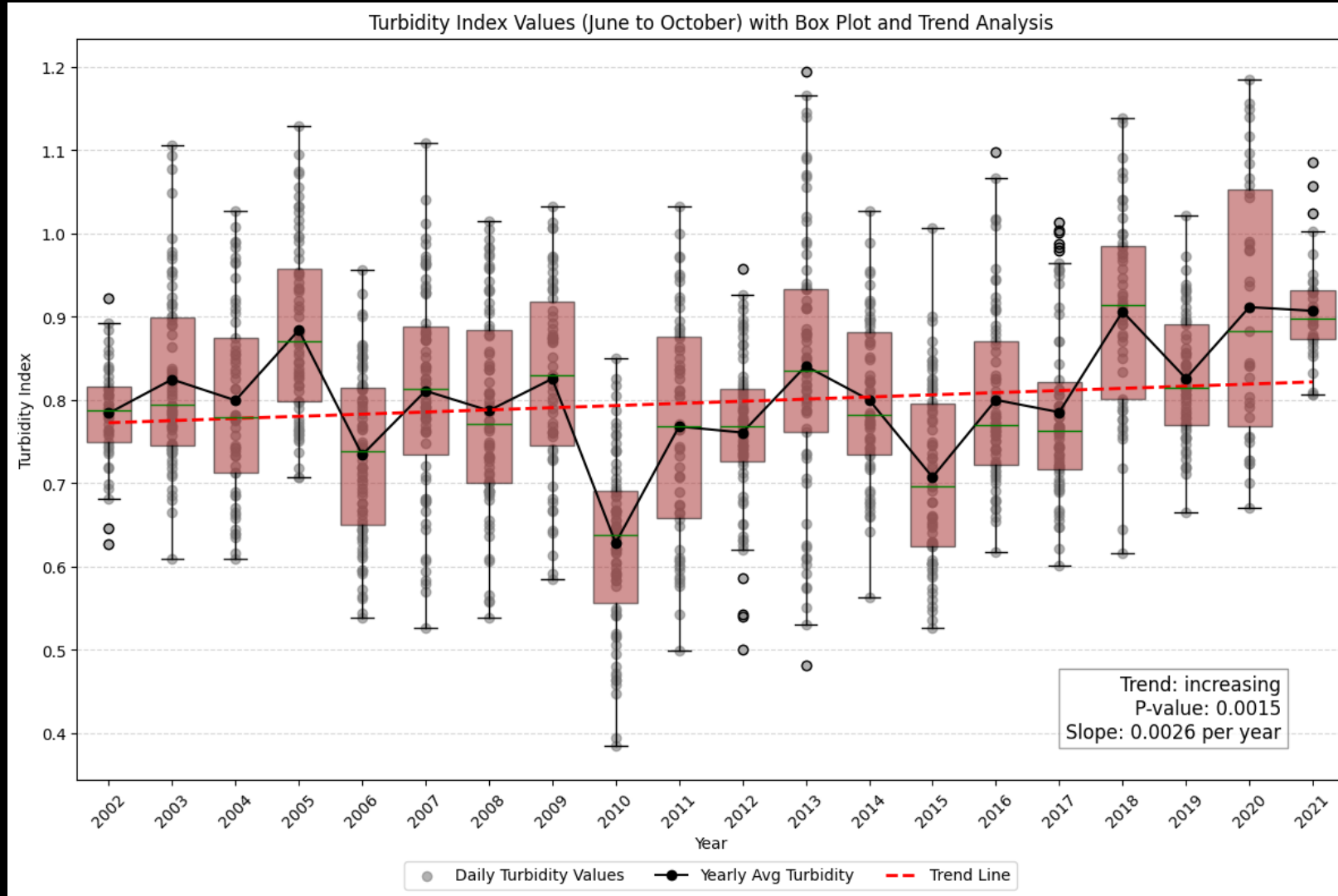
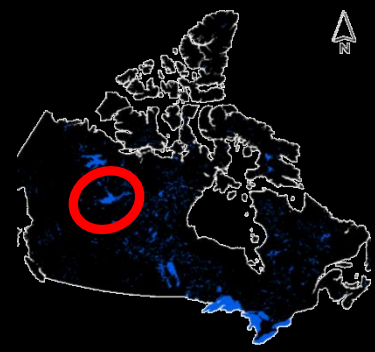
Great Bear Lake (June 2023)

Water Quality – Chl-a Rate of Change Great Bear Lake



Increase in Lake Productivity

Water Quality – Turbidity Trend Great Slave Lake

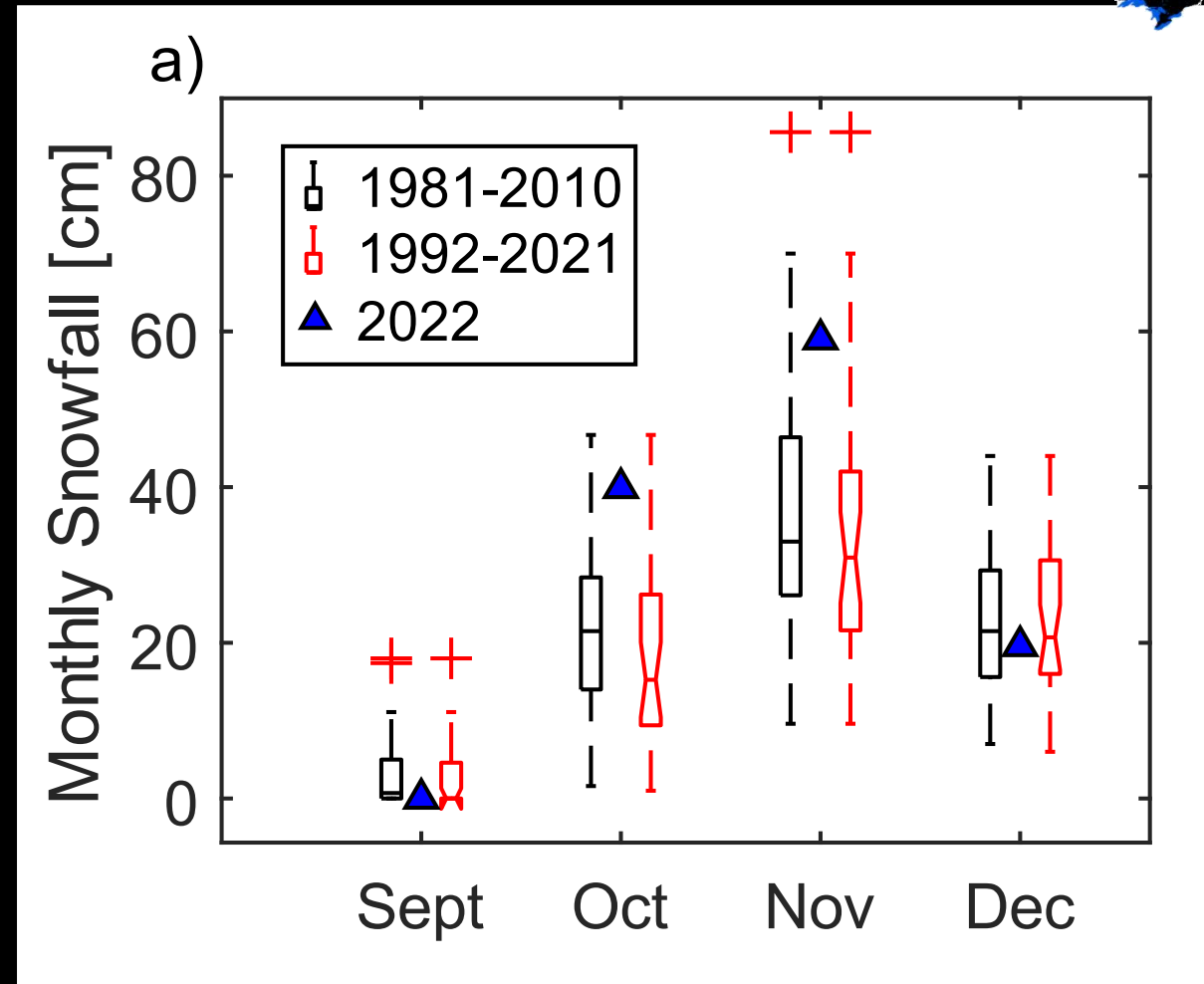
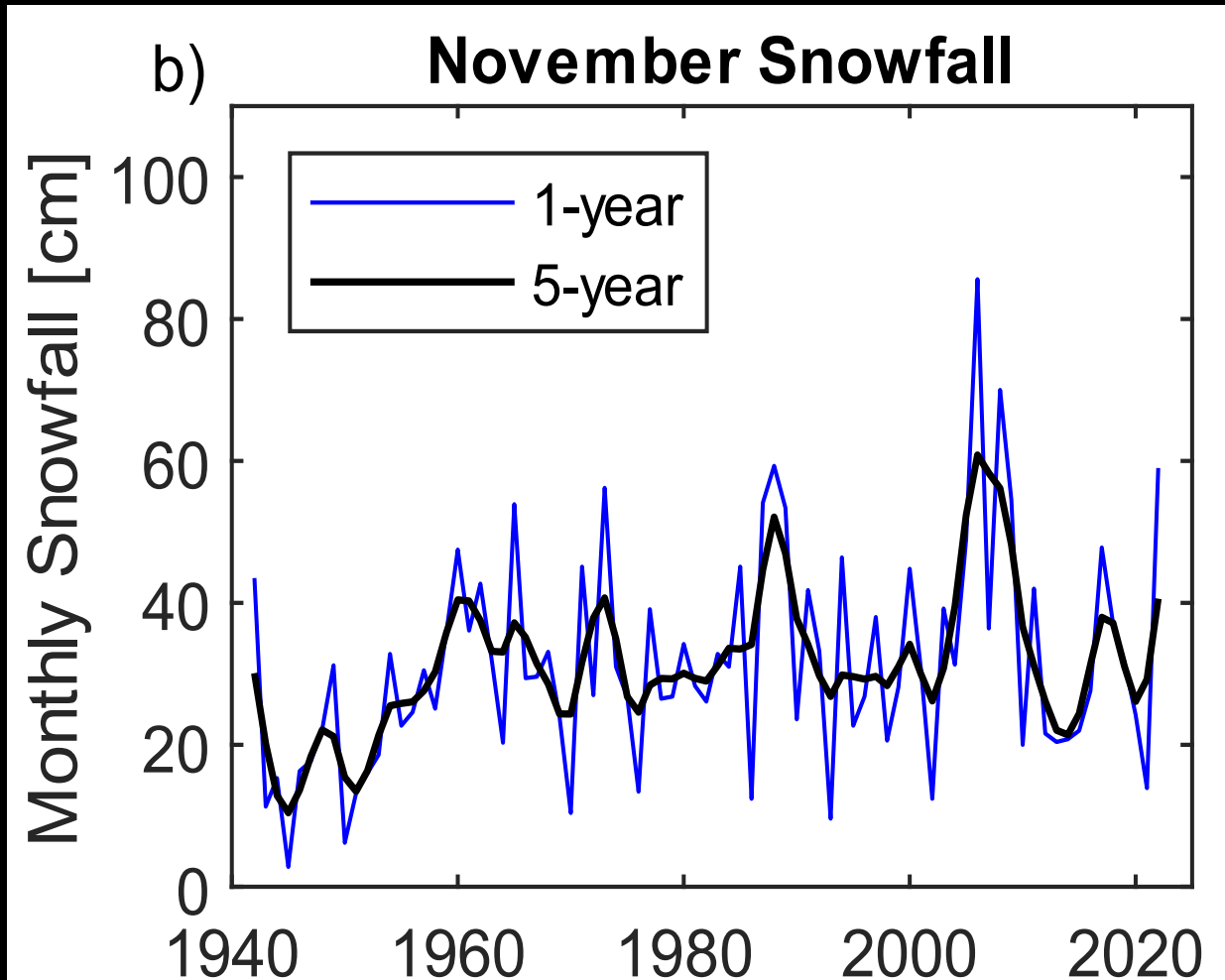


Snow Depth



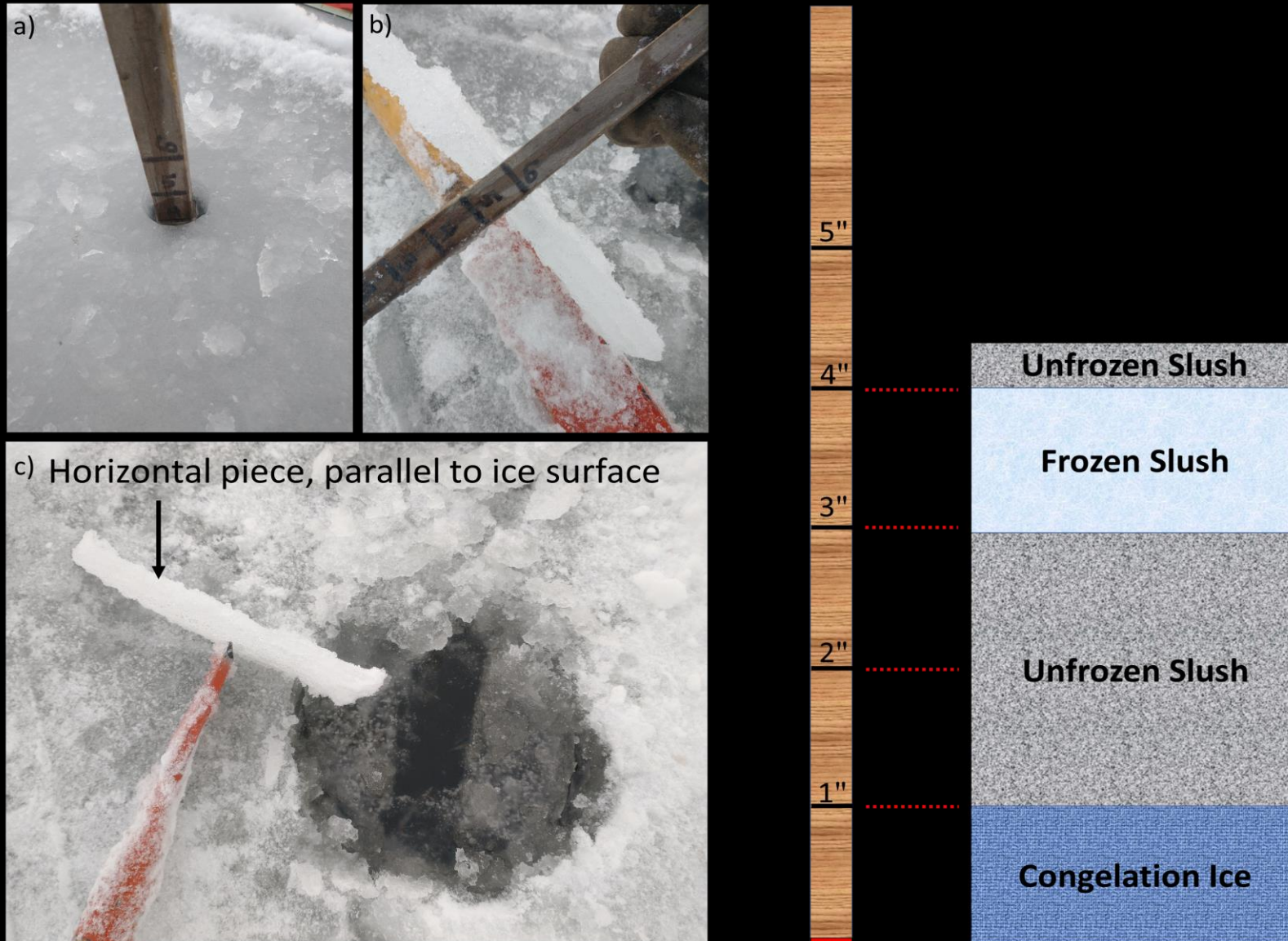
Great Bear Lake (January 2024)

Snowfall Monitoring

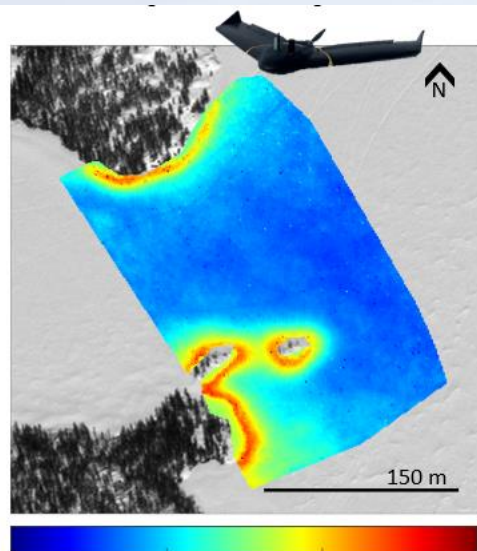


October and November 2022 snowfall was significantly higher

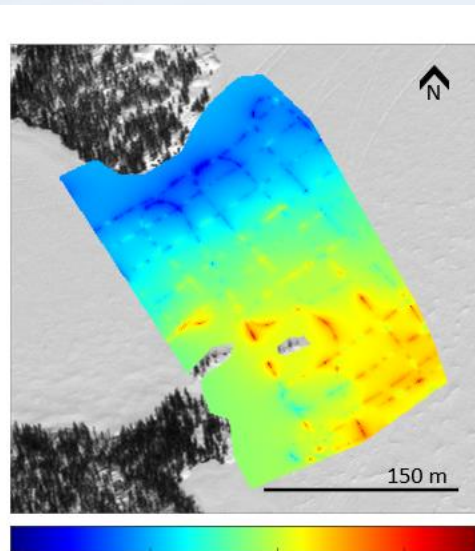
Impact of Snowfall on Ice Thickness



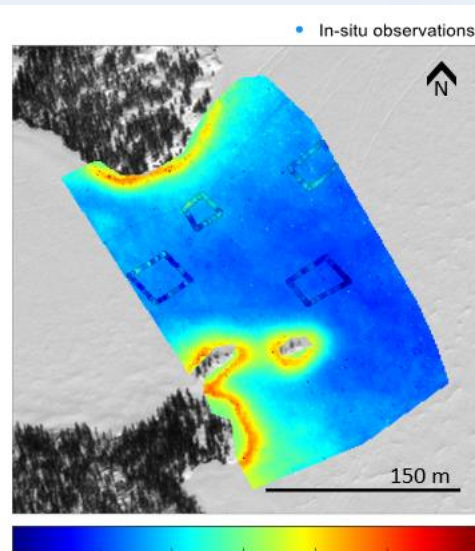
Mapping Lake Snow Depth Distribution



203.1 203.2 203.3 203.4 202.79 202.8 202.81 202.82
Snow Surface Elevation (masl)



202.79 202.8 202.81 202.82



30 35 40 45 50 55 60
Snow Depth (cm)

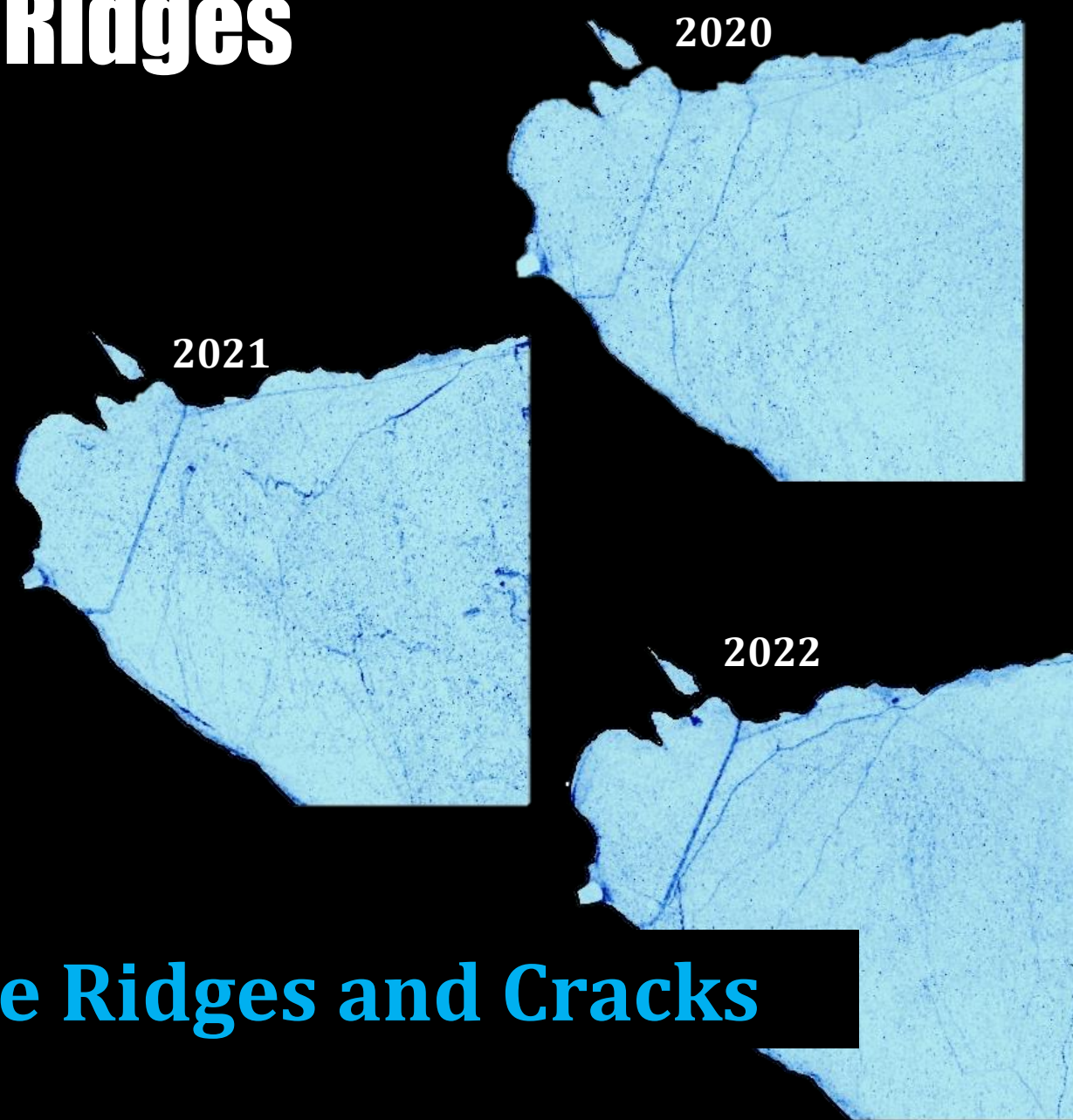
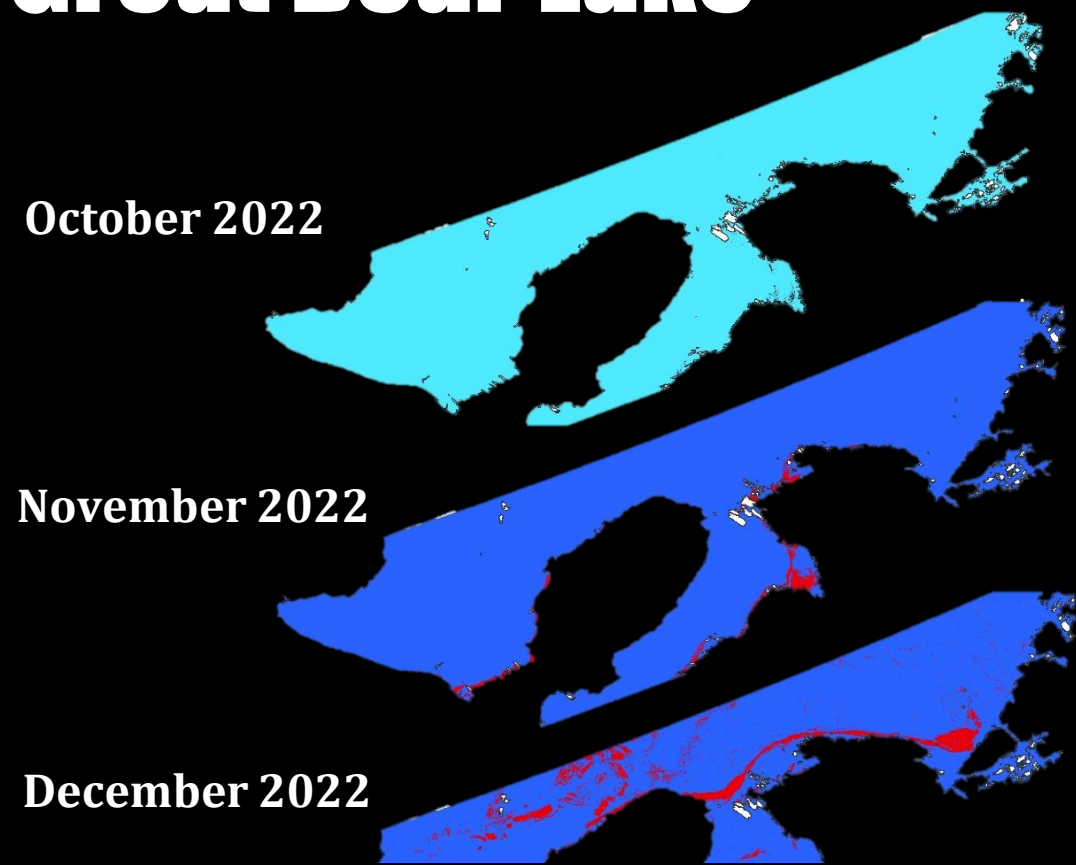
- Measure lake snow depth spatially using a multi-sensor approach
- Examine the changing baseline elevation spatially & temporally of the ice surface

Pressure Ridge



Great Bear Lake (April 2022)

Satellite Derived Pressure Ridges Great Bear Lake

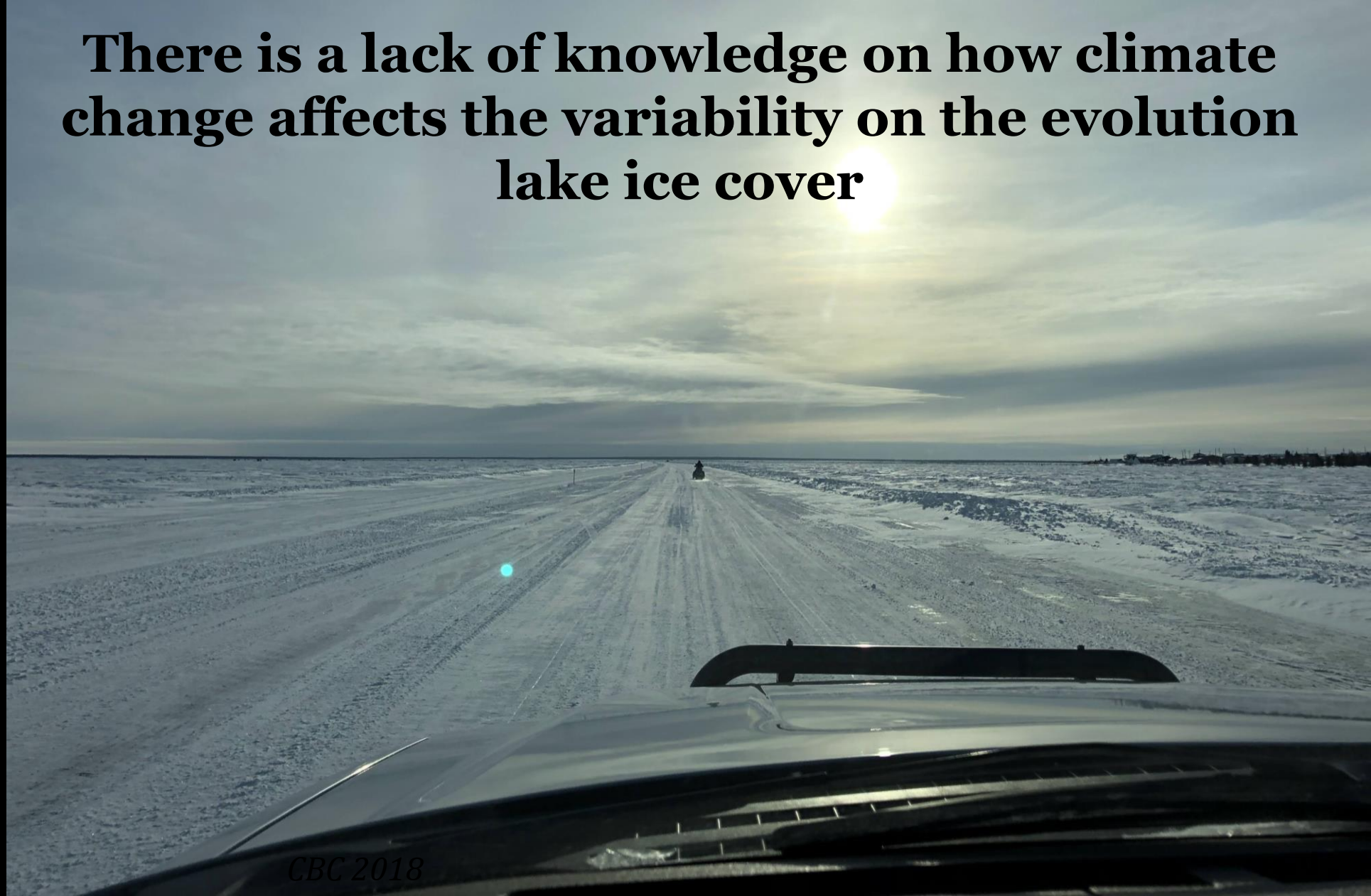


Increase in Ice Pressure Ridges and Cracks

 Water  Ice  Pressure Ridge

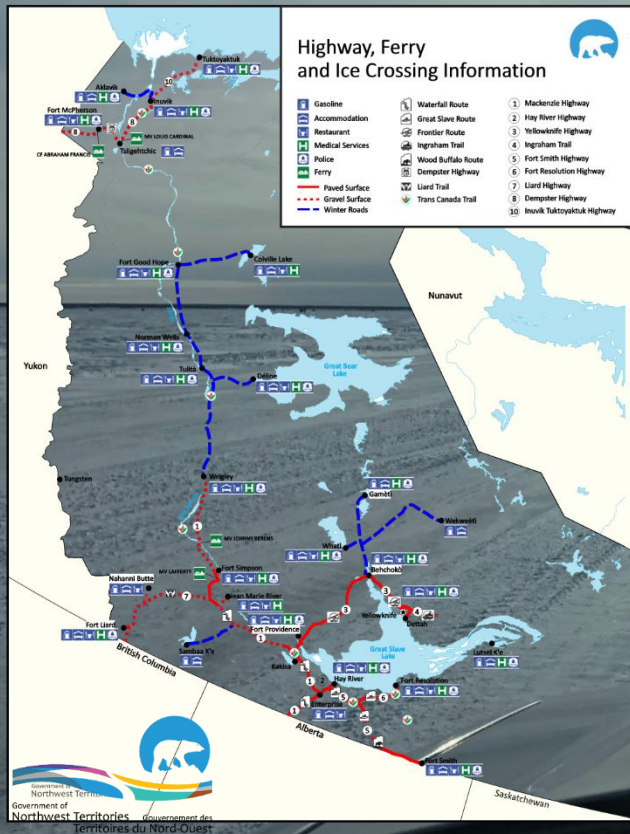
Climate Change & Ice Roads Safety

There is a lack of knowledge on how climate change affects the variability on the evolution lake ice cover



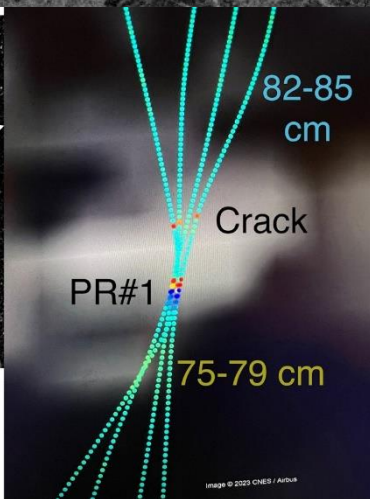
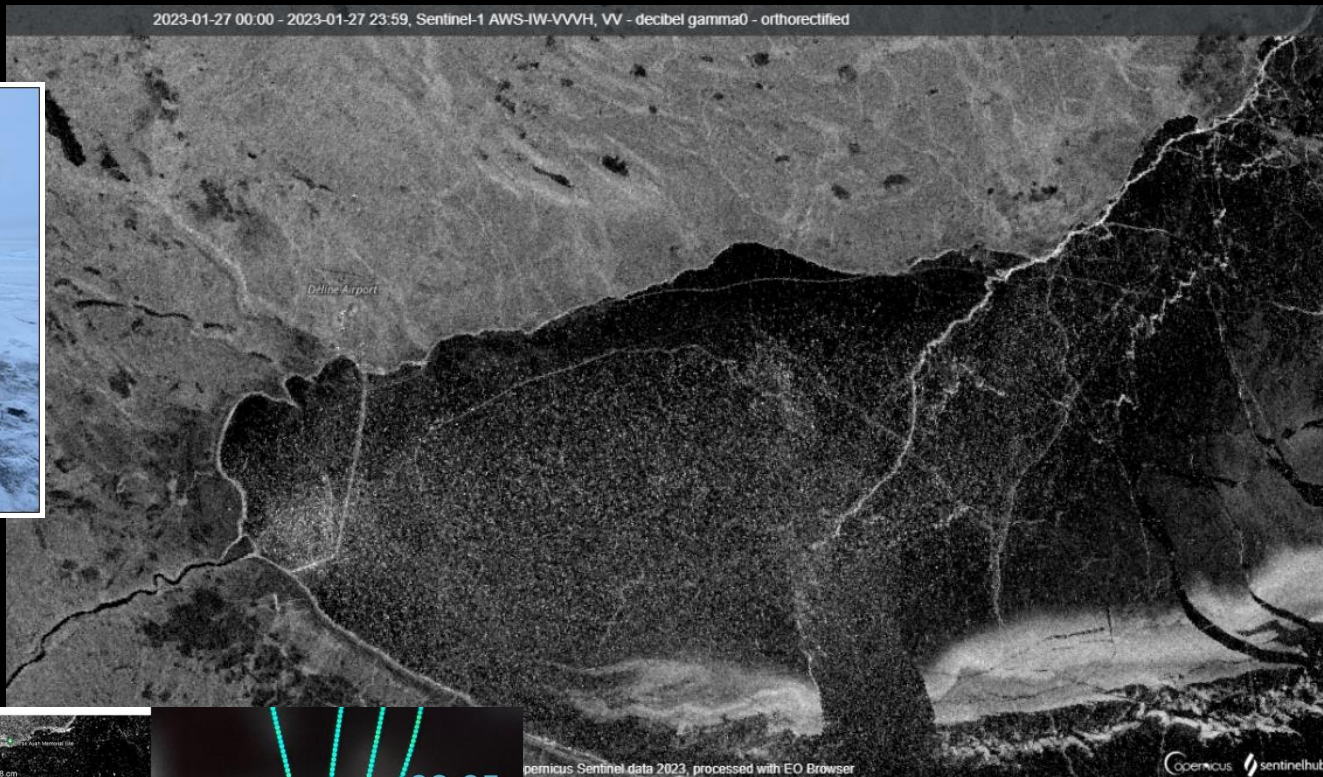
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Ice Roads Constructions

2023-01-27 00:00 - 2023-01-27 23:59, Sentinel-1 AWS-IW-VVH, VV - decibel gamma0 - orthorectified

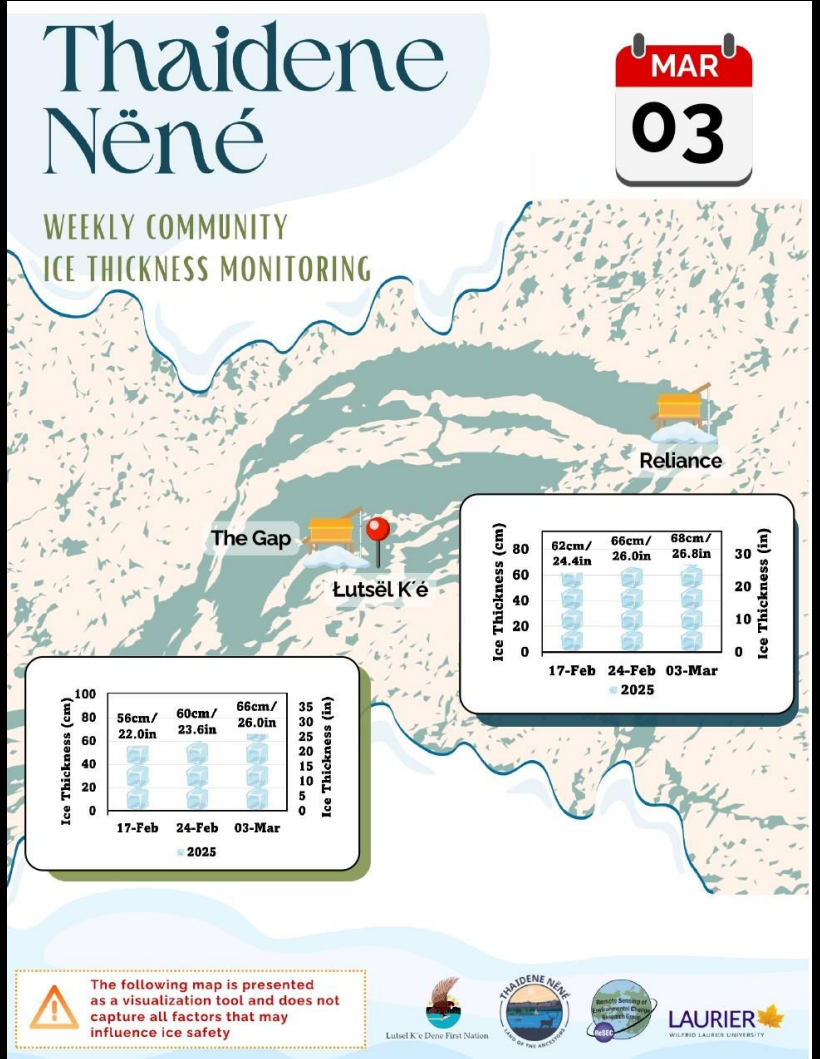
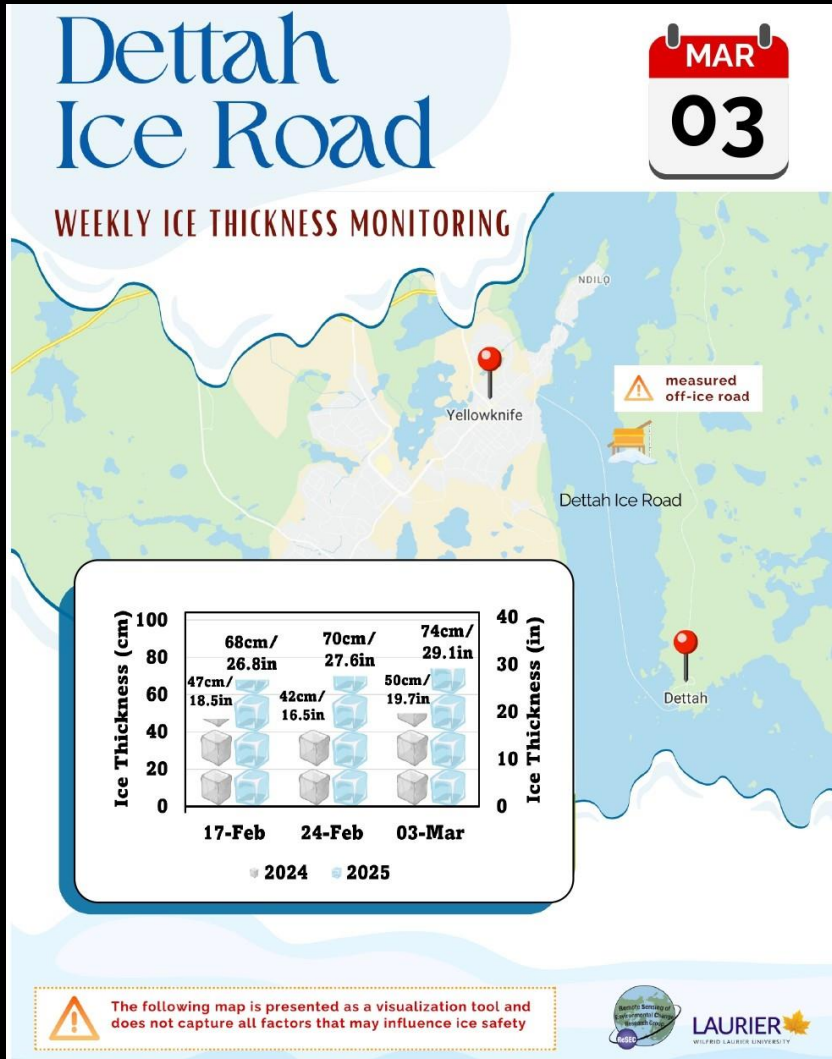
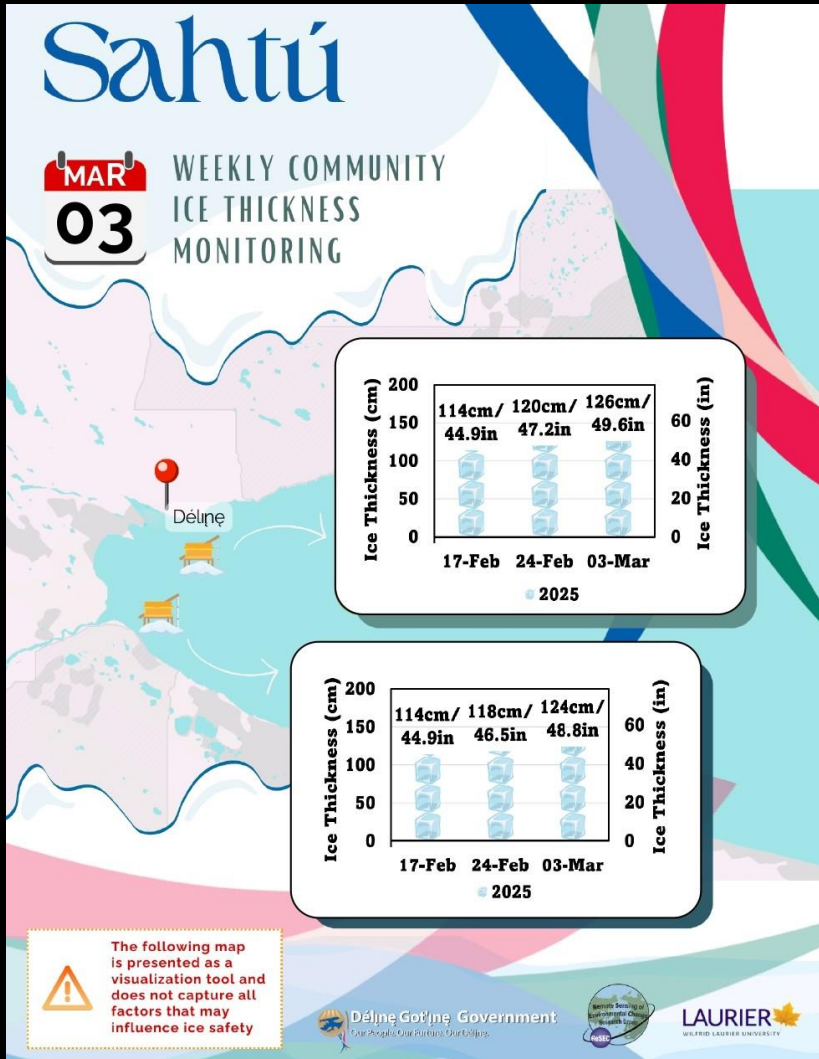


permicus Sentinel data 2023, processed with EO Browser

permicus sentinelhub



Weekly Community Ice Thickness Monitoring



<https://reseclabmap.ca/ice-thickness>

Inspired Research.
REAL IMPACT.



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<https://www.wlu.ca/features/northern-research/homa-kheyrollah-pour.html>



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Inspired Research.
REAL IMPACT.

Thanks!



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