# Use of SAR Satellite Imagery for a River Ice Break-up Prediction

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# OUTLINE

- Why important
- Remote sensing basics
- How it works on Churchill River
- Next steps

# RIVER ICE MONITORING

Why important ?

- Flood risk monitoring
- To ensure travel safety
- Climate change

Bowhay, K. (2021, May 28). *BREAKING: Aklavik moving Elders and vulnerable to Inuvik*. NNSL. https://www.nnsl.com/news/breaking-aklavik-moving-elders-and-vulnerable-to-inuvik/

News ·, A. B. · C. (2018, February 22). *Truck that plunged through Deline ice road in 2016 was 4,000 kg overweight, report finds | CBC News*. CBC. https://www.cbc.ca/news/canada/north/deline-ice-road-crash-infrastructure-report-1.4545787

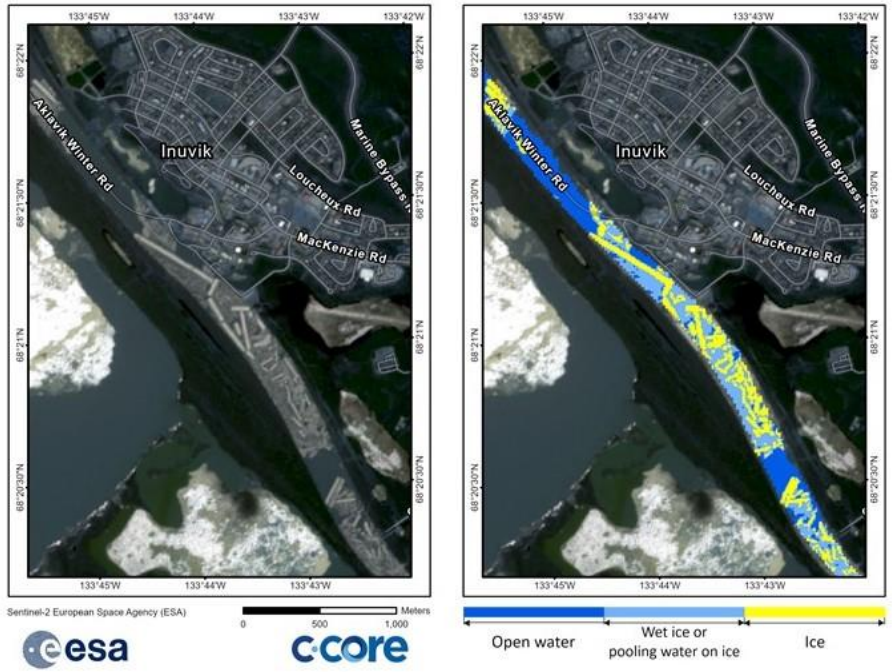
# SATELLITE-BASED RIVER ICE MONITORING

- Ice cover extent
- Ice cover type
- Ice phenology
  - Freeze-up period
    - Freeze onset
    - Freeze-up date
  - Break-up period
    - Melt onset
    - Break-up date
    - Water clear of ice

May 22, 2023 @ 1:30 pm (MDT)

Photo credit: Kristian Binder
https://www.facebook.com/photo/?fbid=10159494012476146&set=gm.3547528215460107&idorvanity=1745524288993851

May 22, 2023 @ 2:38 pm (MDT)



# MELT ONSET

River Ice Break-Up

## Thermal

Direct sunlight and/or warm temperatures

↓

Water on ice decreases the albedo & promotes melting

↓

Ice decays and melts in place

## Mechanical

Rain and/or snowmelt

↓

Increase in streamflow or discharge

↓

Increased hydrodynamic forces lift, break, and dislodge ice

https://www.slideshare.net/etbou24/river-ice-jams-risk-evaluation-driving-conditions-and-geomorphological-impacts-documented-from-treerings-necopastic-river-canada

# MELT ONSET

- Signals the beginning of the spring melt period
- Effects ice stability
- Satellite observations make it possible to

  determine

  - when the melt processes are taking place

  - intensity of snow melt

# SATELLITE REMOTE SENSING

Passive Satellites

- Measure energy reflected by the Earth's surface or atmosphere
- Rely on solar illumination
- Limited by polar darkness
- Limited by cloud cover

Active Satellits

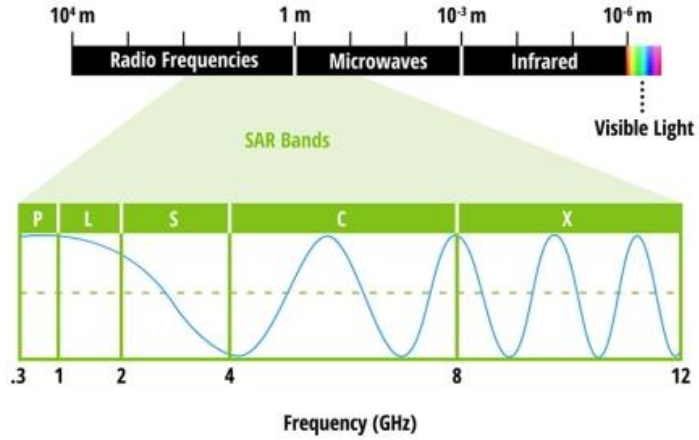
- Emits radiation and then record returns to the sensor
- Does not rely on solar illumination
- Operate both day and night
- Able to penetrate clouds

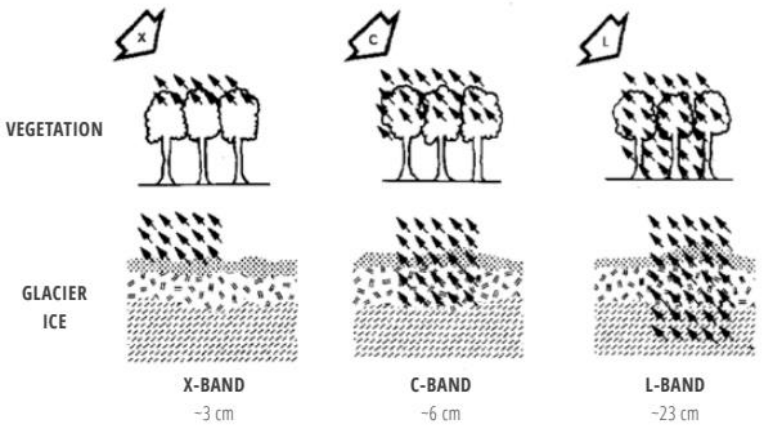
# SYNTHETIC APERTURE RADAR (SAR)

- Backscatter is the portion of the outgoing radar signal that the target redirects directly back towards the sensor

- Backscatter coefficient ($\sigma^0$)- measure of the reflective strength

- Wavelength
  - Longer wavelength → radar signals penetrate deeper
  - C-band is able to penetrate into snowpack



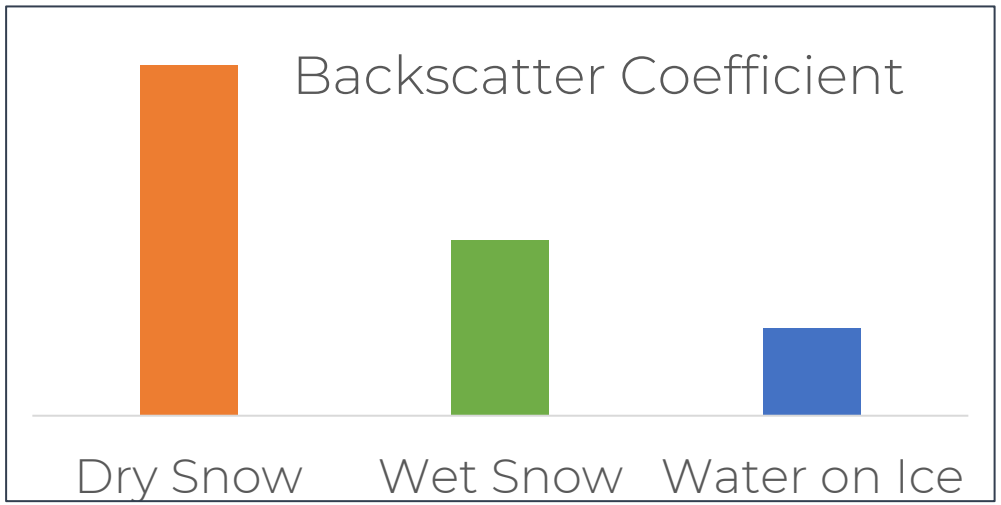



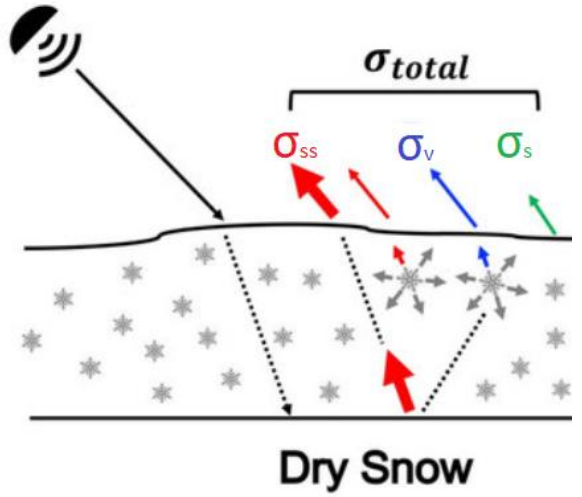
# INTERACTIONS OF SNOW/ICE AND SAR

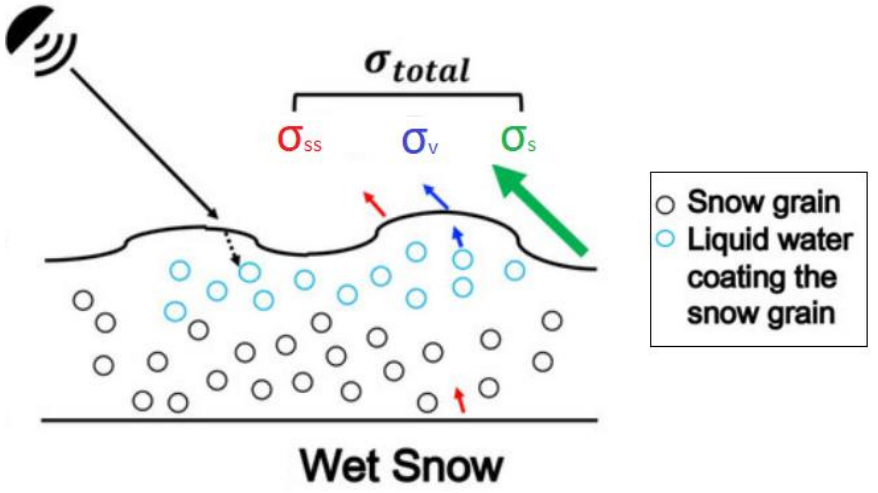
$\sigma_s$ - Surface scattering

$\sigma_v$ - Volume scattering

$\sigma_{ss}$ - Subsurface scattering



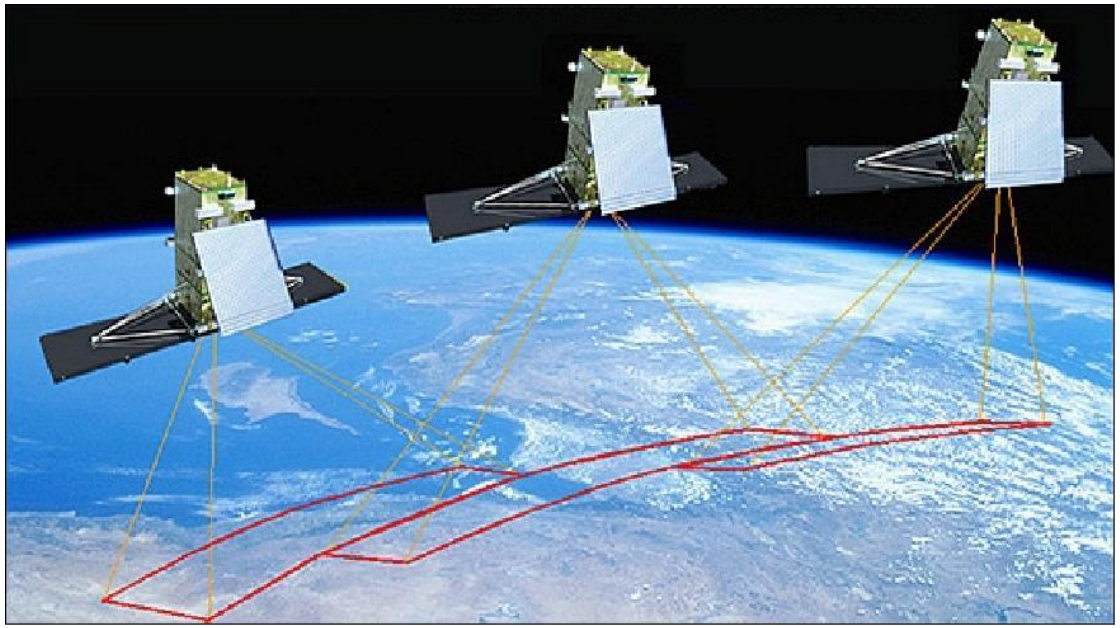

Modified from Park, J., Forman, B., & Hans, L. (2021). Prediction of Active Microwave Backscatter Over Snow-Covered Terrain Across Western Colorado Using a Land Surface Model and Support Vector Machine Regression. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *PP*, 1–1. https://doi.org/10.1109/JSTARS.2021.3053945

# RADARSAT Constellation Mission (RCM)

- Launched in 2019
- Canadian Space Agency
- 3-satellite constellation
- Daily coverage
- C-band radar

| Resolution | | | |
|---|---|---|---|
| Low | Medium | High | Very High |
| 100 m | 16m, 30m, 50m | 5m | 3m |

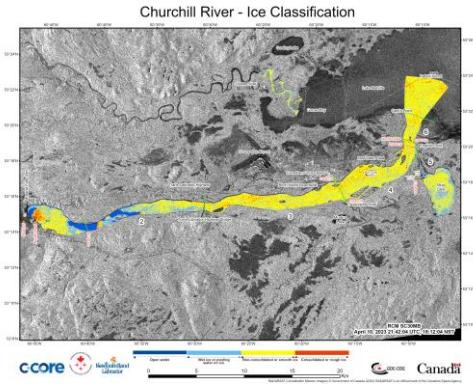
- Weather-independent
- Can see in darkness

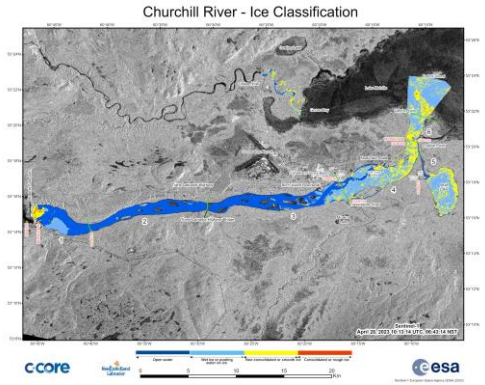


https://www.eoportal.org/satellite-missions/rcm#spacecraft

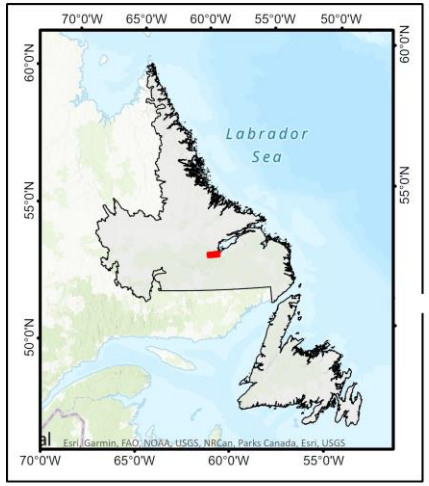
# AREA OF INTEREST

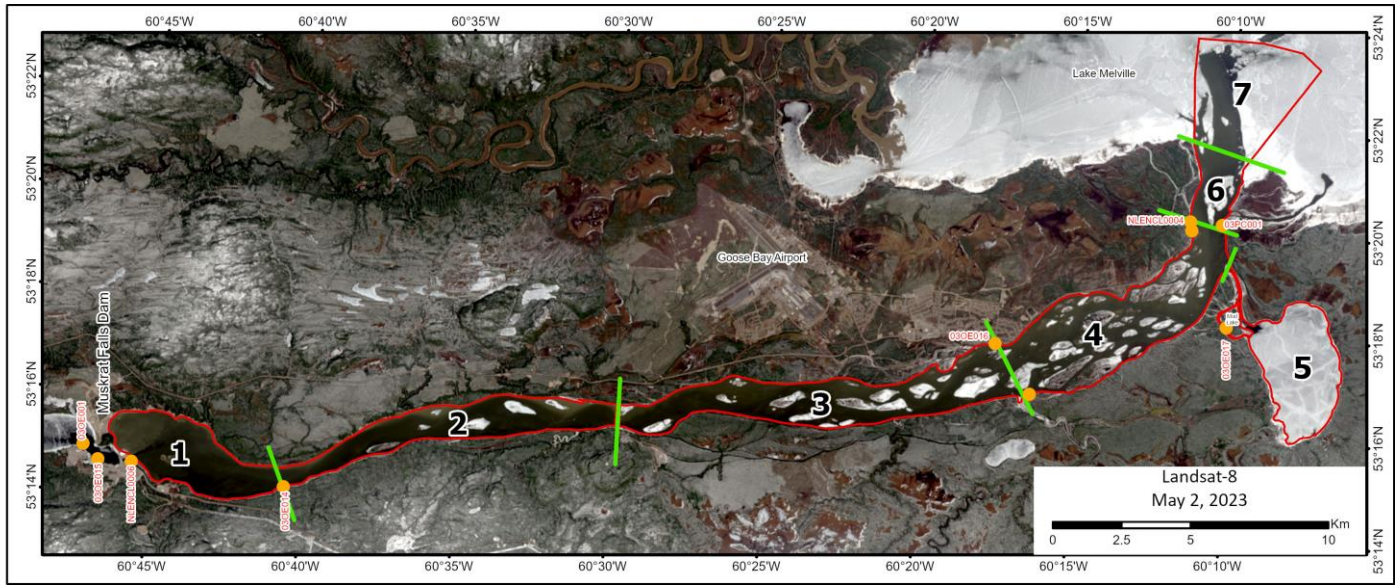
- Churchill River, Labrador
- Lower basin – flood risk
- C-CORE provides
  - River ice classification
  - Ice thickness measurements




https://c-core.ca/river-ice/



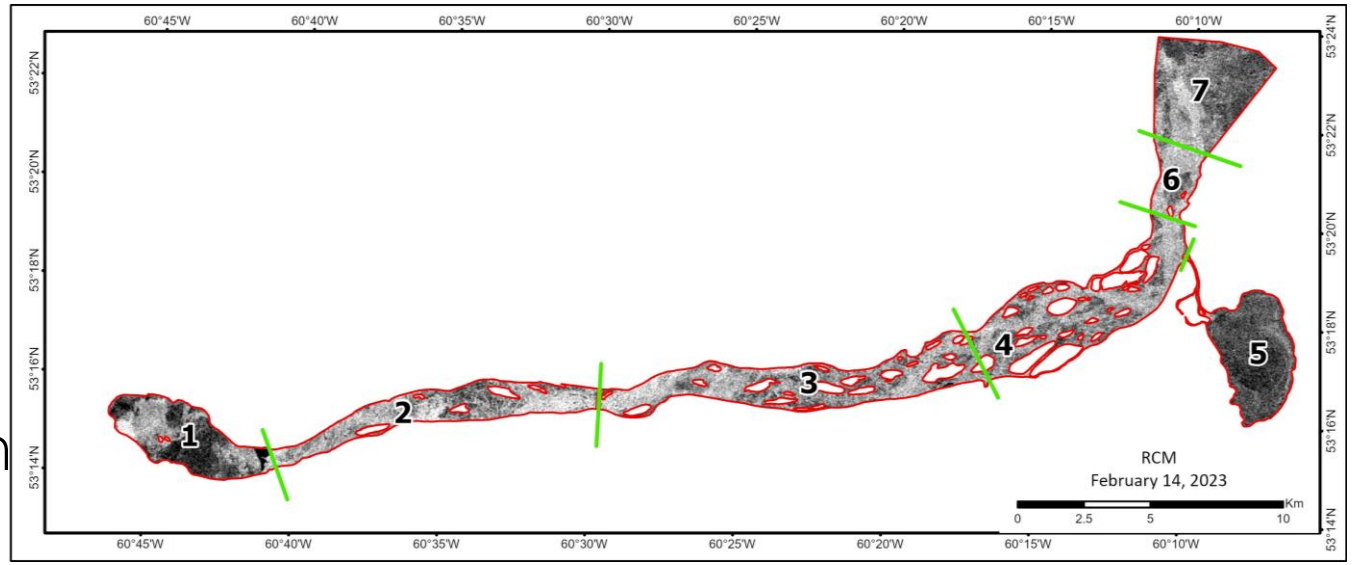



# WORKFLOW

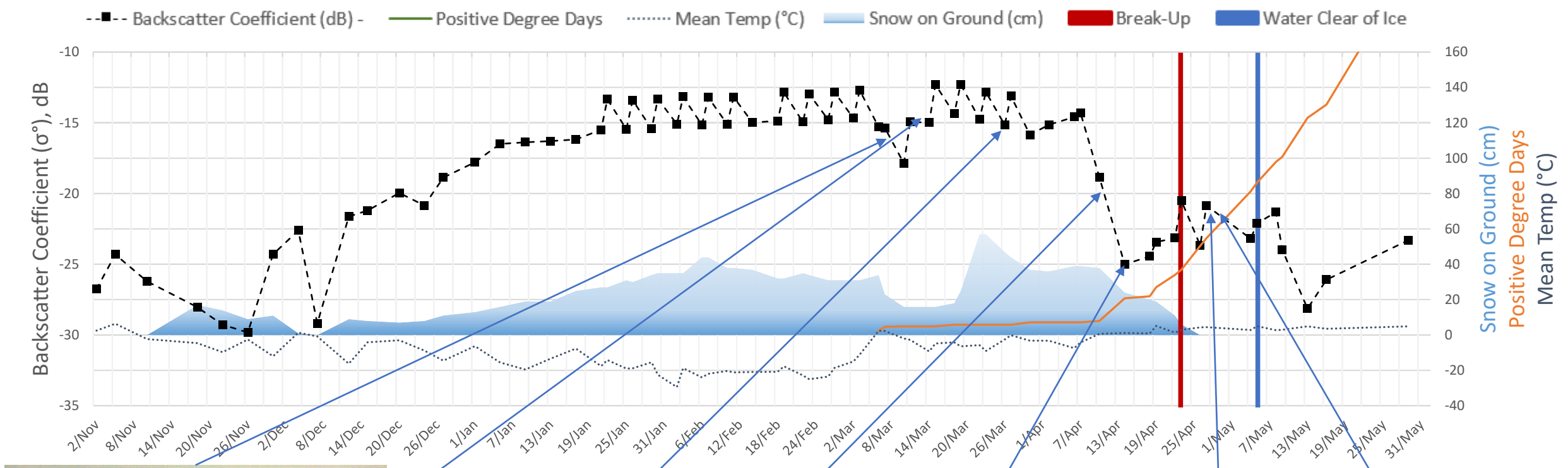
- Radiometric correction

  - Digital number → radar backscatter coefficient ($\sigma^0$ ,dB)

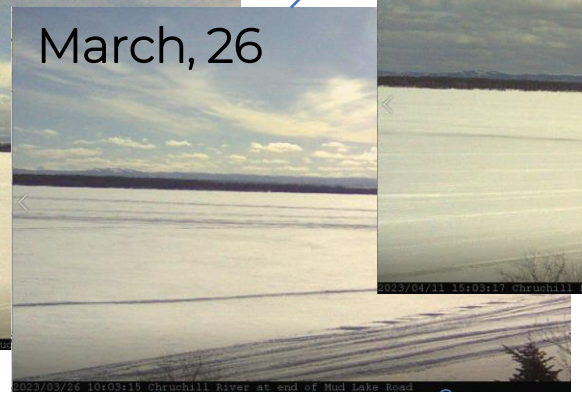
- Speckle filtering
- Geometric terrain correction
- Masking
- Backscatter values extraction



# MELT ONSET 2023



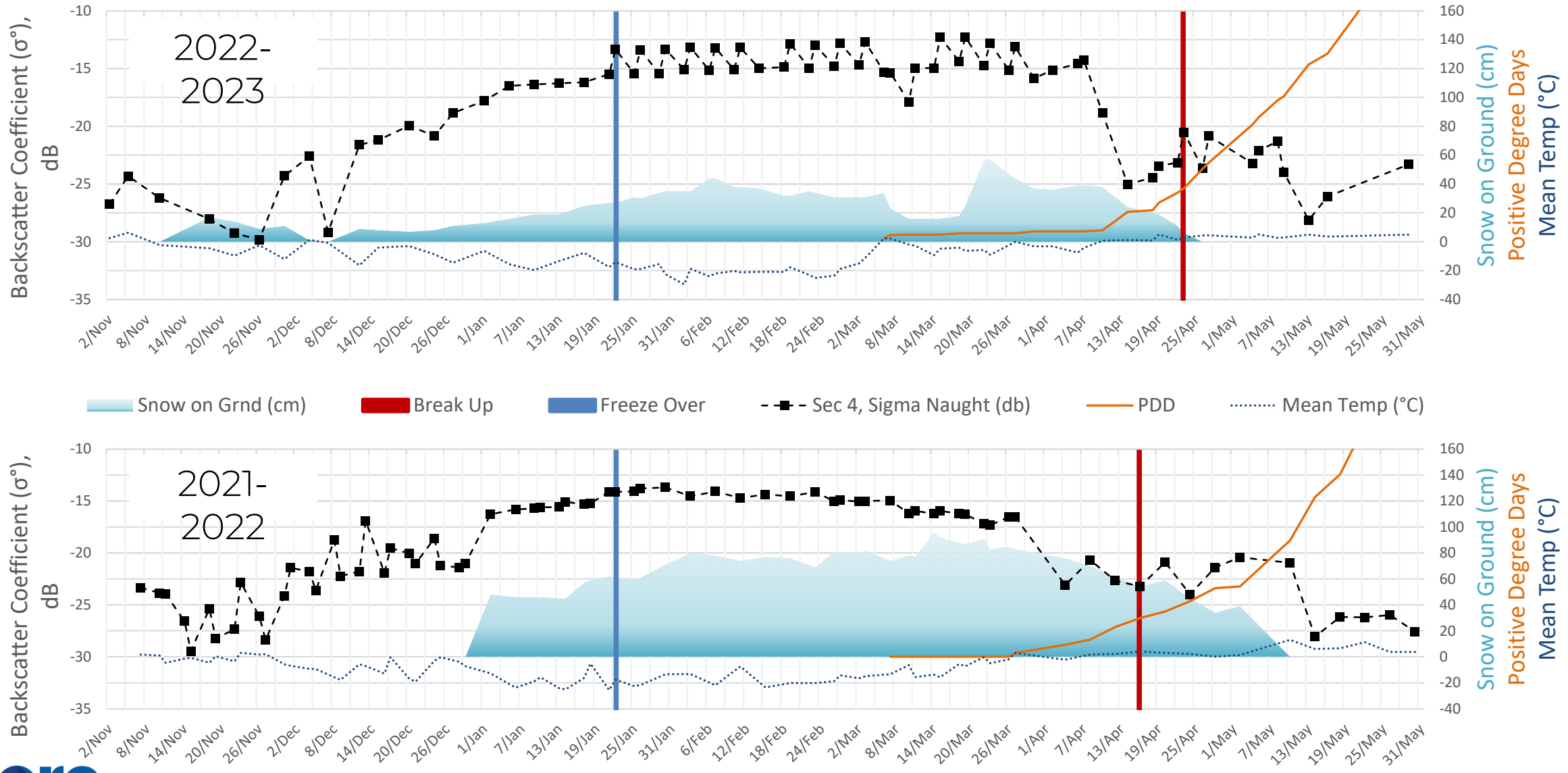






# TIMING COMPARISON

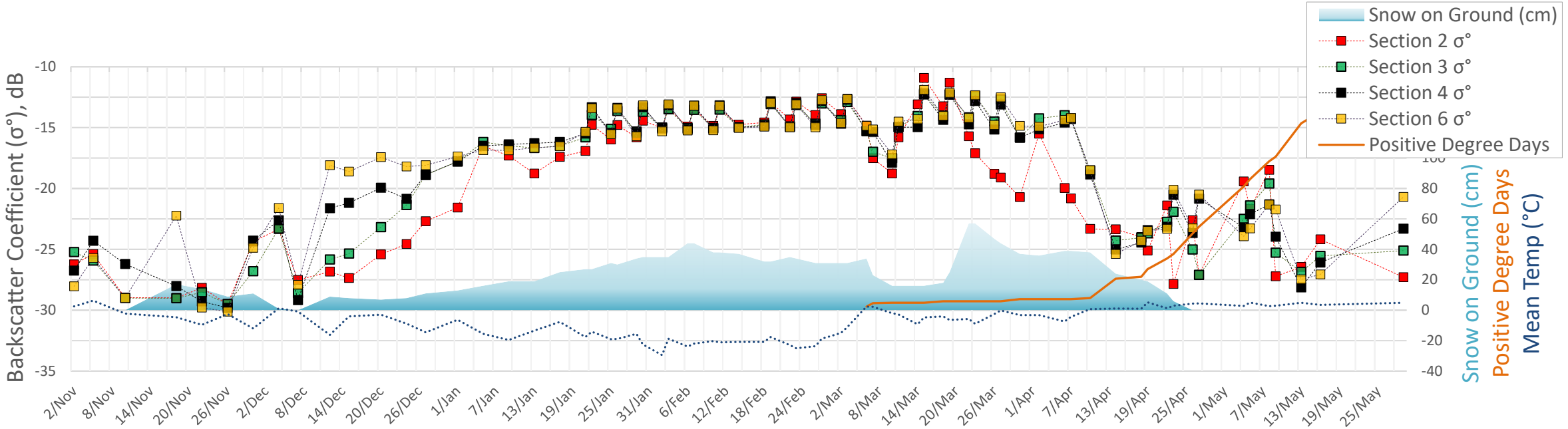


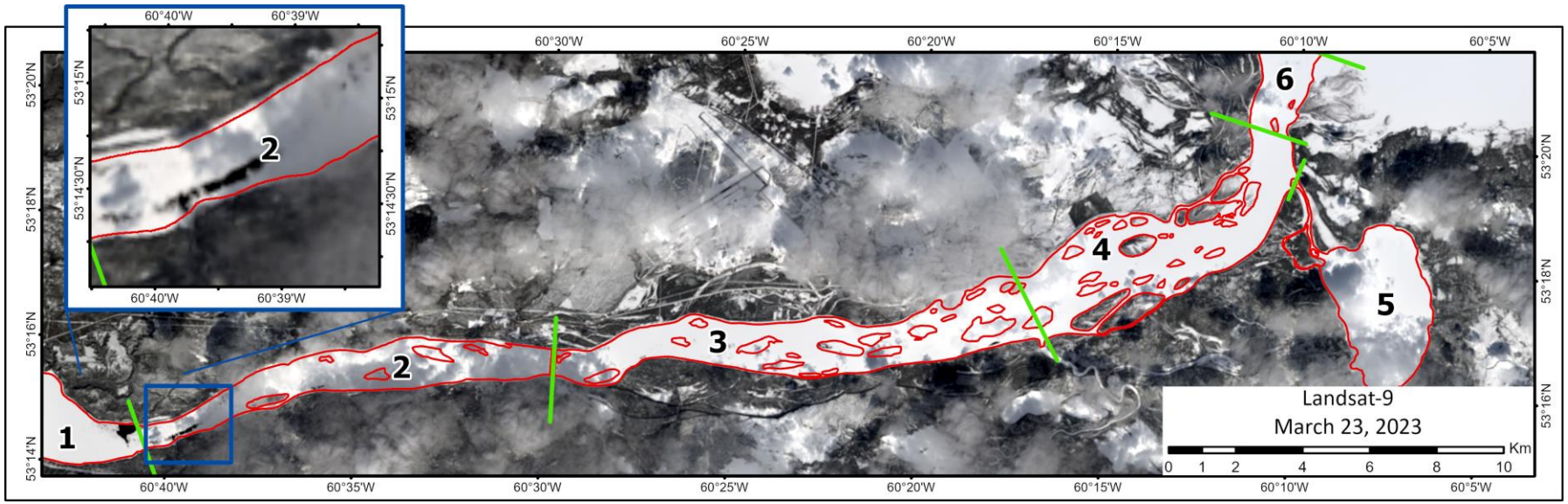
# TIMING COMPARISON

| Year | Backscatter Drop | | | Break-up | Backscatter drop date vs. Break-Up Dates | | |
|---|---|---|---|---|---|---|---|
| | Warning 1 | Warning 2 | Warning 3 | | Δ1 | Δ2 | Δ3 |
| 2023 | Mar 10<br>-17.88 dB | Mar 26<br>-15.15 dB | April 10<br>-18.86 dB | April 19 | 40 | 24 | 9 |
| 2022 | Mar 10<br>-16.2 dB | Mar 23<br>-17.3 dB | April 4<br>-23.10 dB | April 14 | 35 | 22 | 10 |
| 2021 | Feb 28<br>-17.09 dB | Mar 12<br>-17.89 dB | April 1<br>-18.24 dB | April 7 | 38 | 26 | 6 |

- Potential for ice breakup prediction

# GEOSPATIAL COMPARISON



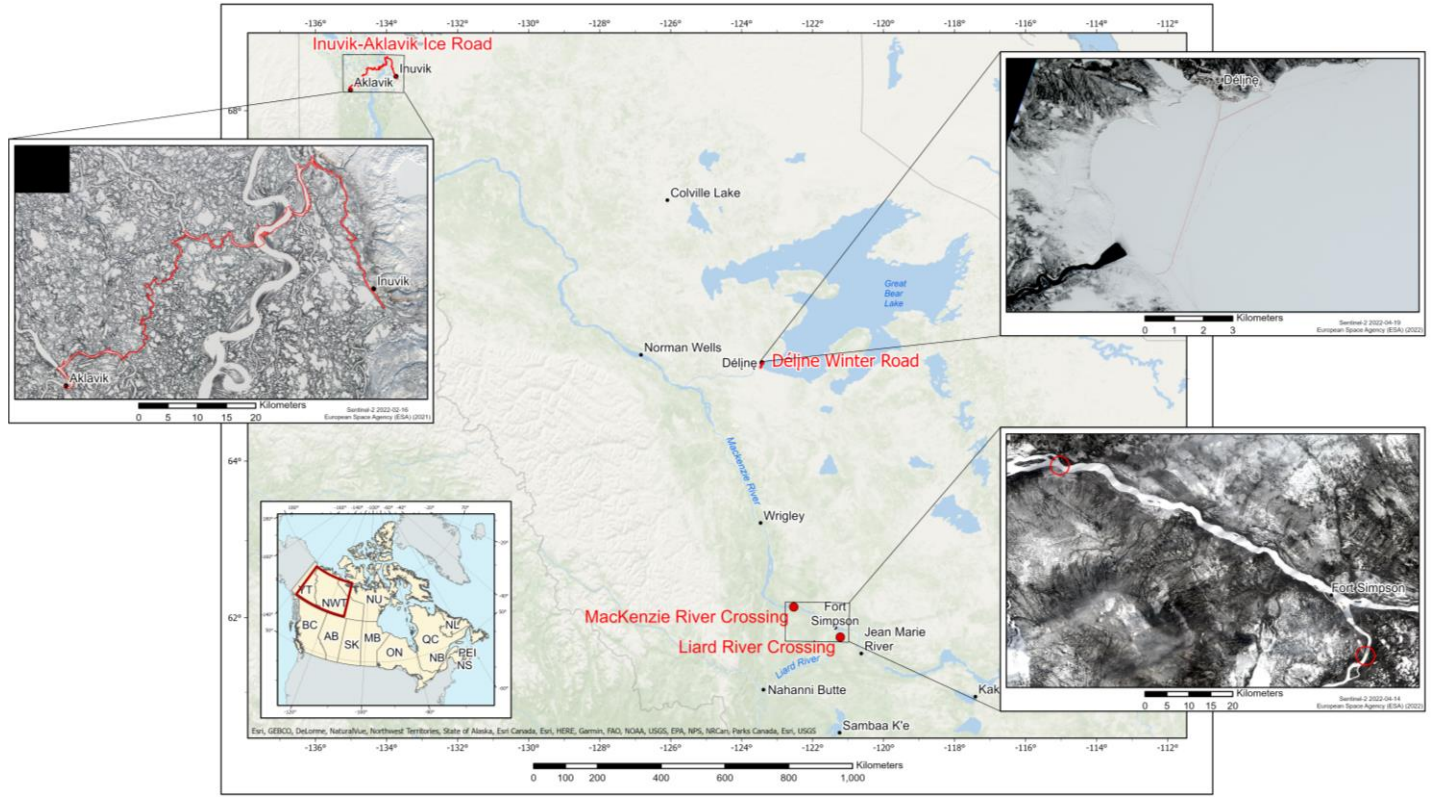



# CONCLUSIONS

- Backscatter coefficient is a reliable indicator of surface melt
- Can be used as an input for an ice breakup prediction model
- Can help in decision-making on travel safety over

# FUTURE WORK

- Include Sentinel-1 data
- Test on other rivers
- Come up with a smart break-up prediction model




Thank you!