

Combining Cryo2ICE and Compact-Polarimetric SAR parameters for snow property investigation

A case study on landfast sea ice in the Canadian Arctic Archipelago

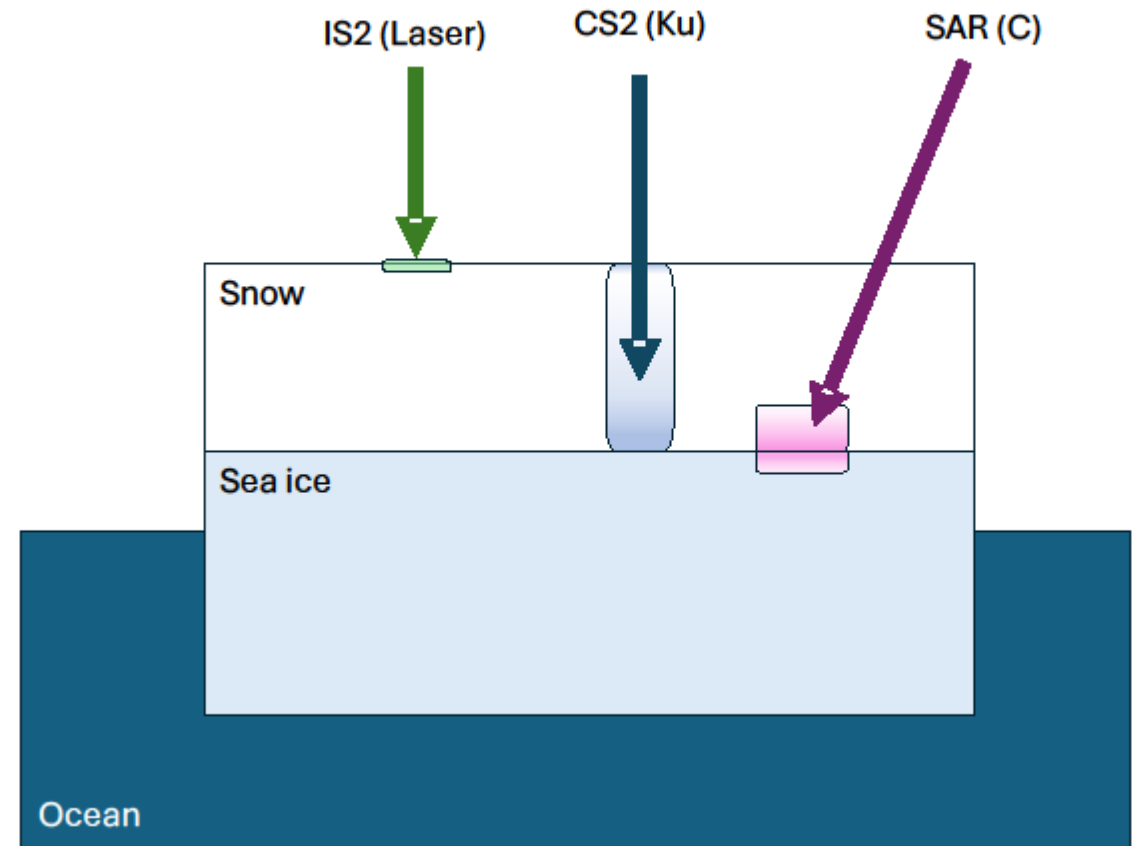
Hoi Ming Lam Torsten Geldsetzer John Yackel Stephen Howell Monojit Saha Julienne Stroeve Vishnu Nandan



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Motivation

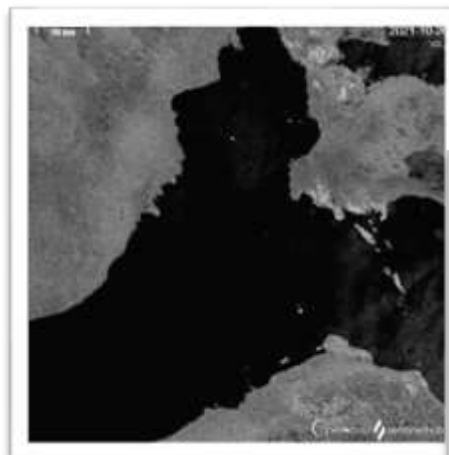
- Cryo2ICE snow depth estimate
 - Narrow water channels
 - Absence of leads in CAA
- C-band SAR imagery
 - Ice surface characteristics
 - Spatial continuity



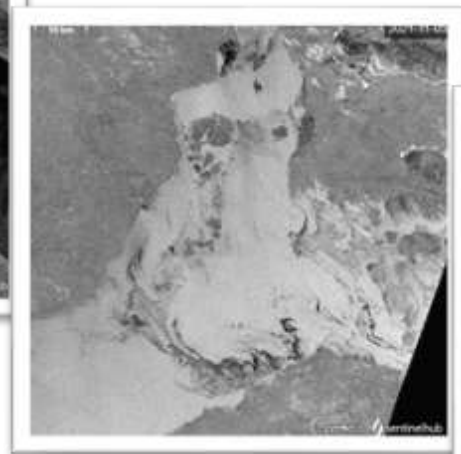
Study Area



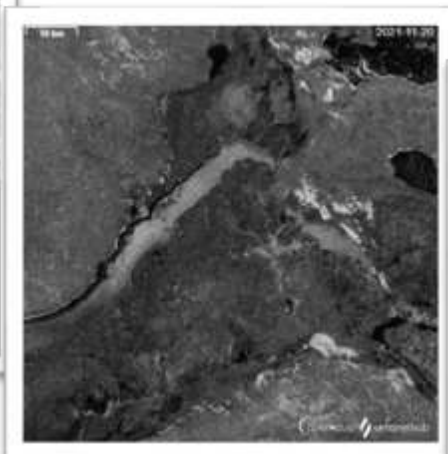
Dease Strait, Nunavut



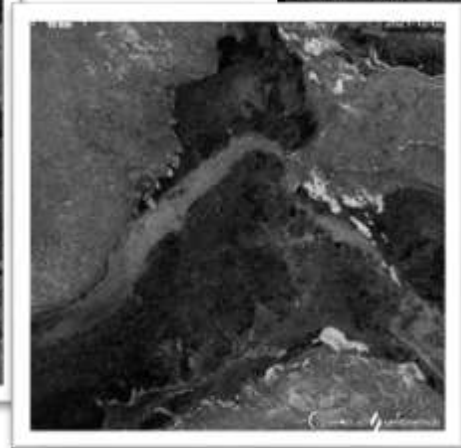
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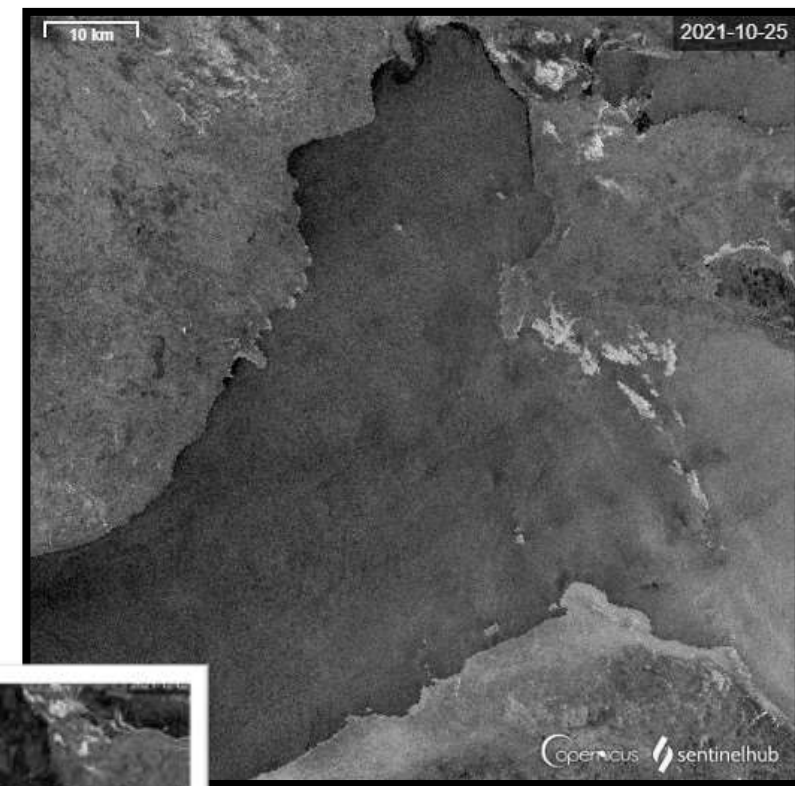
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2021-11-20



2021-12-02



Data

Altimetric Measurements

	<i>ICESat-2</i>	<i>CryoSat-2</i>
Product	ATL07 (v6)	ESA (Baseline-E)
Track ID	0577 (Cycle 15)	63916
Date	April 29, 2022	
Time	21:17 UTC	00:06 UTC
Beam/Mode	GT1L & GT2L (Strong)	SARIn
Footprint	11 m	300 m × 1.6 km
Path	Descending	
Distance	~70 km	

Field Measurements

- May 1, 2022
- Magnaprobe snow depth
- Snow salinity
- Snow density

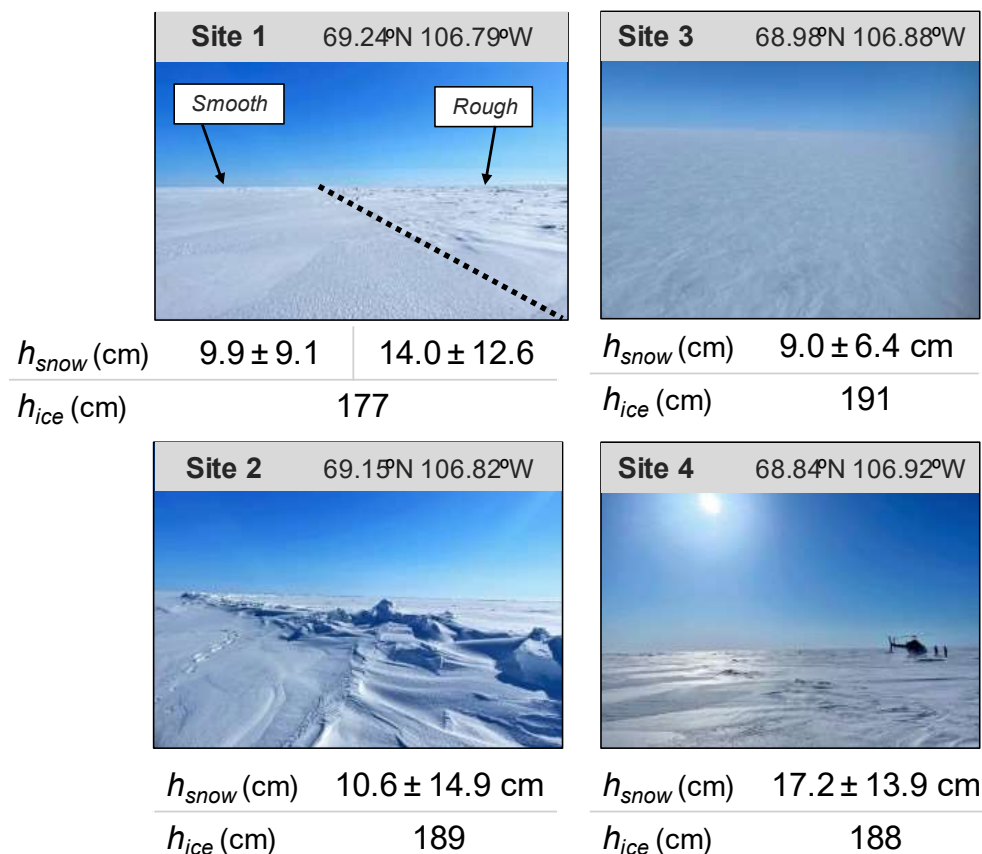


RADARSAT-CM SAR

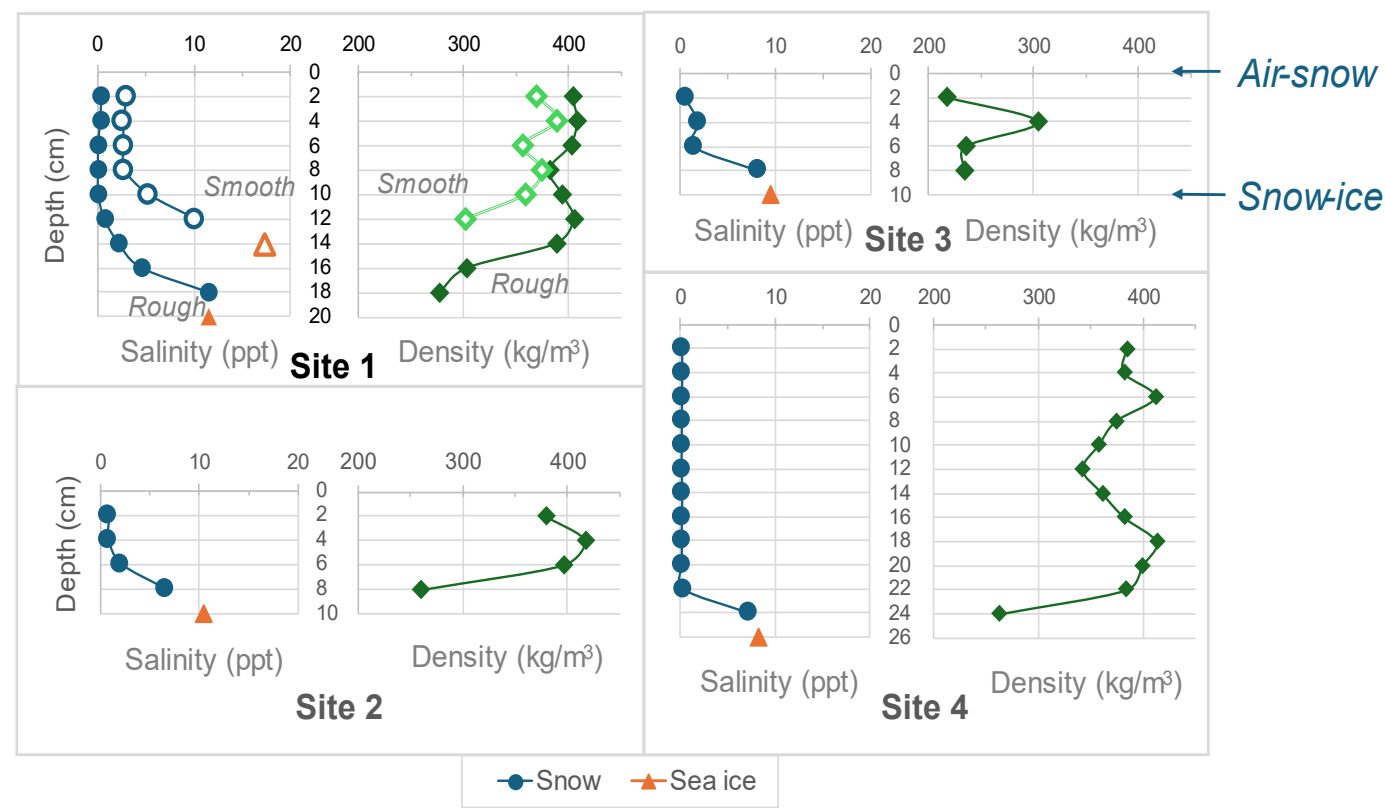
- May 5, 2022
- C-band (5.405 GHz)
- Compact polarimetry (CP)



Snow depth

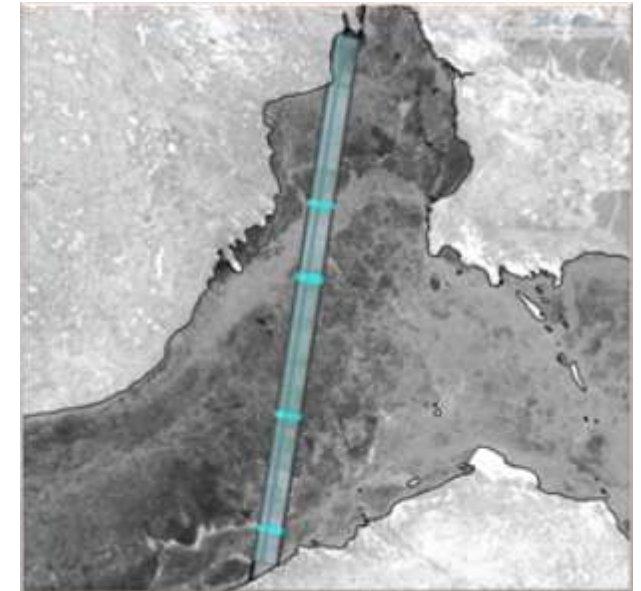
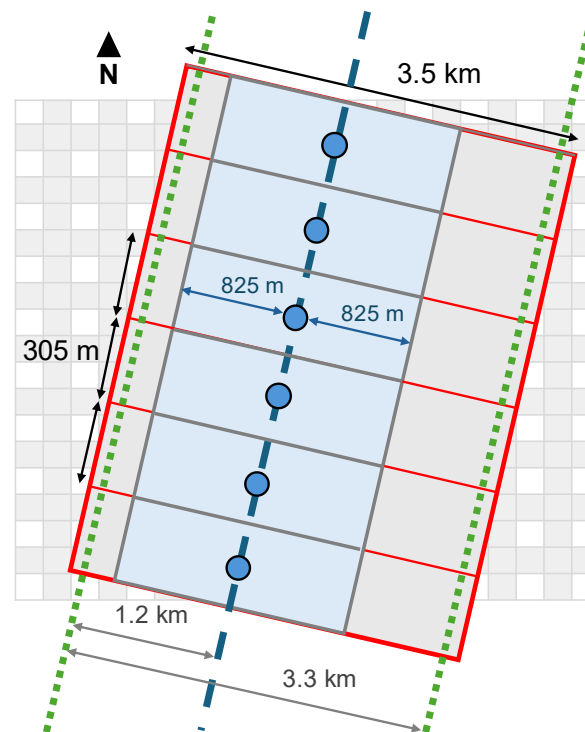


Snow salinity and density



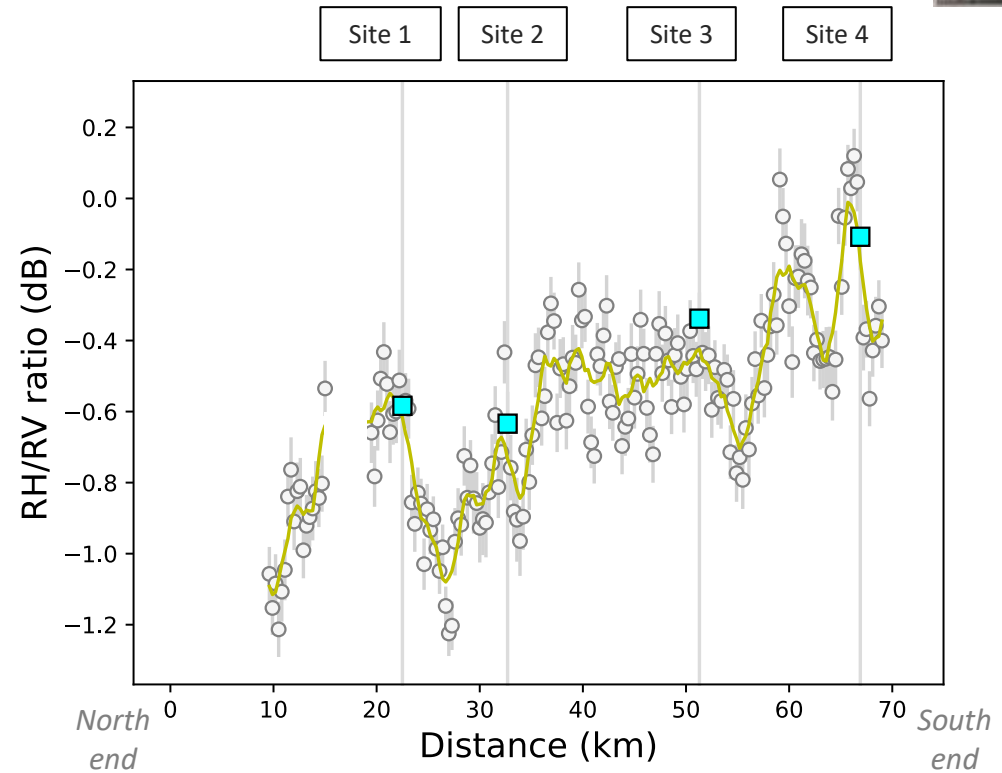
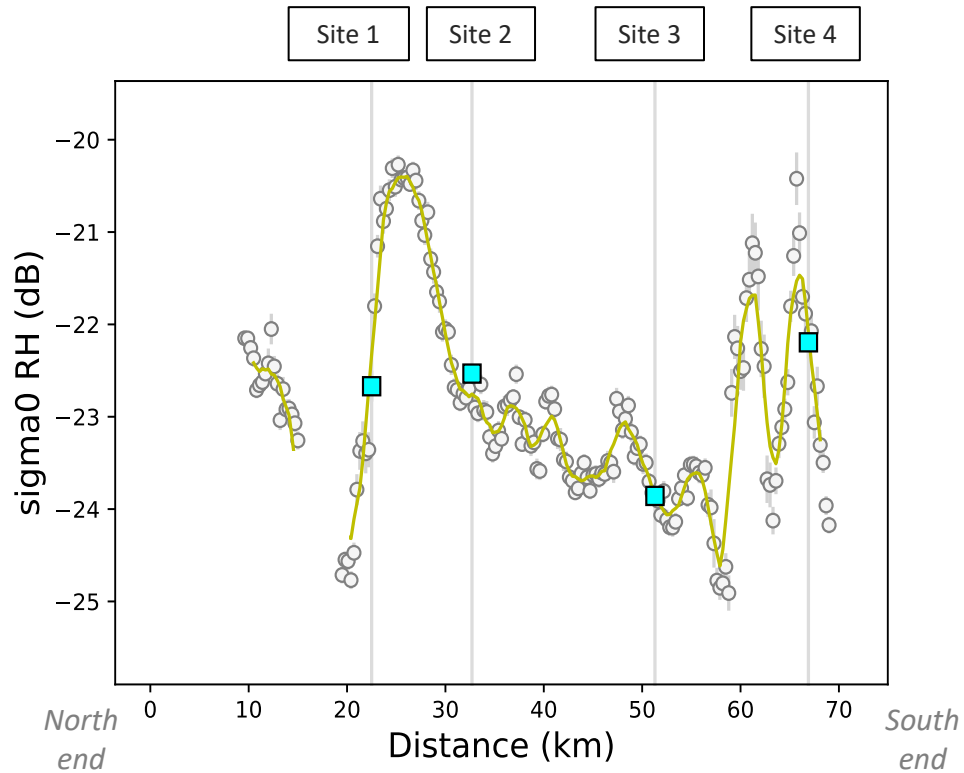
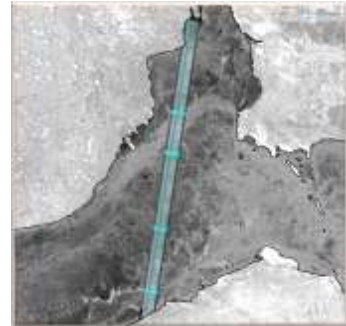
RCM Scene

- Date: May 5, 2022
- Product: CP Medium-resolution 30 m
- Swath width 125 km
- Descending (Right-looking)
- 2 km land buffer
 - 54 of 239 sampling boxes affected
- Total sampling box: 185

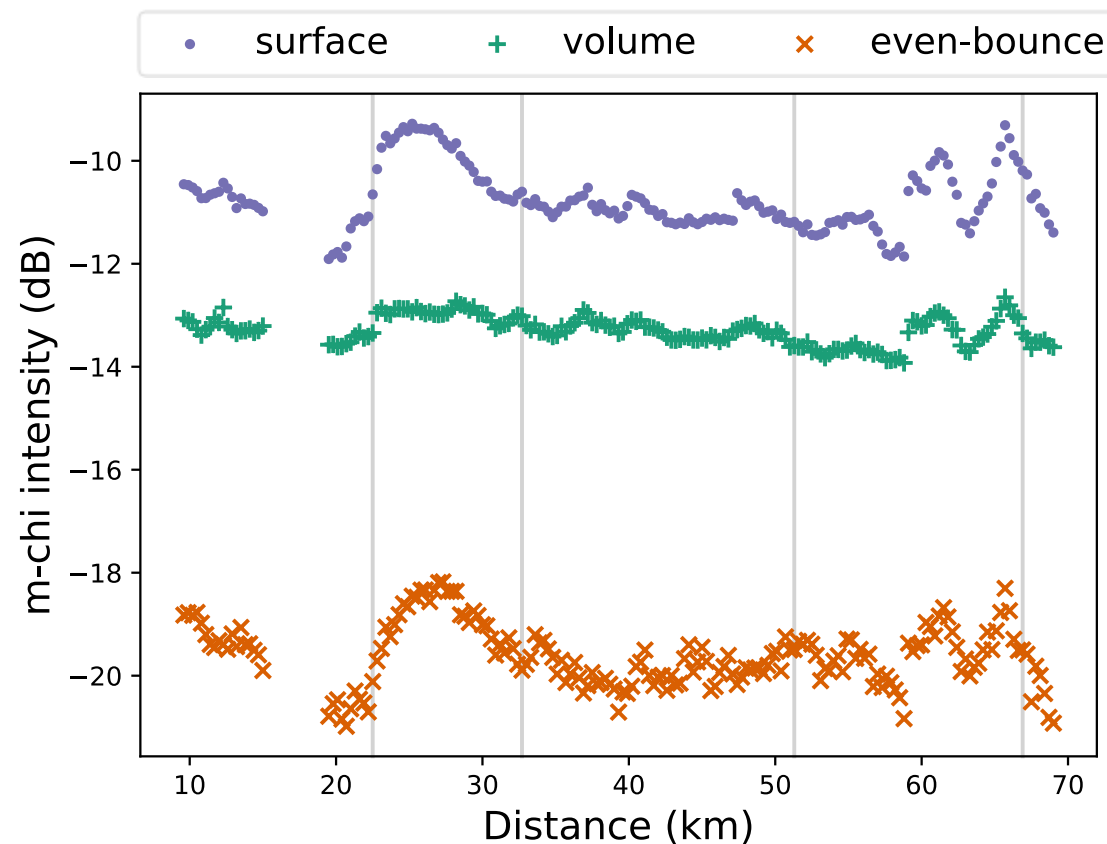


- SAR parameters
- ICESat2 (gt1L and gt2L)
- CryoSat-2 nadir
- CryoSat-2 POCA
- CryoSat-2 SARIn footprint
- Sampling box

Compact-pol Backscatter



m-χ decomposition



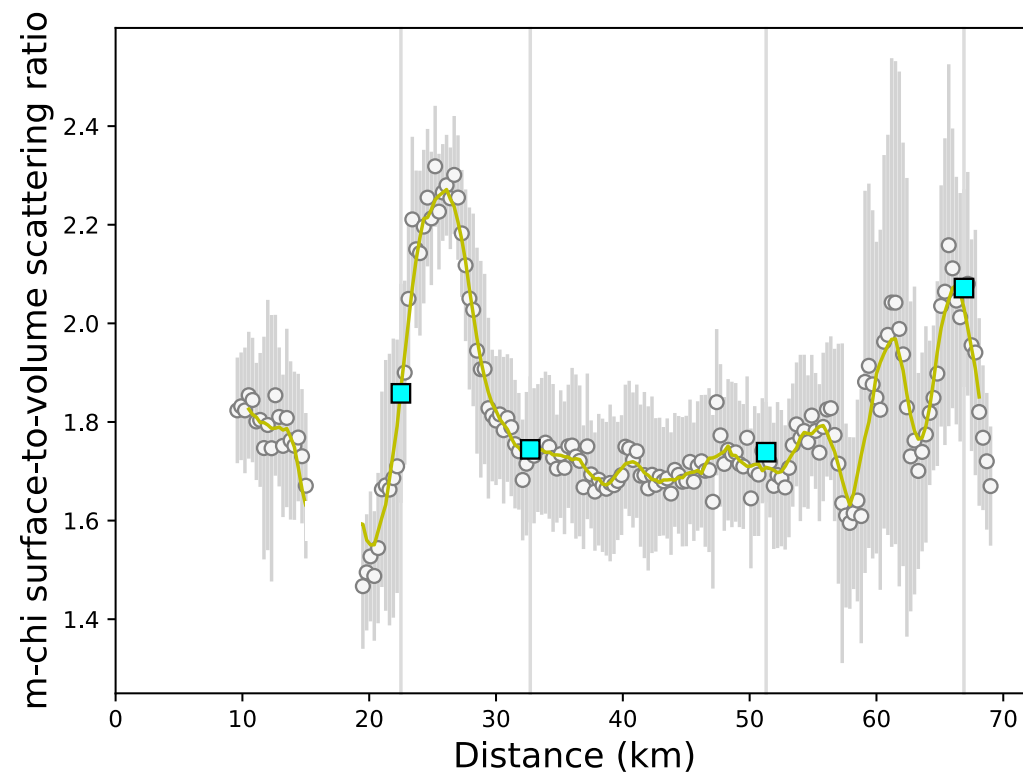
$$P_{surface} = \frac{mS_0(1 + \sin 2\chi)}{2}$$

$$P_{volume} = S_0(1 - m)$$

$$P_{DB} = \frac{mS_0(1 - \sin 2\chi)}{2}$$

m : degree of polarization
 χ : ellipticity
 S_0 : 1st Stokes parameter

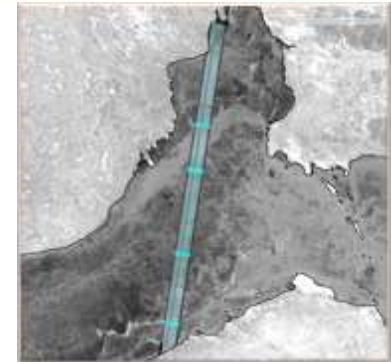
Derivation: Raney et al. (2012)



CP parameters and Cryo2ICE

- Weak correlation
- Snow salinity adds complexity

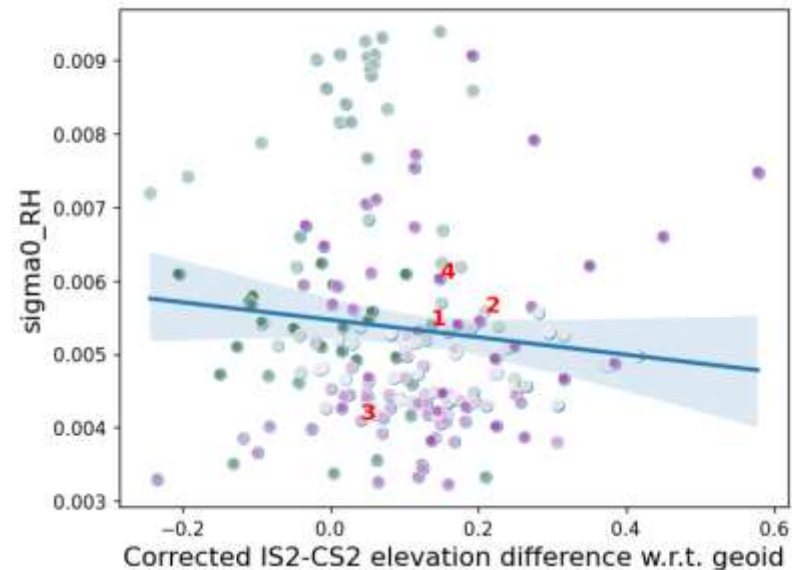
- Location dependency
- Steep salinity profiles in South



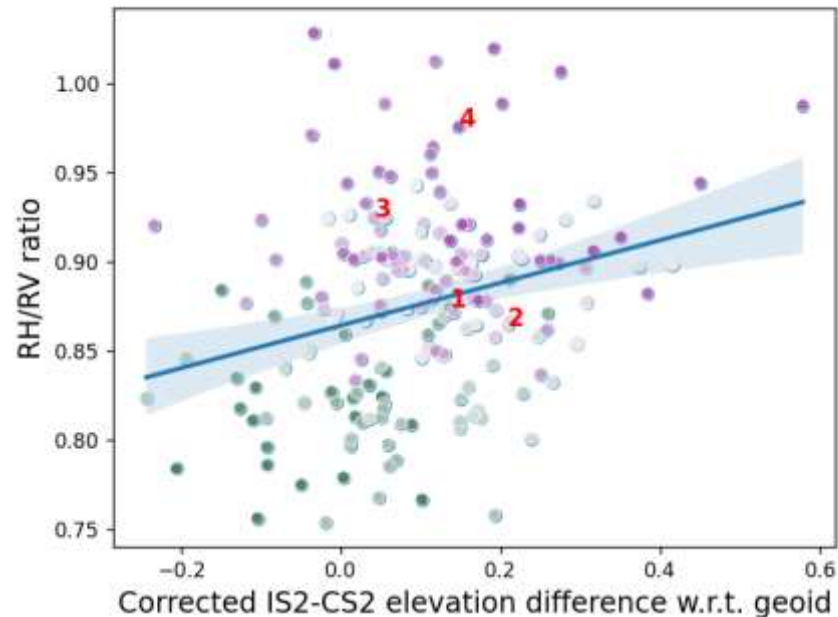
North



South



Spearman R = -0.21 (p=0.001)



Take home messages

- SAR imagery provides spatially continuity for regional scale study
- Snow salinity remains a complexity for radar penetration and SAR parameter retrieval
- Compact-polarimetric (CP) parameters provide further information on snow and ice scattering
- Multivariate CP analysis could further knowledge between altimeters and SAR

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Funding and Logistic support:



Polar Knowledge
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Reference

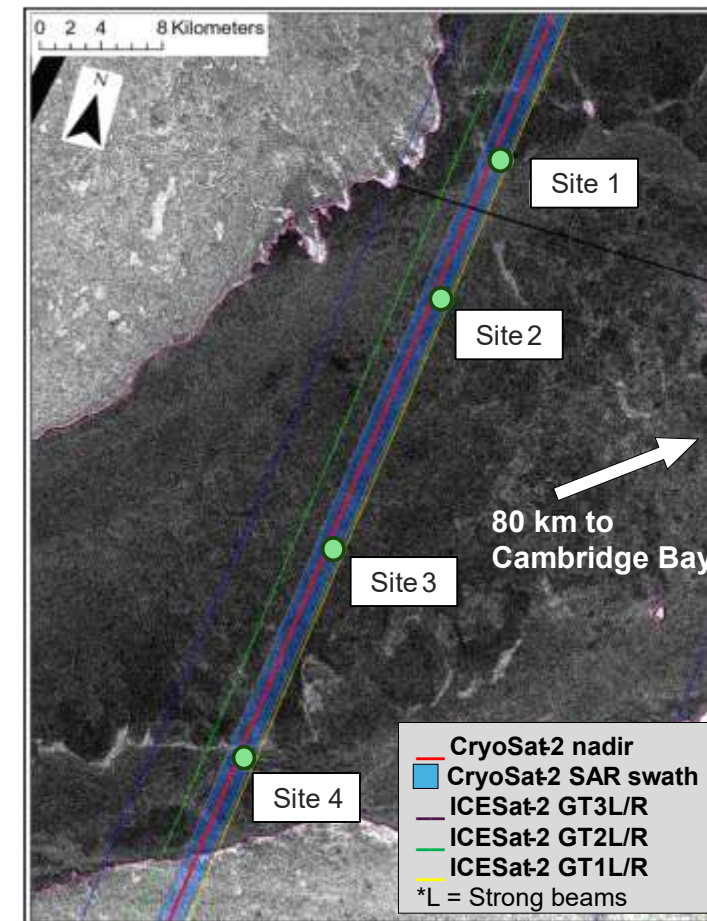
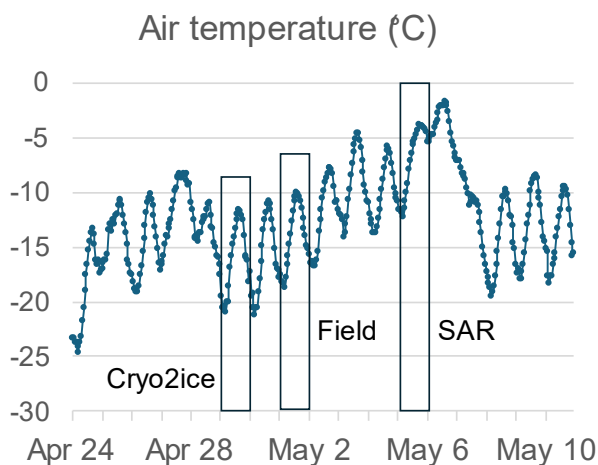
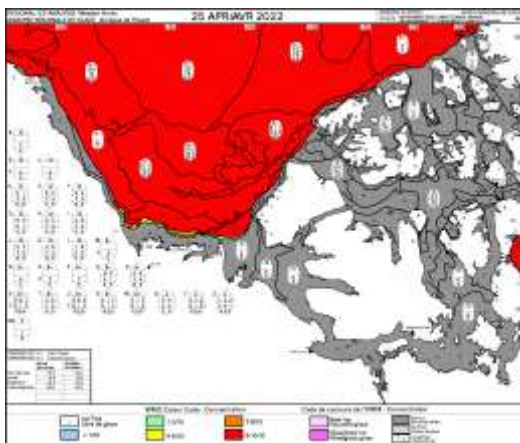
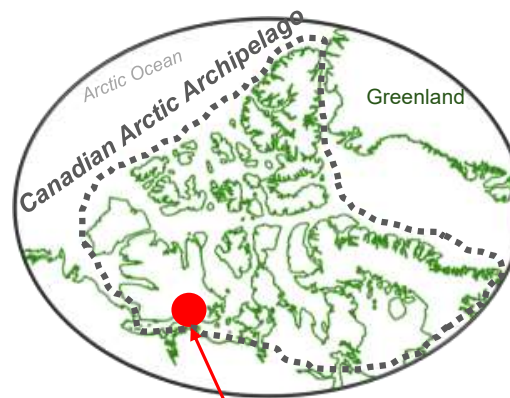
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Cryo2ice Symposium 2024



Sampling sites

- Landfast ice
- Sub-zero temperature
- No blowing snow or cloud flagged by ICESat-2



Background: Sentinel-1 IW HH backscatter (2 April 2022)