Copernicus
Marine Service

COPERNICUS MARINE
8th GENERAL
ASSEMBLY

White Ocean Observations

C. Wettre, M. Brandt-Kreiner, I. Karagali,
J. Buus-Hinkler, T. Wulf, F. Dinessen, A. Korosov,
R. Saldo, S. Hendricks, L. Kaleschke,
J. Karvonen, J. Seppanen,C. Prevost, F. Ardhuin

Copernicus
Marine Service
PROGRAMME OF
THE EUROPEAN UNION
Copernicus
Europe's eyes on Earth
implemented by
MERCATOR
OCEAN
INTERNATIONAL

White Ocean Observations in Copernicus Marine Service

Provide invaluable data for many different user groups:

- Climate monitoring and research,
- Data assimilation and validation of ocean models
- Support for navigation and operations in ice-covered regions

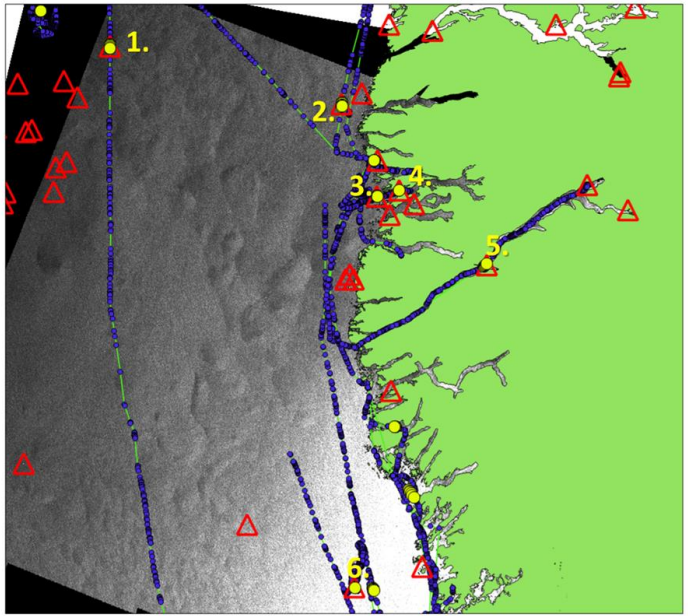
Provide a wide range of products:

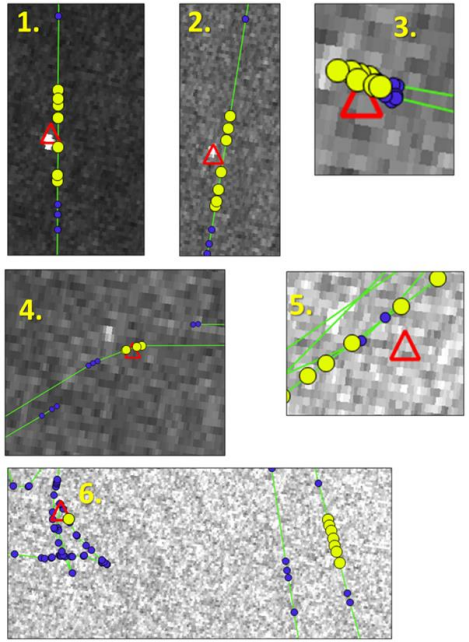
- Sea Ice Concentration, Edge, Type, Stage of development, iceberg
- Drift, Thickness, Sea and Ice Surface Temperature
- Ocean monitoring indicators; anomalies and trends

At different temporal and spatial resolutions for the Arctic, Baltic, and Antarctic

Evolutions in 2023

Automatic removal of ships (falsely detected as icebergs) was implemented with EIS 2023

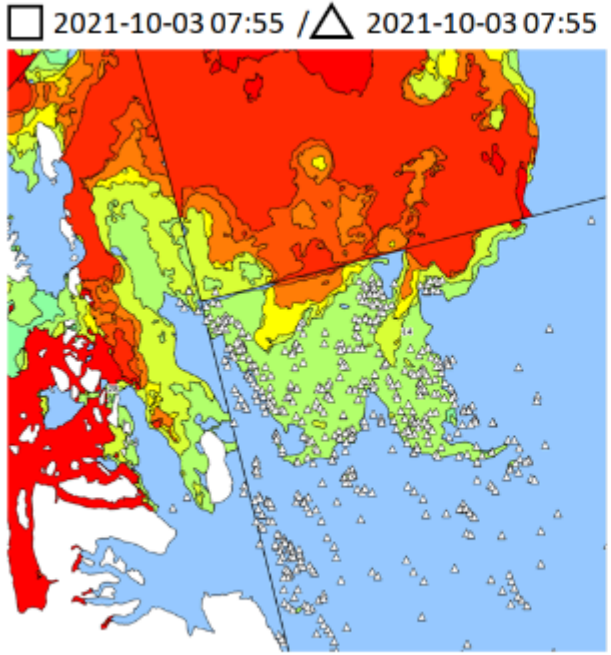




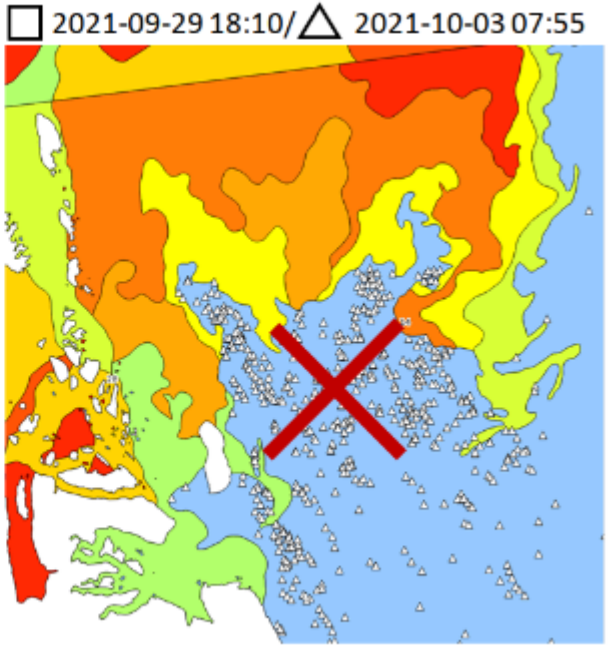
Example of “ship removal” from Southwest Greenland

Zooms 1-6:
AIS- positions highlighted with yellow are within a time-range of +- 5 mins. from satellite acquisition. Iceberg-targets (red triangles) in the vicinity of these positions are considered as ships, and will thus be removed.

New ASIP based sea-ice filter was implemented in Nov. 2023



ASIP auto ice chart + icebergs



Ice chart + icebergs

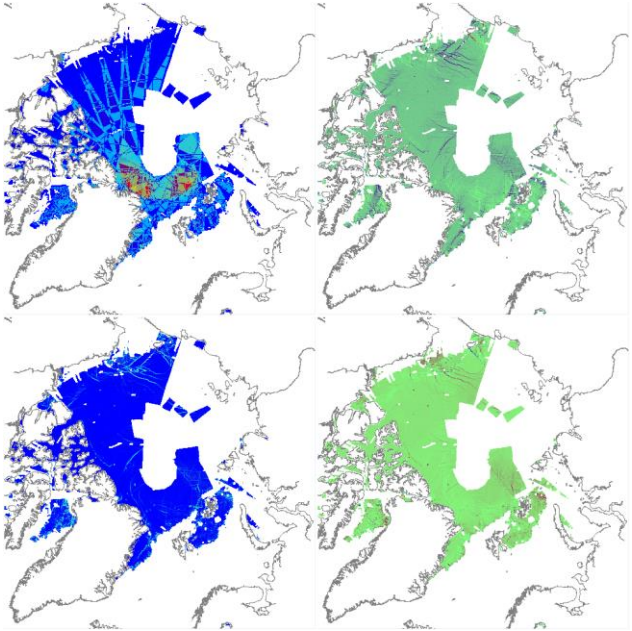
The ASIP- and iceberg products are based on exactly the same SAR scenes, and they thus match perfectly in time and space (which may not be true for ice charts and iceberg detection).

This prevents detection of false iceberg targets (i.e. sea-ice floes) near the sea-ice edge - as indicated by the red cross in the right figure.

New MY product: Global HR Sea Ice Drift

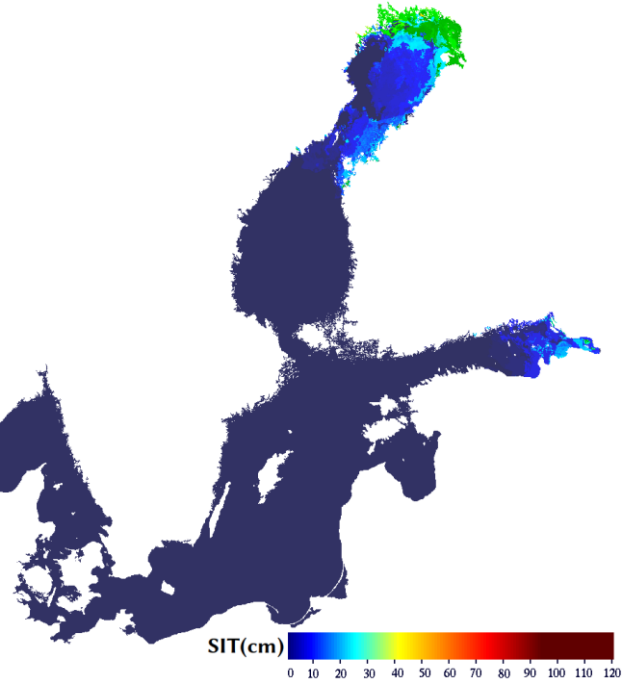
A reprocessed multi year version of the mosaic product was introduced in 2023.

Full reprocessed Sentinel1 period from 2014 until 2023 with one dataset daily. Updated yearly.



top left to bottom right:
number of samples, divergence,
shear and vorticity (pre S1B failure)

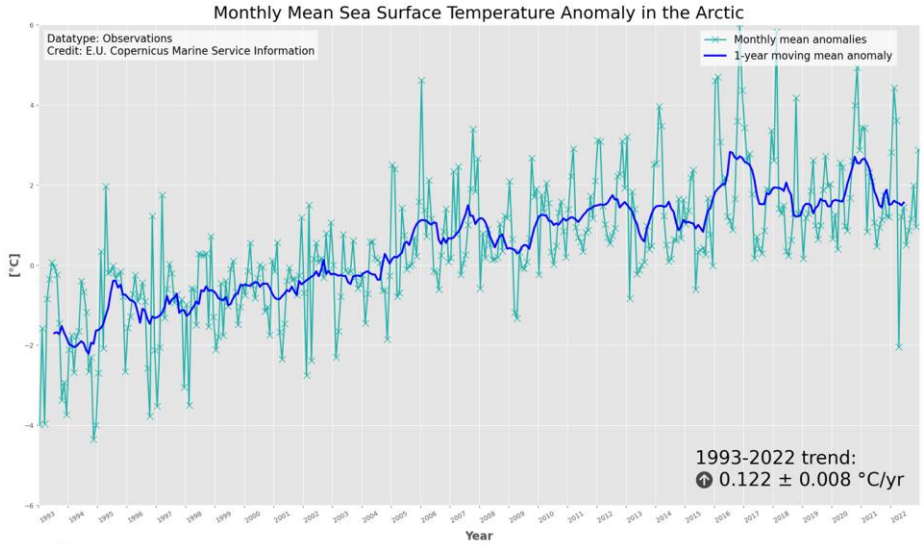
Sea Ice products for the Baltic Sea

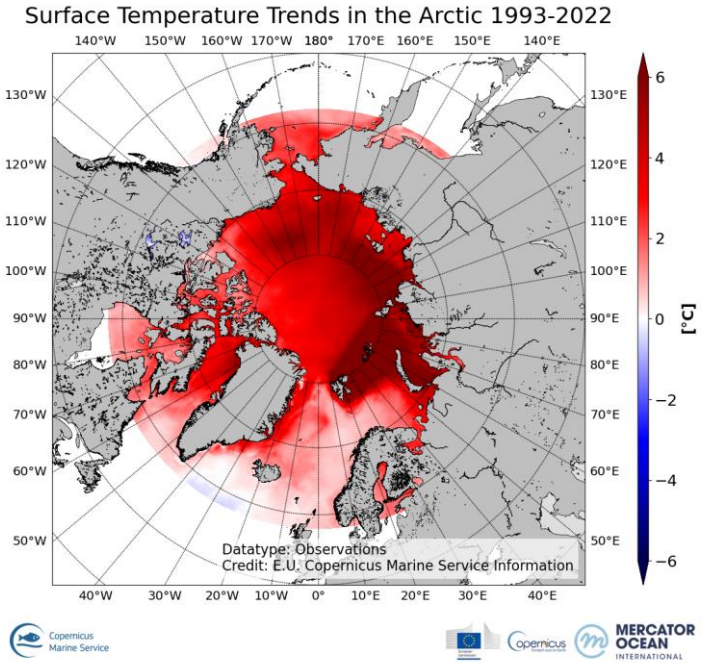


- Since Dec 2023 X-band Sea Ice Thickness based on X-band HH-polarized SAR (currently TSX, CSK and PAZ), SIT history from ice charts and a thermodynamic ice model
- Figure shows an example of X-band SIT mosaic of 1 March 2024

New Ocean Monitoring Indicators

DMI - SST/IST OMIs

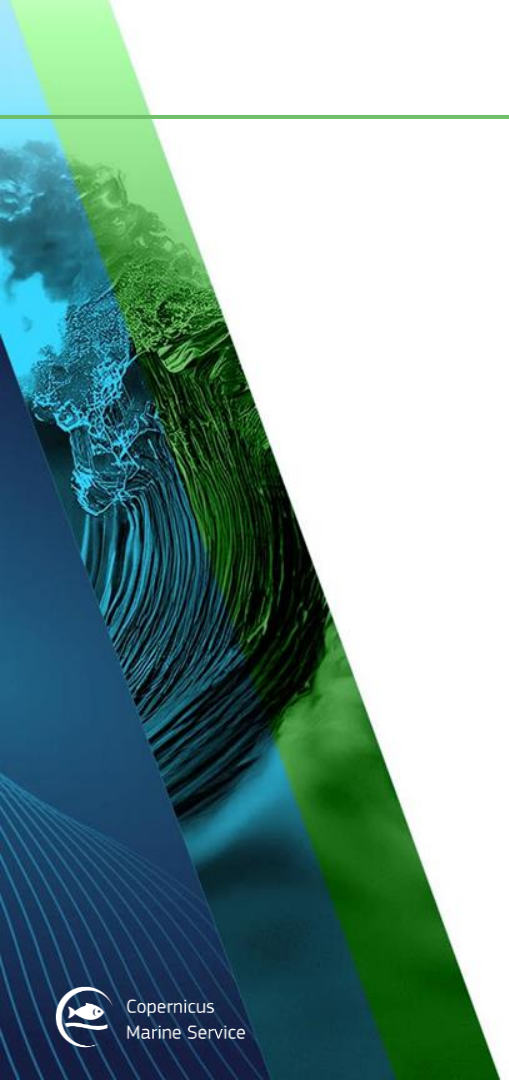




Coming in 2024

Expanded geographical coverage for several products

- Sea Ice Concentration will get pan-Arctic coverage
- Iceberg point-position-products will be geographically extended to also cover the Barents Sea
- Sea Ice Thickness: Expansion to the Southern Hemisphere of NRT product

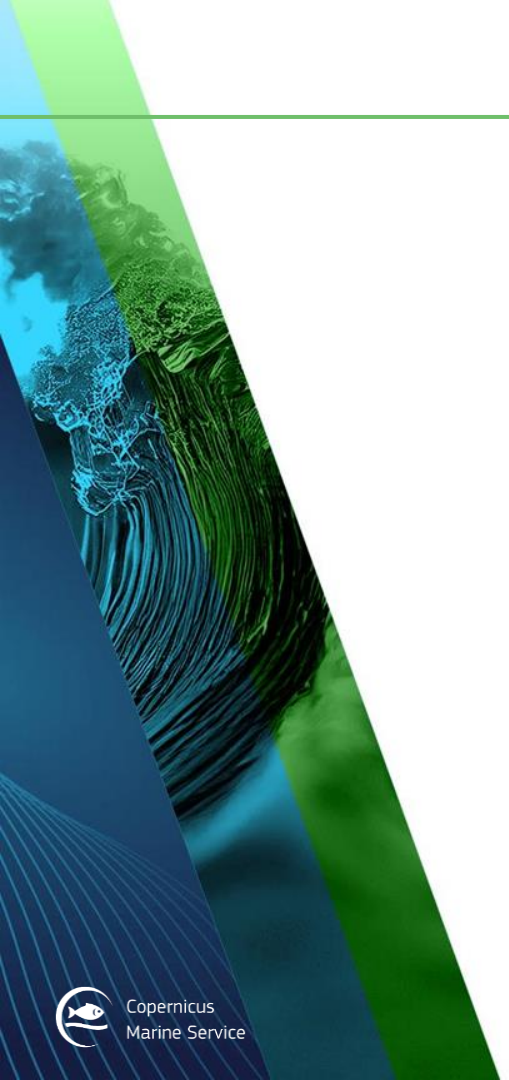


Use of AI in sea ice products continues to increase

Examples

- Greenland ice chart
- DMI-ASIP (Automated Sea Ice Products) for the Arctic and Antarctic
- Antarctic sea ice concentration replacing edge from BAS
- Study by NERSC on use of AI for deriving sea ice products from SAR and PMW data.

Copernicus Marine Service



Some datasets will be replaced

- **SEAICE_ARC_SEAICE_L4_NRT_OBSERVATIONS_011_002**
  - The **Ice charts from MET Norway** will been updated with a new data quality flag and several updates to the metadata. A spatial offset has been fixed. The new dataset will be reprocessed 2 year back in time. Dataset names change from METNO-ARC-SEAICE_CONC_L4-NRT-OBS to cmems_obs_si_arc_phy_nrt_1km_svb_P1D-irr.

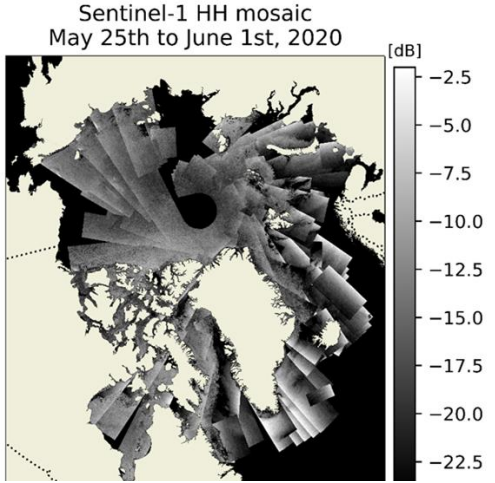
- **SEAICE_ARC_SEAICE_L3_NRT_OBSERVATIONS_011_015**
  - The **automatic sea ice product for Greenland** cmems_obs-si_arc_phy_nrt_l3_P1D will retire and be replaced by the new automatic pan-Arctic sea ice product

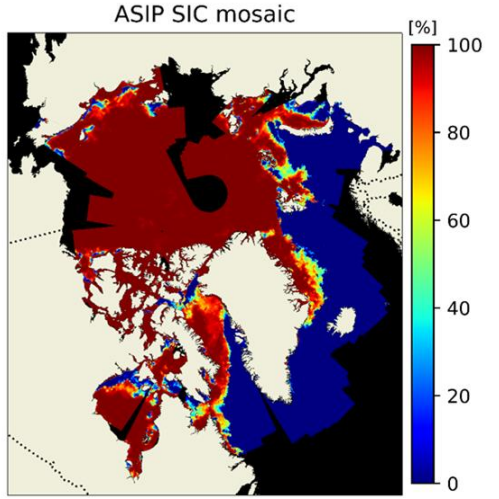
- **FMI-BAL-SEAICE_THICK-MOSAIC-SAR-NRT-OBS**
  - The **Baltic Sea ice thickness mosaic dataset** will be replaced by a new dataset cmems_obs-si_bal_phy-sit_nrt_l4_P1D_m. The new dataset will include all the ice thickness information based on C- and X-band SAR instruments. The old product only includes SIT based on C-band wide swath data.

PanArctic Sea Ice products

Daily SAR-based sea ice concentration, stage-of-development and floe size information,
and associated uncertainties:

- Available in CMEMS catalogue from EIS Nov. 2024
- Based on improved version of the CNN-model used for the Greenland and Antarctic products (on previous slide).
- Will be available as L3 MY and NRT datasets, covering the period from 2014 to NRT daily updates.
- In addition, L4 MY and NRT datasets will be available, where the L3 mosaic is "gap-filled" with OSI SAF SIC data.





The Danish Meteorological Institute

Norwegian Meteorological Institute

NERSC

Copernicus Marine Service

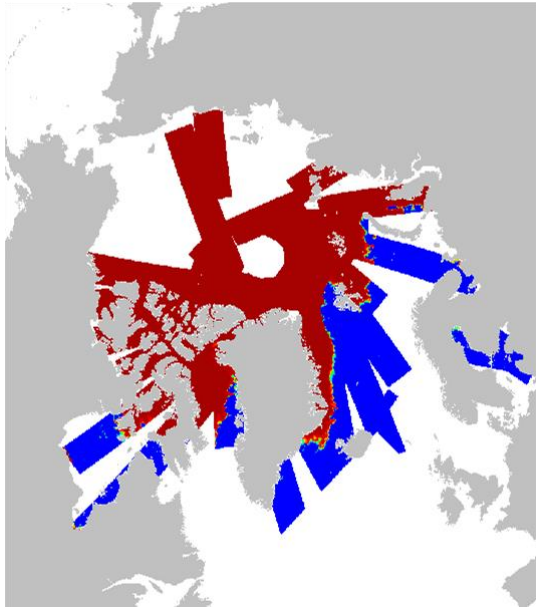
Pan-Arctic Sea Ice Concentration product gap-filling with AMSR2 (passive microwave) data:

The daily L3 product will be used as basis.

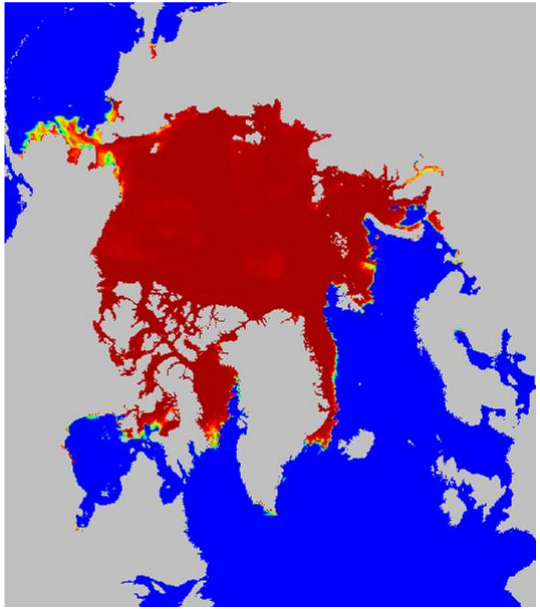
OSISAF SIC will be used to fill areas not covered by the L3

A status layer indicate used data source.

Level 3



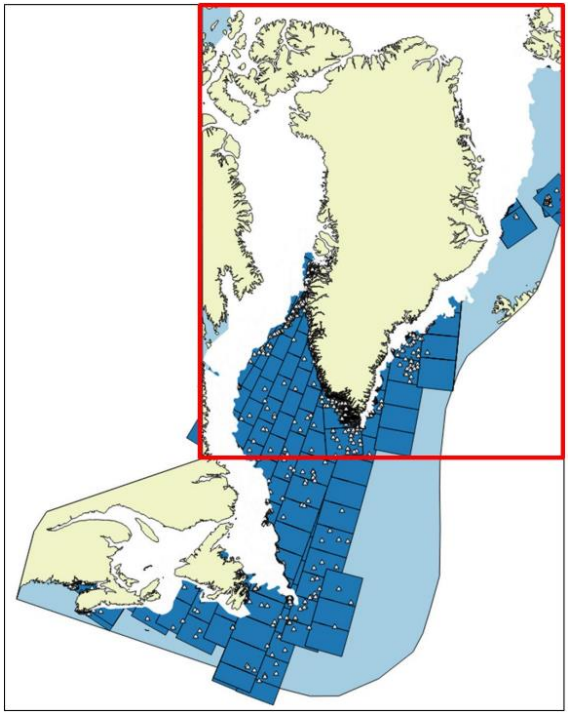
Level 4



Norwegian Meteorological Institute

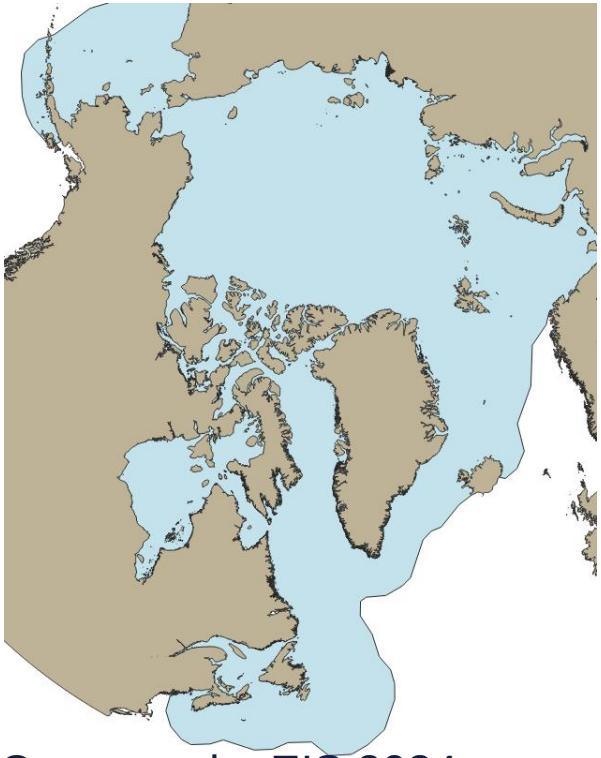
Copernicus Marine Service

Extended iceberg AOI by EIS 2024 - towards Pan-Arctic coverage



Present coverage

- With the new DMI-ASIP sea-ice level-3 product “Filtering out” ice infested areas at Pan-Arctic level is now possible in NRT.
- Thus, along with introduction of the Pan-Arctic DMI-ASIP sea-ice product (L3), the geographical extent of iceberg products will be extended accordingly (using the same SAR scenes for both products).
- In the first place the extension will only be applied for the point-position (vector) datasets.
- In the future, when sufficient observations are available for “built-in” statistics, the extension will be applied also to the gridded concentration-datasets



Coverage by EIS 2024

Copernicus Marine Service

Red polygon indicates gridded coverage for iceberg concentration

Sea Ice Type Evolutions

Testing informativeness of satellite data:

Different combinations of ice concentration, ice type and floes size distributions were attempted to be derived from SAR and PMW data.

The accuracy matrix shows that some combinations are reconstructed well and some are confused.

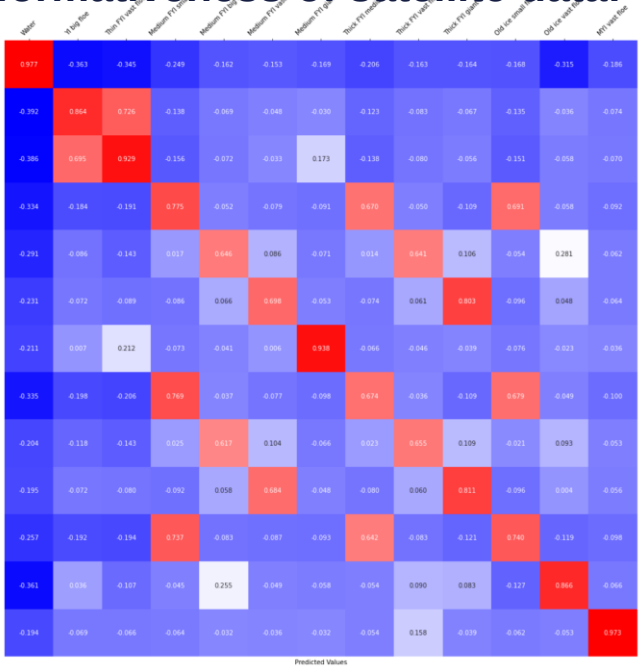
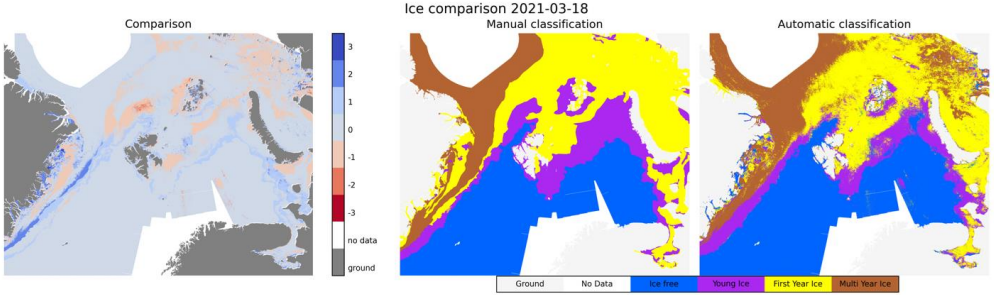


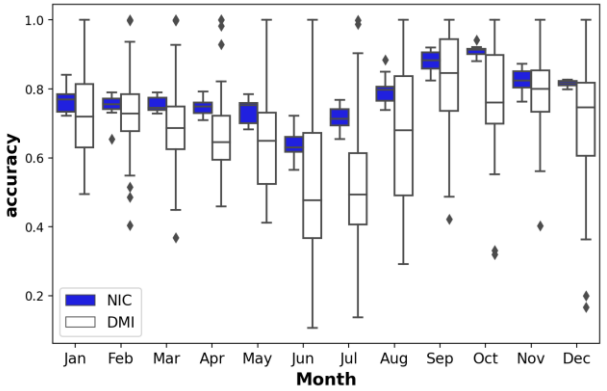
Figure 4.16: The Pearson correlation matrix by the 13 classes network with AMSR2

Conclusions:
Not all combinations of type and form of ice are well presented in training data and retrievable from SAR/PMW data. A list of feasible combinations of SoD and FoI is downselected for future.

Sea Ice Type Evolutions

Thorough Validation of the Current Sea Ice Type Product



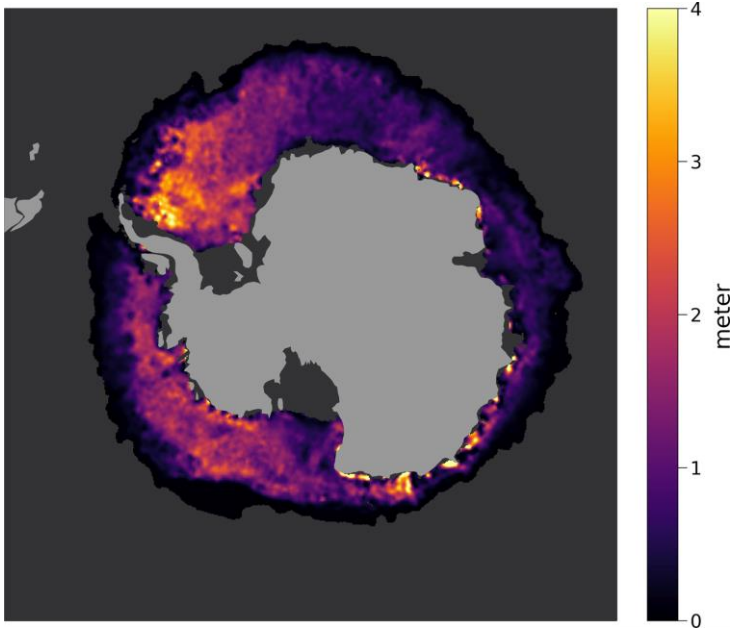


The automated ice type product was validated against the U.S. (NIC) and Danish (DMI) ice charts for 3+ years of operation (2021 - now). Validation shows that accuracy is lower in summer (especially for DMI ice charts that were not used in training).

A new operational and MY-product based on SAR and PMW data is developed by DMI to overcome that.

NRT Sea Ice Thickness in Antarctica

Near real-time sea ice thickness information will be extended with data coverage to the southern hemisphere. The data files will be brokered from the ESA SMOS & CryoSat-2 Sea Ice Data Product Processing and Dissemination Service.

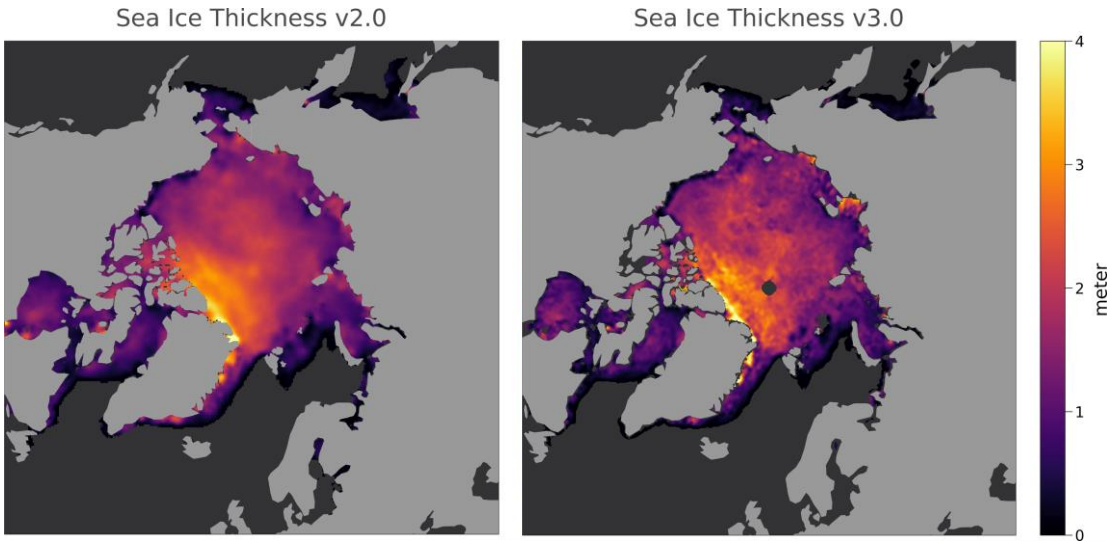


Sea Ice Thickness based on optimal interpolation of CryoSat-2, Sentinel-3A, Sentinel-3B (radar altimetry) and SMOS (L-Band radiometry data).
2. September 2023 (grid resolution: 12.5 km)

NRT Sea Ice Thickness - Increased resolution

Data from Sentinel-3A/B will be included in the optimal interpolation scheme with adjustment of optimal interpolation window size and duration of the observation period to improve temporal and spatial resolution

Example: April 2nd, 2023



CryoSat-2 & SMOS @ 25 km

CryoSat-2, Sentinel-3A, Sentinel-3B & SMOS @ 12.5 km

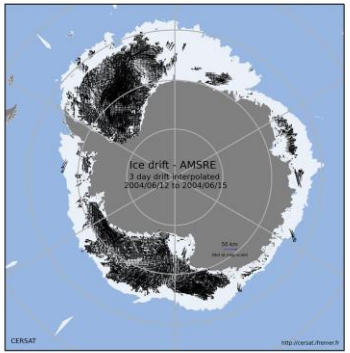
Sea Ice Drift from Scatterometer and Passive Microwave Radiometer

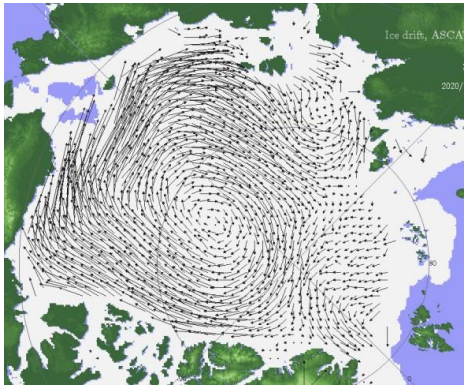
Arctic

- Extend the temporal coverage of MY product (addition of the December 2023-November 2024 dataset) using scatterometer-radiometer **merged** dataset (using available ASCAT data from MetOp-A, -B and -C, CFOSAT & SSM/I).

Both Arctic and Antarctic:

- The temporal coverage of the Antarctic reprocessed sea ice drift time series based on AMSR datasets will be extended in 2024 if data is available.





Sea Ice products for the Baltic Sea

- From Dec 2024 a daily **SIT mosaic** based on **all the available single SAR SIT products** (C-band HH/HV from RS-2 and RCM, C-band VV/VH from S-1, and X-band HH from TSX, CSK and PAZ)

Other planned evolutions:

- **Sea ice deformation based on advanced Machine Learning (ML)**
- **New C-band HH/HV SIT algorithm**
- **New SIC algorithm based on advanced ML**
- **Daily SID mosaic**





The Sea Ice TAC Team!