SWOT KaRInSea Ice Detection Across Resolutions

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Context

- SWOT KaRIn provides two-dimensional observations over two 60-km wide swaths
- Due to their high-resolution and low signal-to-noise ratio, KaRIn observations are well suited for cryospheric monitoring (although mission primary objectives are the ocean and land water bodies)
- In polar regions (up to 78° latitude), SWOT provides optical like spatial detail while remaining unaffected by cloud cover (an advantage over passive optical sensors)

Data Used

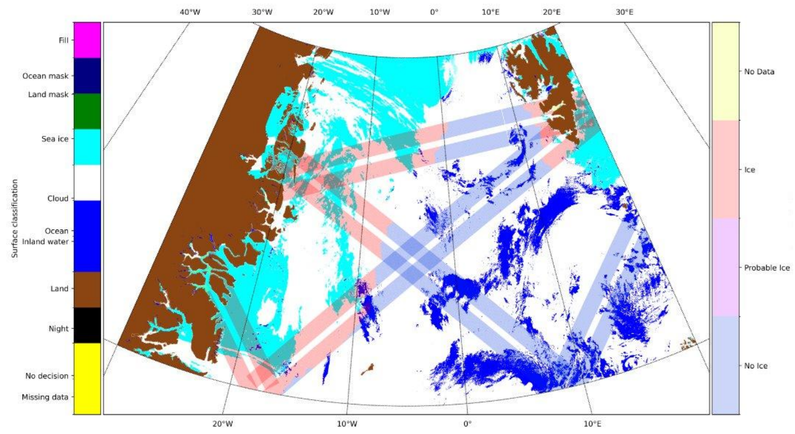
Analysis based on 3 different products/resolutions:

1. SWOT Level 2 Low-Rate @ 2 km (Smoothed)
2. SWOT Level 3 Low-Rate @ 250 m (Unsmoothed)
3. SWOT Level 2 High-Rate @ 30 to 180 m

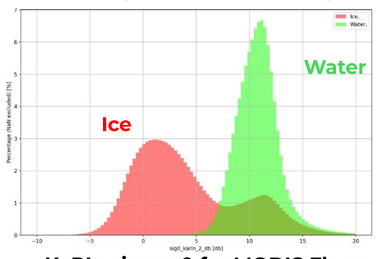
1. SWOT Level 2 Low-Rate @ 2 km (Smoothed)

- In current SWOT products, sea ice identification relies on the OSISAF model (modeled sea ice concentration interpolated from native grid onto the SWOT swaths)
- Due to the coarser model resolution relative to KaRIn measurements, SWOT ice flag exhibits limited performance
- Comparison with daily composite maps MODIS reflectance maps and surface classification shows an overestimation of the sea ice extent

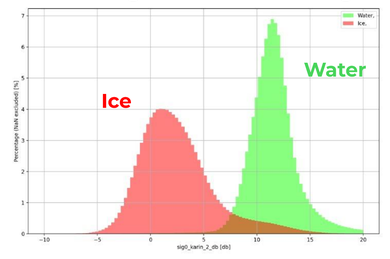
KaRIn ice flag vs MODIS surface flags



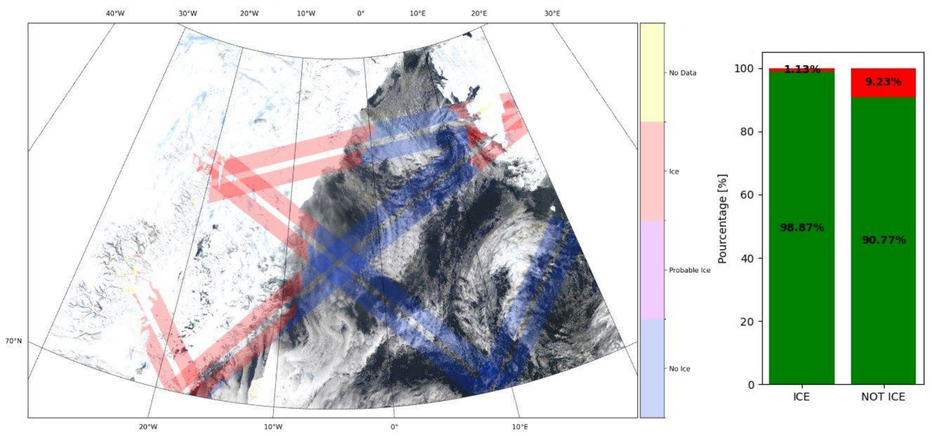
KaRIn sigma-0 for KaRIn Flags



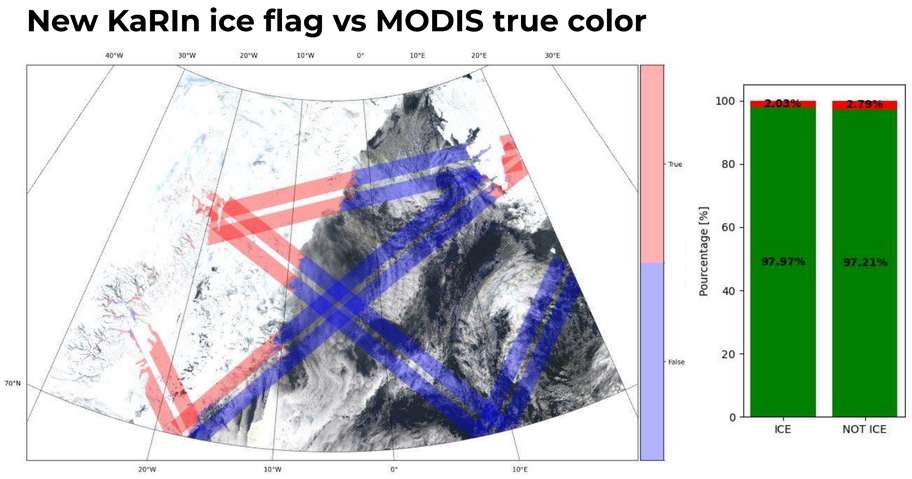
KaRIn sigma-0 for MODIS Flags



KaRIn ice flag vs MODIS true color



New KaRIn ice flag vs MODIS true color

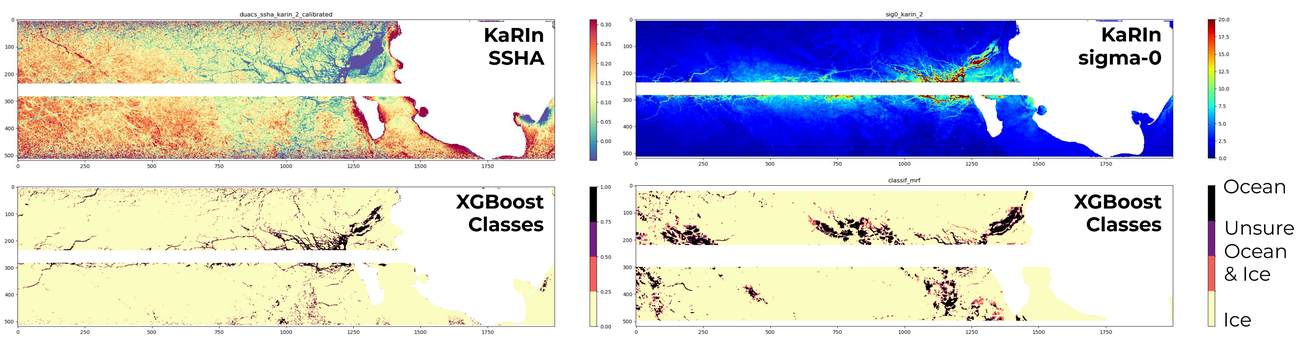


- New flag based on KaRIn sigma-0 derived parameters
- Calibrated via comparison with MODIS flags
- Promising preliminary results (i.e **less water detected as ice**, although slightly more ice non detected)

- New KaRIn-based ice flag to be further refined to account for seasonal and geographical (Arctic vs. Antarctic) variability in ice characteristics
- Both impact the average values and variance of the KaRIn sigma-0 parameters on which the new flag is based

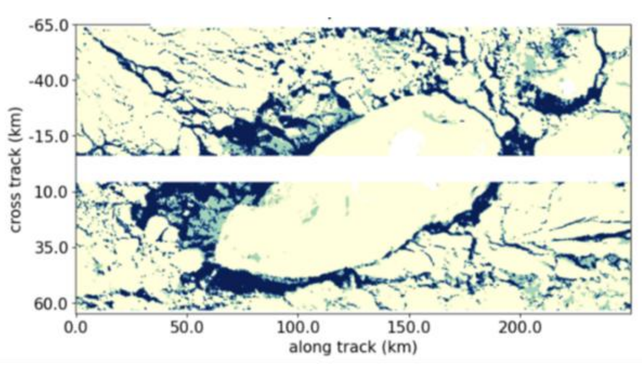
2. SWOT Level 3 Low-Rate @ 250 m

- The greater level of detail provided by KaRIn LR unsmoothed required artificial intelligence–based
- Different methods were independently implemented and evaluated by groups at CLS/CNES (left) and LEGOS/CNES (right)



- XGBoost: gives probability, sensitive to noise and to rain cells, robust to the season
- MRF: gives probability, detection of fake leads, robust to the season

For further info see the EGU 2026 presentation by Tréboutte et al.
"*Sea Ice classification in SWOT L3 products*"



surface type	flag
ocean (including leads and polynyas)	#0
probable ocean	#18
probable ice	#19
ice pack, ice floes	#20

- The classification is computed from multiple layers of k-means clustering
- Good agreement with MODIS, IceSat-2 and S3 observation

For further info see the OSTST 2026 presentation by Jestin et al.
"*Sea ice classification, concentration and freeboard using SWOT altimetry data.*"

3. SWOT Level 2 High-Rate @ 30 to 180 m

- HR sea ice classification based on k-means clustering algorithm
- Computer vision methods are applied to successive observations of the same scene (temporal spacing of 1.7 hours) to obtain measurement of the sea ice drift (red vectors)
- Preliminary study to be further extended to obtain estimates of freeboard height as well as full maps of ice drifts for both Arctic and Antarctic regions

For further info see the OSTST 2026 poster by Rivollet et al.
"*Exploring sea ice drift and concentration using SWOT HR data*"