

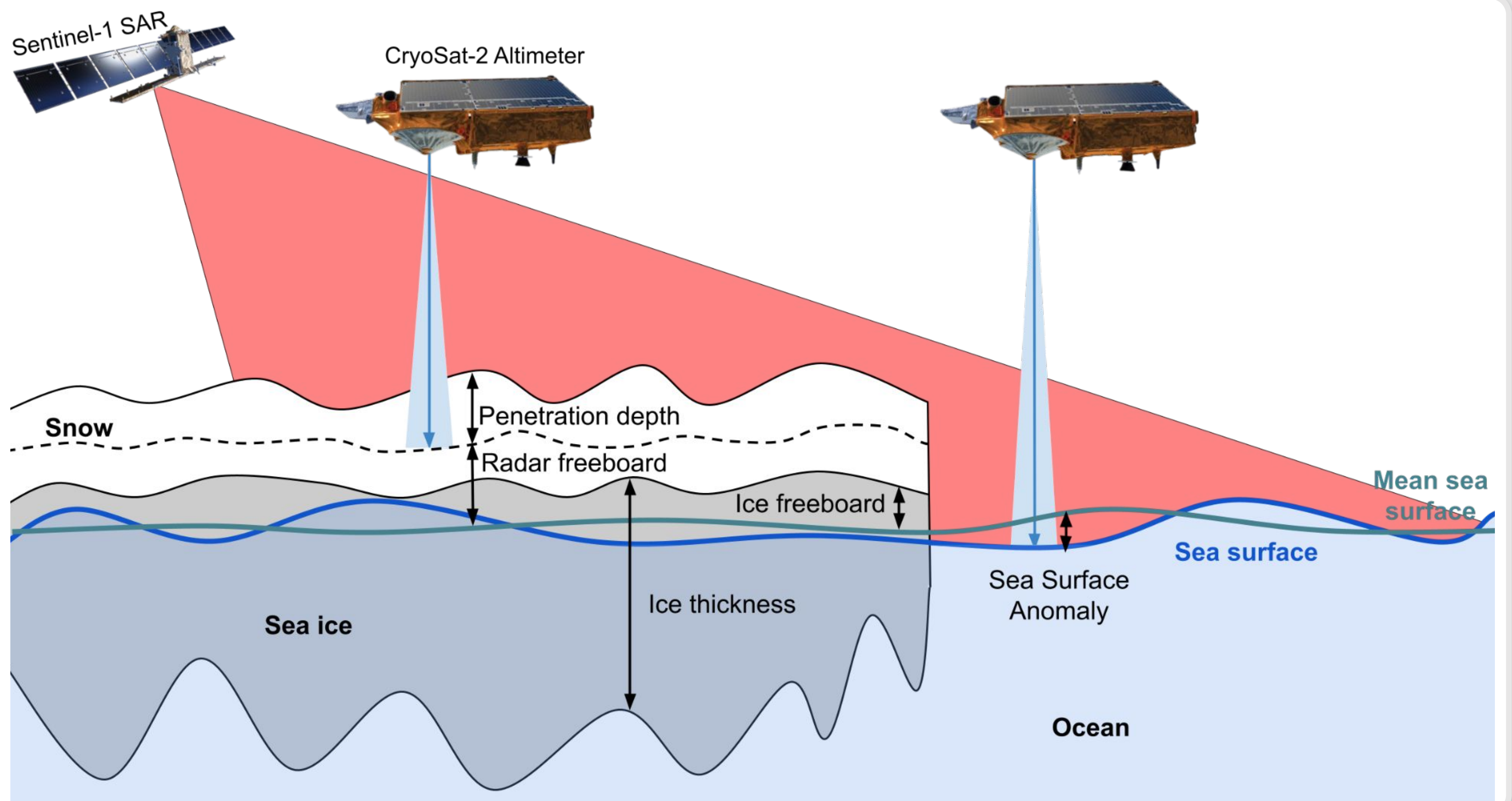
Cryo2S1: Cross-Sensor Representation Learning for Sea Ice Radar Freeboard and Leads in Sentinel-1 SAR

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Motivation & Aims

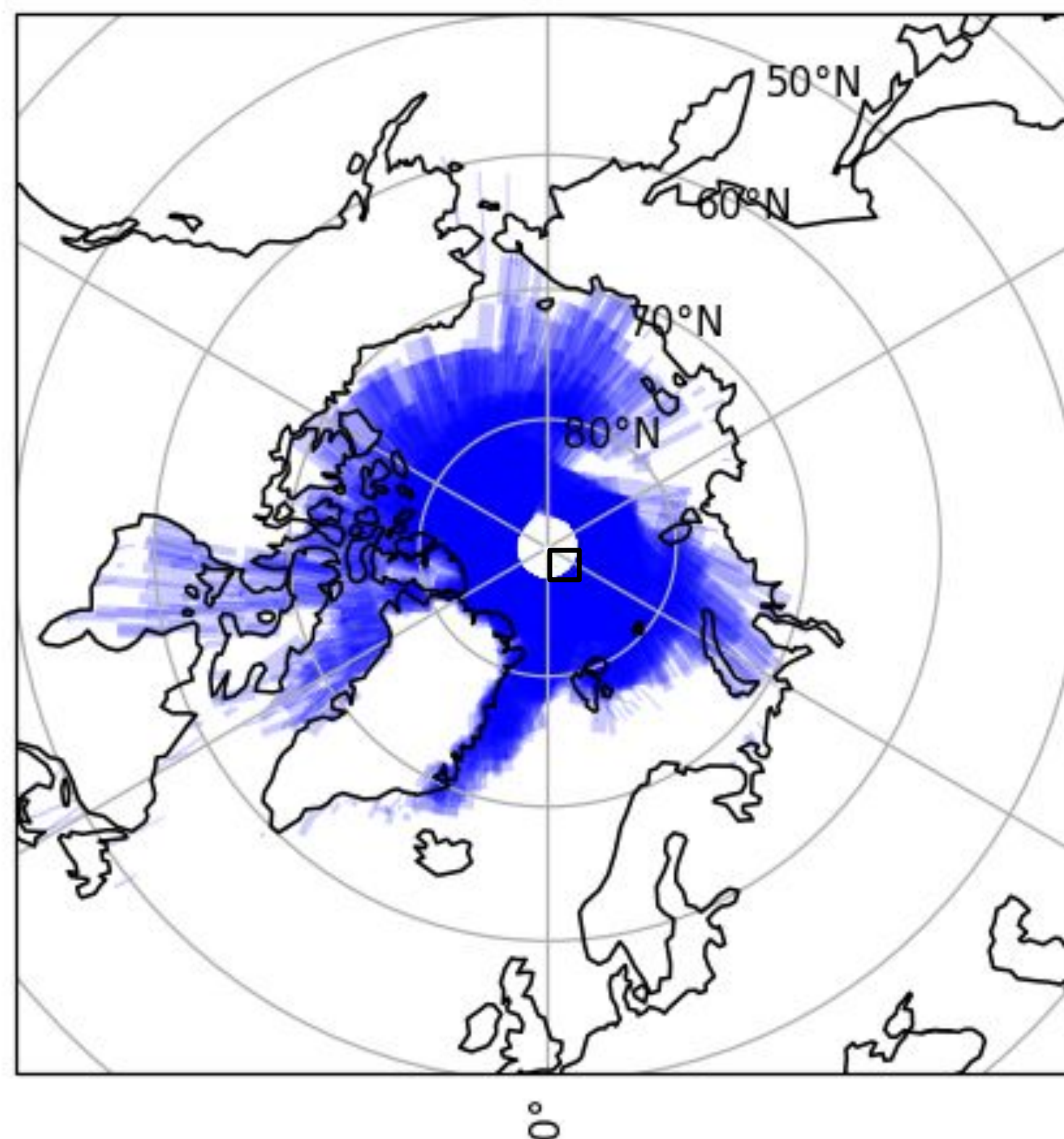
- Sentinel-1 SAR offers wide coverage but only captures surface features to classify ice type, not ice thickness or height.
- Satellite altimeters, like CryoSat-2, measure sea ice radar freeboard (height above ocean) to estimate thickness.
- CryoSat-2's swath (~1600 m across track) limits spatial coverage compared to Sentinel-1's 250/400 km swath.
- Combining SAR and altimeter data could improve sea ice thickness mapping by merging wide coverage with freeboard.
- We tests fusing these two satellite data sources for improved sea ice thickness mapping with deep learning.



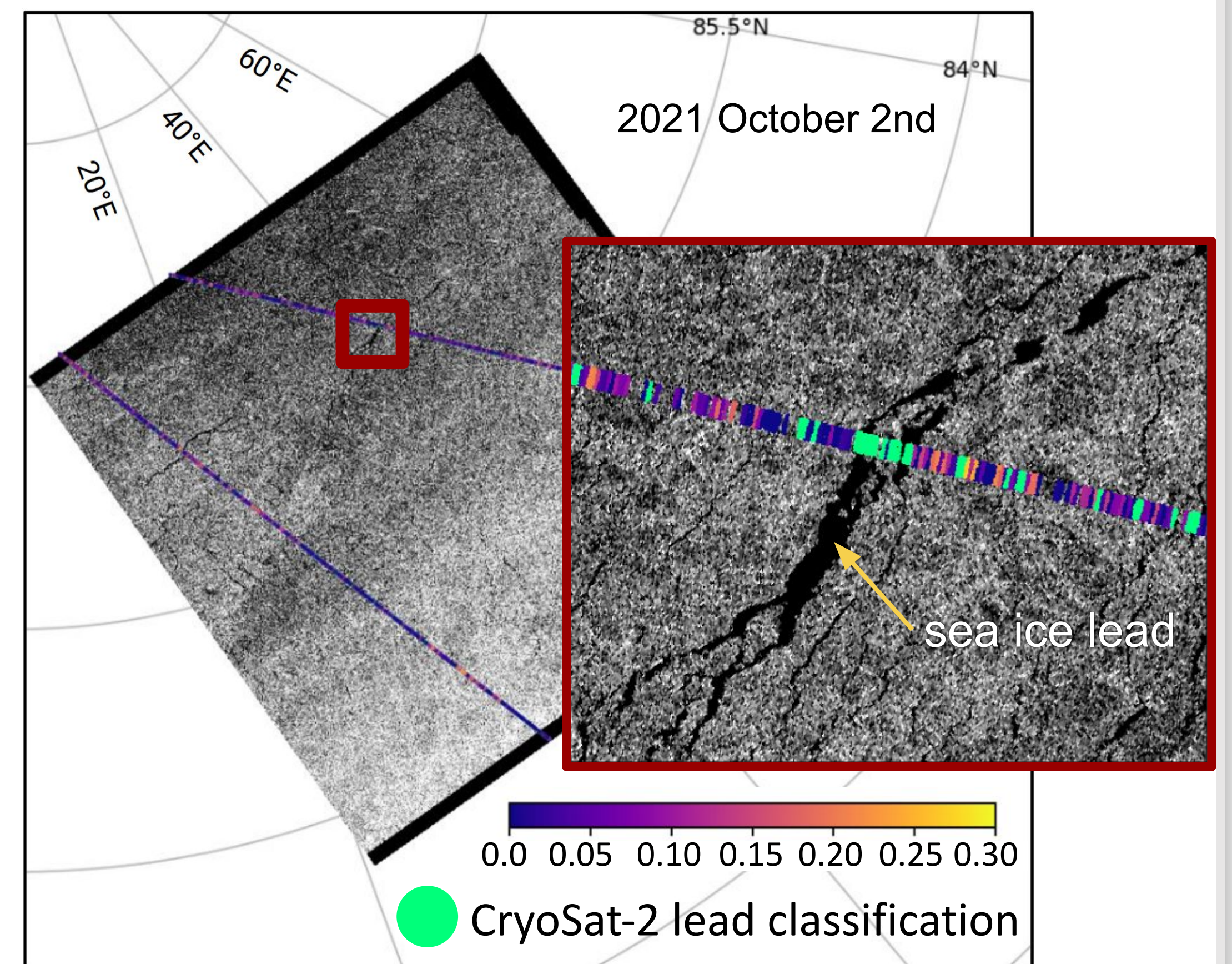
Data

- Geographical coverage: Pan-Arctic
Most scenes North of Greenland
- Winter period: January-April + October-December, 2020-2021
- Sentinel-1 Noise Corrected (ESA IPF v3.2-4) IW + EW GRD (10 / 40 m pixel spacing)
- CryoSat-2 Sea ice radar freeboard, sea ice roughness and sea ice lead classification
- Sentinel-1 and CryoSat-2 overlap: +- 1 hour
- ~4516 processed crossover scenes
 - Training: 3866 scenes
 - Validation: 219 scenes
 - Testing: 431 scenes

Geographical overview

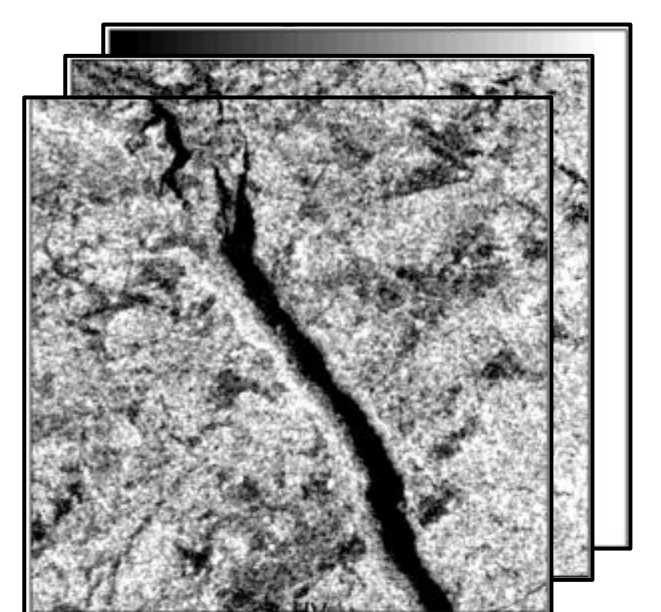


Sentinel-1 SAR HH + CryoSat-2 altimeter



Model and results

input:
SAR HH, HV, incidence angle



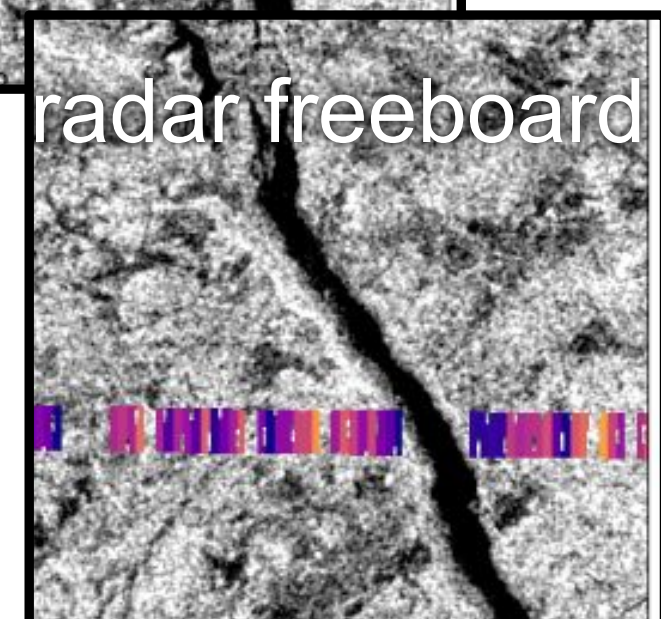
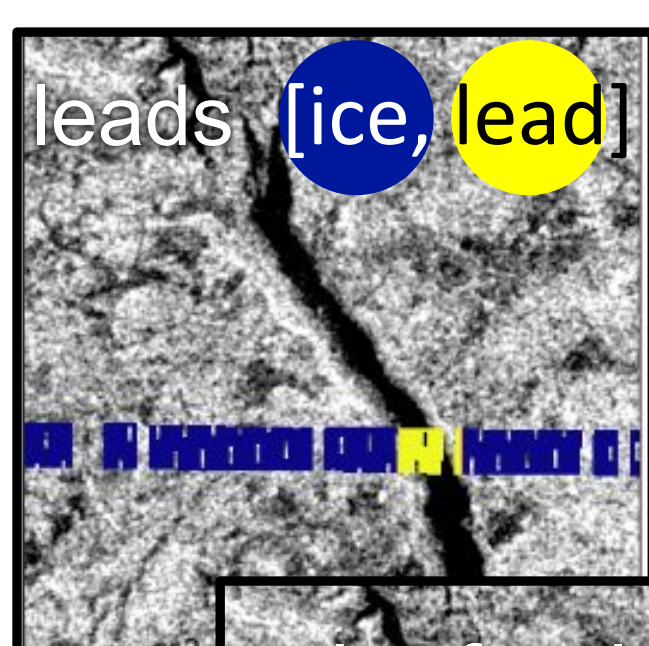
Task 1: lead classification
with binary cross entropy

$$\mathcal{L} = \mathcal{L}_{lead} + \lambda \cdot \mathcal{L}_{freeboard}$$

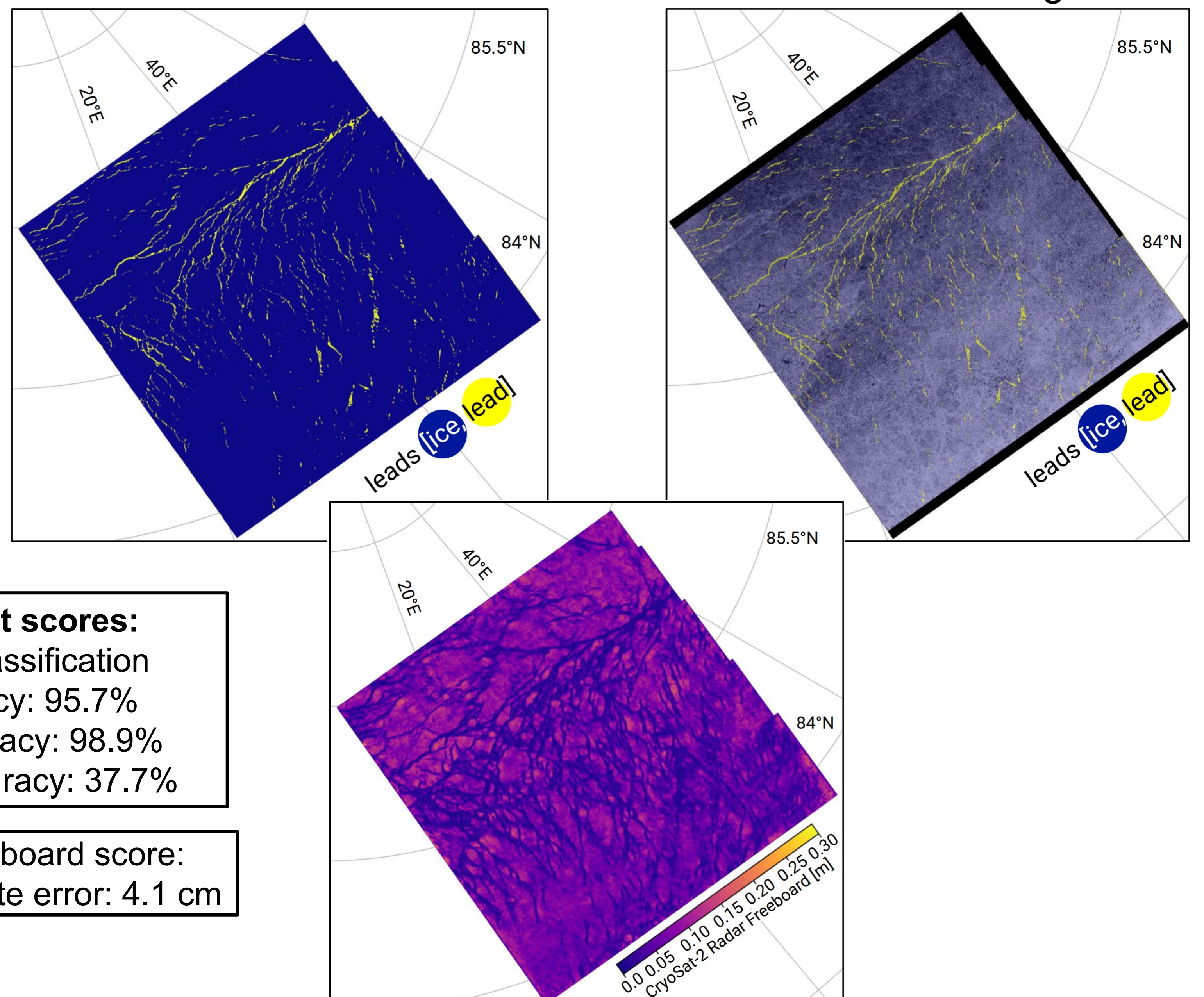
Task 2: height regression
with mean square error

U-Net CNN

CryoSat-2
reference:



Model inference results on a full Sentinel-1 SAR image



Test set scores:
Lead classification
Accuracy: 95.7%
Ice accuracy: 98.9%
Lead accuracy: 37.7%

Radar freeboard score:
Mean absolute error: 4.1 cm

conv 3x3, ReLU
copy and crop
max pool 2x2
up-conv 2x2
conv 1x1