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EUMeTrain
High Latitudes Event Week 2023

Operational Monitoring of the Baltic Sea Ice and the Various EO-data Used

Patrick Eriksson
Oceanographic Services

Abstract

The Baltic Sea, a relatively small semi-closed basin with brackish water, is one of the most heavily trafficked sea areas in the world. Thousands of vessels visit ice-infested ports every winter, which requires well organized icebreaking. To support this winter navigation operation, the Ice Service at FMI conducts monitoring and forecasting of the sea ice throughout the winter. An essential source of information is obviously satellite data. Imagery from several satellite platforms is not only processed to serve ice charting and reporting, but is also delivered in near-real-time straight to the bridges of the icebreakers. The dark and cloudy Nordic winter has proven the Synthetic Aperture Radar instruments (SAR) to be the most suitable when analysing the development of the sea ice. Different passive instruments are also used, light and cloudiness permitting. All satellite platforms bring their various strengths and limitations on the ice analyst's desktop, causing constantly changing challenges to the charting of sea-ice features. So far, the analysis has been predominantly manual work, but the ever increasing data volumes are setting a demand for AI-based automatic interpretation.

Patrick Eriksson

FMI, Oceanographic Services

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Sea Ice is...

Sea Ice is...

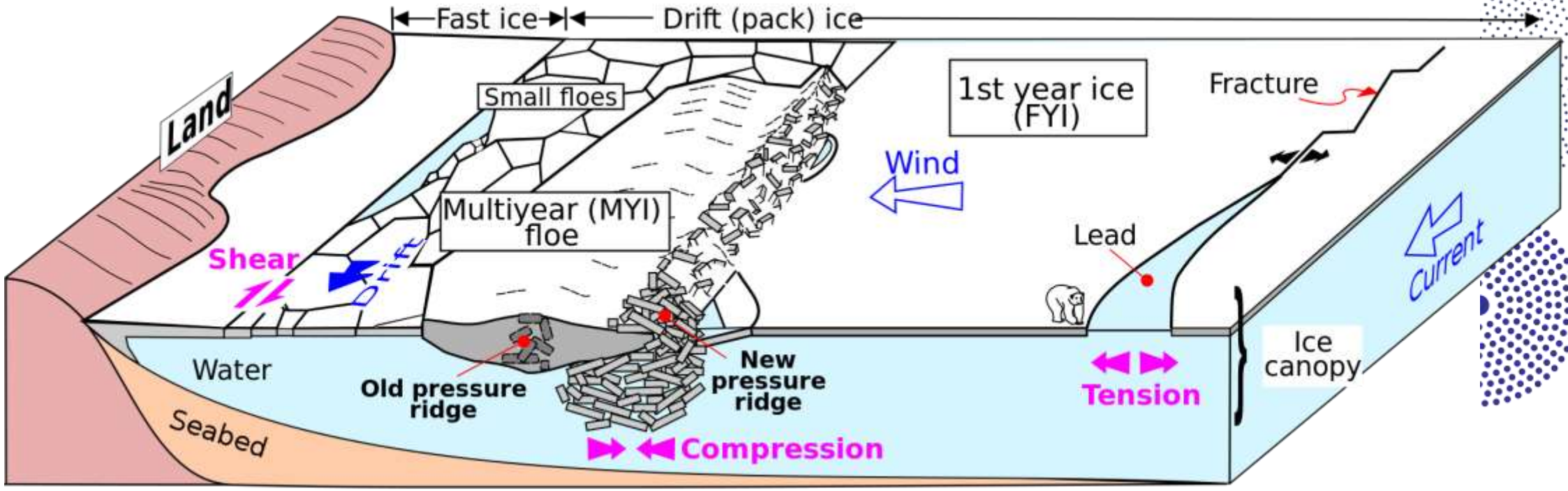
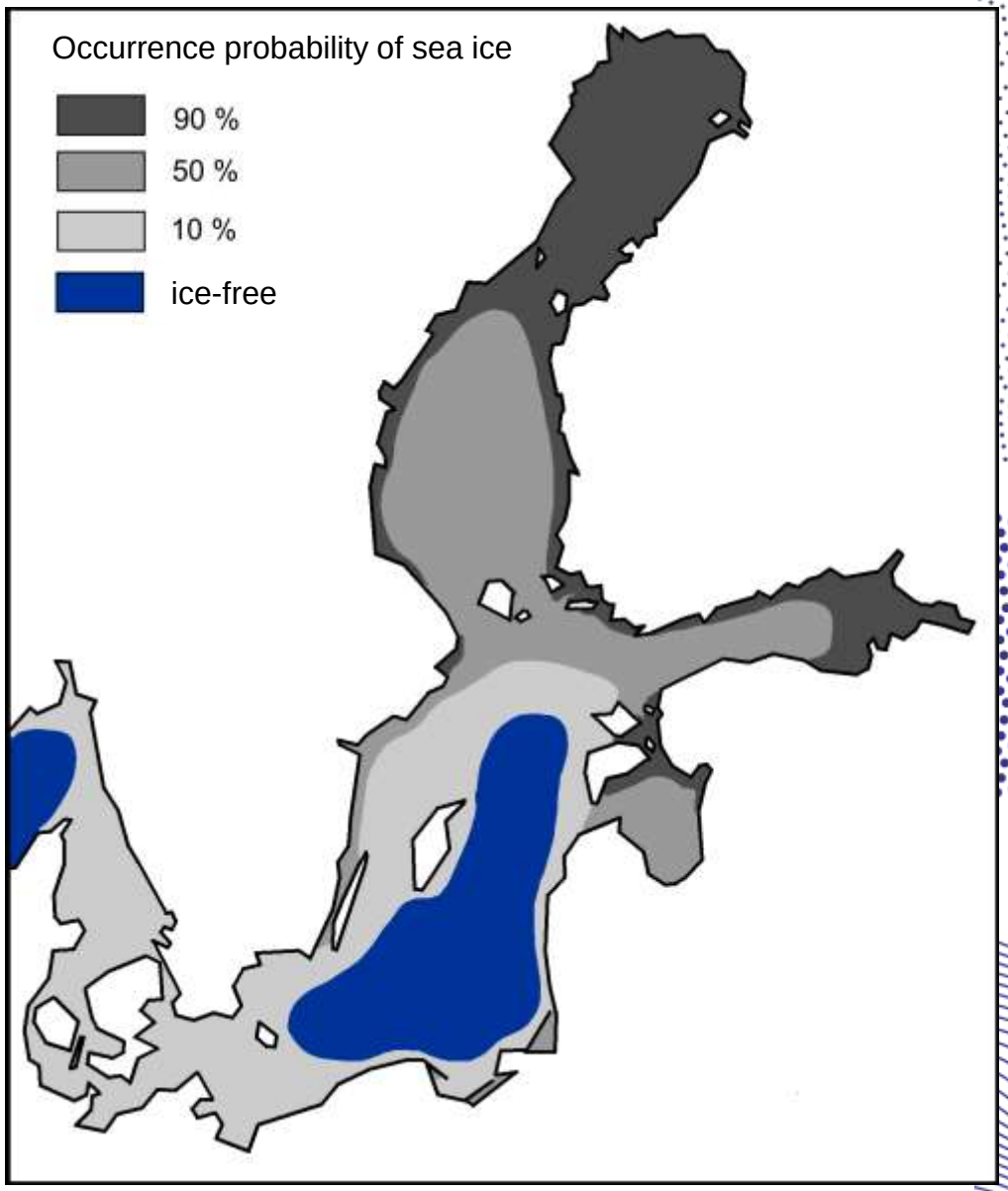

Fast ice
Drift (pack) ice
Land
Small floes
1st year ice
(FYI)
Fracture
Wind
Multiyear (MYI)
floe
Lead
Shear
Drift
Current
Water
Old pressure
ridge
New
pressure
ridge
Tension
Ice
canopy
Seabed
Compression

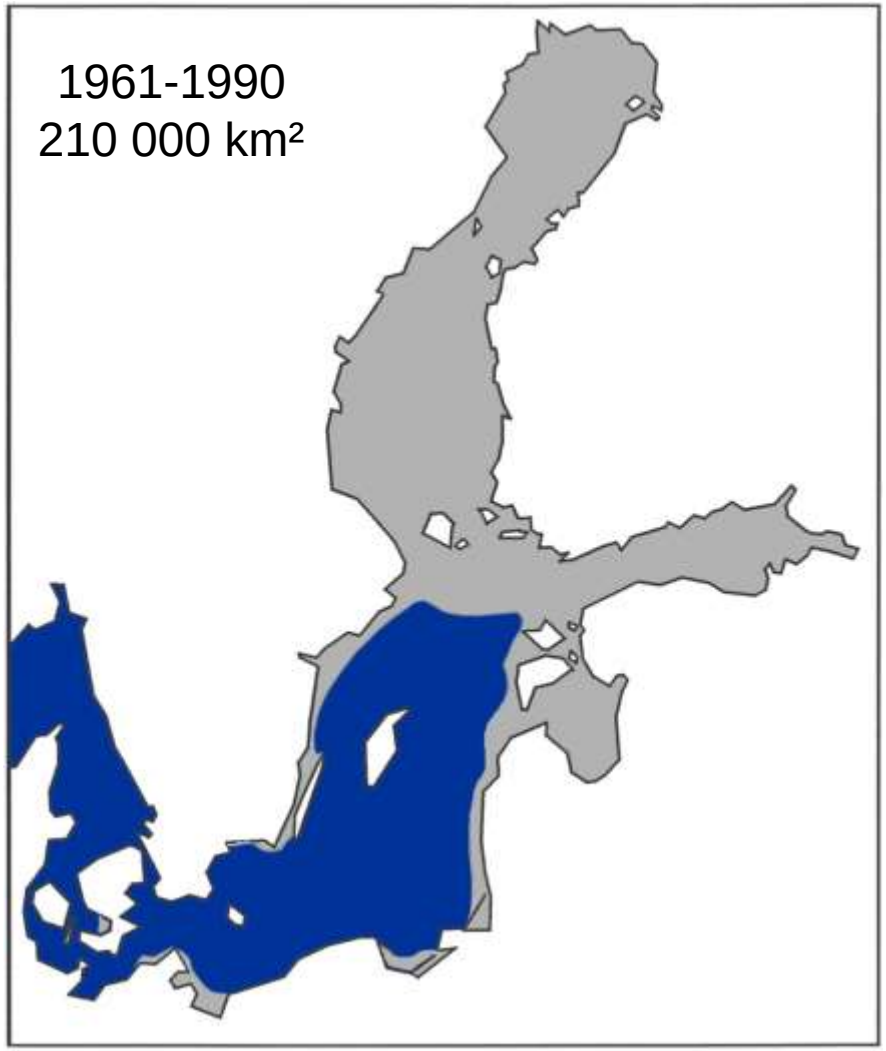
Photo: Martin Jakobsson

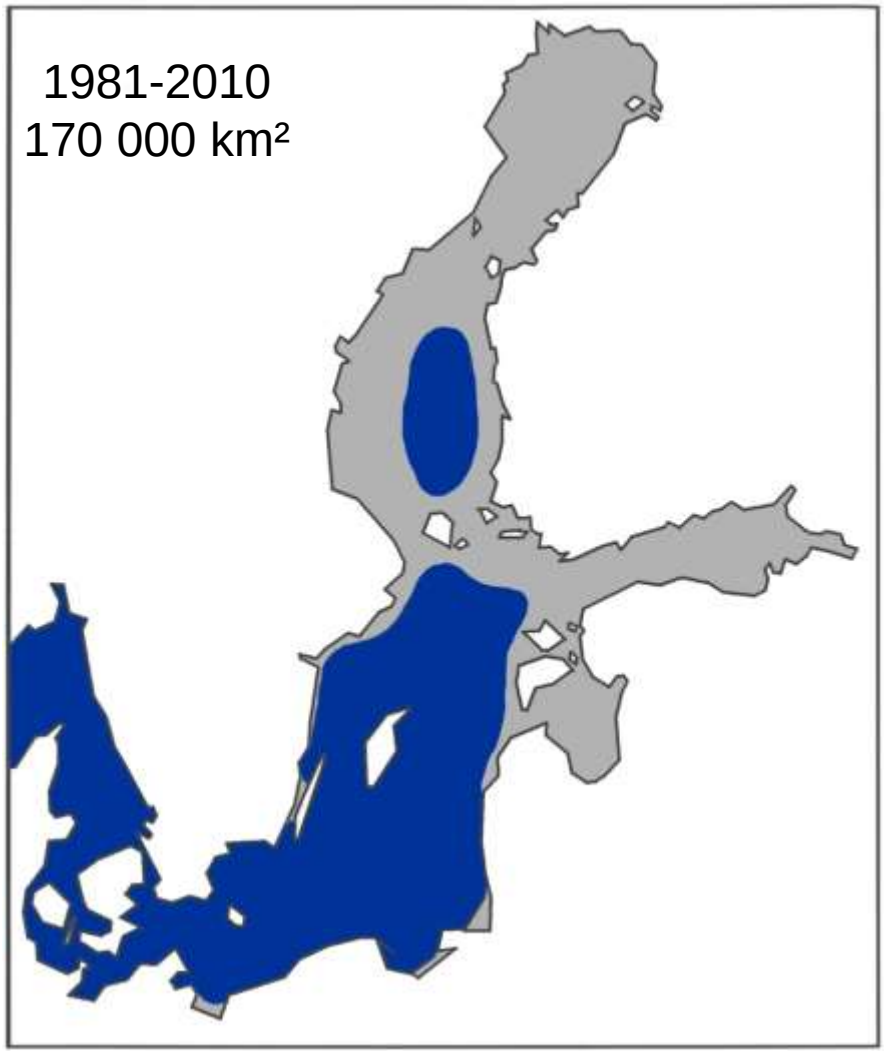
Baltic Sea Ice Winters

- Yearly ice coverage
  37 000 km² - 422 000 km²
- Duration from few weeks to more than half a year
- Affects shipping every year to Finland, Sweden, Russia and Estonia



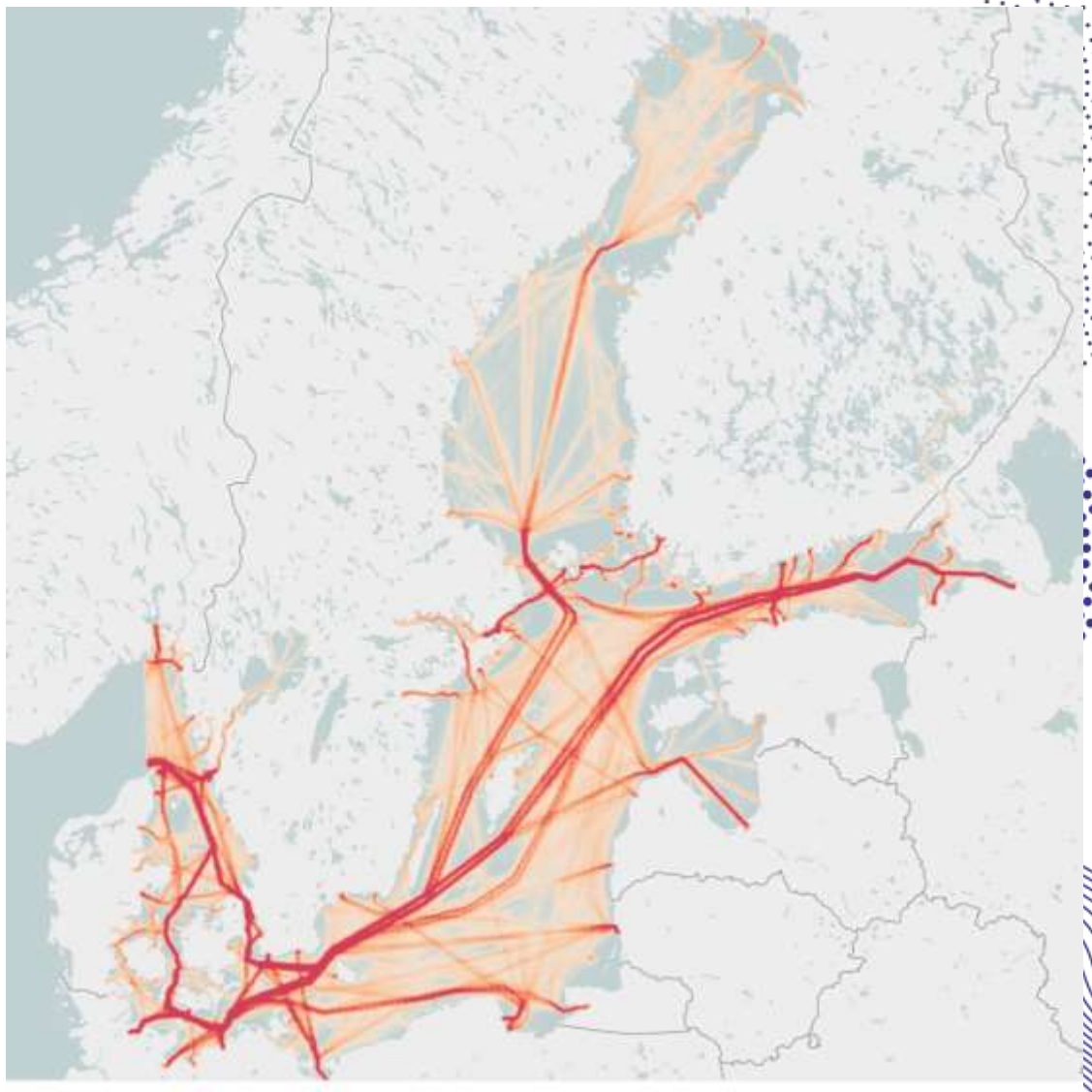
Comparison of two 30-year reference periods and the average of their yearly maximum ice extent





“Finland is an island”

- Ship traffic
  Nov 2018 - May 2019
- Port calls to Finland: 7400
- Assisted by icebreakers: 1300 (18%)

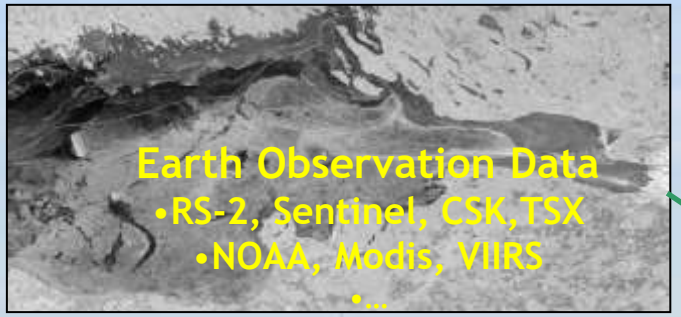


Source: Finnish Traffic Infrastructure Agency, Winter Navigation

Ice service – from past to present

- Finland has long experience in ice monitoring – first done in 1846.
- Systematically since 1897.
- First icebreakers in 1890’s.
- Ice chart published once a week starting in 1915.
- Ice report published in newspapers once a week starting January 1918.
- All major ports kept open since 1971
- Nowadays ice chart published daily during winter months (co-produced with Swedish Ice Service)
- 700 SAR satellite images/winter

Finnish Ice Service



Ice Service

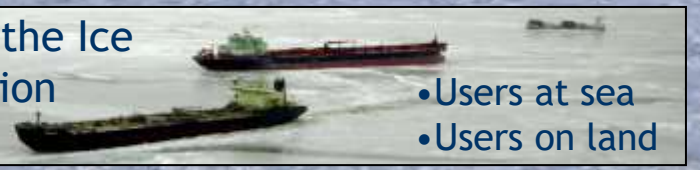
- Collection
- Analysis
- Production
- Distribution

Oceanographic and Weather Models

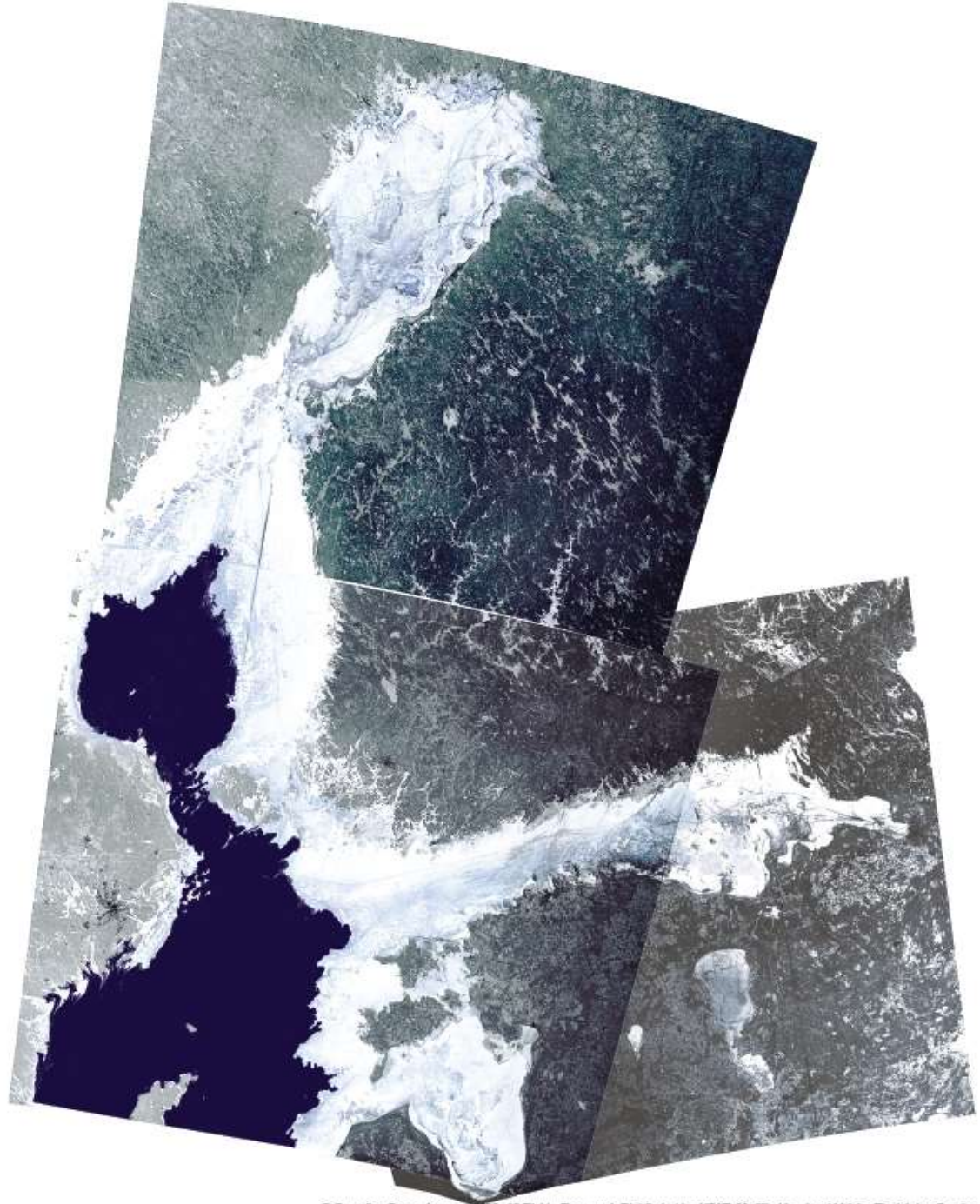
Ice Information Products

- Charts
- Reports
- Ice code
- Forecasts
- Satellite images
- Image classifications

Users of the Ice Information



- Users at sea
- Users on land



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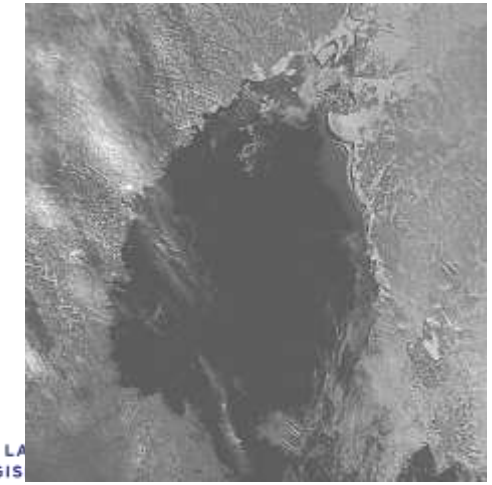
Past to present – satellite data

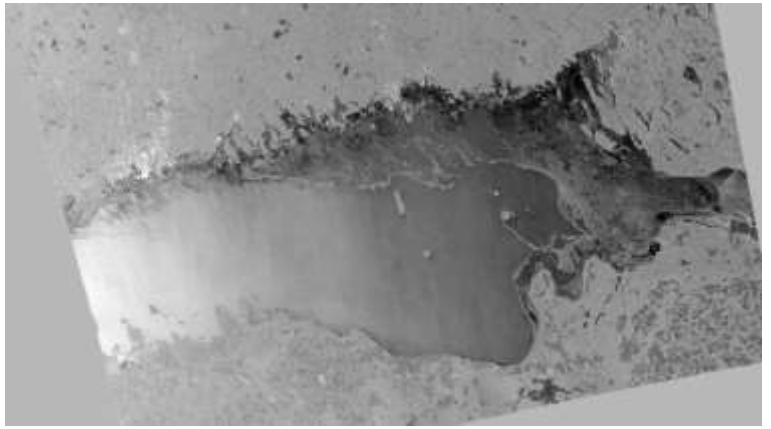
First ever satellite image used in FMI ice monitoring:
ESSA, February 14th 1968.
Resolution >5 km.

Past to present – satellite data

ESSA, February 14th 1968.
Resolution >5 km.

1968: ESSA data into operational use.
1981: NOAA receiving station in use
1992: ERS-1 SAR data into experimental operational use
1994: Acquiring of ~100+ ERS SAR scenes/winter
1997: RADARSAT in experimental use
1998: Purchasing of 100+ RADARSAT images a winter
2002-12: ENVISAT ASAR
2014: 500+ RADARSAT images during winter
2015> : Sentinel-1





Utilized Satellite Data

SAR

- Sentinel-1 (C)
- Radarsat-2 (C)
- COSMO-SkyMed (X)
- TerraSAR-X (X)
- Hisdesat PAZ (X)
- RCM (C)
- ICEYE (X)

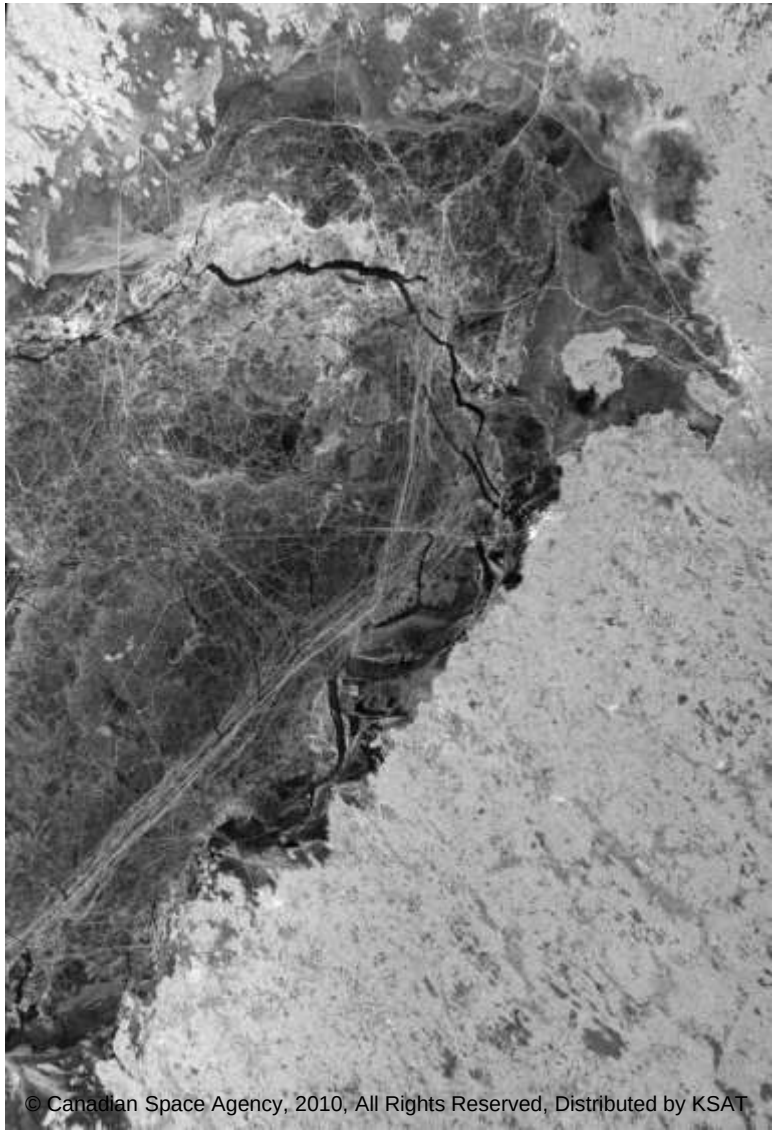
- Through Copernicus licences

Optical

- Suomi NPP VIIRS
- Modis Terra/Aqua
- Sentinel-2
- AMSR
- Sentinel-3

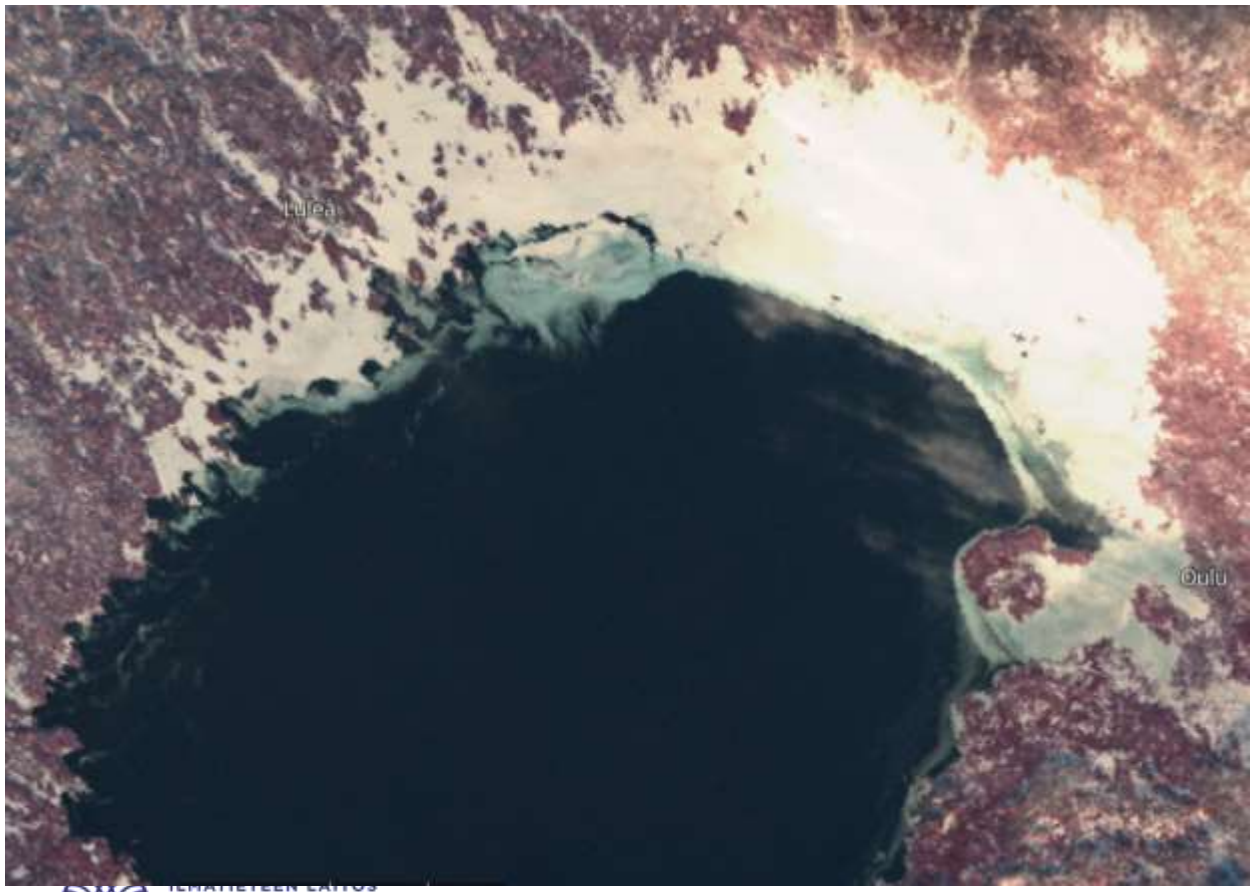
Optical vs. SAR image

Image courtesy of MODIS Rapid Response Project at NASA/GSFC

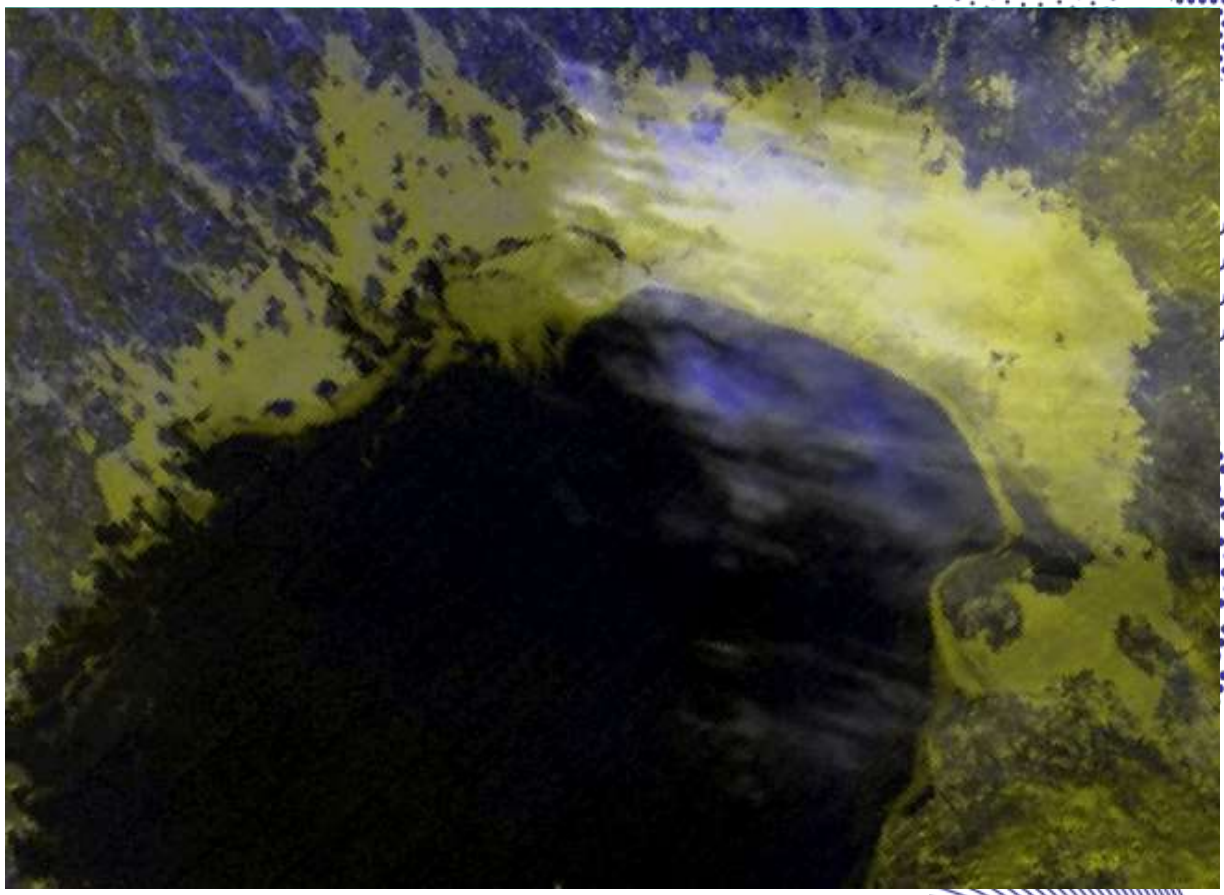


Northern Bay of Bothnia 2023-01-24

- **Sentinel-3 OLCI/SLSTR**
- Res. ~ 300/1200 m
- Spectral bands: 21
- Operated by ESA+EUMETSAT
- Great potential, not yet fully utilized (OLCI+ SLSTR bands)



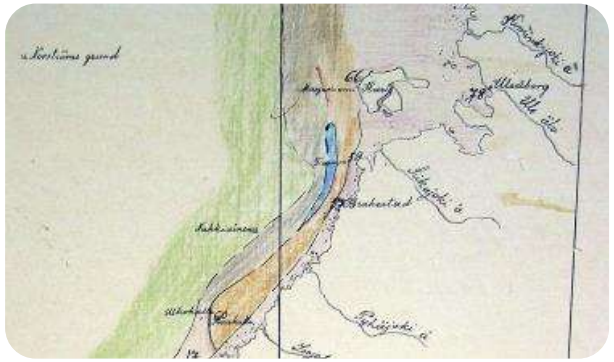
- **Suomi NPP VIIRS**
- Res. ~ 380/740 m
- Spectral bands: 21 + dnb
- Operated by NASA
- Day/Night Band (DNB)

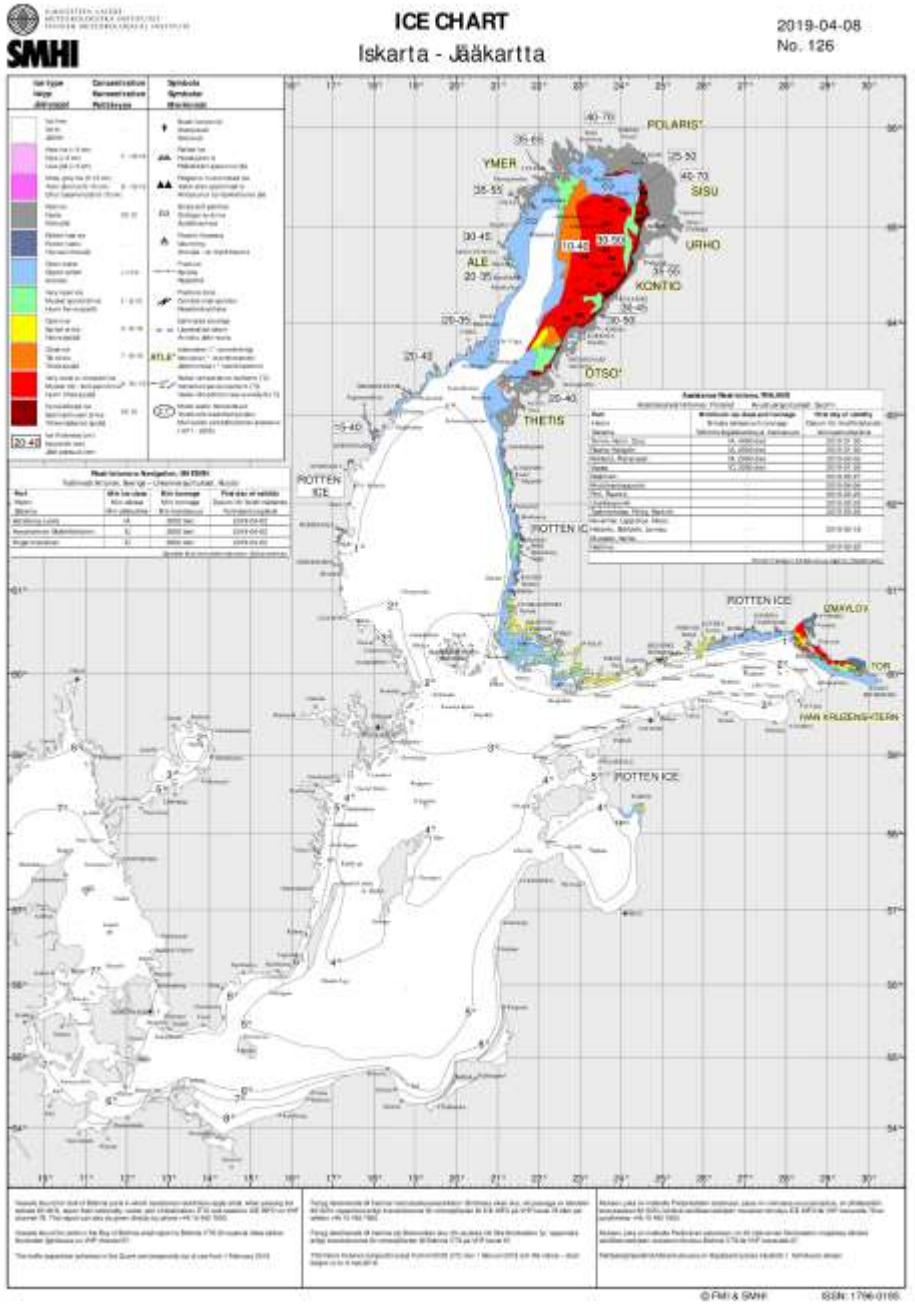


The Baltic Sea ice chart

- Issued daily during winter season
  - (~ November - May)
  - Co-produced with SMHI (bi-weekly)
- Primarily to serve winter navigation needs
- Includes information about
  - Prevailing ice conditions
  - Sea surface temperature
  - Icebreaker locations
  - Assistance restrictions to ports
- Drawn according to satellite imagery and observations
- Direct link to PDF chart
- Access to older charts

- First NRT ice chart in 1915





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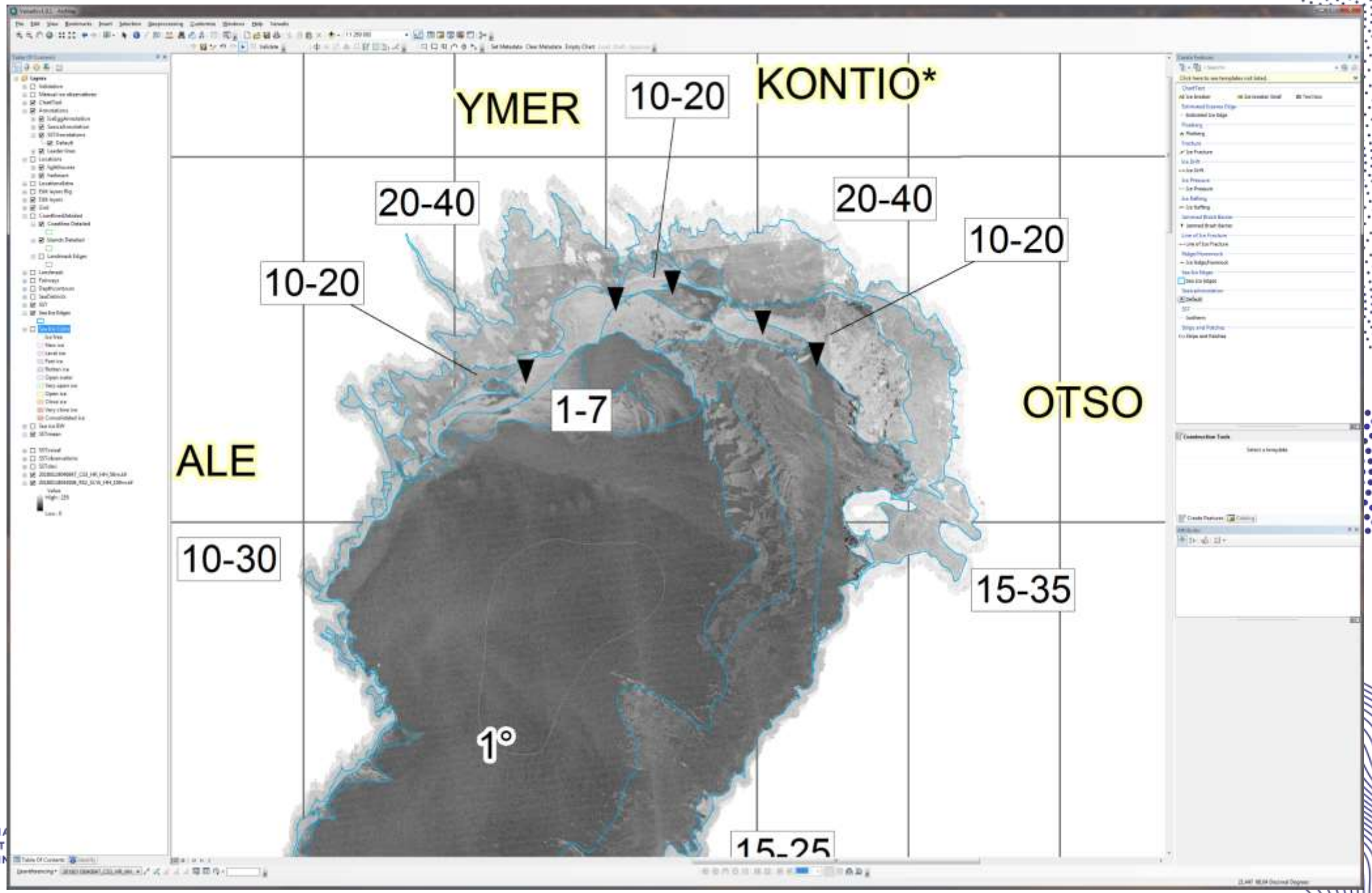
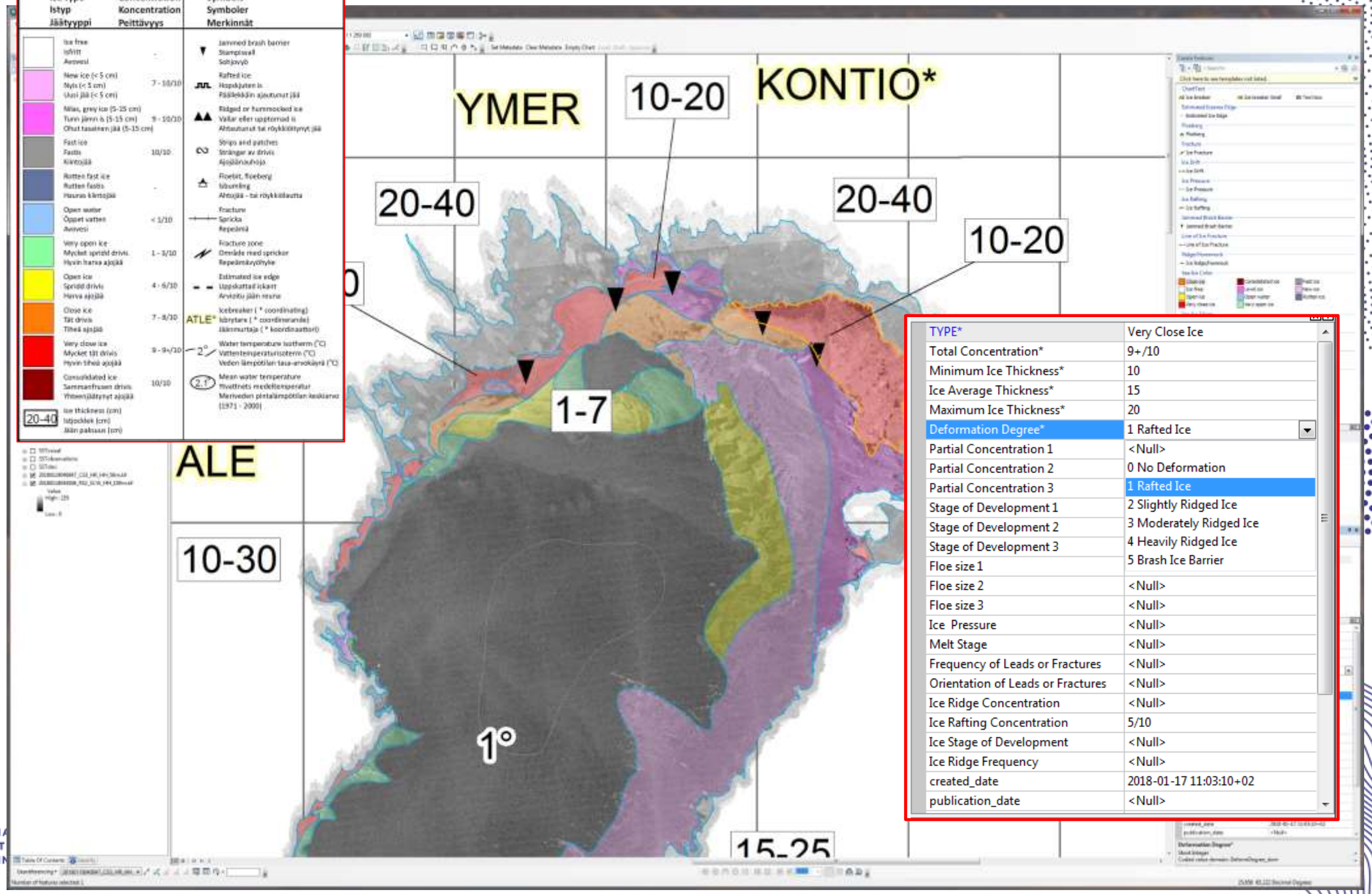
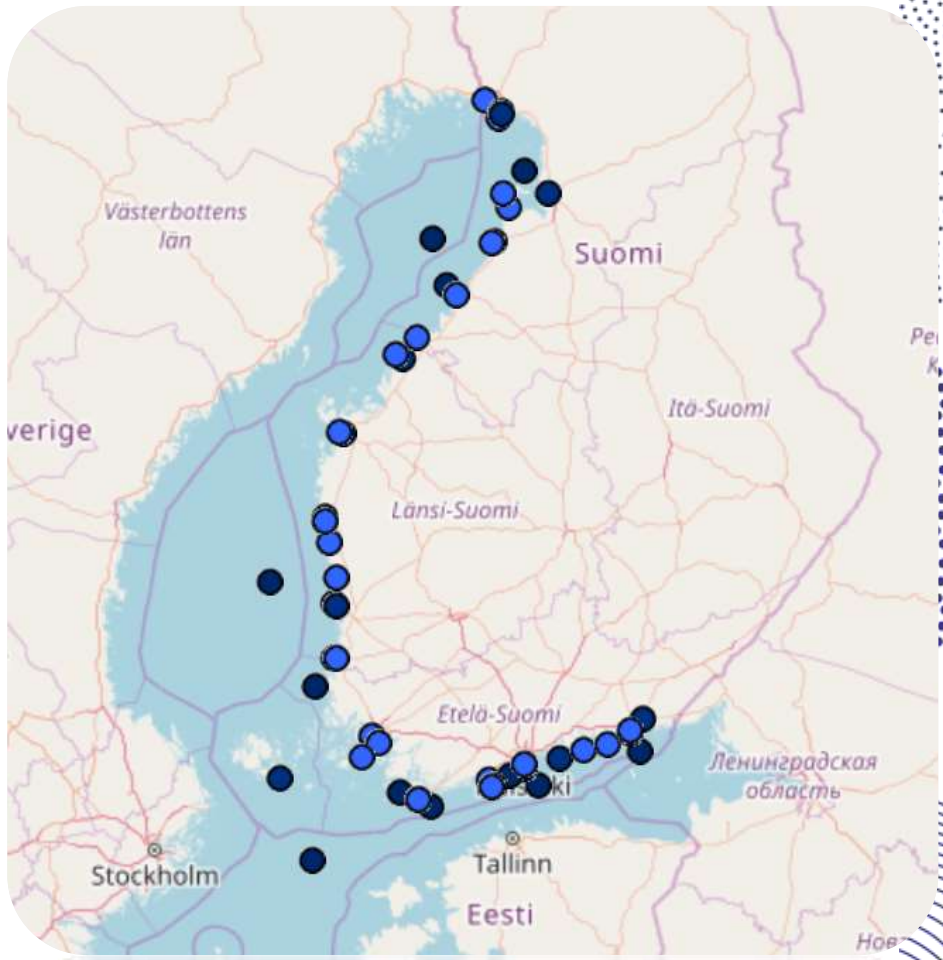

YMER
10-20
KONTIO*
20-40
20-40
10-20
10-20
1-7
OTSO
ALE
10-30
15-35
1°
15-25


Ice type
Istyp
Jäätyyppi
Concentration
Koncentration
Peittävyys
Symbols
Symboler
Merkinnät
YMER
10-20
KONTIO*
20-40
20-40
10-20
1-7
ALE
10-30
1°
15-25
TYPE*
Very Close Ice
Total Concentration*
9+/10
Minimum Ice Thickness*
10
Ice Average Thickness*
15
Maximum Ice Thickness*
20
Deformation Degree*
1 Rafted Ice
Partial Concentration 1
Partial Concentration 2
Partial Concentration 3
Stage of Development 1
Stage of Development 2
Stage of Development 3
Floe size 1
Floe size 2
Floe size 3
Ice Pressure
Melt Stage
Frequency of Leads or Fractures
Orientation of Leads or Fractures
Ice Ridge Concentration
Ice Rafting Concentration
Ice Stage of Development
Ice Ridge Frequency
created_date
publication_date
<Null>
0 No Deformation
1 Rafted Ice
2 Slightly Ridged Ice
3 Moderately Ridged Ice
4 Heavily Ridged Ice
5 Brash Ice Barrier
2018-01-17 11:03:10+02

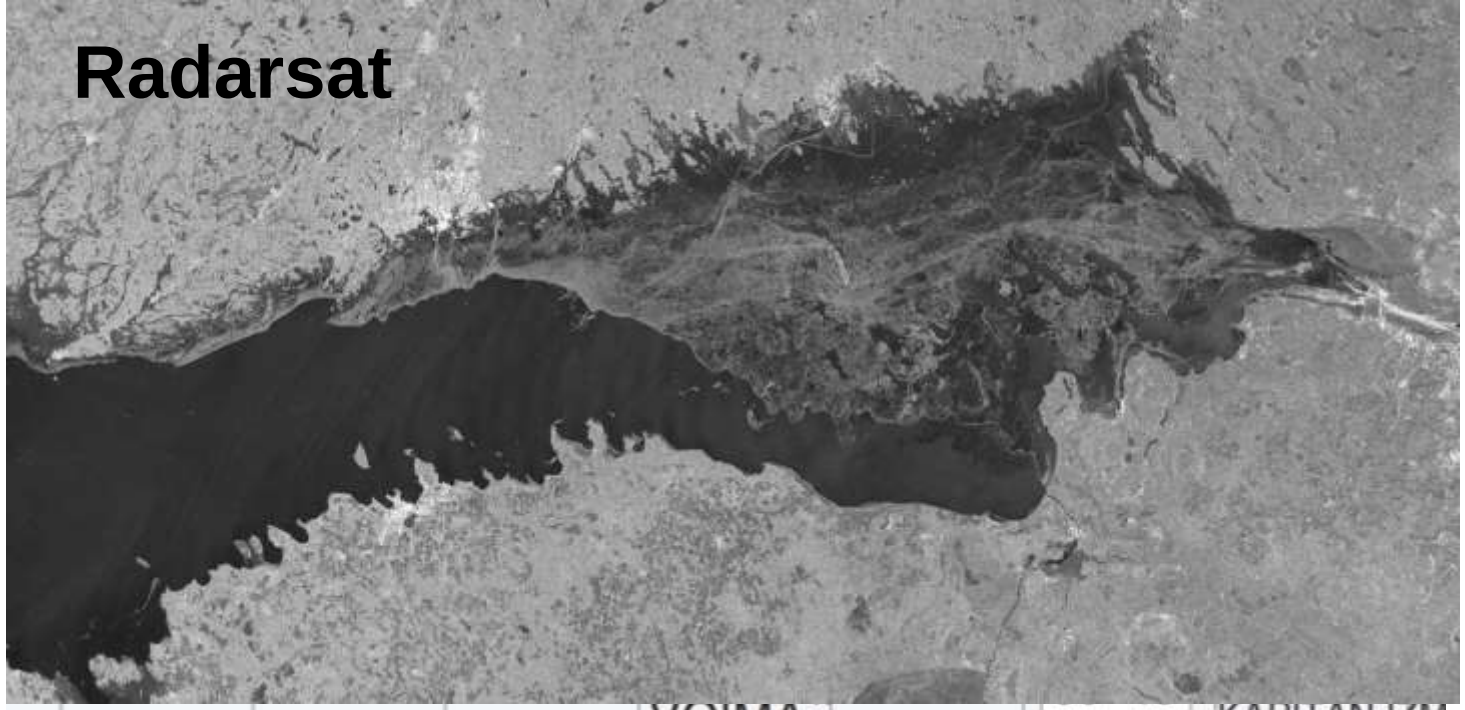
FMI Observations

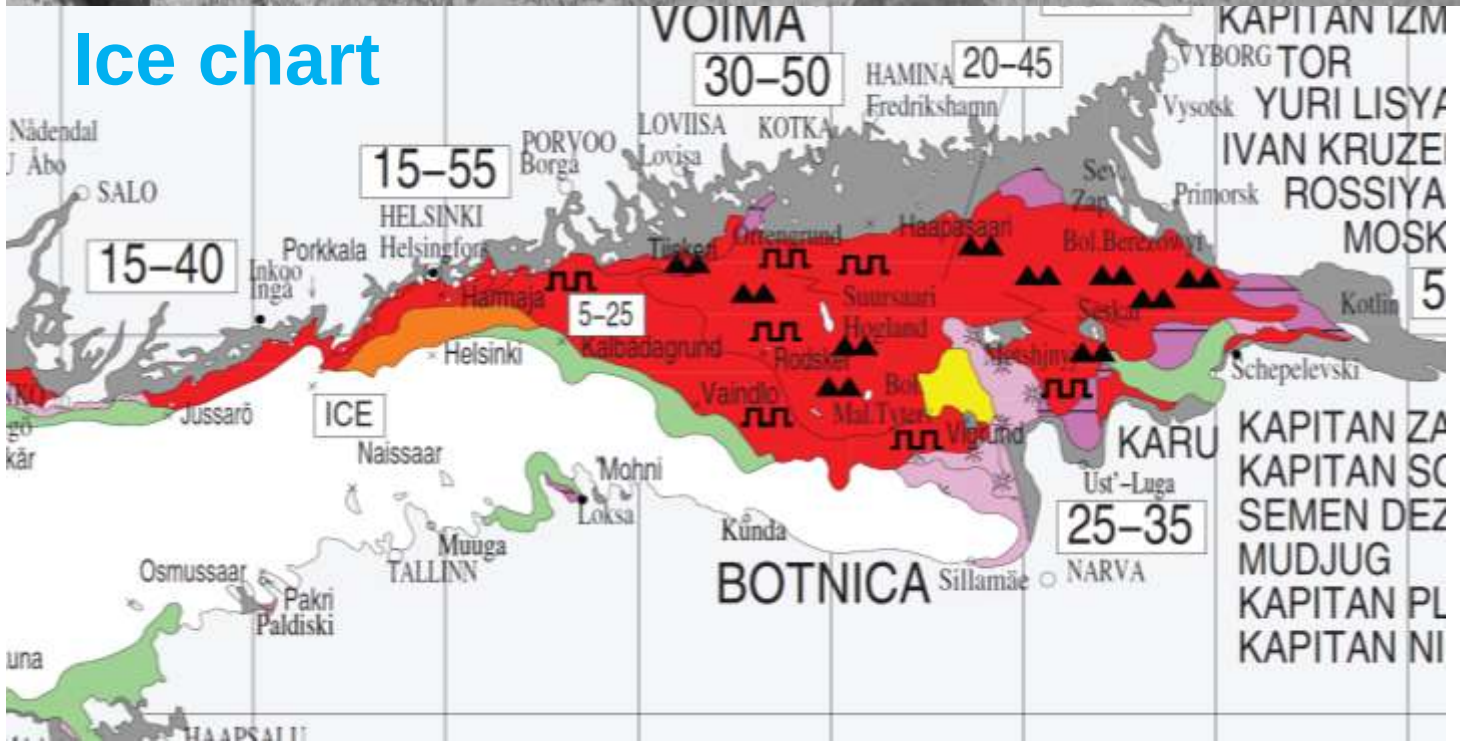
- Mareographs 14
- Wave buoys 4
- SST buoys 7
- Sea ice observation stations 22

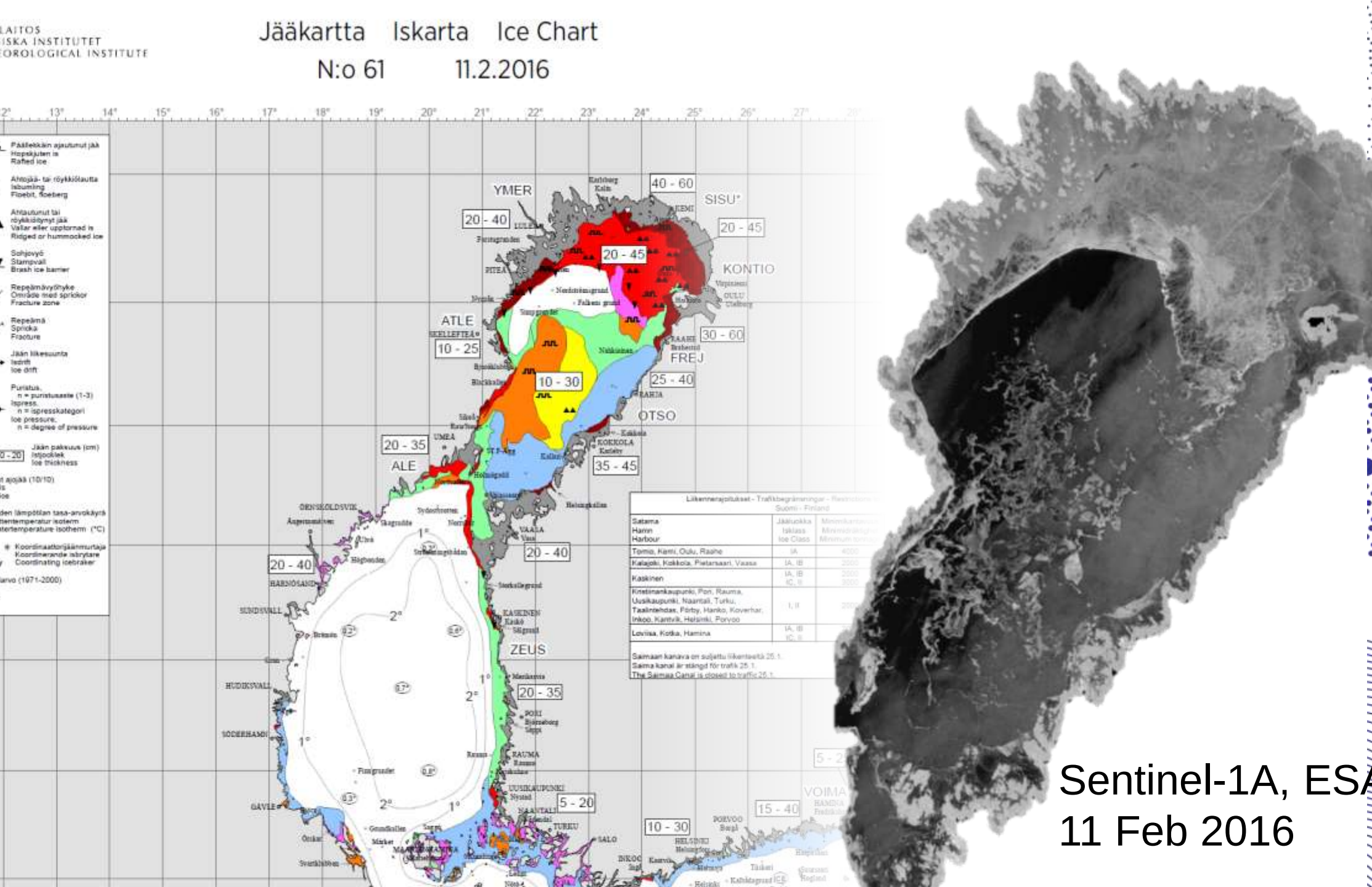


Satellite Image

Ice Chart



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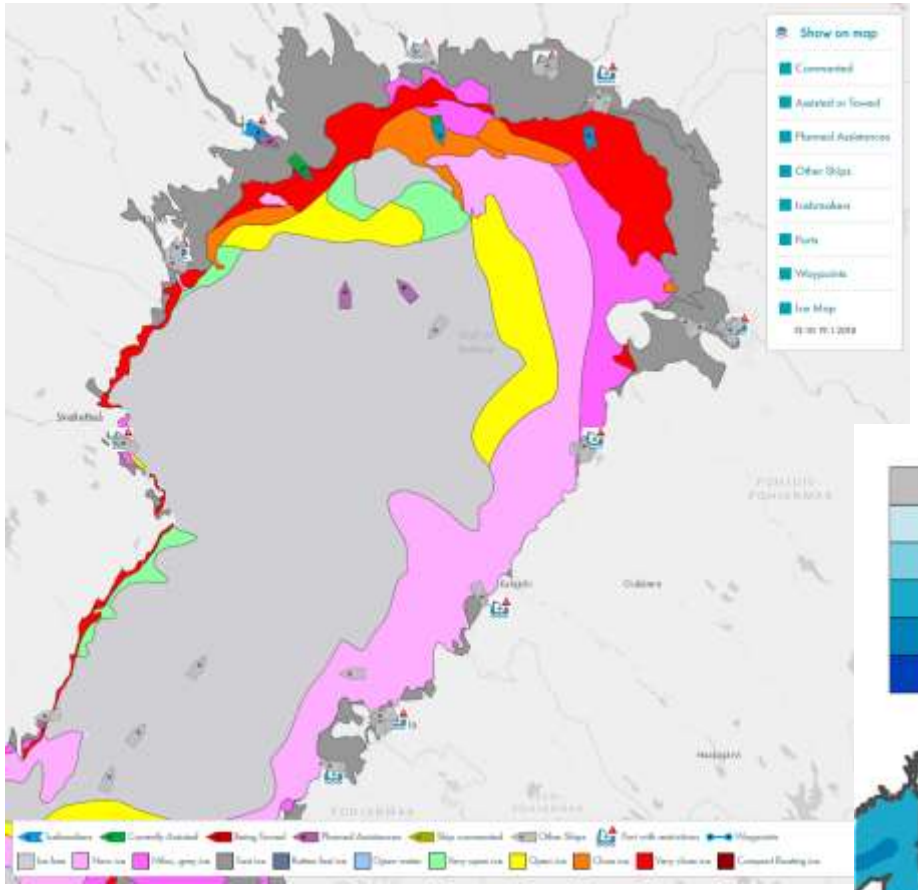
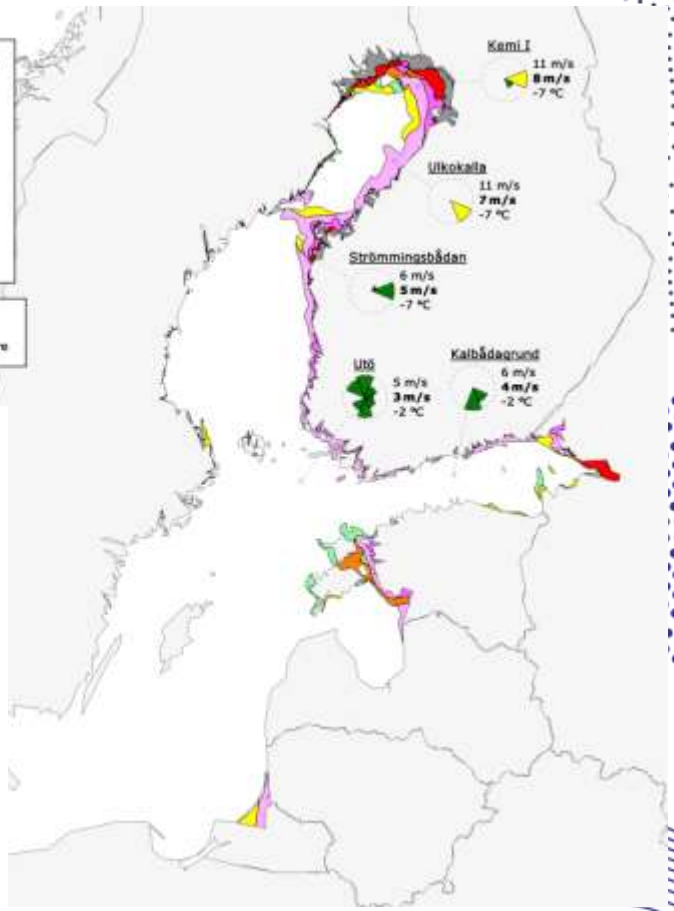
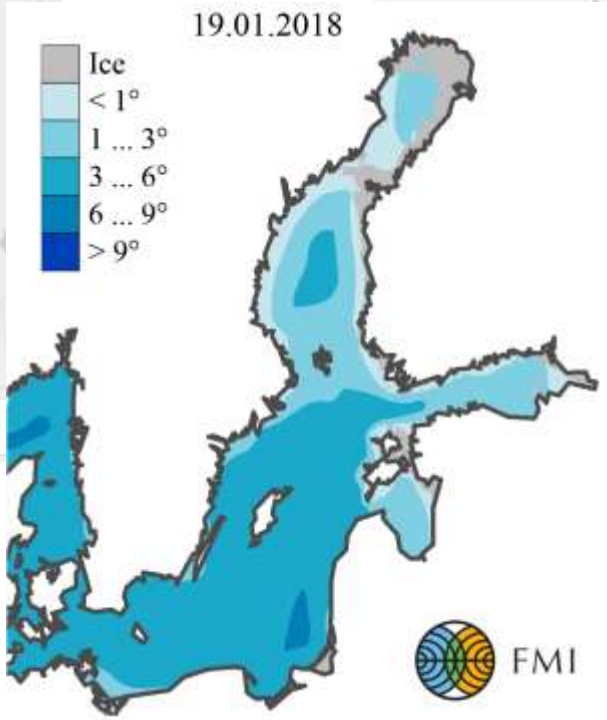
Jääkartta Iskarta Ice Chart
N:o 61 11.2.2016
YMER
SISU*
KONTIO
ATLE
FREJ
OTSO
ALE
ZEUS
VOIMA
40 - 60
20 - 40
20 - 45
20 - 45
30 - 60
10 - 25
10 - 30
25 - 40
20 - 35
35 - 45
20 - 40
20 - 40
20 - 35
5 - 20
10 - 30
15 - 40
5 - 2
Sentinel-1A, ESA
11 Feb 2016

Ice Chart Products

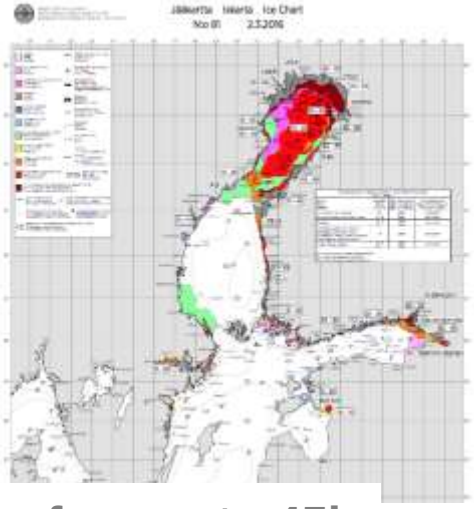




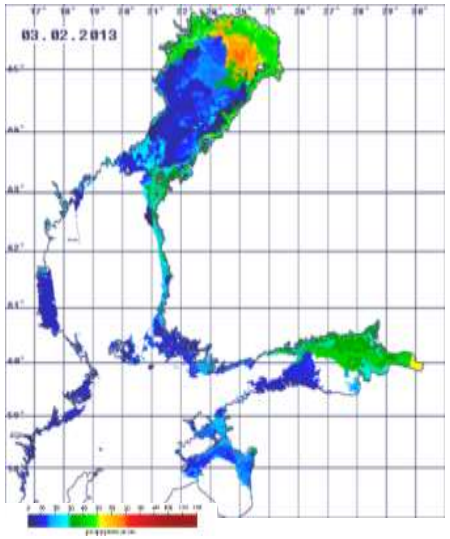


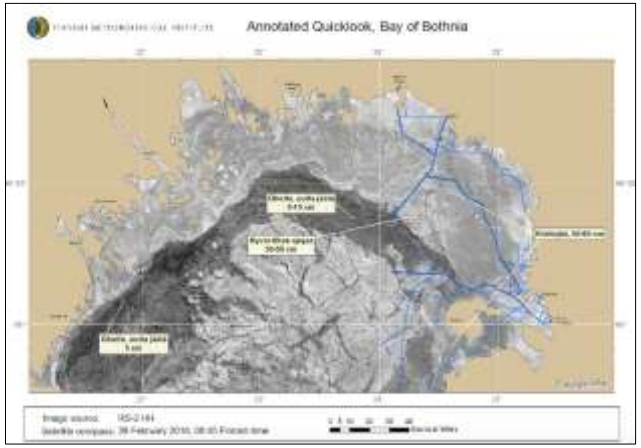
Examples of ice service products for the Baltic Sea

Daily ice analysis chart

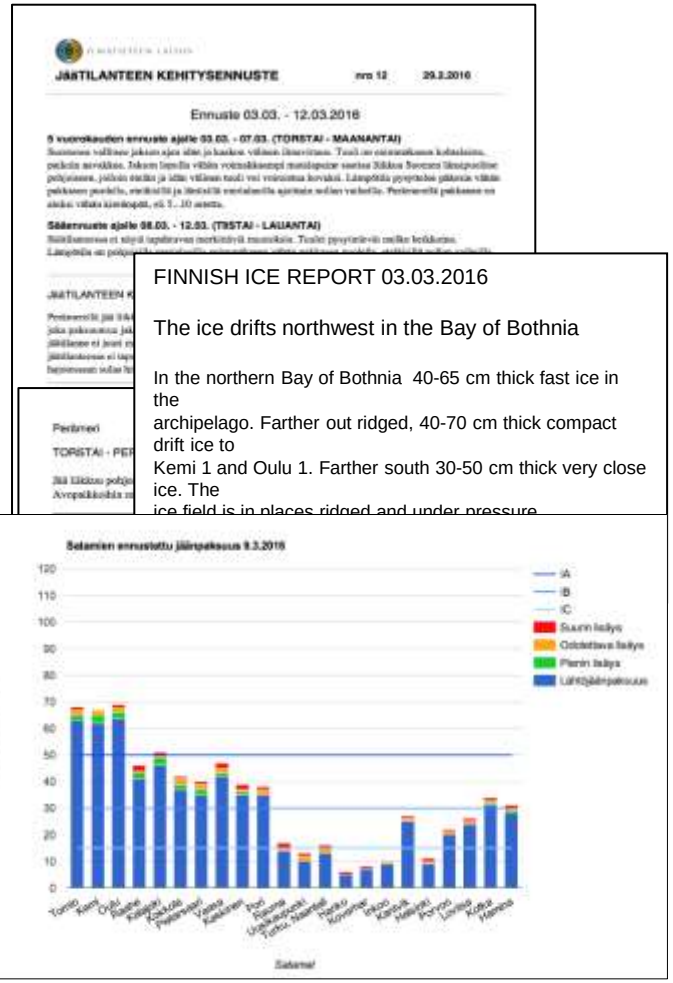


Ice thickness analysis
Ice drift (SAR satellite data)



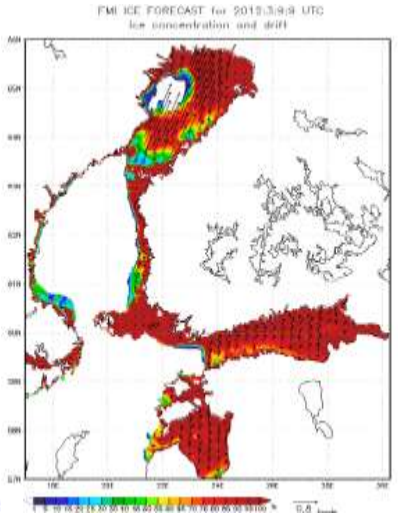


Ice Forecasts and reports



Ice forecast +45h

(drift, coverage, thickness, deformation, pressure)



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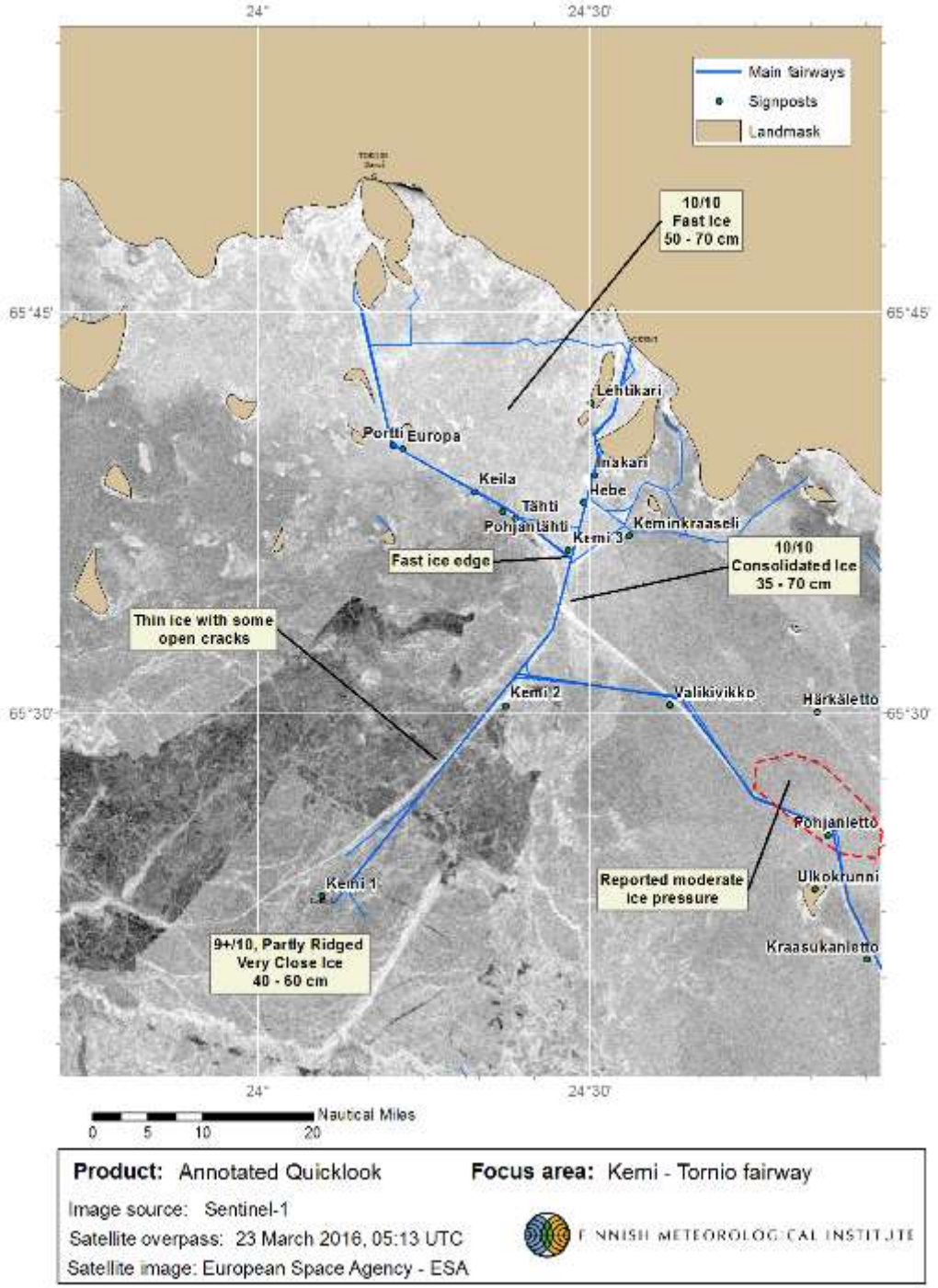
Annotated Quick Looks

- Fast and quick way to visualize satellite images
- Piloted spring 2016 in Northern Bay of Bothnia
- Quick-looks can be partly automatized
- Annotations highlight the most relevant features



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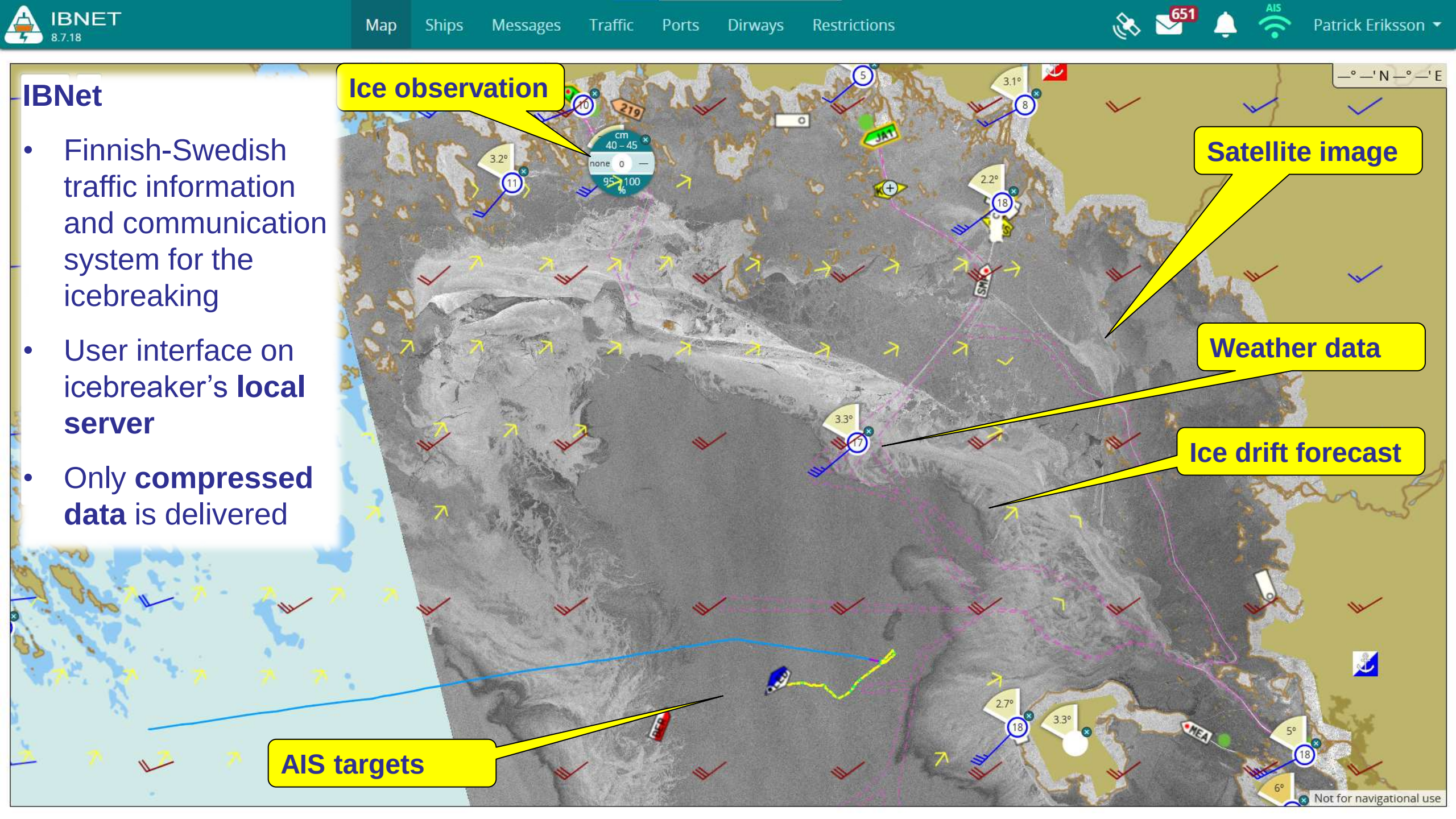
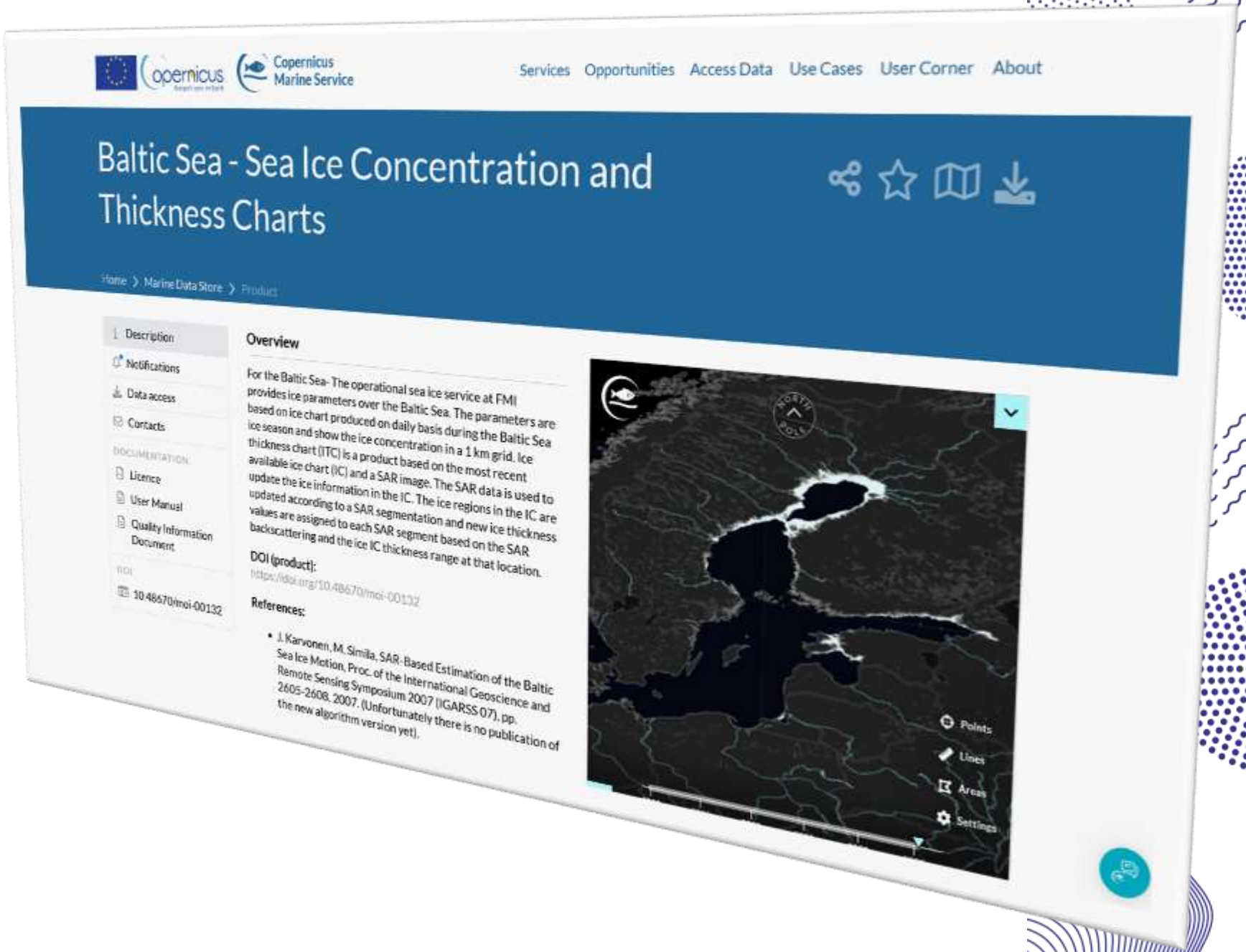

IBNET
8.7.18
Map
Ships
Messages
Traffic
Ports
Dirways
Restrictions
651
AIS
Patrick Eriksson
IBNet
Finnish-Swedish traffic information and communication system for the icebreaking
User interface on icebreaker's local server
Only compressed data is delivered
Ice observation
Satellite image
Weather data
Ice drift forecast
AIS targets
Not for navigational use

Ice chart data available in Copernicus Marine Service

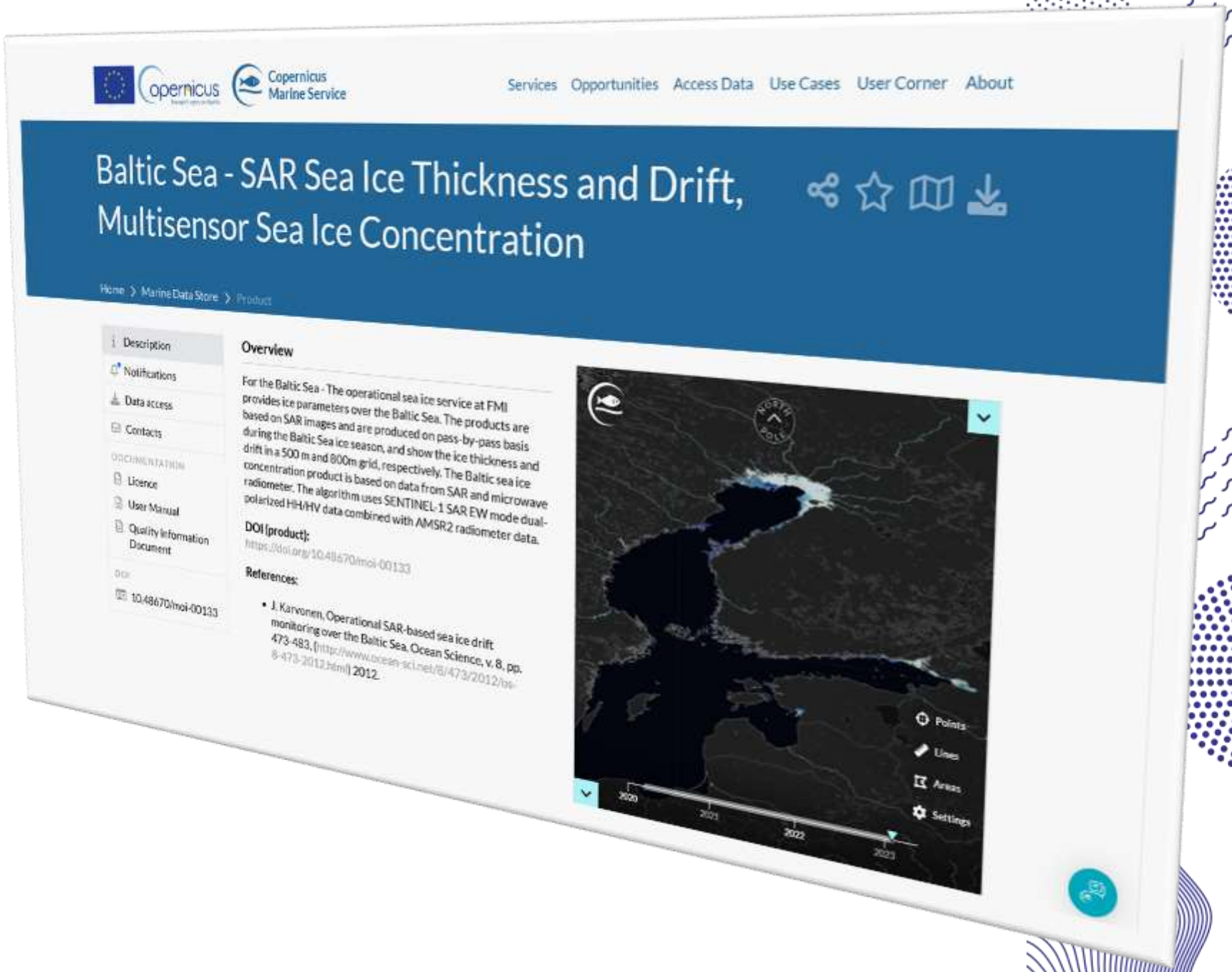
- https://data.marine.copernicus.eu
- https://doi.org/10.48670/moi-00132



Automatic SAR analysis – Concentration, Thickness, Drift

- RS-2
- Sentinel-1
- (coming: RCM)
- Ongoing development

- https://data.marine.copernicus.eu
- https://doi.org/10.4867 0/moi-00133



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