SEA ICE CLASSIFICATION USING COMBINED SENTINEL-1 AND SENTINEL-3 DATA

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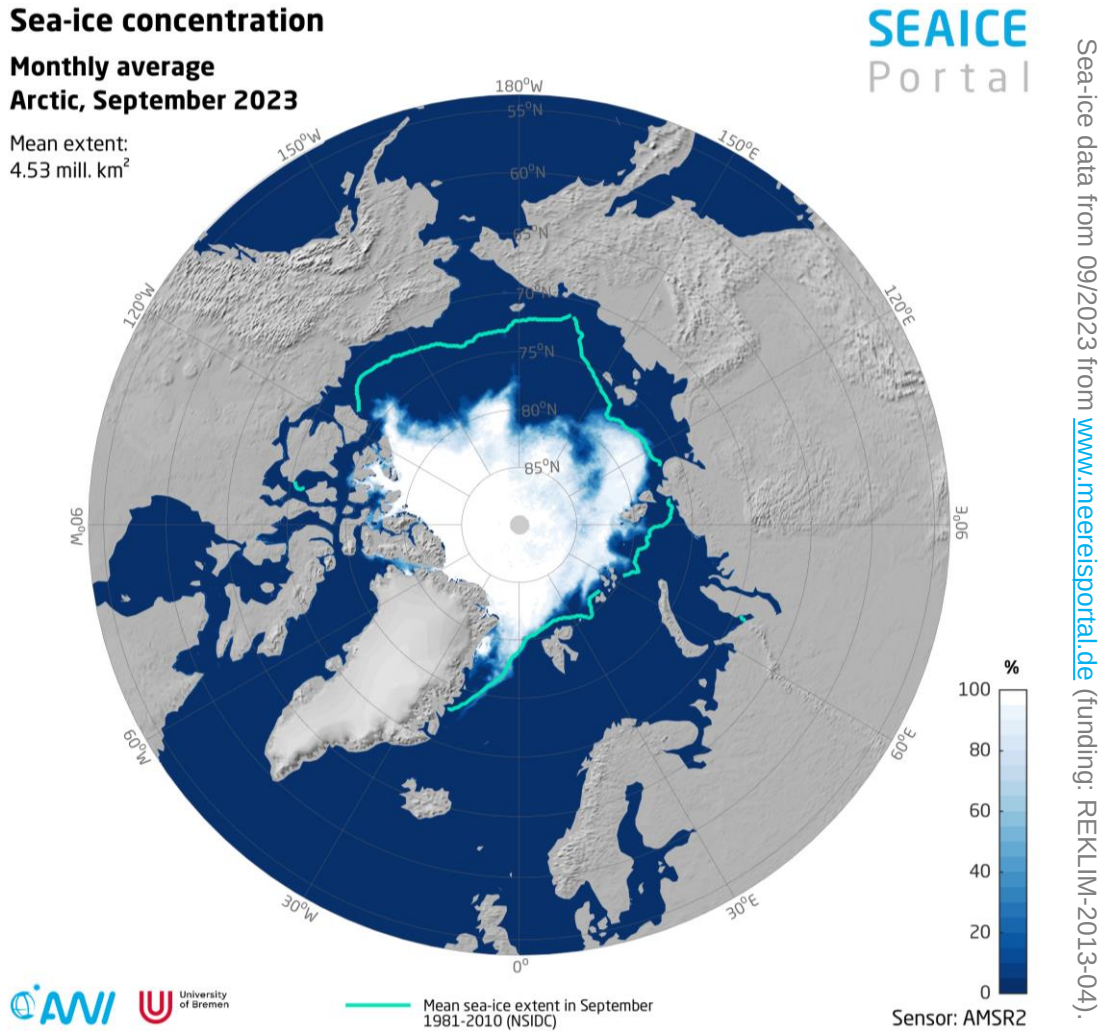
DLR

Motivation

- Global warming reduces sea ice coverage
- Arctic shipping routes opening, usage increases
- Remaining sea ice poses threat to shipping

- Remote Sensing provides near real-time information on sea ice for ships
- Goal: combine SAR and optical data for improved sea ice classification product



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SAR and optical data

SAR data

- Reliable all-day all-weather coverage
- Detects surface roughness

Optical/thermal data

- Sensitive to moisture
- Can measure thin ice thicknesses (up to ~50 cm)

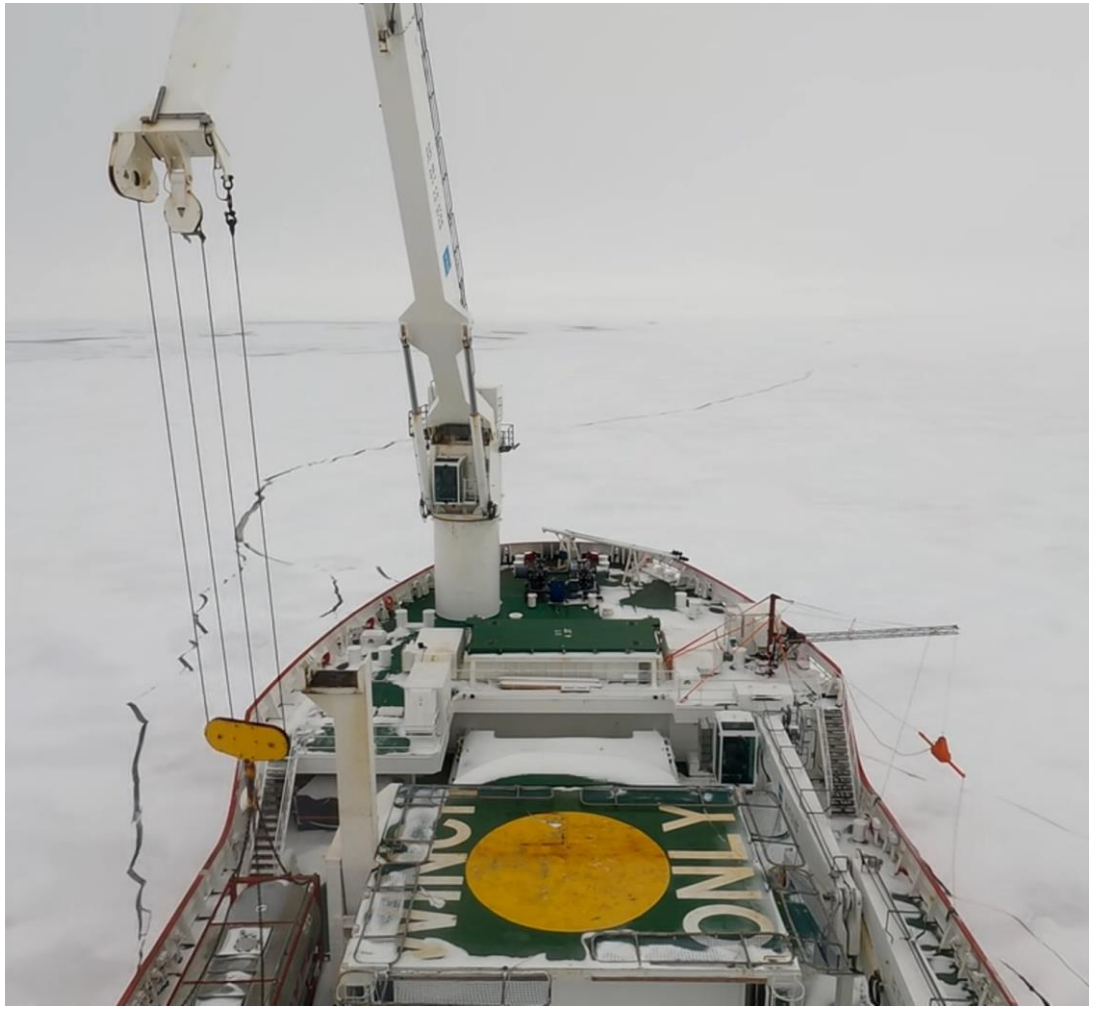

Image credit: D. Murashkin, Endurance22 expedition, Antarctica

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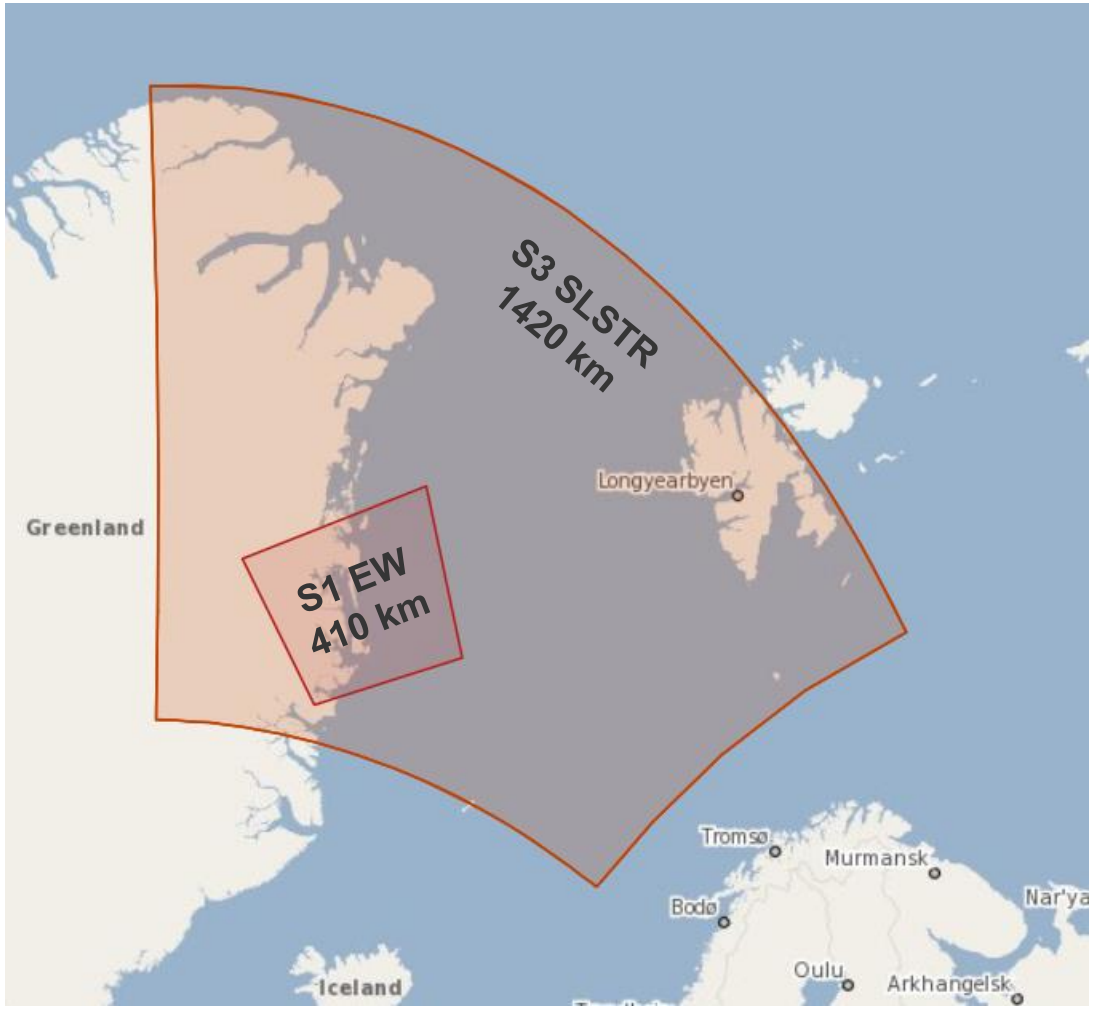
Sentinel-1 and Sentinel-3 SLSTR data

Sentinel-1 data

- 410 km swath width
- 40 m pixel spacing
- Data acquisition schedule

Sentinel-3 SLSTR data

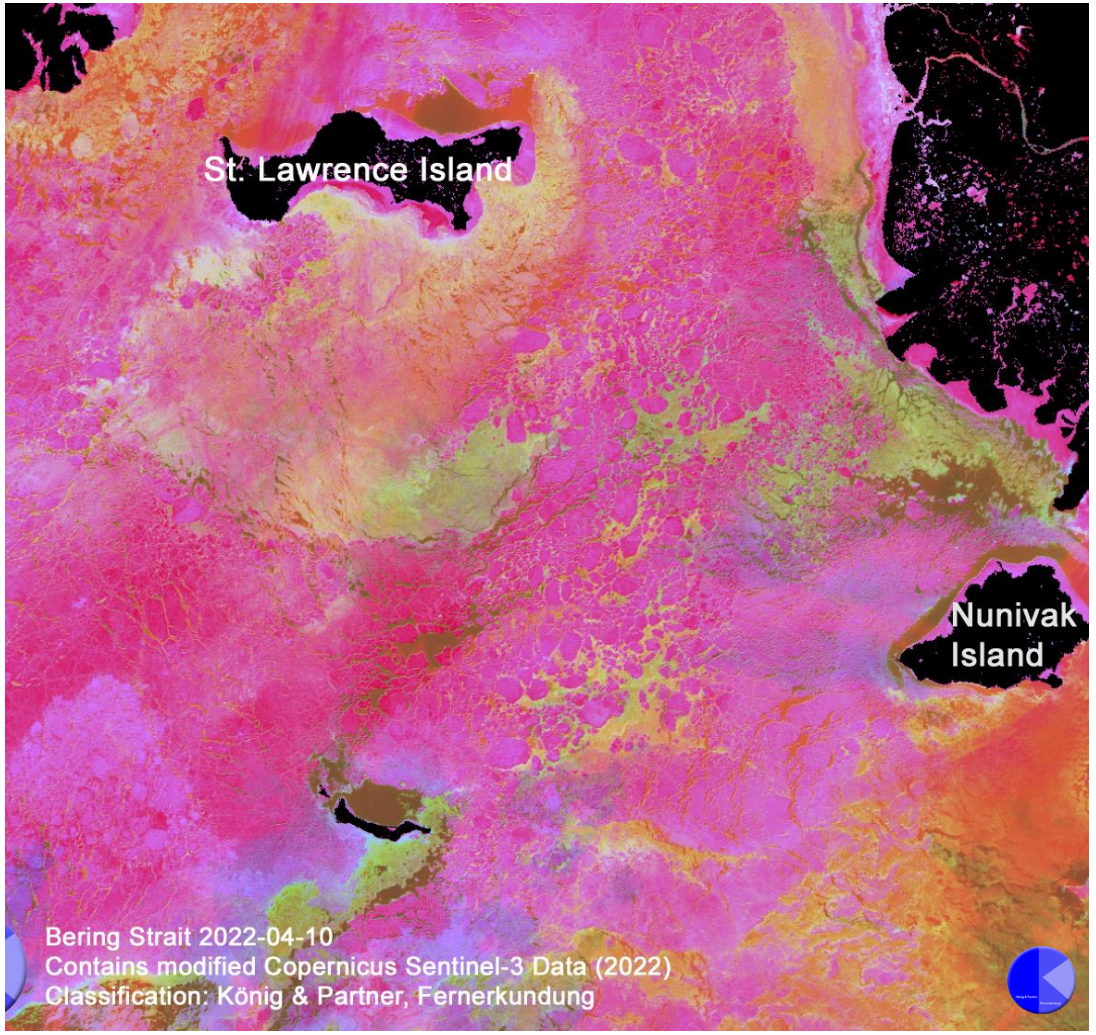
- 1420 km swath width
- 500 m pixel spacing
- Continuous data acquisition



Screenshot: Copernicus Data Hub

SLSTR classification

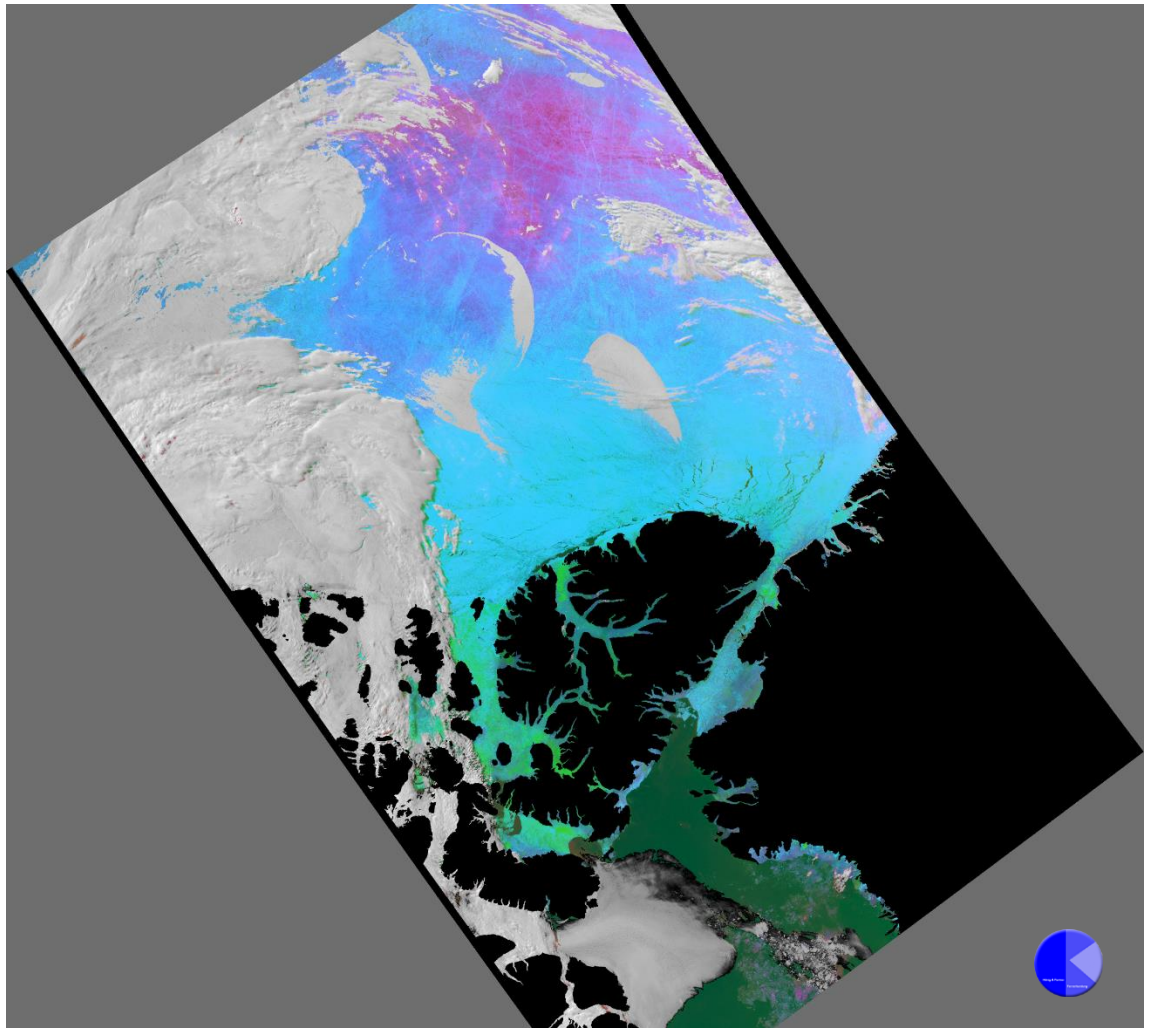
- Single pixel classification
- Resolution of classified product: 500 m
- Continuous color scale
- 15 main classes / colours



König, C.; König, T.; Singha, S.; Frost, A.; *Combined Use of Space Borne Optical and SAR Data to Improve Knowledge about Sea Ice for Shipping*, Remote Sens. 2021, 13, 4842

Legend of Sentinel-3 SLSTR sea ice classification

- open water
- nearly freezing water or mixed ice/water Pixel or very thin ice (e.g. frazil ice)
- ice without snow cover especially: dark and light nilas (>10cm)
- young ice without snow cover; especially: grey ice (10-15 cm)
- young ice without snow cover, especially: grey-white ice (15-30 cm)
- ice without snow cover thicker than grey-white ice (probably >30cm)
- land
- grey variations: clouds
- ice of uncertain thickness with dry snow cover
- ice of uncertain thickness with aged dry snow cover
- ice of uncertain thickness with aged snow cover
- ice of uncertain thickness covered by aged snow (increased grain size of snow)
- ice of uncertain thickness covered by further aged snow compared to dark pink
- ice of uncertain thickness covered by further aged snow compared to medium and dark pink
- ice of uncertain thickness covered by aged snow but with increasing temperatures than with the color pink
- ice of uncertain thickness covered by aged snow but with increasing temperatures than with the color dark violett
- thick ice covered by slightly wet snow (thickness not well defined)
- ice covered by increasingly wet snow; partial pixel coverage by melt ponts possible
- ice with standing water on the surface either flat in the form of meltponds; or re-frozen water on ice



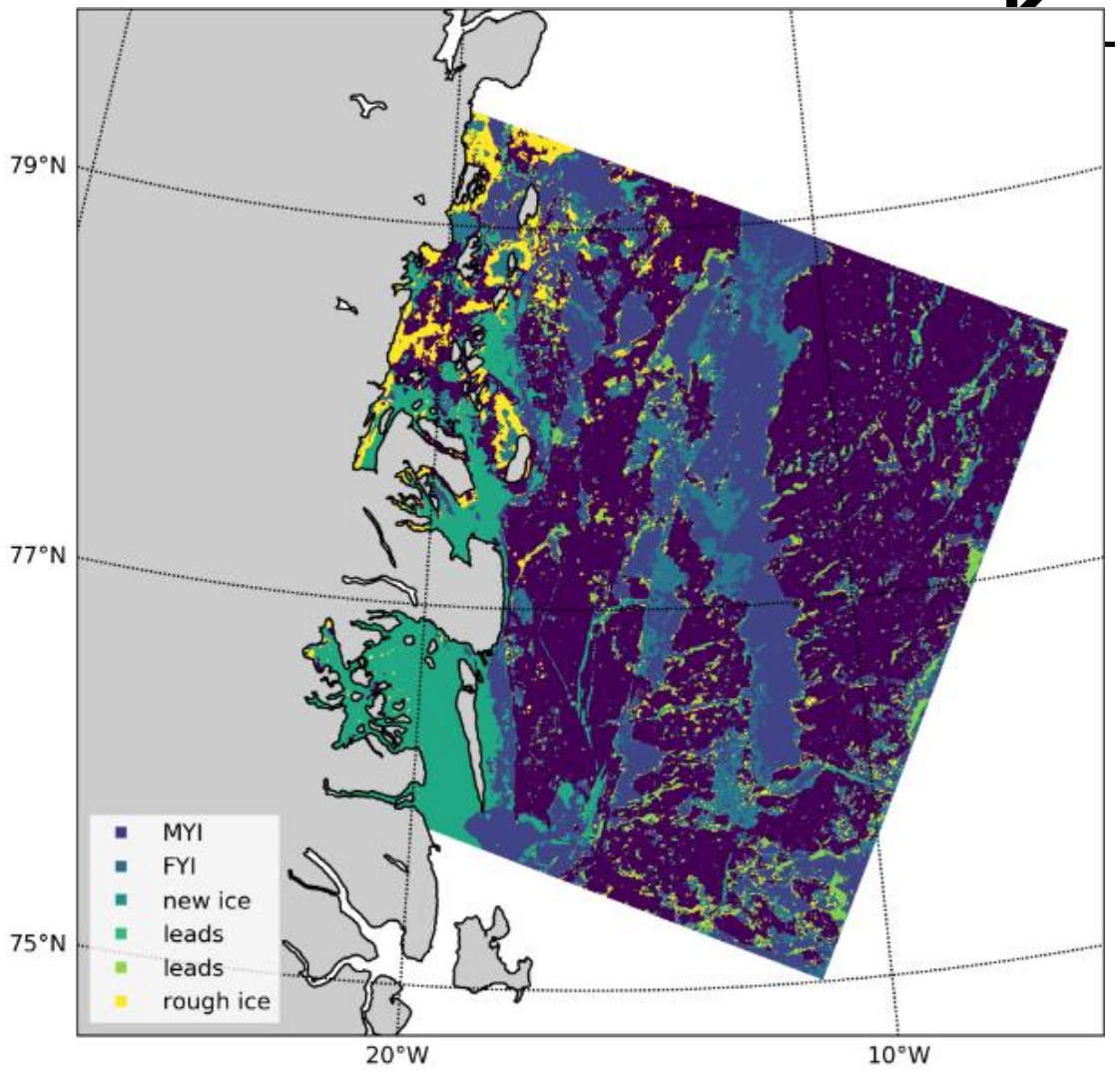
Classification example: Arctic Ocean/Nares Strait, 29/06/2020

Contains modified Copernicus Sentinel data (2020)

Sentinel-1 classification

- Convolutional Neural Network (CNN)
- Using HH+HV polarizations
- Resulting spatial resolution: 160 m
- Differentiation of six classes

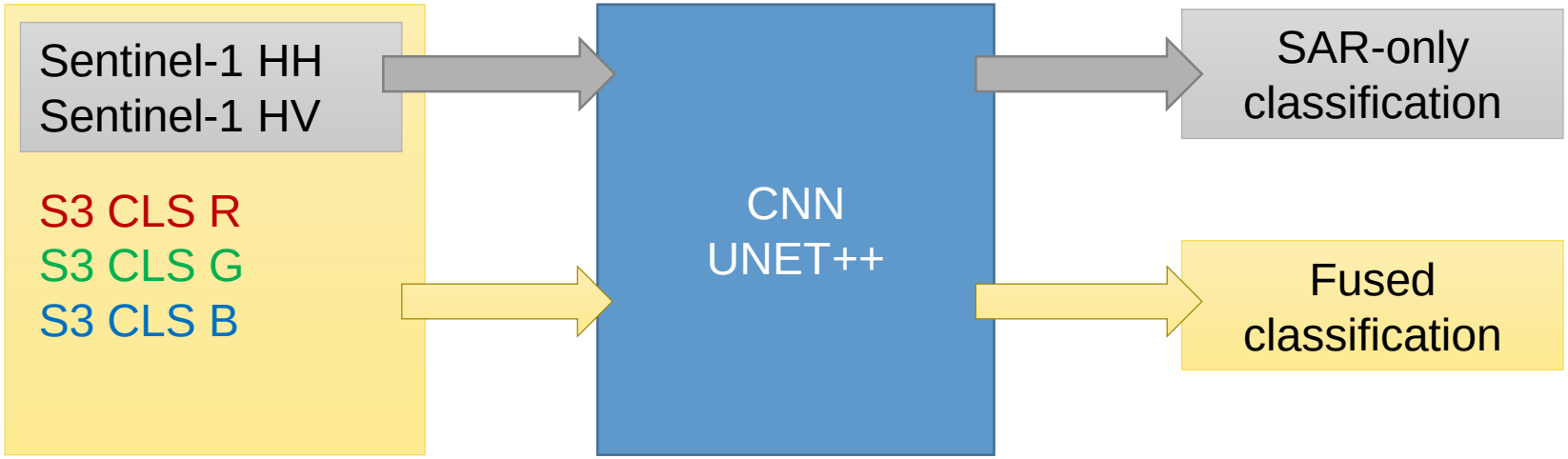
Murashkin, D.; Frost, A.: *Arctic Sea Ice Mapping Using Sentinel-1 Sar Scenes with a Convolutional Neural Network*, IGARSS 2021



Sentinel-1 sea ice classification, Greenland east coast

Fused Sea Ice Classification

- Fusion implementation based on SAR classification

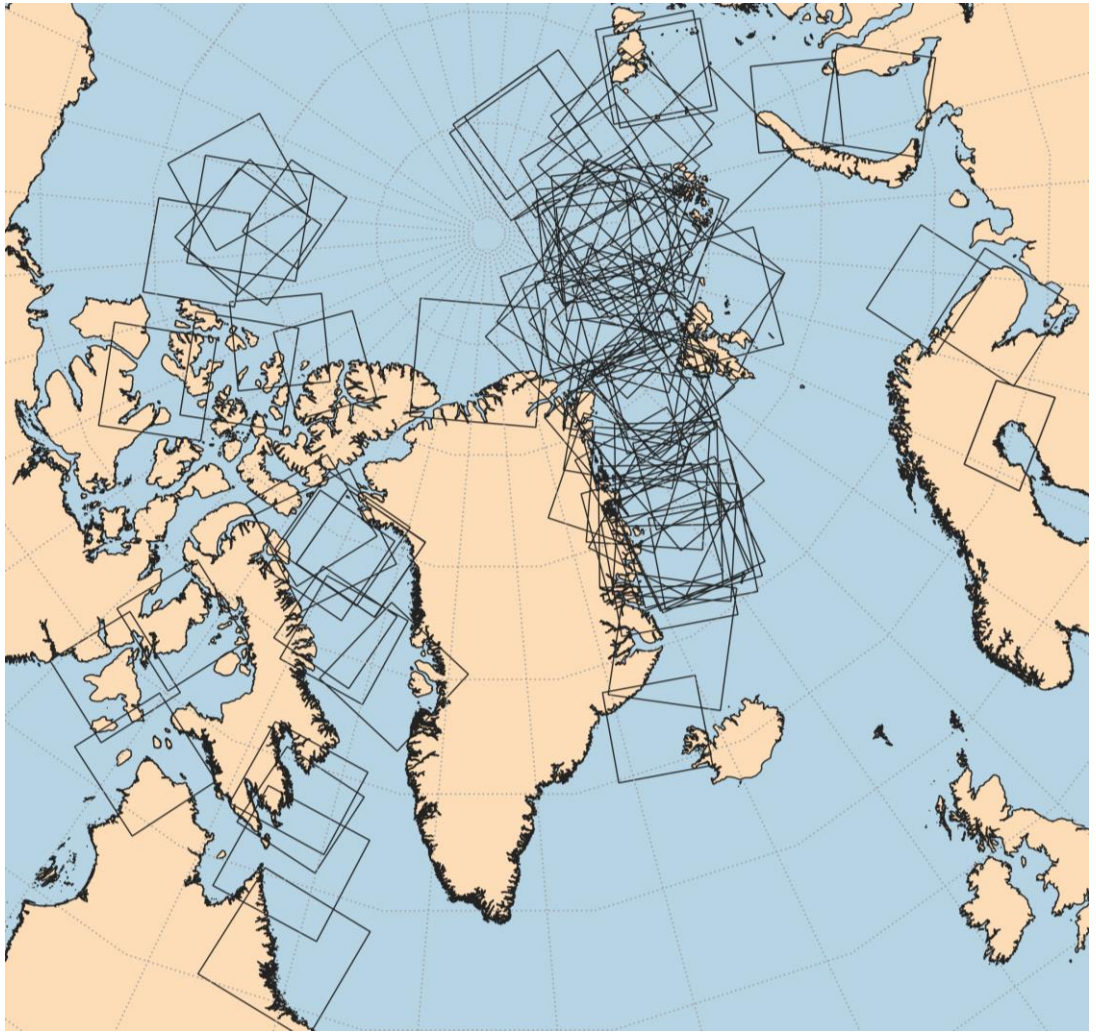


- Essentially the same network, but different training data

Data overview and collocation

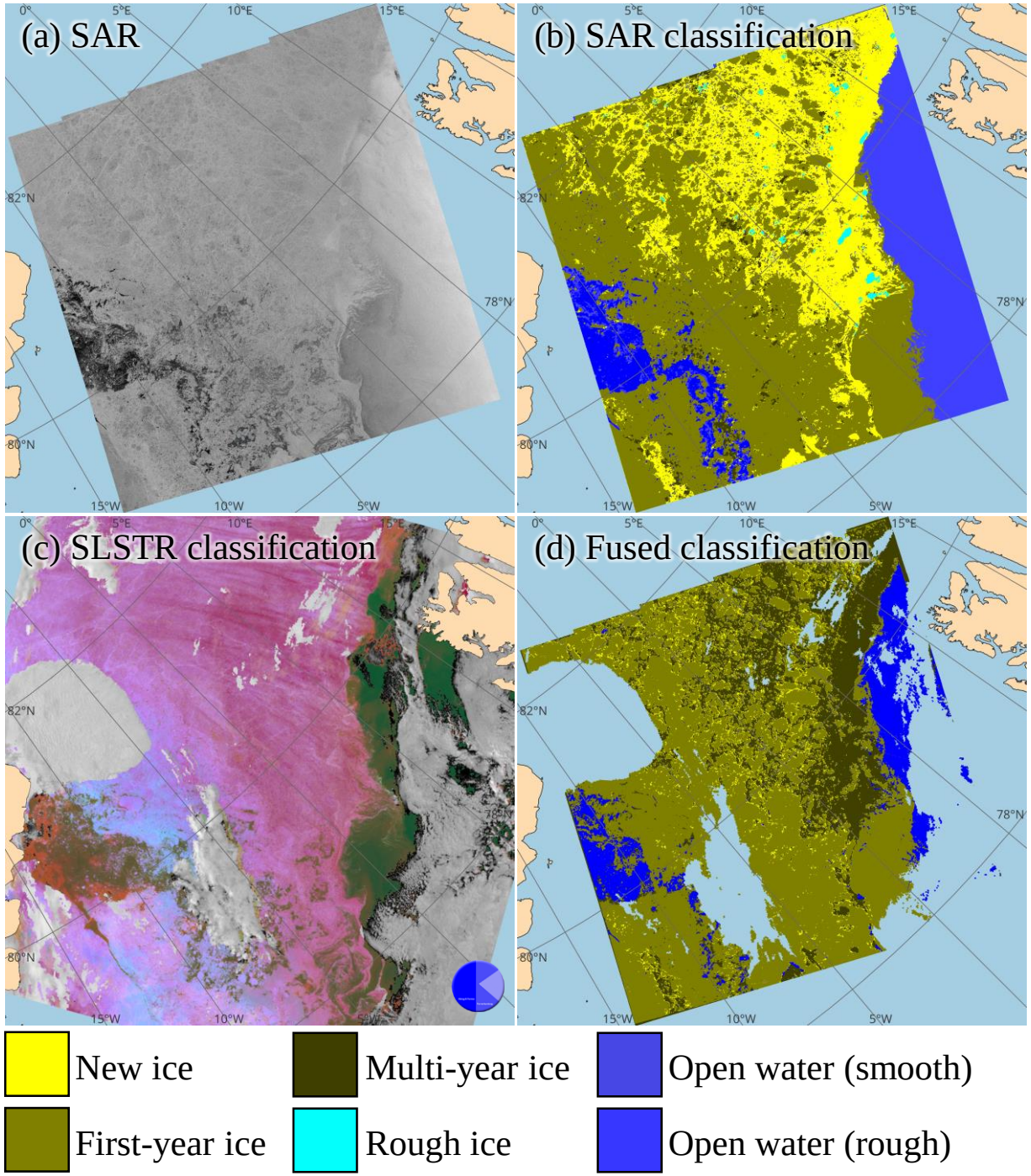
- 100 Sentinel-1 EW scenes and collocated Sentinel-3 SLSTR classifications
- Collocation steps:
  - Project to same CRS
  - Upscale S3 to S1 resolution
  - Cut to common extend

  ➔Same location in each image pixel for S1 and S3
- Validity mask applied for cloud, land, and no-data areas



Results

- Consistent results for many cases
- Fusion sometimes older/thicker ice than SAR
  - Optical classification cannot distinguish first-year and multi-year ice
  - CNN apparently learned some features there



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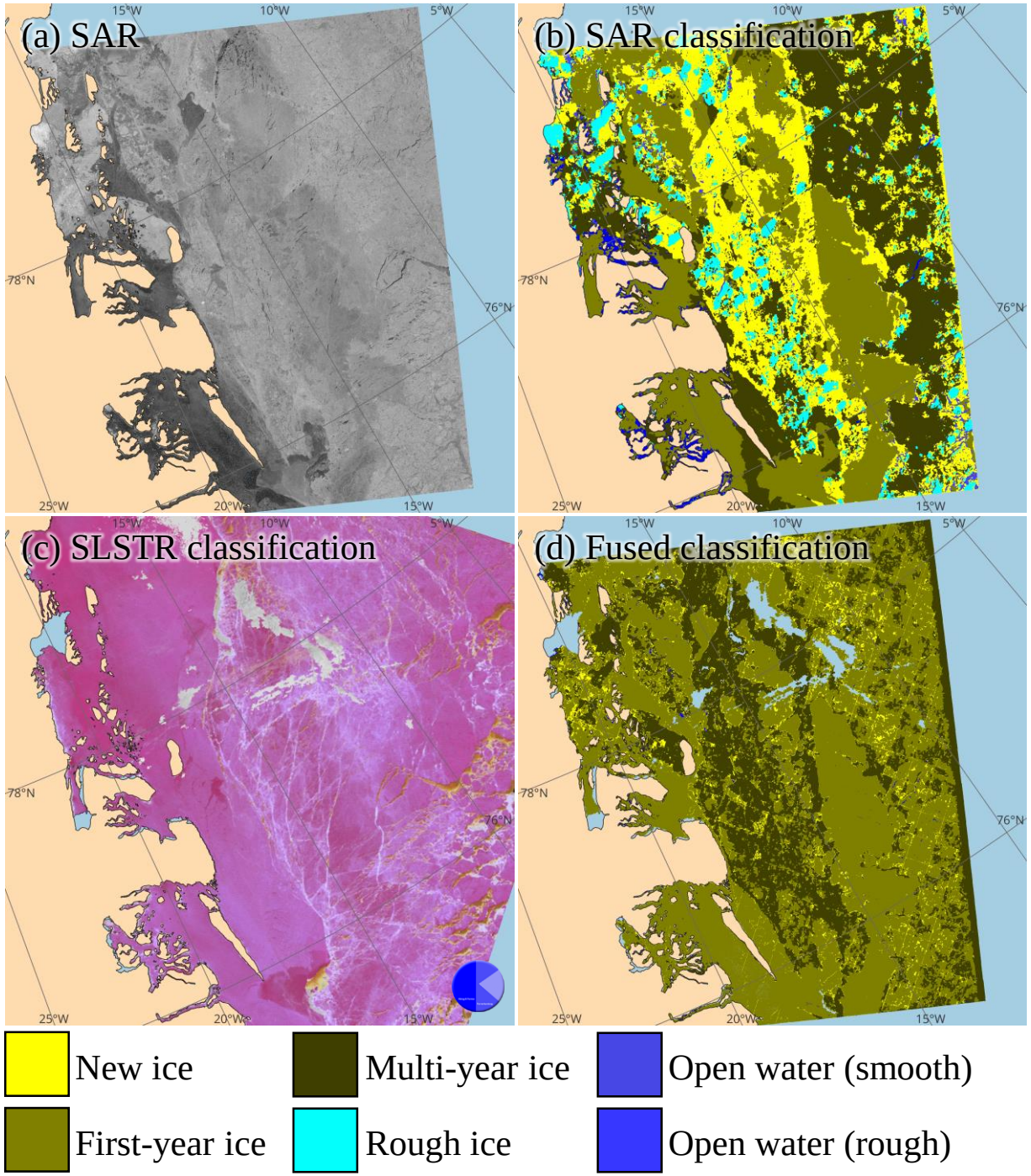
Results

- Fusion sometimes thinner ice than SAR
- Fusion better in open water detection
  - Here: no open water in the inlets



Summary

- Sea ice classification using collocated data
  - Sentinel-1 EW (HH/HV)
  - Sentinel-3 SLSTR classification (RGB)
- Consistent classification results, improvement over SAR-only classification
- More training might be needed for further improvements

- Classifications (SAR, SLSTR, fused) provided to ships in near-real time via icysea.app , developed by Drift+Noise Polar Services

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Author:	Stefan Wiehle
Institute:	Remote Sensing Technology Institute

Appendix: Unet++ for SAR