Operational Monitoring of River Ice on the Churchill River, Labrador

Real-Time Water Monitoring Workshop

November 7-8, 2023

Outline

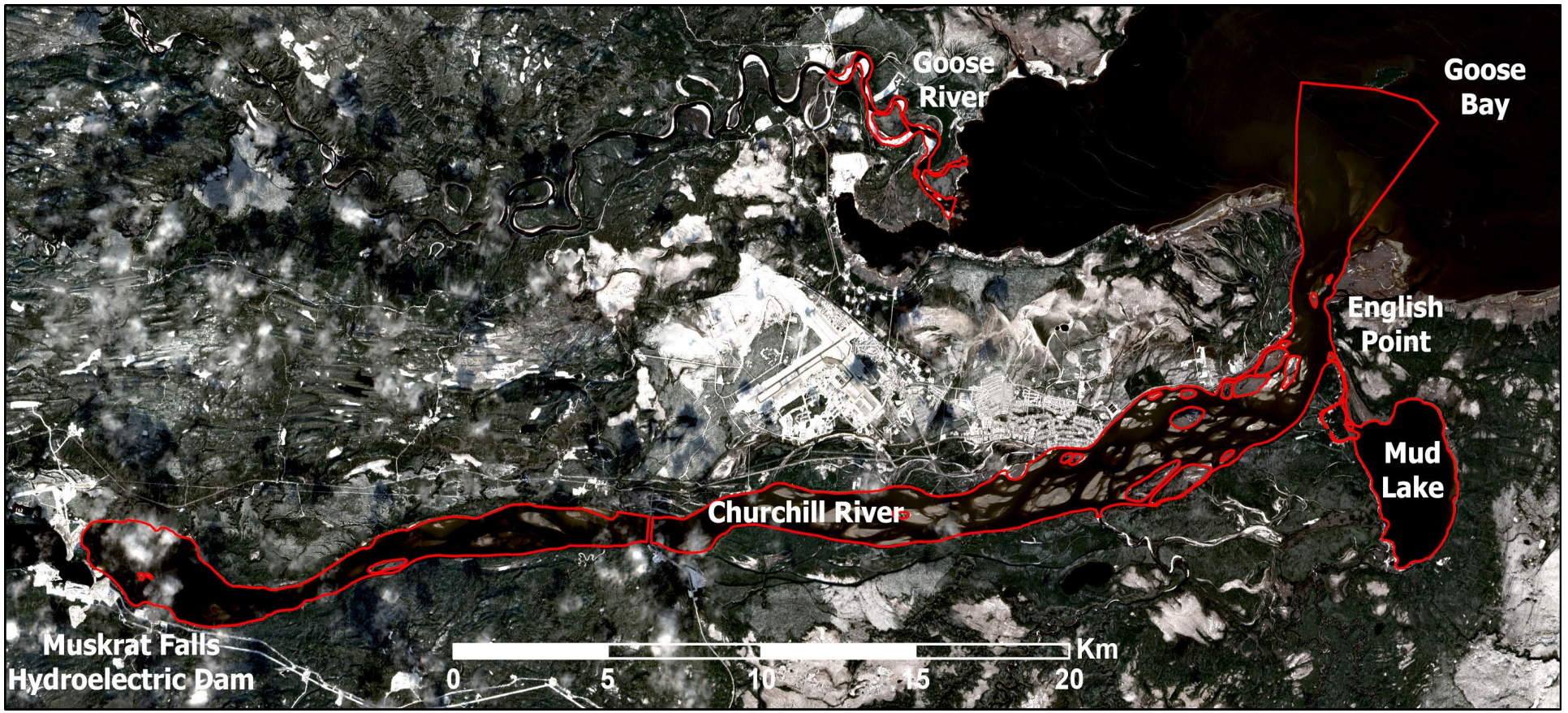
- Background
- Satellite Monitoring
  - Sandbar analysis
  - Ice cover monitoring
- Ice Thickness Monitoring
  - Sea Ice Mass Balance Apparatus (SIMBA)
  - Ground Penetrating Radar (GPR)
  - Ice thickness prediction modeling
- www.churchillriver.app

Area monitored

Muskrat Falls Dam east to Goose Bay

Goose River

Mud Lake

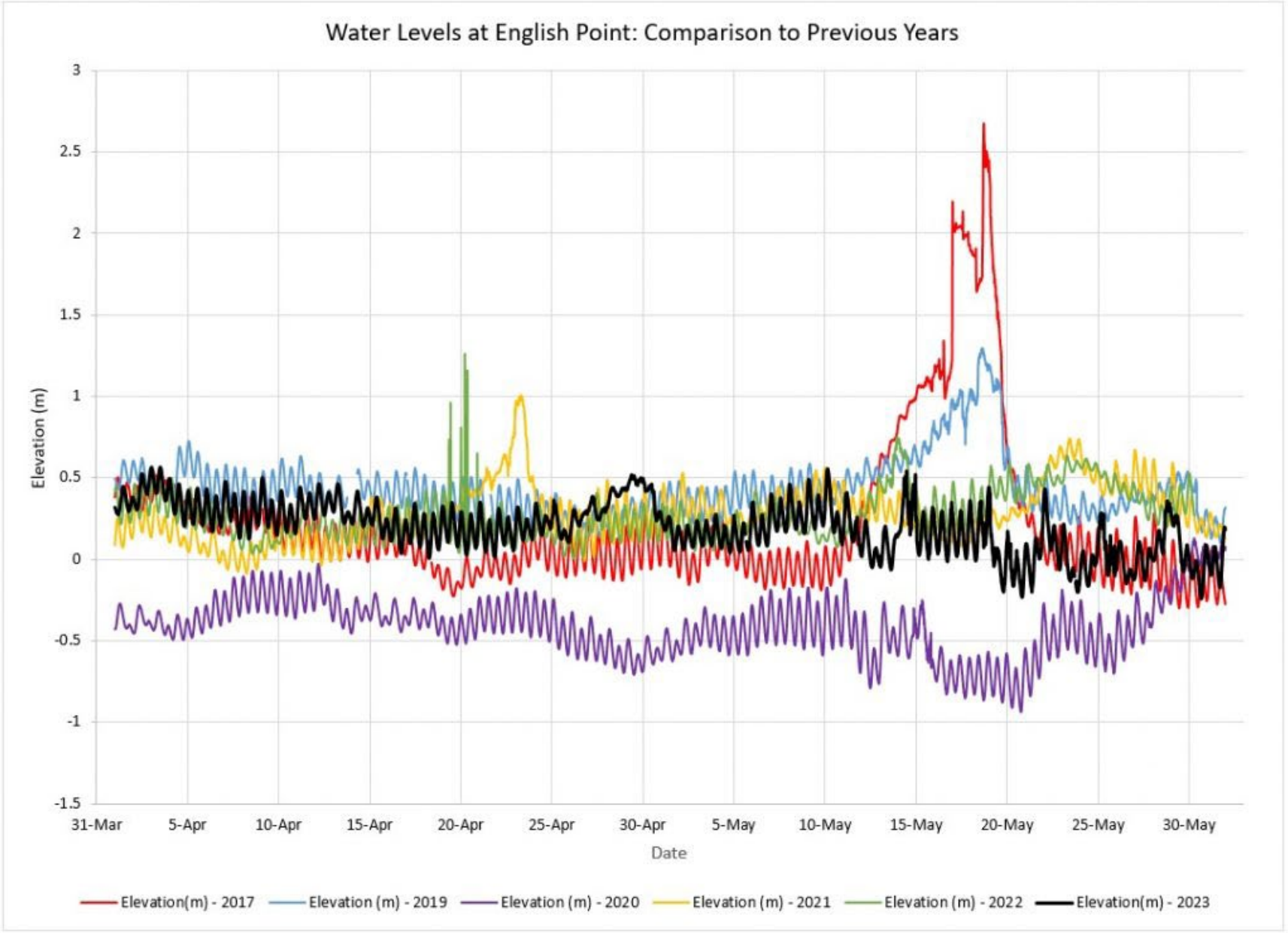


Introduction – Why monitor the Churchill River?

Mitigate impact of flooding in communities;

Infrastructure costs;

May 2017 flood event triggered a need for increased monitoring



Churchill River Ice Monitoring History

- Satellite ice monitoring of the Churchill River since 2008
- GPR ice surveys operational since 2018
- SIMBA ice thickness program since 2019-2023
- Ice thickness prediction modeling

Satellite Monitoring

- RADARSAT Constellation Mission (CSA) – SAR satellites
  - 3 satellites, daily coverage possible
- Sentinel-1 (ESA) – SAR satellite
  - 1 satellite
- Sentinel-2 (ESA) and Landsat-8/9 (NASA & USGS) - Optical satellites
- Future satellite missions
  - Sentinel-1C launch date is March 2024

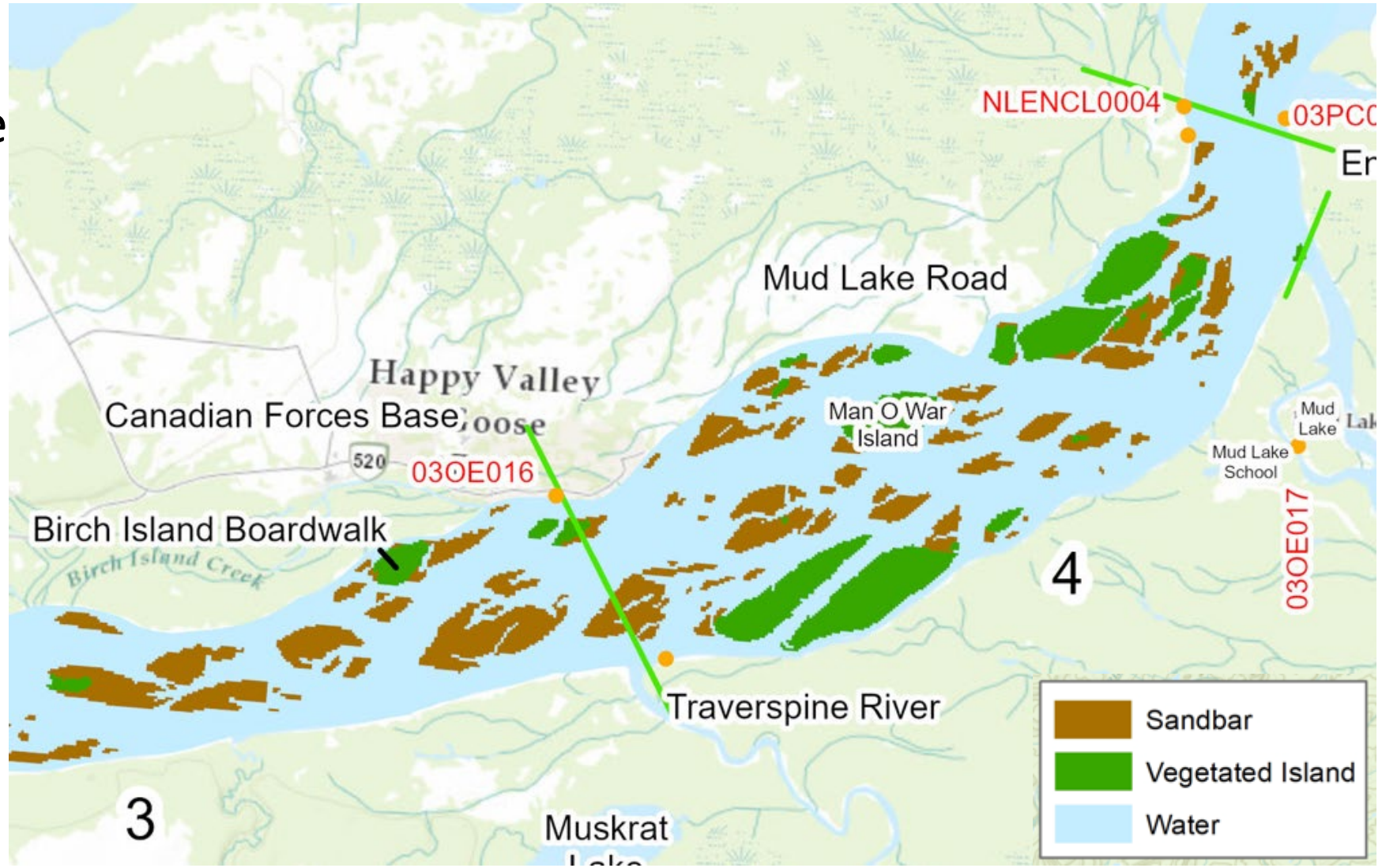
Sandbar Annual Changes

Sandbar Analysis

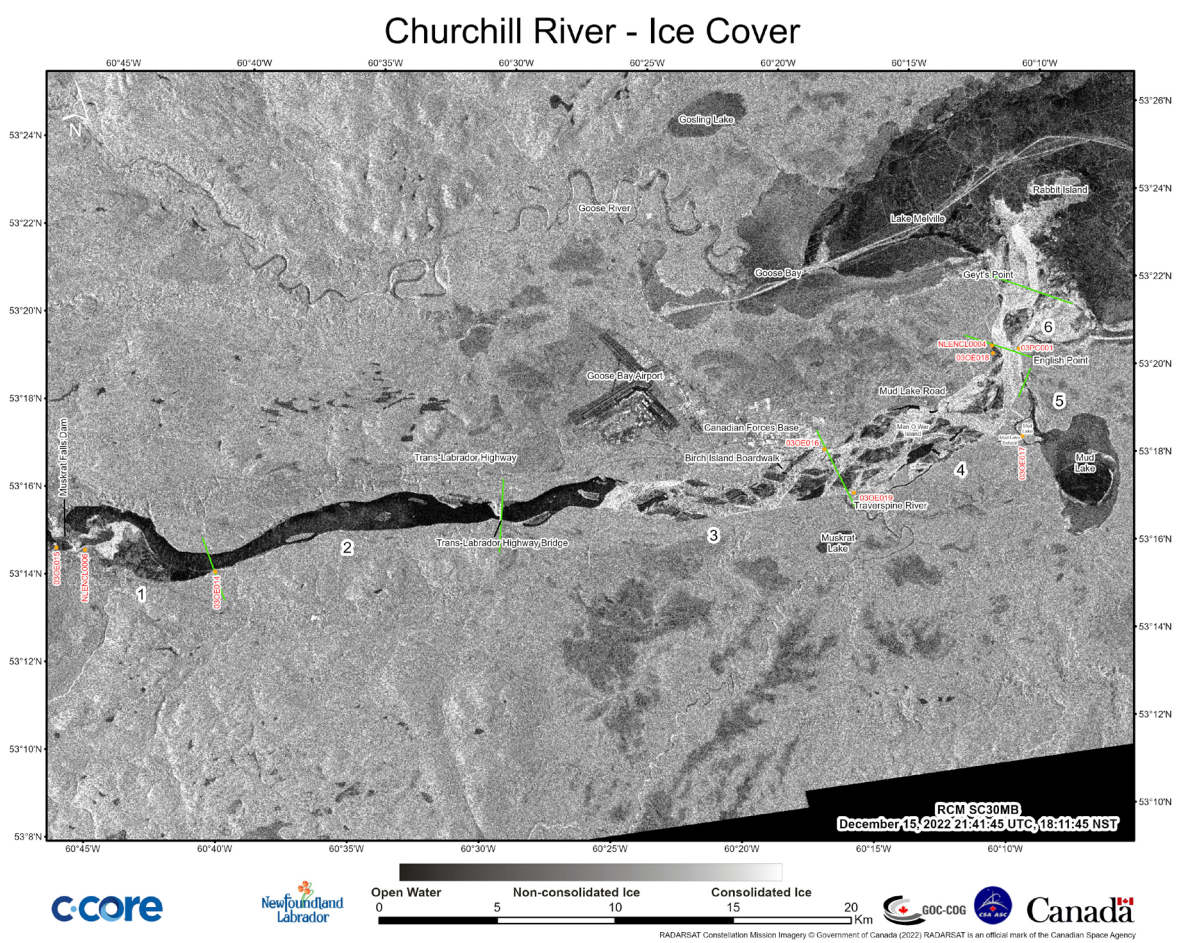
Sandbars are identified using the last cloud free S2 image before ice begins to form.

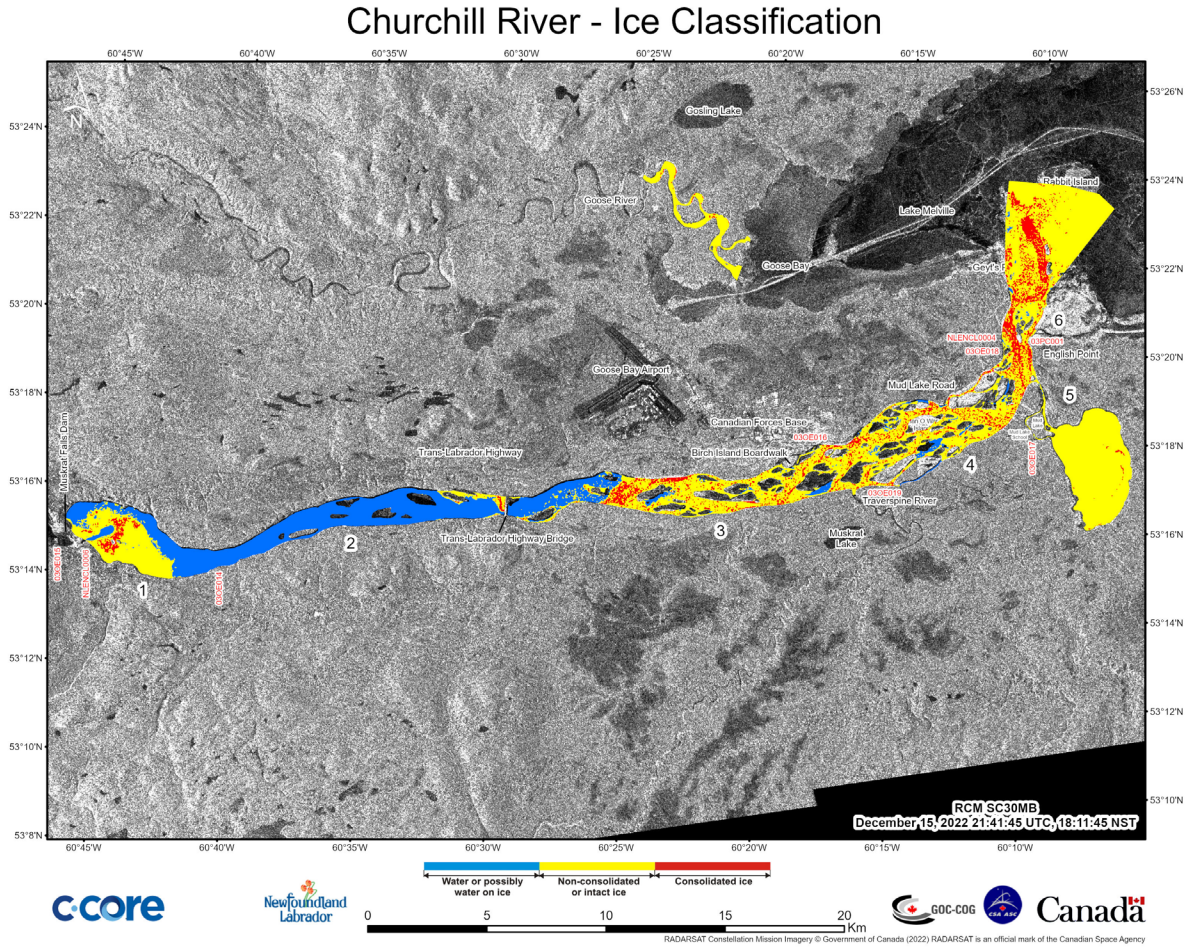
The results are used with SAR images to update the river mask.

Most sandbars are below the water surface and are not detected in SAR.



Satellite Monitoring

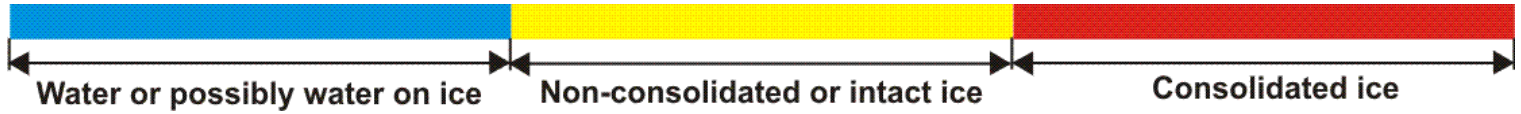




Ice Cover

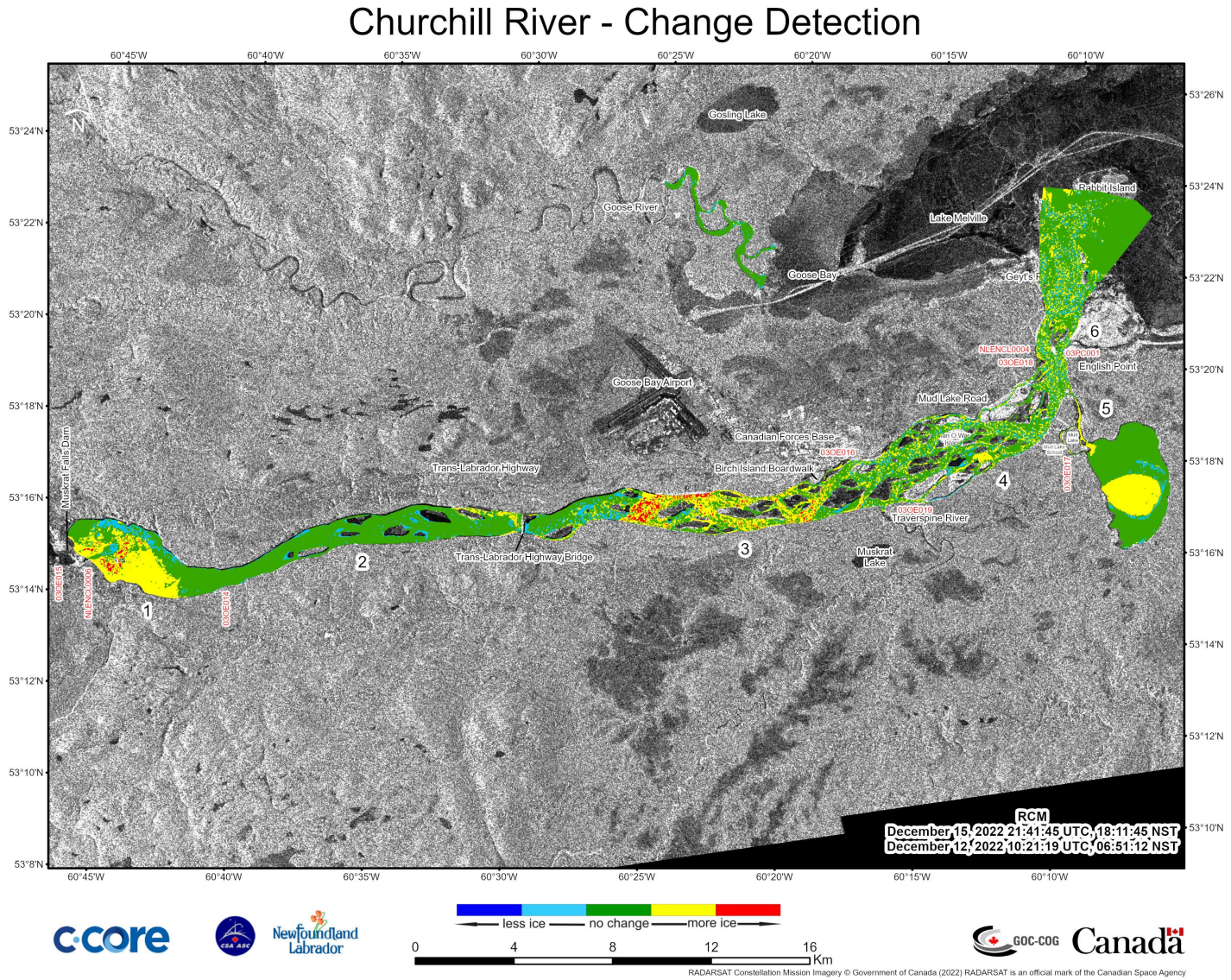
Ice classification

December 15, 2022 - RCM



Satellite Monitoring

Change Detection is the difference between two most recent classifications

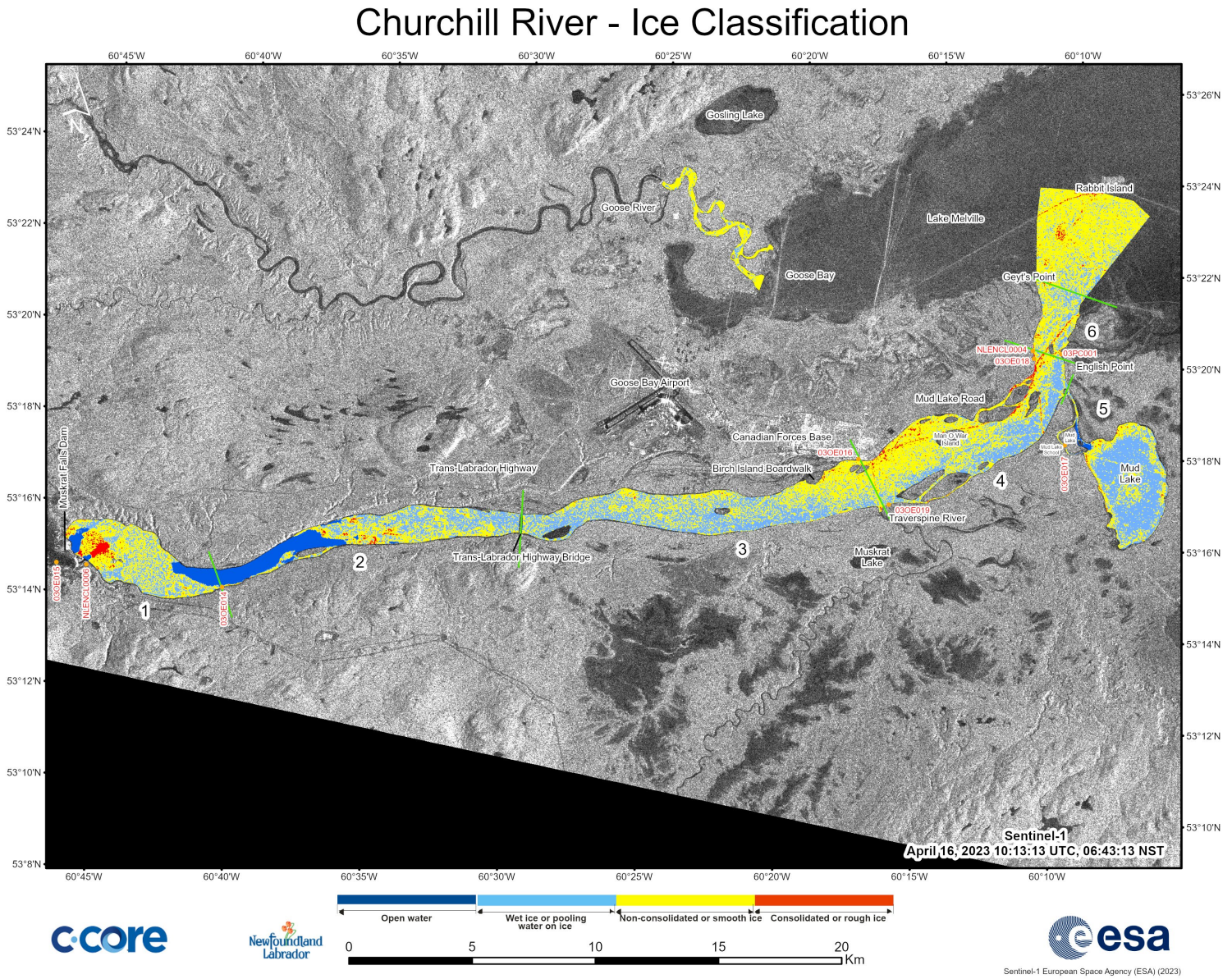


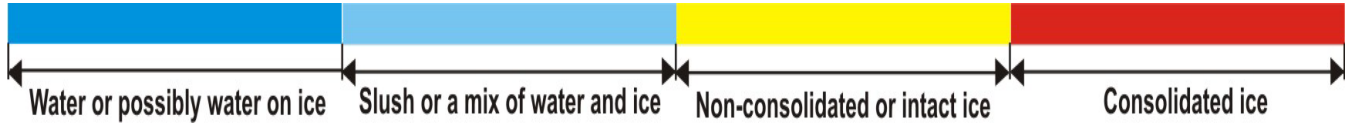
December 15, 2022
December 12, 2022
RCM

Satellite Monitoring

During break-up a 4th class is added to the classification representing water and slush on the ice cover

April 16, 2023 – S1





Ice Thickness – SIMBA Units

Sea Ice Mass Balance Apparatus (SIMBA);

4 locations;

4m thermistor chain;

Thermistors, GPS, magnetometer, barometric sensor;

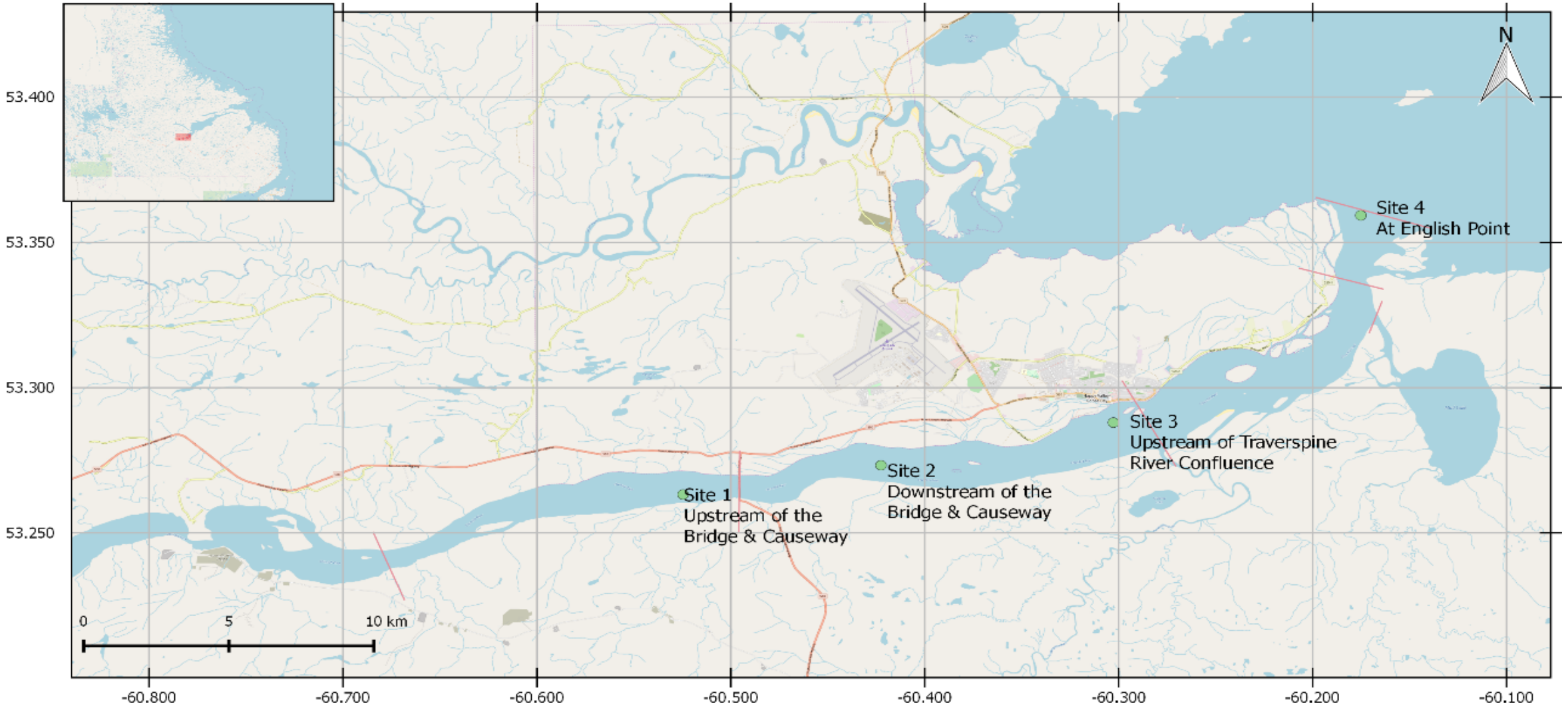
Data transfer via satellite;

Remote configuration including restart

Most of the unit parts can be reused with only the thermistor chains and batteries requiring replacement

https://www.sams-enterprise.com/services/autonomous-ice-measurement/

Ice Thickness – SIMBAs



Ice Thickness – SIMBA Installation

Installed when ice conditions safe;

SIMBA elevated and protected;

Manual measurements;

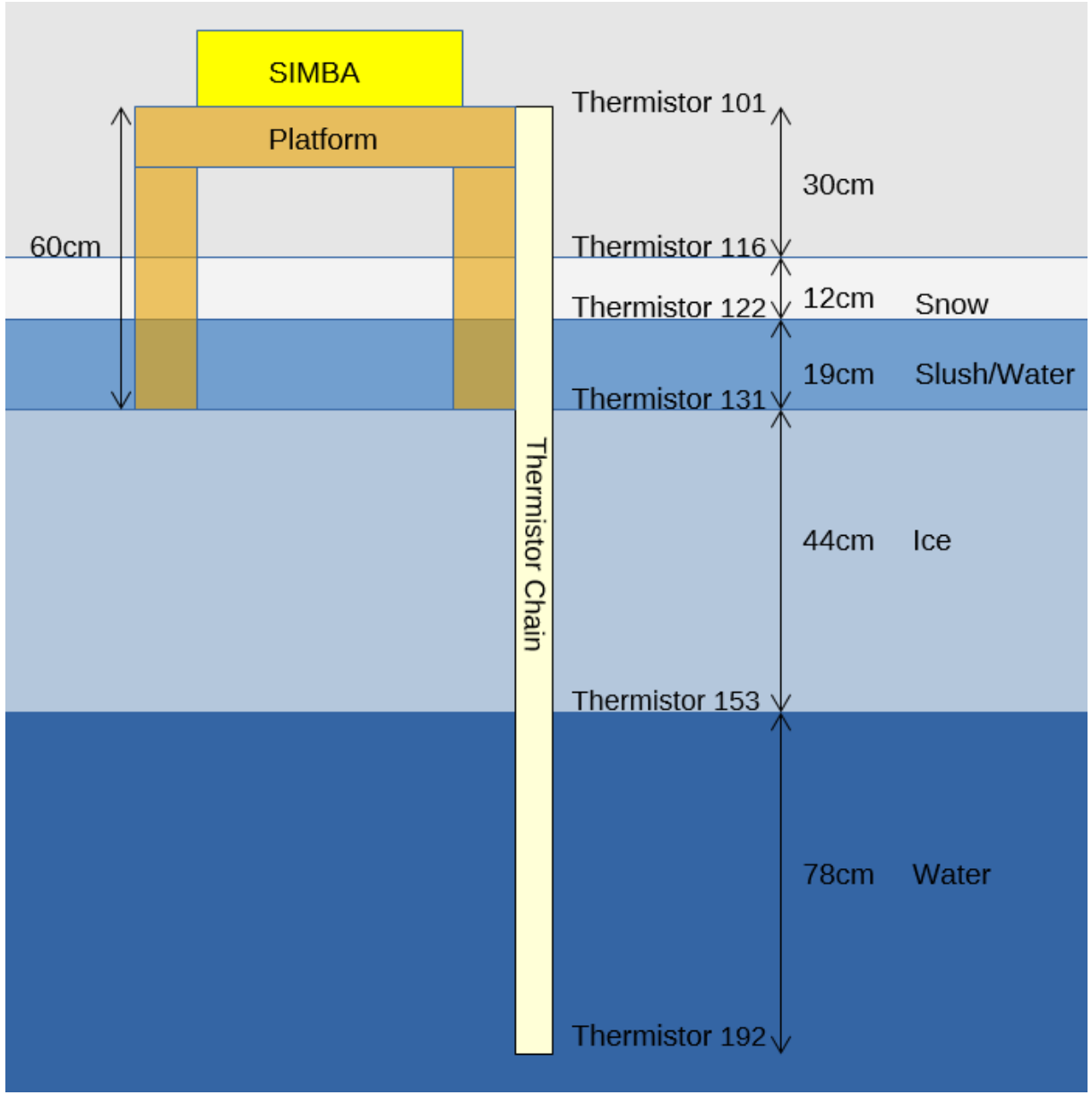
Deployment design

Ice Thickness – SIMBA Deployment Design

Vertical chain through air, snow, ice, and water;

Measure ice growth above and below ice cover;

Elevated case



Ice Thickness – SIMBA

- SIMBA records
  - Temperature data every 6 hours
  - Heating cycle every 24 hours
    - Temperatures recorded at 30s and 90s
  - Custom configuration
- Status
- GPS

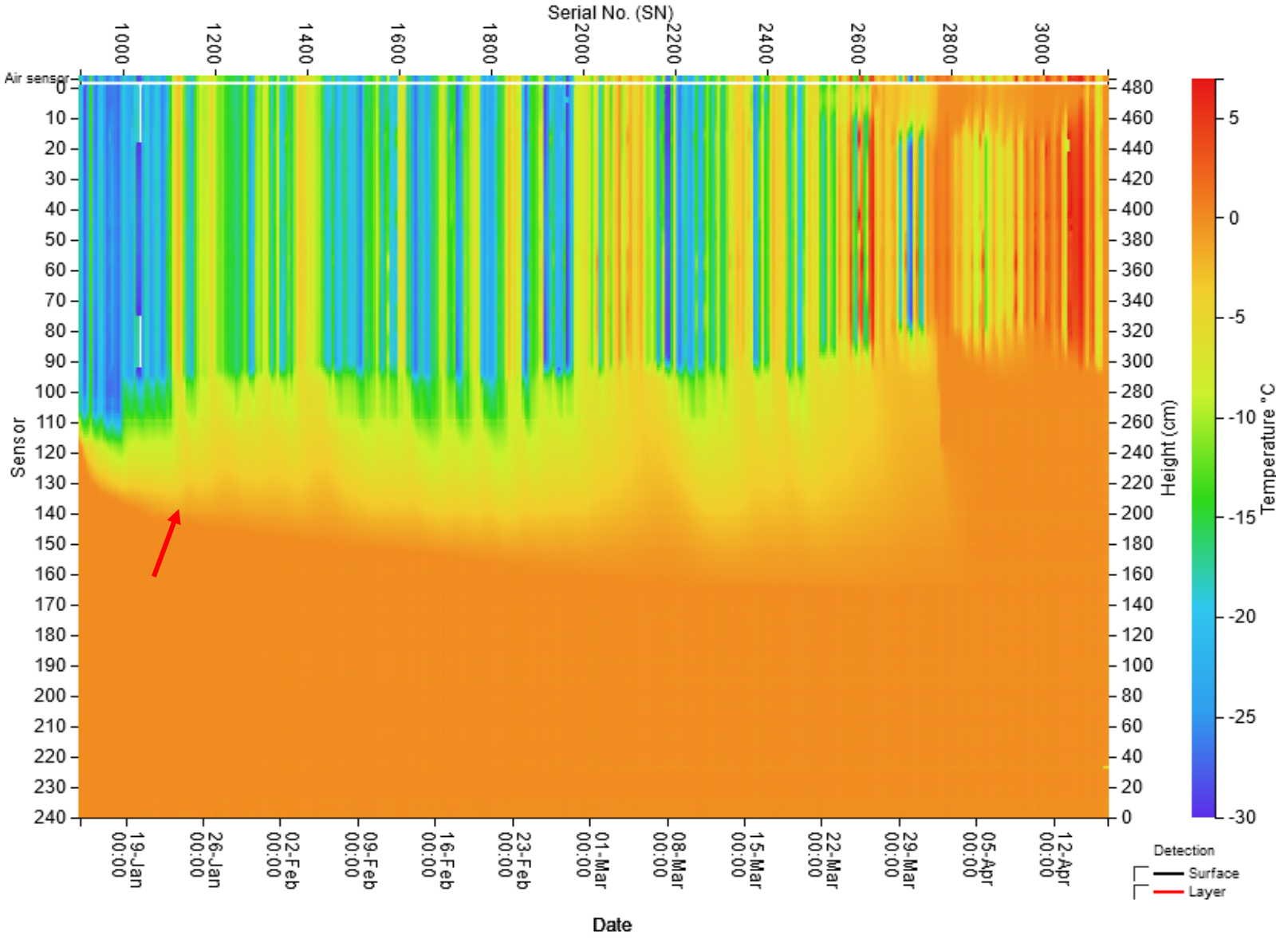
Ice Thickness – SIMBA Data

4 temperature measurements per day;

Entire ice season;

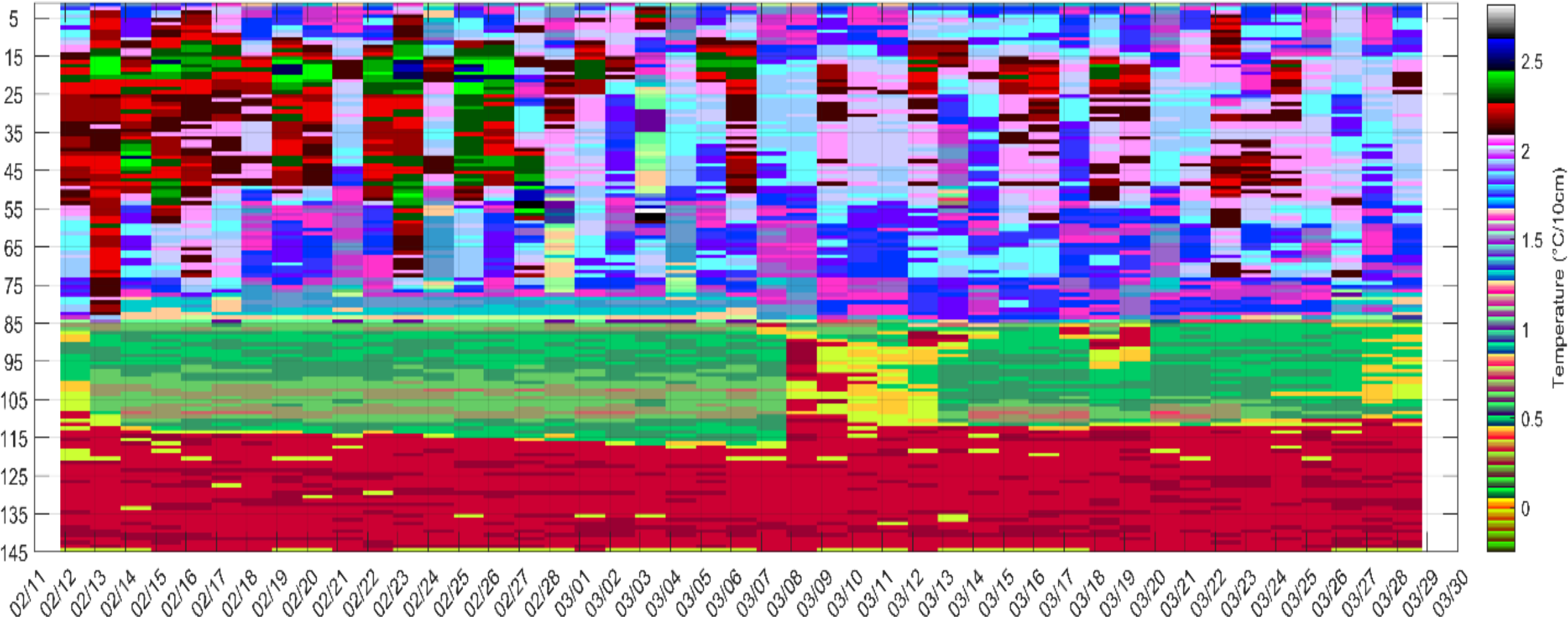
Fluctuating air temperatures;

Chain melt out April 1



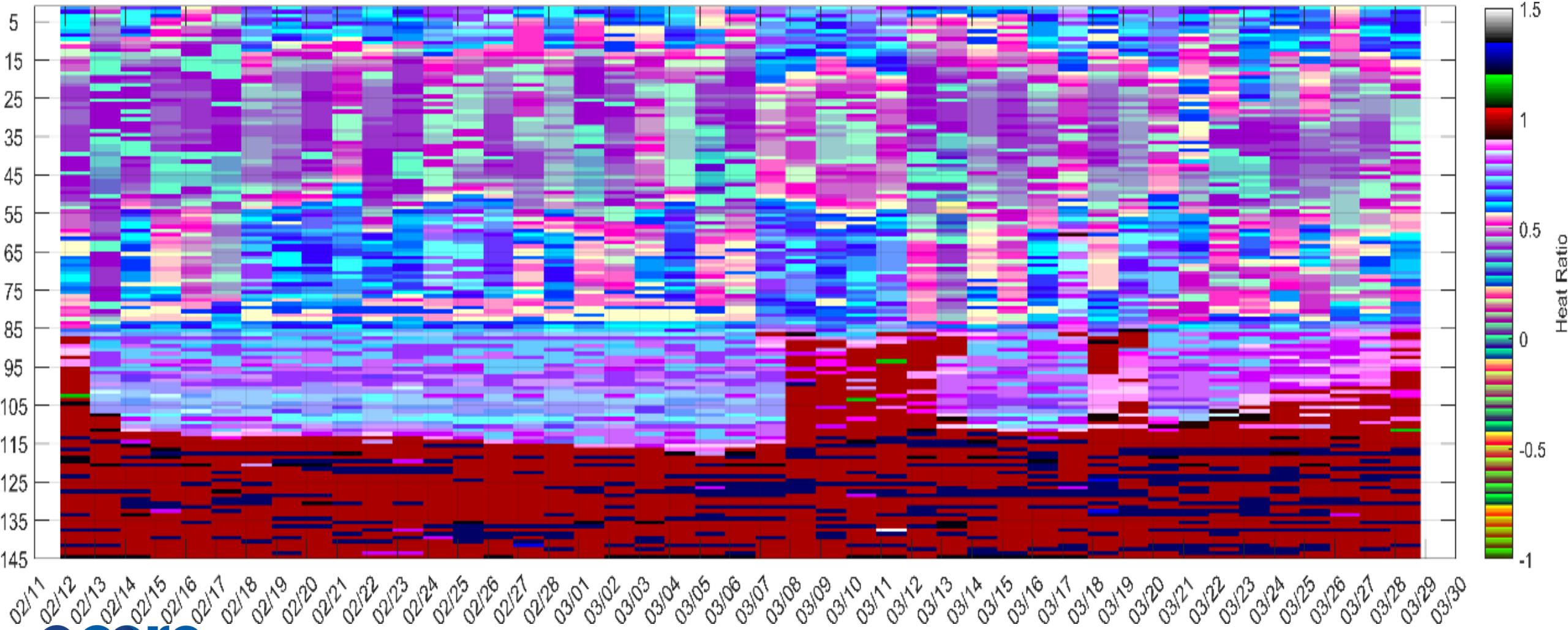
Ice Thickness – SIMBA Data

Processed data – Heating cycle – top of ice



Ice Thickness – SIMBA Data

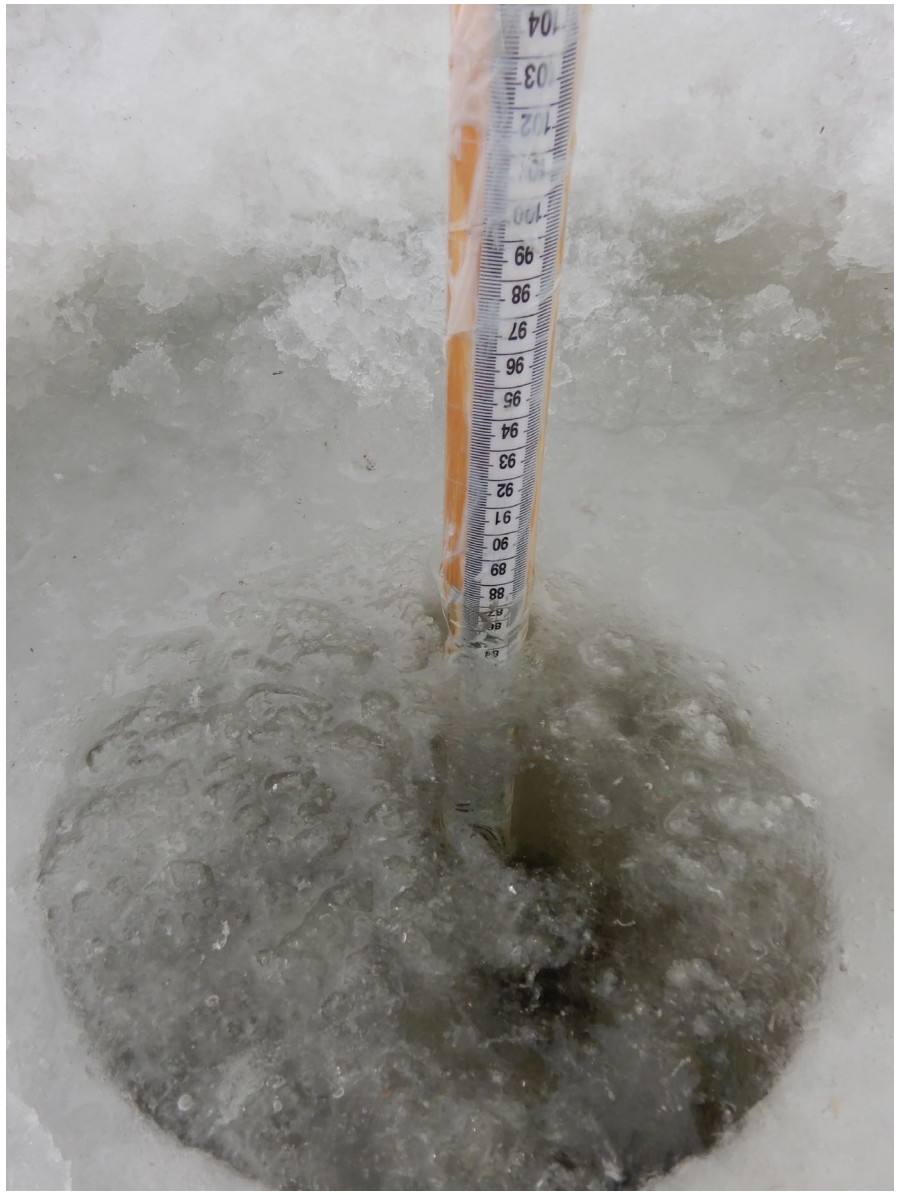
Processed data – heating cycle - bottom of ice cover



Ice Thickness – SIMBA Data and Field Measurements

Getting closer

Site	Field (cm)	SIMBA (cm)
1	56.5	63
2	65	68
3	65	64
4	84.5	83



Ice Thickness – GPR Survey

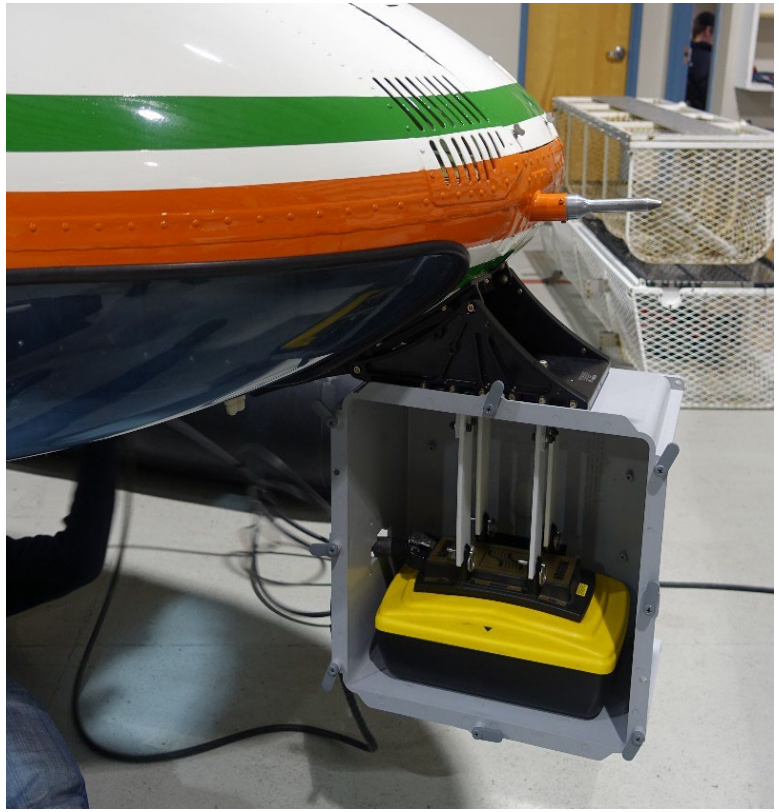
Installation on helicopter nose;

Custom housing;

Steady helicopter altitude and speed required;

Requires cold, dry ice conditions;

Survey performed when the ice cover is close to its maximum thickness



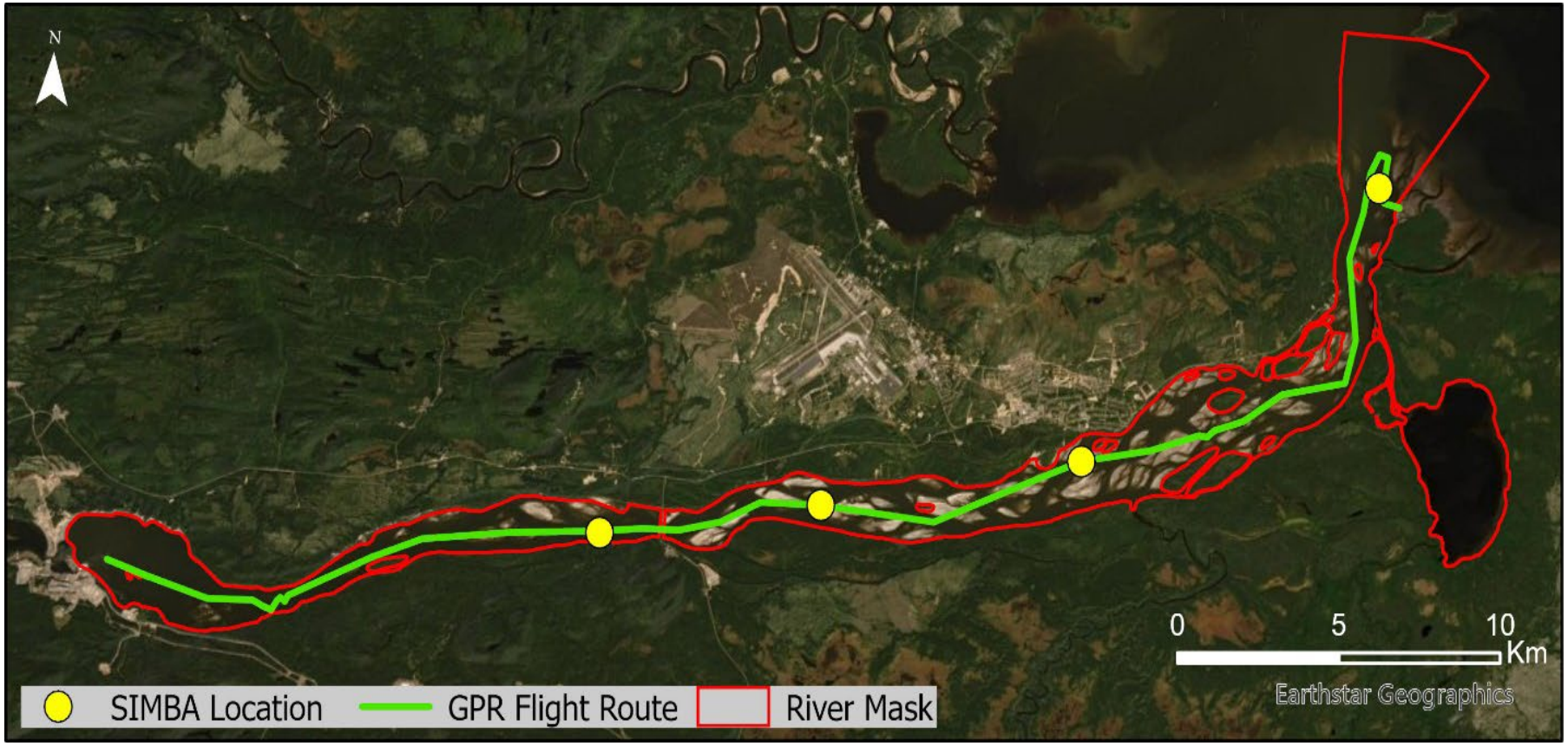
Ice Thickness – GPR and SIMBA

Survey route is about 45km;

2 hours;

Intercept SIMBA locations;

Avoid islands and sandbars;



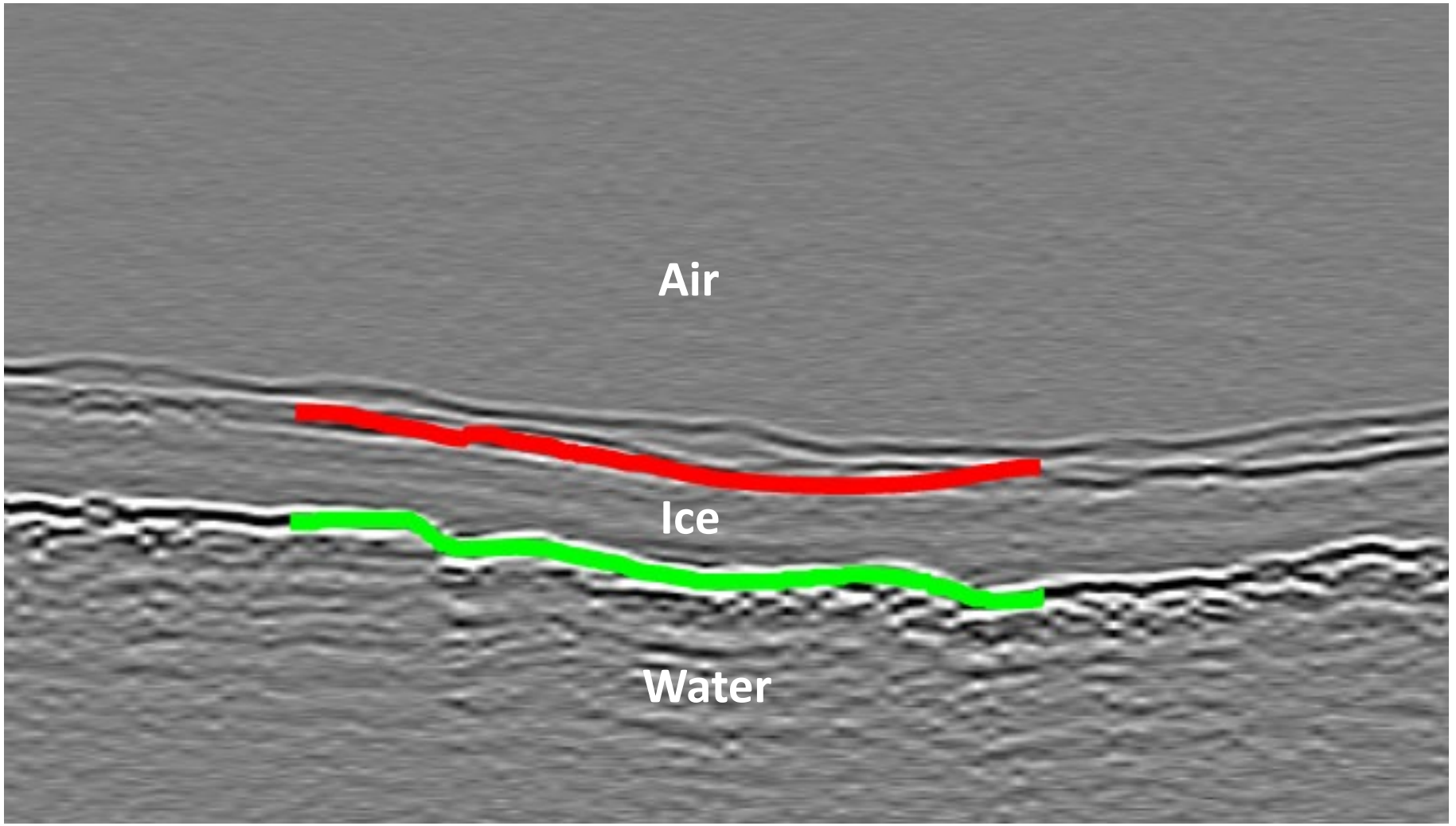
Ice Thickness – GPR Radargram

GPR is an active sensor;

Air, snow, ice, water interfaces;

Strongest reflection tends to be at the ice/water interface;

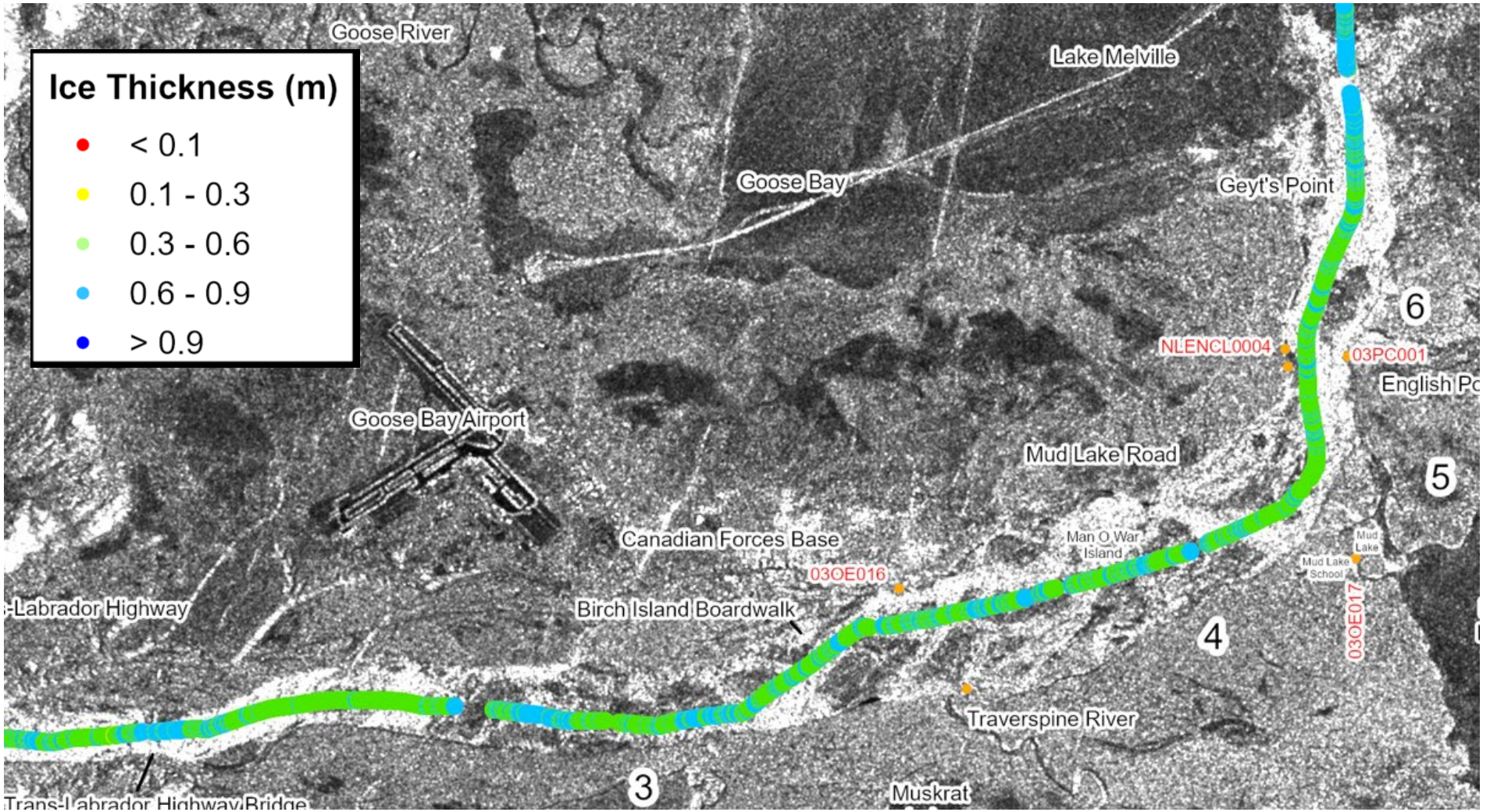
Wet snow/ice and shallow water pose challenges



Ice Thickness – GPR

February 12, 2023 survey;

GPR measurements within 0 to 14% of field measurements



Ice Thickness Prediction Modeling

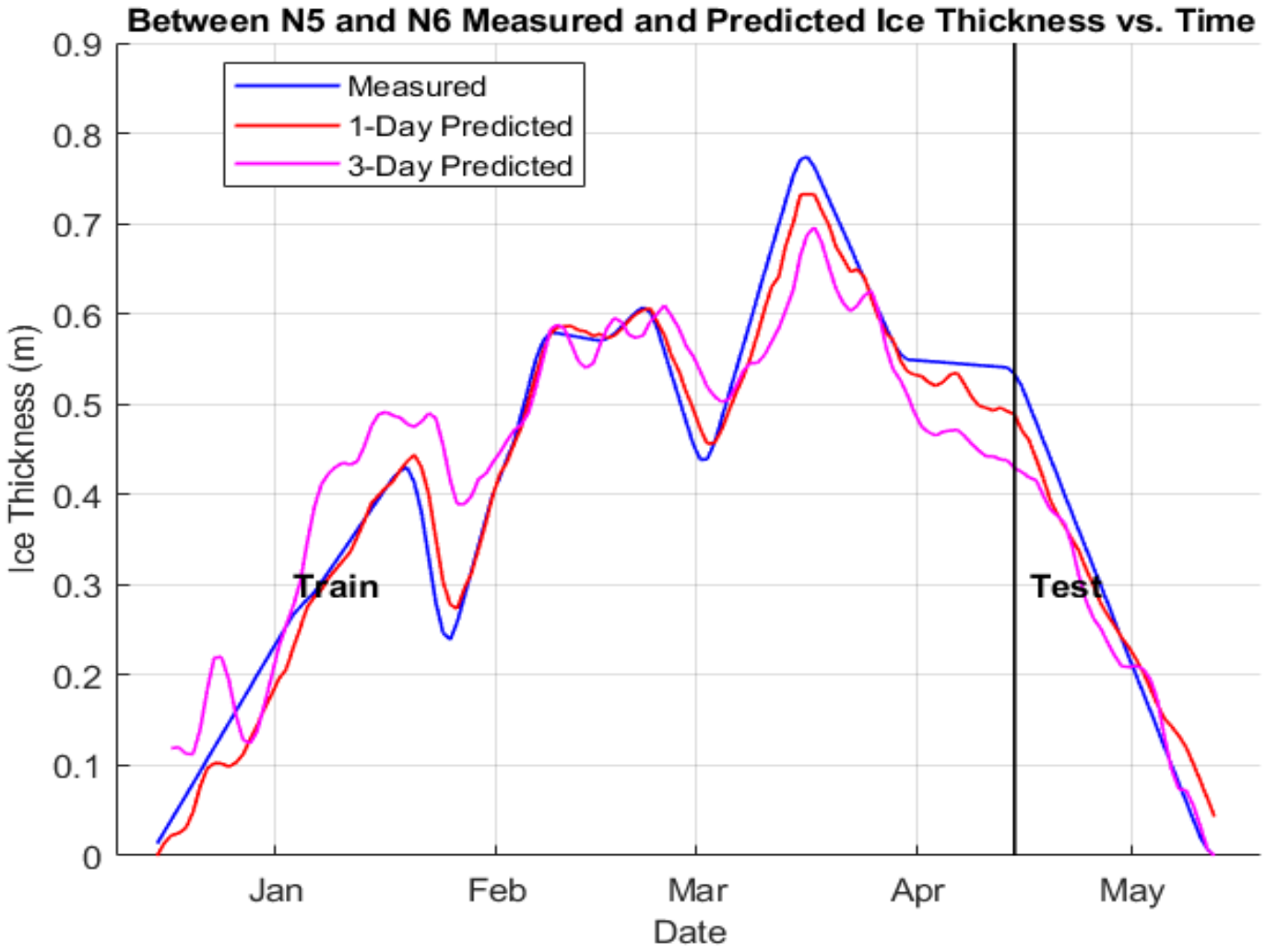
- C-CORE has developed eight site-specific ML-based models to predict ice thickness along the Churchill River
- Input data includes weather, hydrometric, MODIS land surface temperature, WSP field measured ice thickness
- One and three day forecast horizons
- Built on the last 5 years of data

Measurement Locations

Ice Thickness Prediction Modeling

80% of available data used to train the model

20% of data for testing



www.churchillriver.app

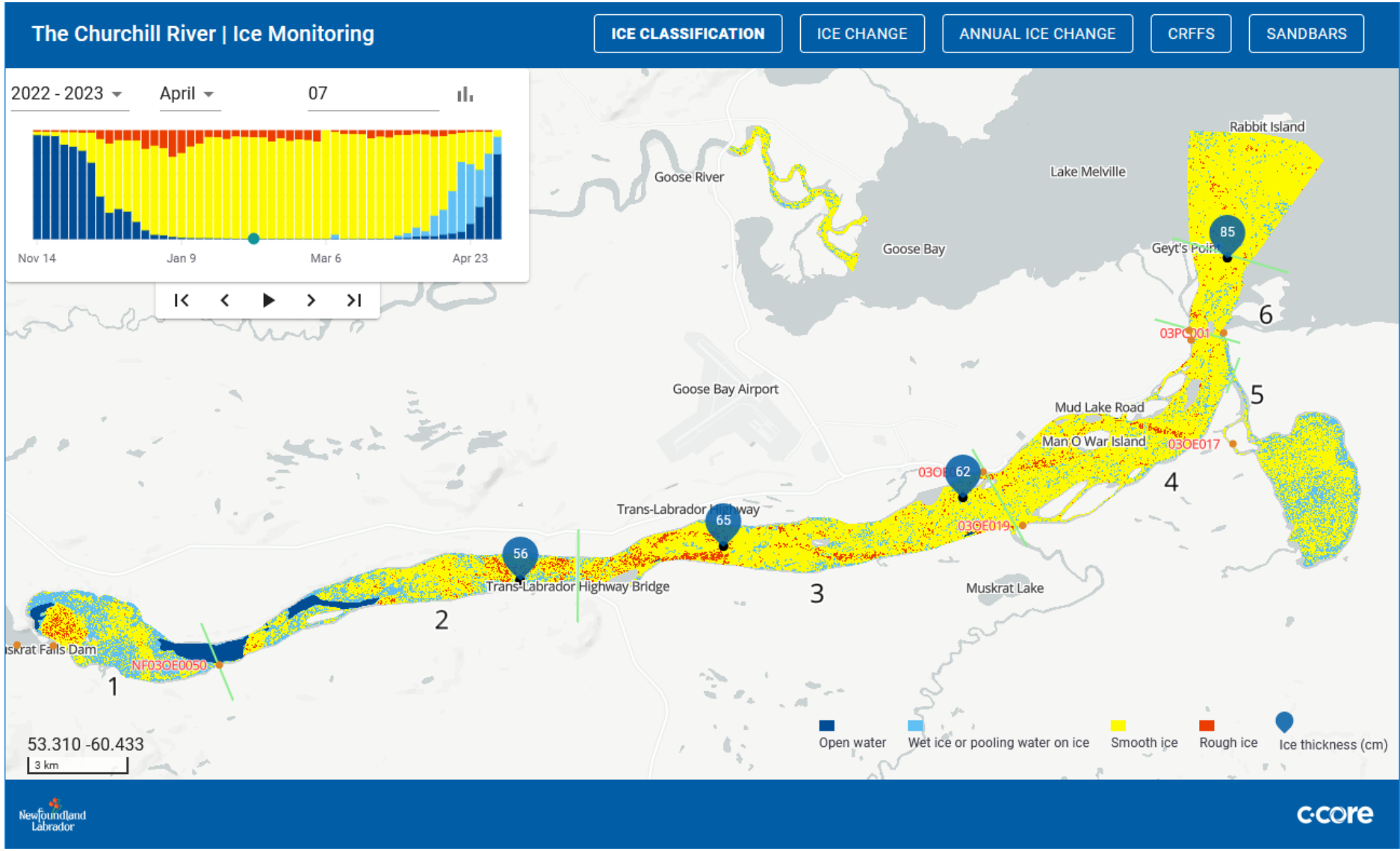
Accessible through web browser, smart phone, tablets;

Open;

Ice classification, change detection, historical data;

Analytics and cloud storage;

More features to come



c-core

Questions?