A Synthetic Aperture Radar (SAR) image of sea ice, showing a dark, textured surface with some lighter, irregular patches. The image is oriented vertically, with the top of the frame showing the ice edge. The background is white.

## Sea Ice monitoring from S-1 SAR data

Alexandru Gegiuc<sup>1\*</sup>, Juha Karvonen, Markku Similä, Marko Mäkynen, Mikko Lensuu,  
Patrick Eriksson, Jouni Vainio, Anni Montonen, Tuomas Niskanen, Eero Rinne

Finnish Meteorological Institute (FMI), PB 503, FI-00101, Helsinki, Finland

<sup>1</sup>Email: [firstname.lastname@fmi.fi](mailto:firstname.lastname@fmi.fi)

09 November 2018

BalticSatApps Copernicus User Uptake

## Sea Ice

Sea Ice affects the shipping navigation and needs to be monitored:

- in real time to inform users about the ice situation and avoid accidents or save money
- for long time analysis of the ice changes to understand the changes of the environment, develop new monitoring techniques, and ideally to forecast the ice situation for shipping routes optimization.



Aranda Research Vessel in Gulf of Finland

Photo from: <http://www.physics.helsinki.fi/tutkimus/get/english/geo/proj/seaice.html>



## Research



Nearly 1,100 people were trapped on two passenger ferries and two cargo ships that got stuck in ice in the Baltic Sea.



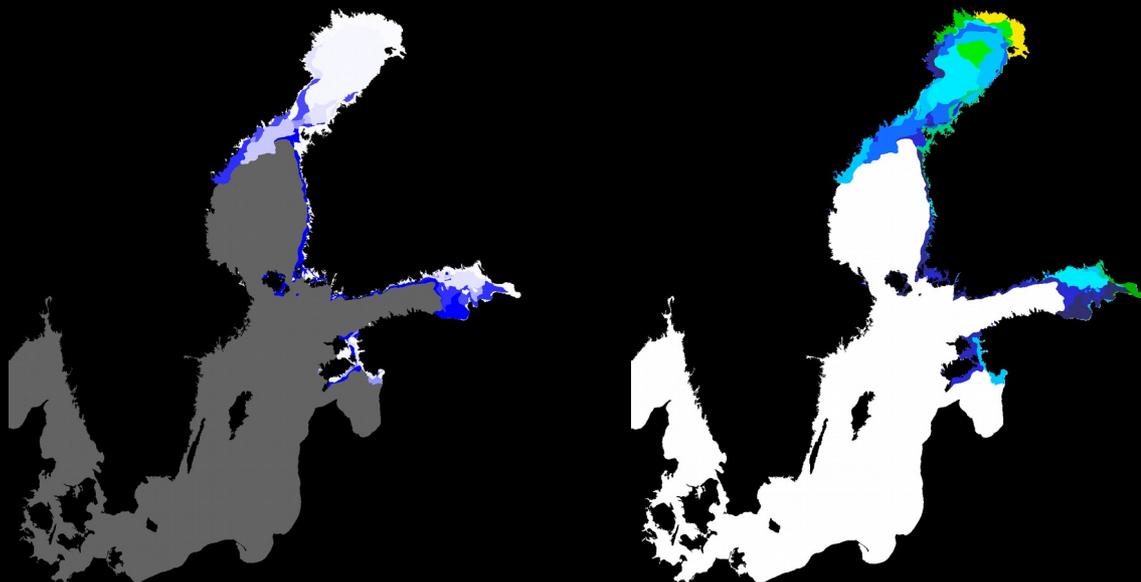
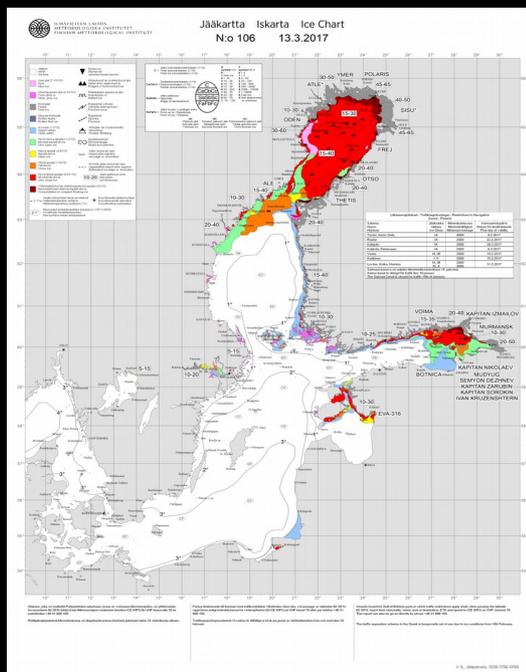
9:44PM GMT 04 Mar 2010

Photo: REUTERS  
Source: <http://www.telegraph.co.uk/>

## Navigation



# Ice Charting



# Automated Sea Ice products

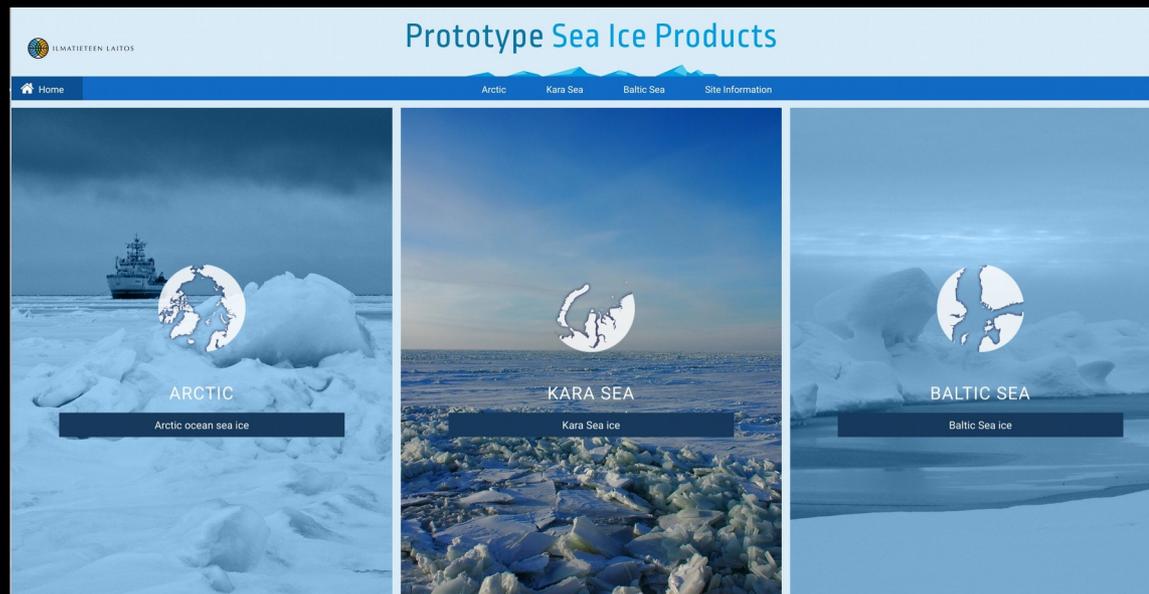


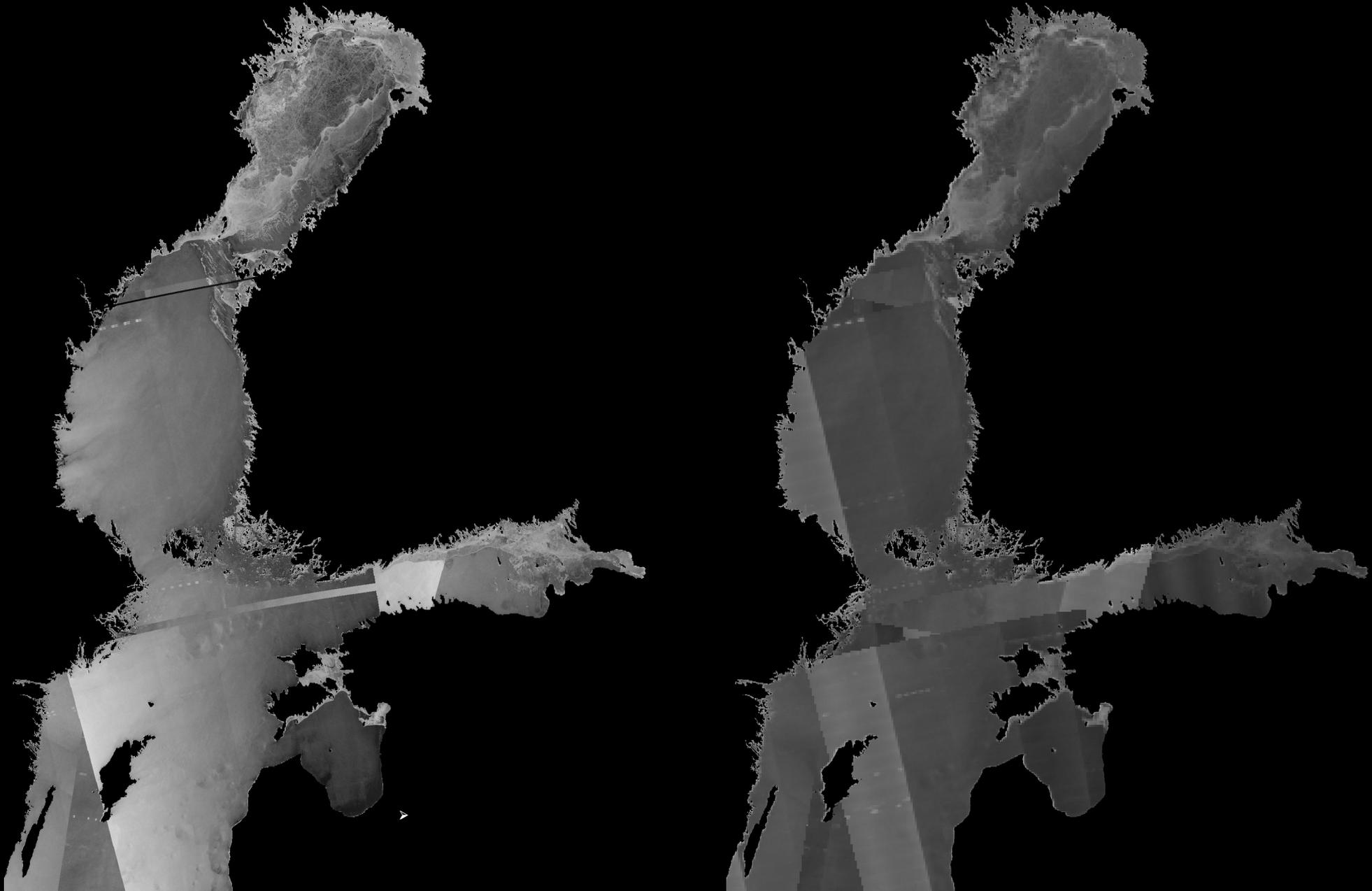
## CMEMS

- Copernicus Marine environmental monitoring service (CMEMS) is a part of the EC funded Copernicus programme.
- Copernicus programme consists of the space component (SENTINEL's), InSitu component, and service component. CMEMS is the marine monitoring service under the service component.
- Provides marine data derived from EO data and forecasts. The products are currently in NetCDF format, other formats are under consideration.
- FMI (CMEMS Baltic production unit) provides the Baltic Sea ice information based mainly on EO data.  
Current FMI products:
  - SIC and SIT based on daily ice charts.
  - SIT based on C-band SAR data.
  - Ice drift based on multi-temporal SAR analysis.
- Data freely available on <http://marine.copernicus.eu> (requires registration)



- S1 IW (VV/VH) mode data are used only in ice charting and EW (HH/HV) mode data are used for automated products. HH/HV is better suitable for sea ice monitoring than VV/VH.
- Current setup: EW (HH/HV) from S1B and IW (VV/VH) from S1A.
- automated products using S1 IW (VV/VH) mode under development.
- Fully automatic production and dissemination through <http://ice.fmi.fi/> and the CMEMS portal <http://marine.copernicus.eu/>.





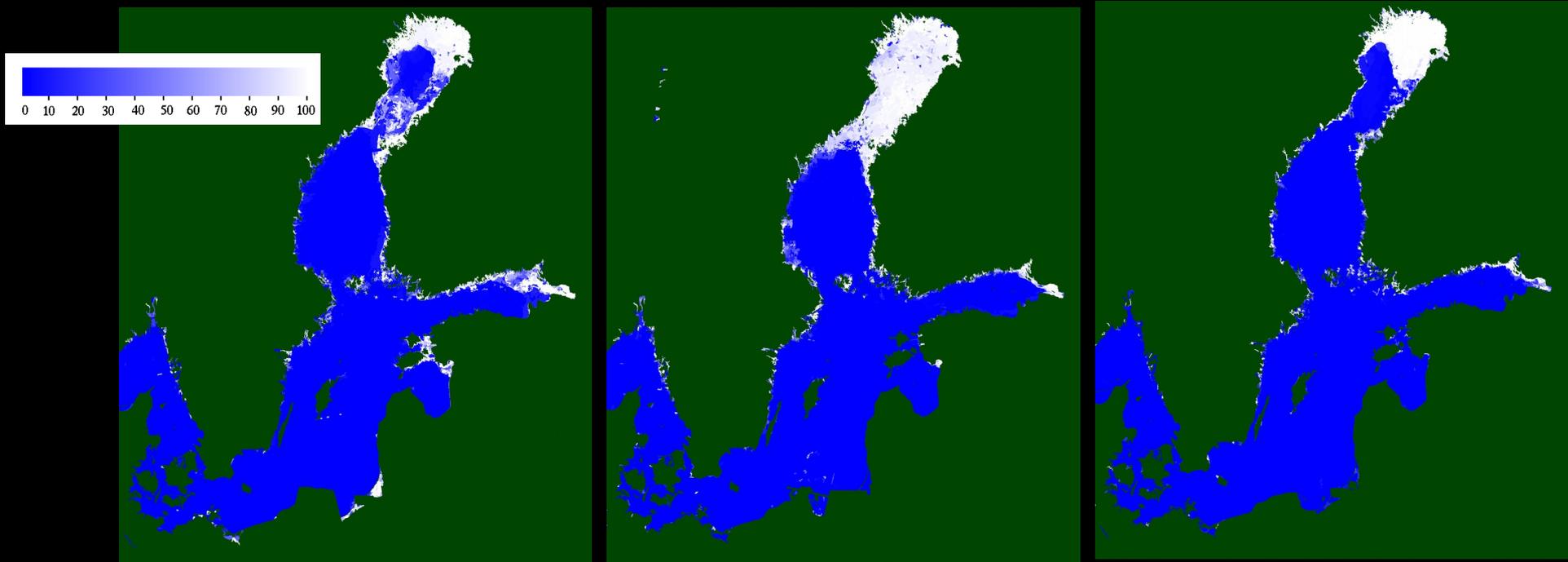
SAR mosaics of Feb 14 2018, HH on the left and HV on the right.

## Sea Ice Concentration (SIC)

- Not an operational CMEMS products yet.
- Based on SENTINEL-1 and RADARSAT-2 dual-polarized SAR data and AMSR-2 passive microwave radiometer brightness temperatures on several frequency channels.
- Produced as daily mosaics covering the Baltic Sea (500m res).

→ Publication:

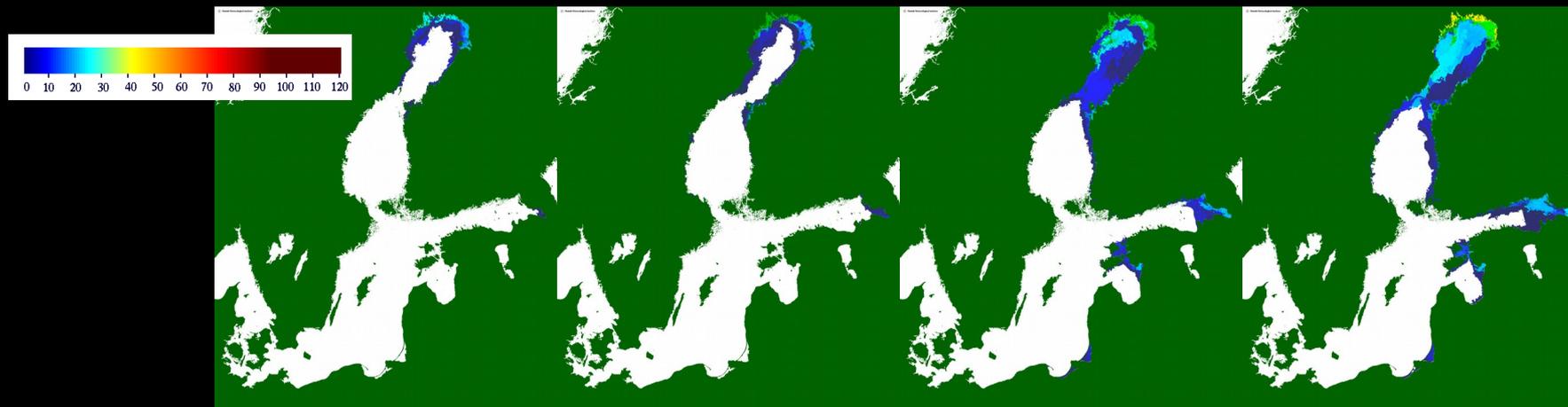
Juha Karvonen, Baltic Sea Ice Concentration Estimation Using SENTINEL-1 SAR and AMSR2 Microwave Radiometer Data, IEEE Transactions on Geoscience and Remote Sensing, v. 55, n. 5, pp. 2871 - 2883, 2017.



SIC based on C-band SAR and AMSR-2 at the end of Jan, Feb and March 2016.

## Sea Ice Thickness (SIT)

- Resolution 500 m.
- Based SENTINEL-1 and RADARSAT-2 SAR data and ice thickness history from ice charts. Also modeled background SIT can be used instead of ice charts.
- Both SIT based on single SAR frames and SIT mosaics (twice daily) provided.



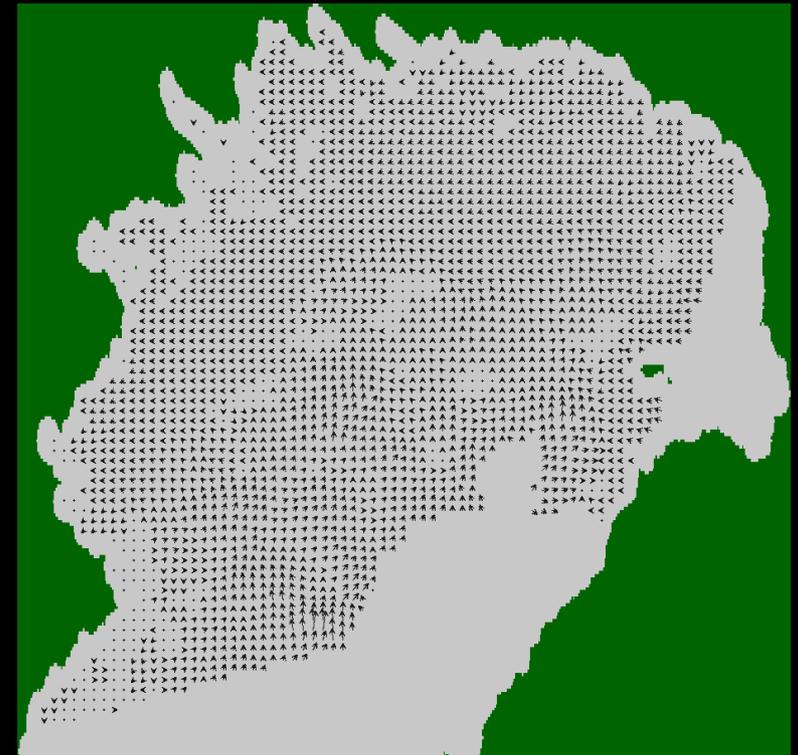
SIT mosaics of Jan 1, Jan 15, Feb 1 and Feb 15, 2018.

## Sea Ice Drift (SID)

- Resolution 800 m.
- An operational (CMEMS) product.
- Based on locating the same features in overlapping C-band SAR image pairs by maximum phase correlation.
- Plans of a mosaicked Baltic SID product.

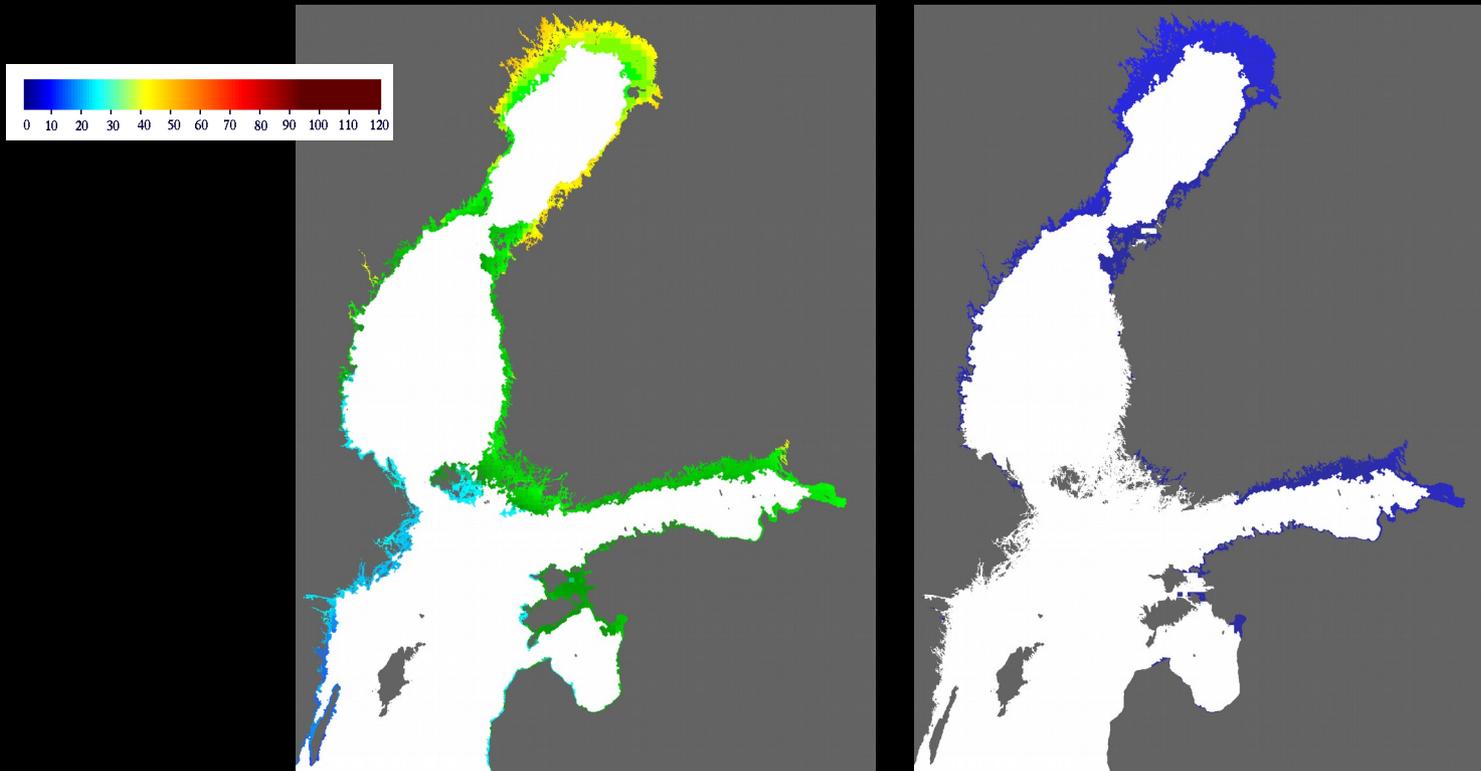
→ Publication:  
Juha Karvonen,  
Operational SAR-based sea ice drift monitoring  
over the Baltic Sea, Ocean Science 8(4),  
473-483, 2012.

Estimated ice drift vector field (Gulf of Bothnia)  
between Feb 10 2018 15:49:06 UTC and Feb 11  
2018 05:12:27 UTC.



## Baltic Sea Landfast Ice (BAL-FI)

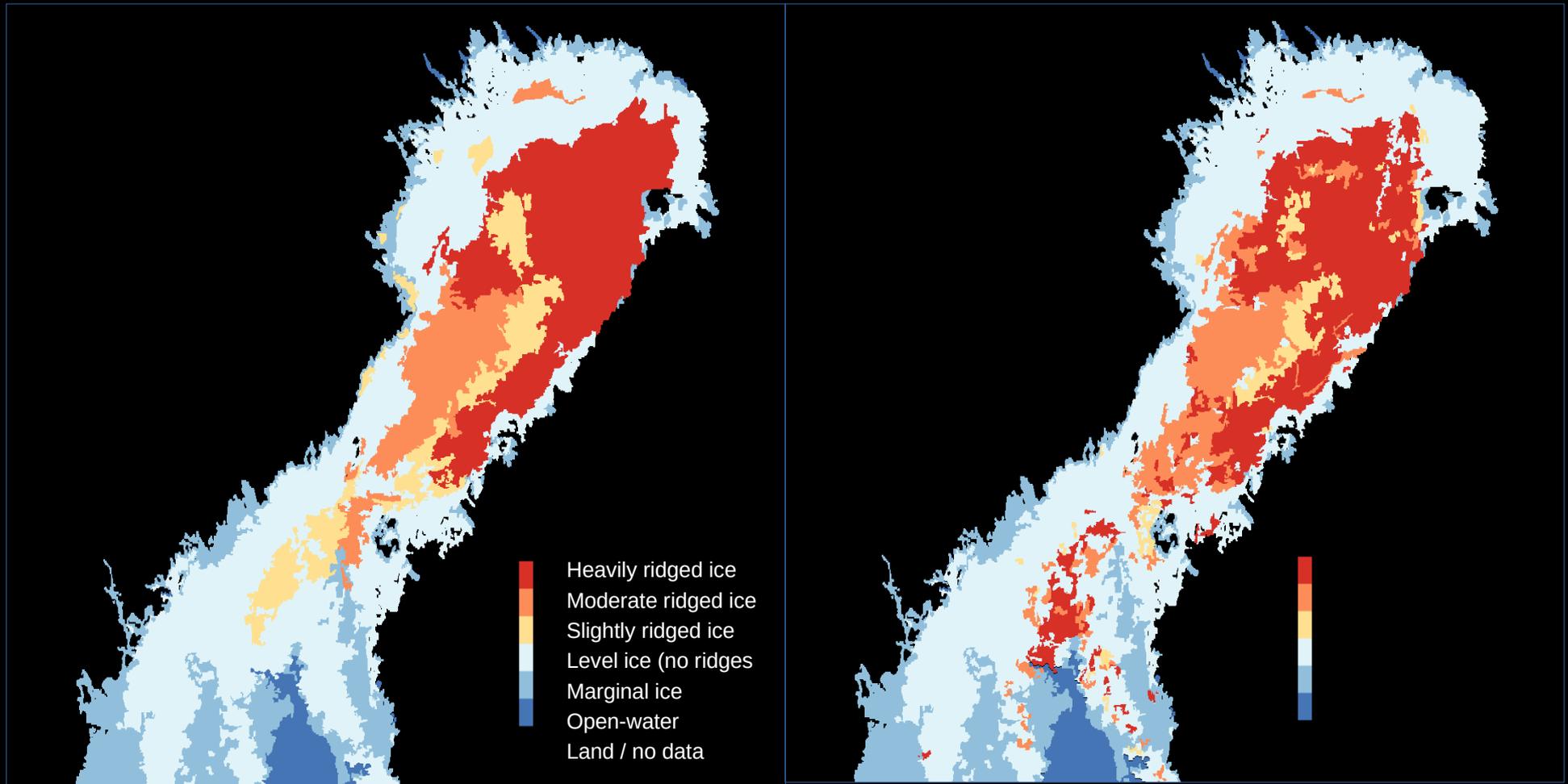
- A new free CMEMS downstream service will be launched in winter 2018-2019.
- A web service giving detailed information over the Baltic fast ice zone, such as ice and snow thickness, location of major ship tracks.
- Targeting to all leisure and professional activities over the fast ice zone (ice roads, fishing, skiing, skating, etc.)



## Degree of Sea ice Ridging (DIR)

(non-operational, development/test phase)

- based on SAR and Ice Chart data (IC + DIR)
- indicates areas where the ice is easy (light blue) or difficult to navigate through (red)

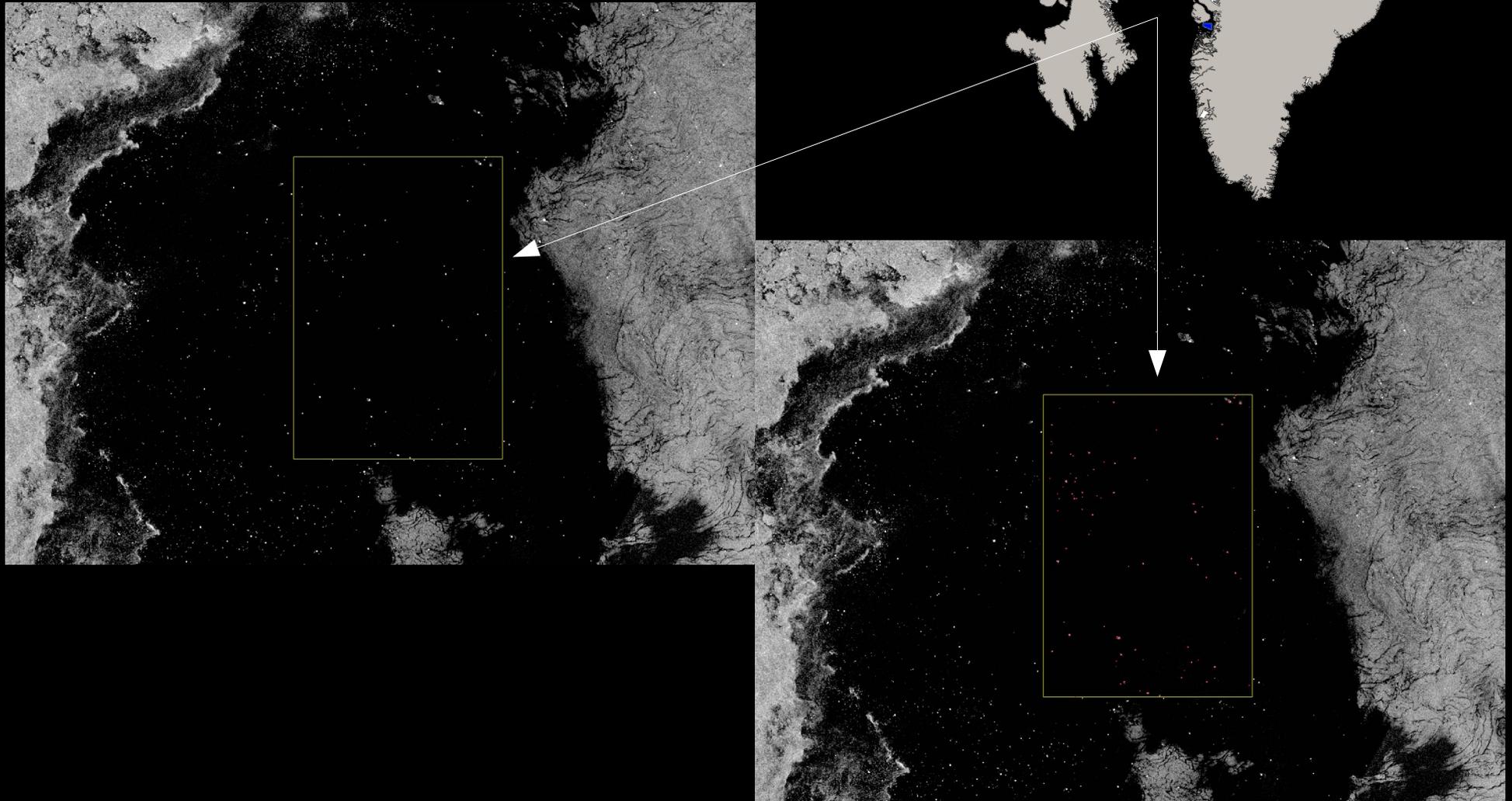




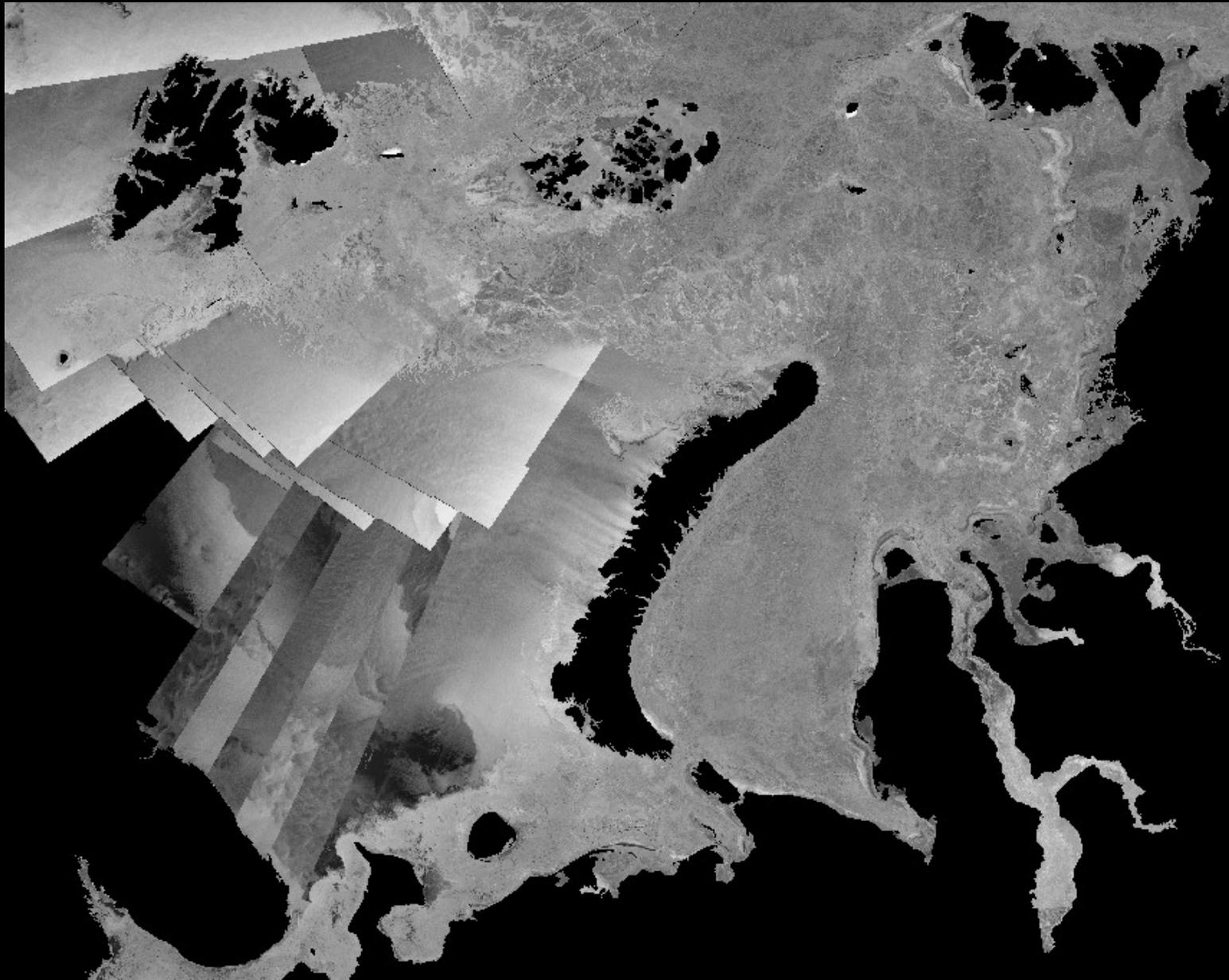
## Arctic Products

- Products mainly based on S-1 data complemented by AMSR2.
- Currently only over the FMI Arctic study area. Products are in research phase, but operational delivery on demand possible.
- SIC (AMSR-2 + SAR), SIT (AMSR-2 + SAR), SIT (Cryosat-2 + SMOS, included in the CMEMS product portfolio)
- Plans to produce DIR, improved SIT (Cryosat-2 + SAR), SID.
- Plans to implement an automatic iceberg detection routine, for Greenland waters.
- Difficult to validate as in-situ data is very restricted.

## Iceberg detection from S-1 SAR (non-operational)



Example of icebergs seen in S-1A SAR from 16<sup>th</sup> of July 2015, West Greenland



S1 HH channel mosaic over the FMI Arctic study area 26 March 2018.