

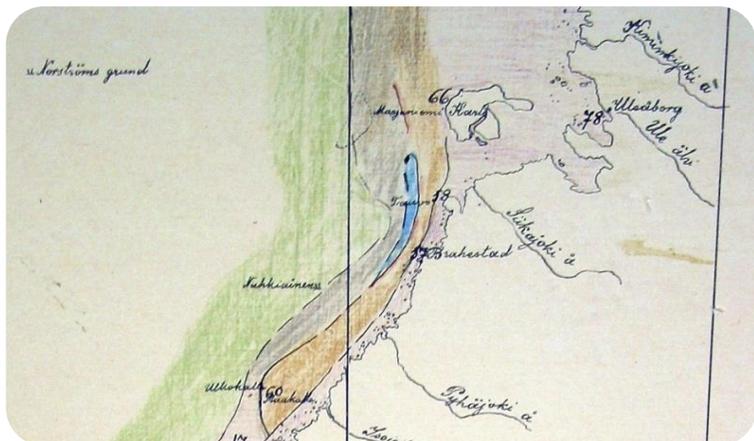


Sea ice charts and SAR for sea ice classification

Patrick Eriksson
Juha Karvonen
Jouni Vainio



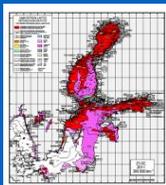
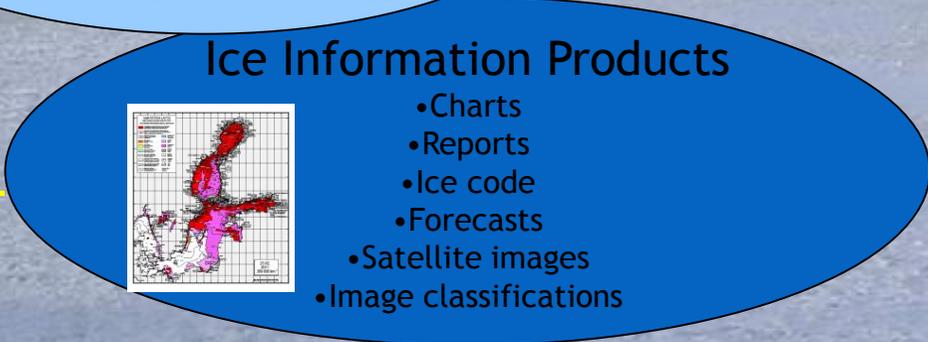
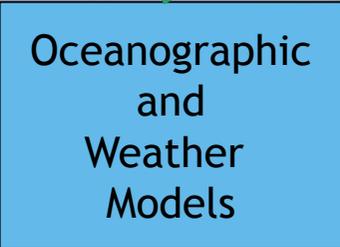
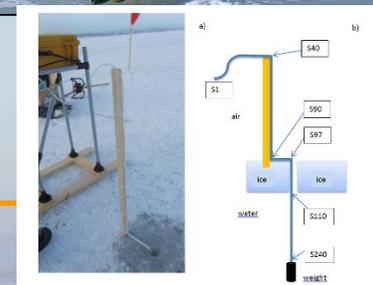
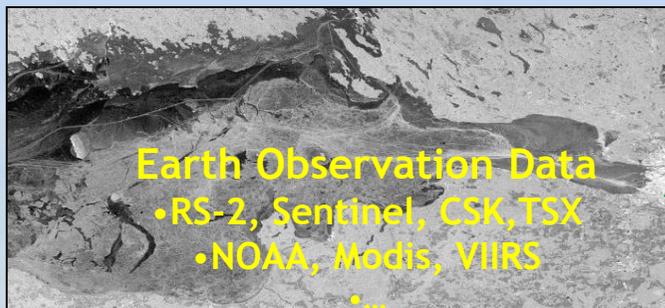
Ice service – from past to present



- 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
- 700 SAR satellite images / winter
- Visual bandwidth images as available

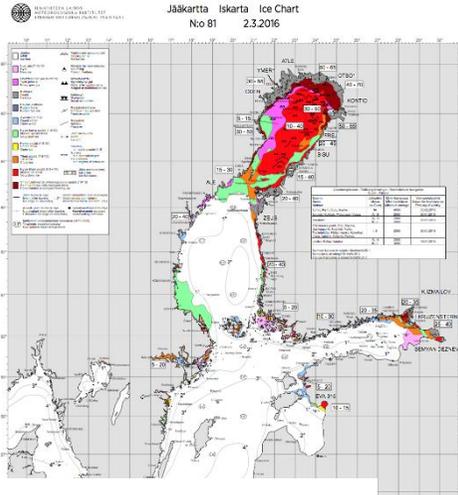


Finnish Ice Service

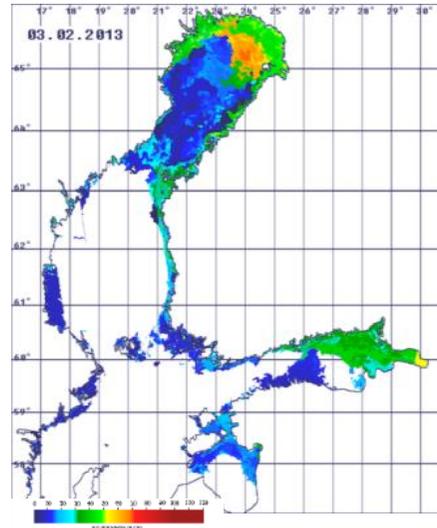


Examples of ice service products for the Baltic Sea

Daily ice analysis chart



Ice thickness analysis Ice drift (SAR satellite data)



Ice Forecasts and reports

ILMATIETEEN LAITOS
JÄÄTILANTEEN KEHITYSENNUSTE nro 12 29.2.2016

Ennuste 03.03. - 12.03.2016

5 vuorokauden ennuste ajalle 03.03. - 07.03. (TORSTAI - MAANANTAI)
Suomessa vallitseva jakson ajan sään ja kaakon vilnen ilmavirtaus. Tuuli on enimmäkseen kohtalaista, paikoin navakkaa. Jakson lopulla vähän voimakkaampi matalapaine saattaa liikkua Suomen länsipuolelle pohjoiseen, jolloin etelän ja idän välinen tuuli voi voimistua kovaksi. Lämpötila pysyttelee pääosin vähän pakkasen puolella, eteläisillä ja läntisillä merialueilla ajoittain nollian vaiheilla. Perämerellä pakkasen on aluksi vähän kireämpää, eli 5...10 astetta.

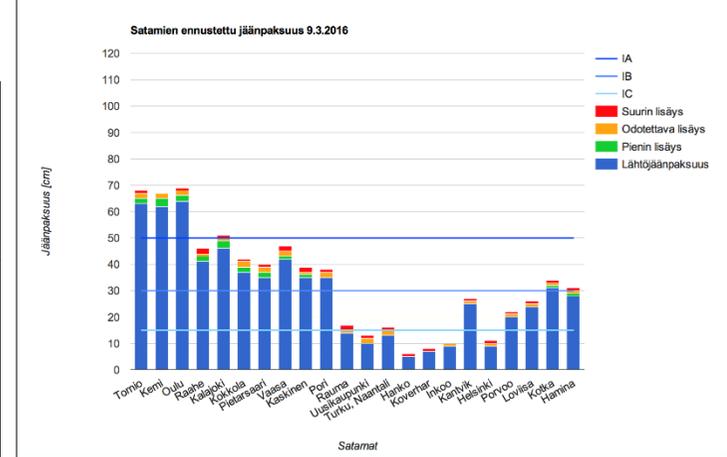
Sääennuste ajalle 08.03. - 12.03. (TIISTAI - LAUANTAI)
Säätilanteessa ei näytilä tapahtuvan merkittäviä muutoksia. Tuulet pysyttelevät melko heikkoina. Lämpötila on pohjoisella merialueella pakkasen puolella, eteläisillä merialueilla nollian vaiheilla.

FINNISH ICE REPORT 03.03.2016

The ice drifts northwest in the Bay of Bothnia

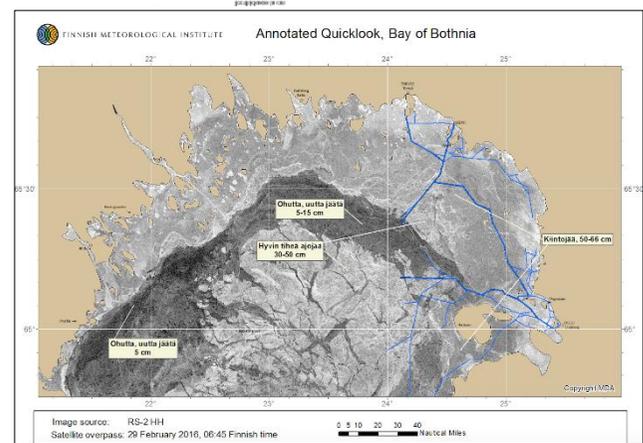
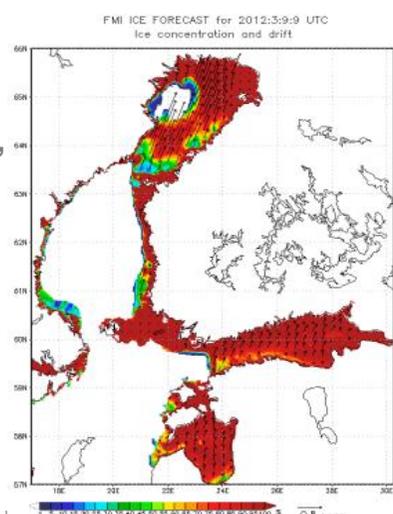
In the northern Bay of Bothnia 40-65 cm thick fast ice in the archipelago. Farther out ridged, 40-70 cm thick compact drift ice to Kemi 1 and Oulu 1. Farther south 30-50 cm thick very close ice. The ice field is in places ridged and under pressure.

Perämeri
TORSTAI - PER
Jää liikkuu pohjo-
Avopaikkoihin m



Ice forecast +45h

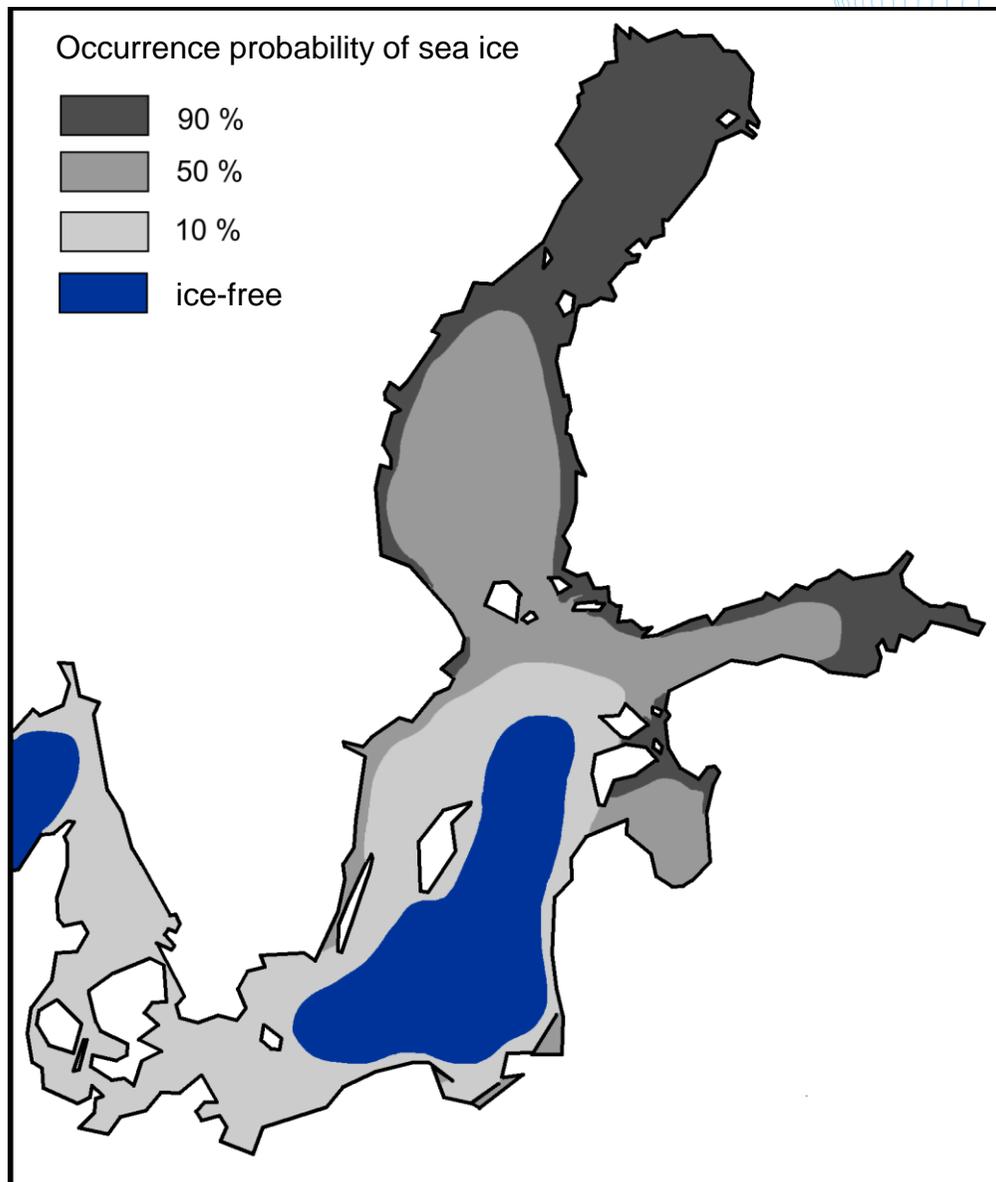
(drift, coverage, thickness, deformation, pressure)





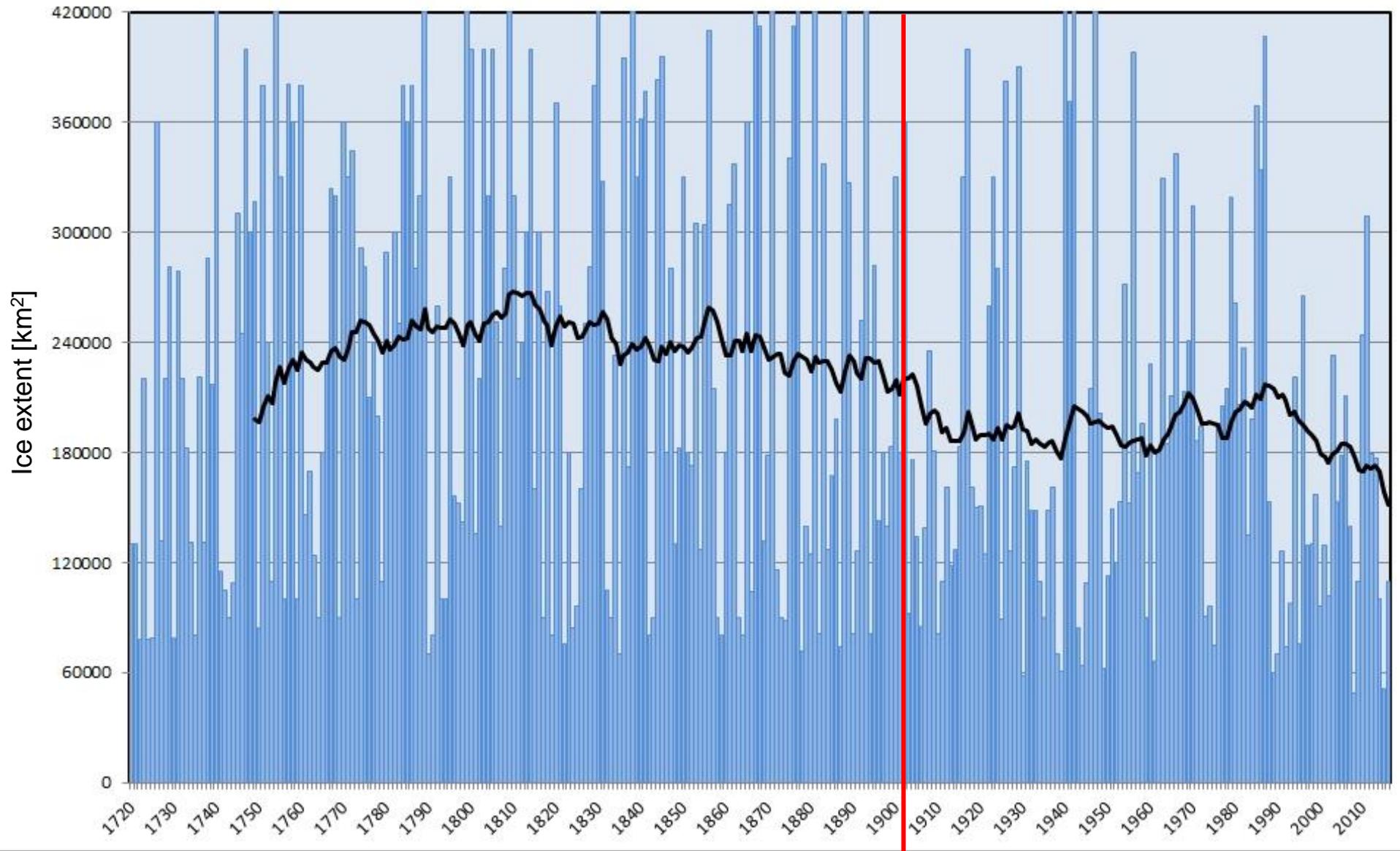
Baltic Sea Ice Winters

- Yearly ice coverage
49 000 km² - 422 000 km²
- Duration from few weeks to more than half a year
- Affects shipping every year to Finland, Sweden, Russia and Estonia



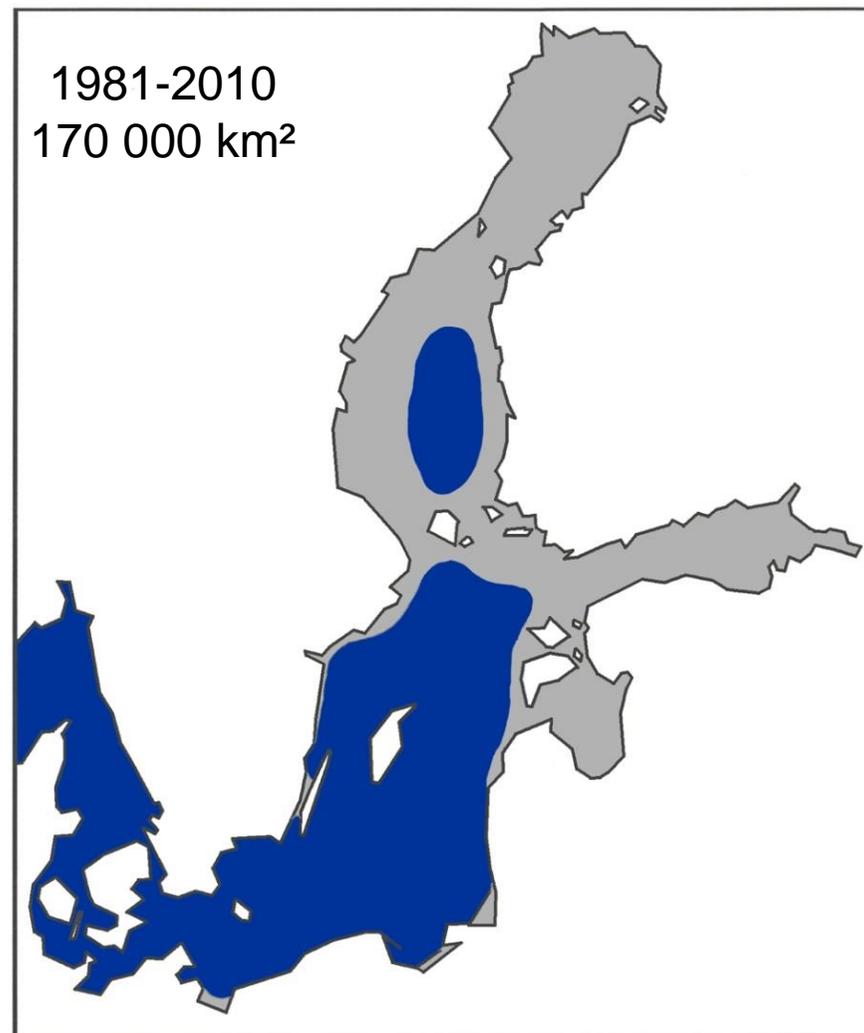
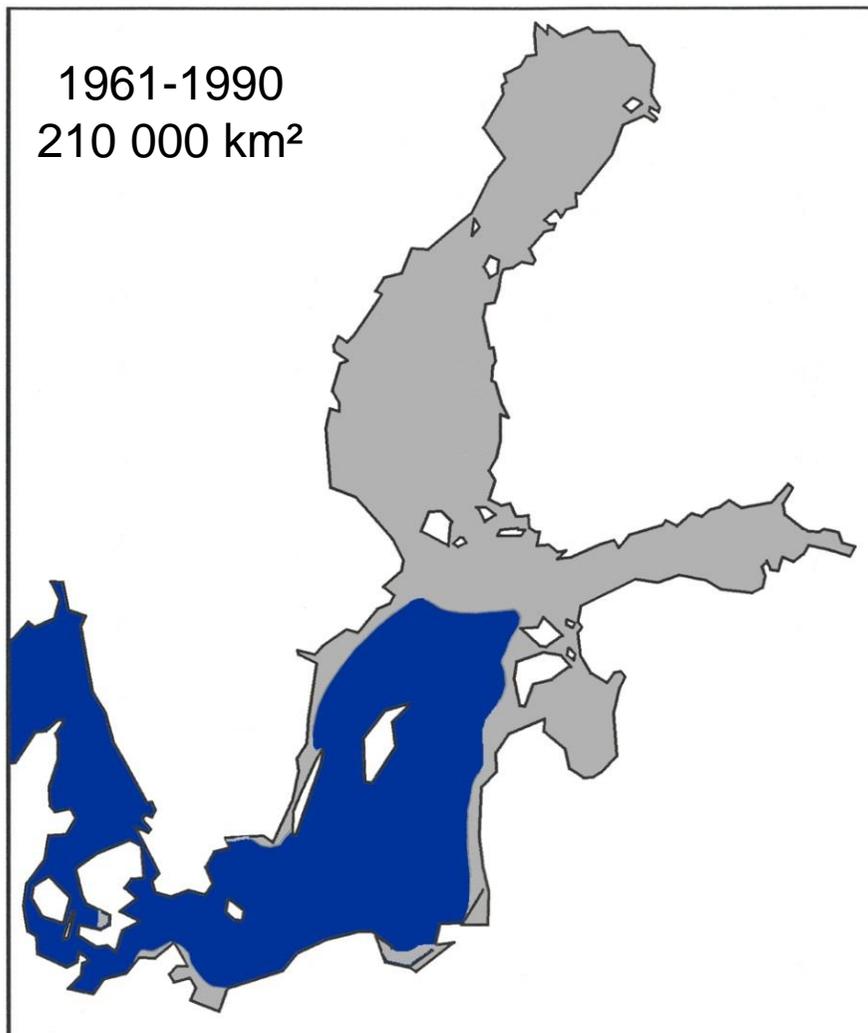


Maximum yearly ice extent 1720-2016 and 30-year moving average





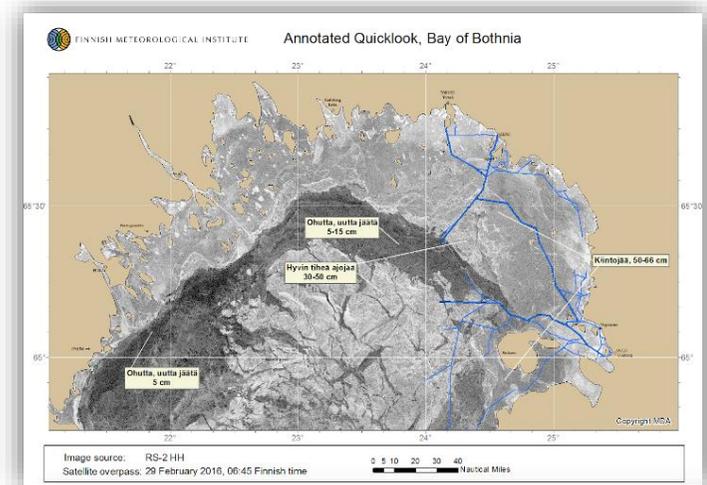
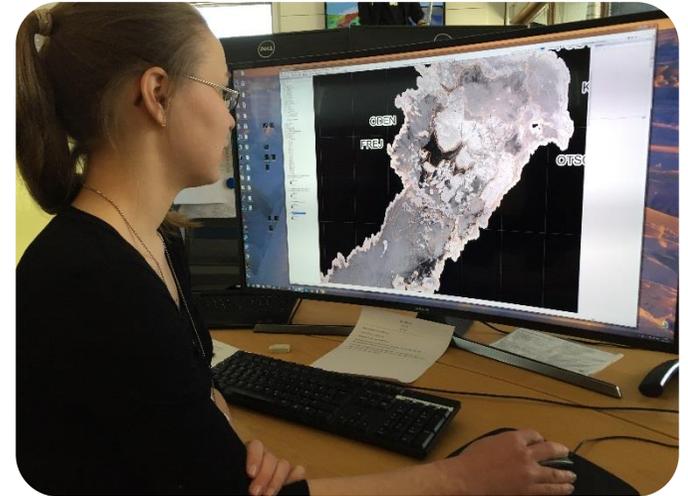
Comparison of two 30-year reference periods and the average of their yearly maximum ice extent

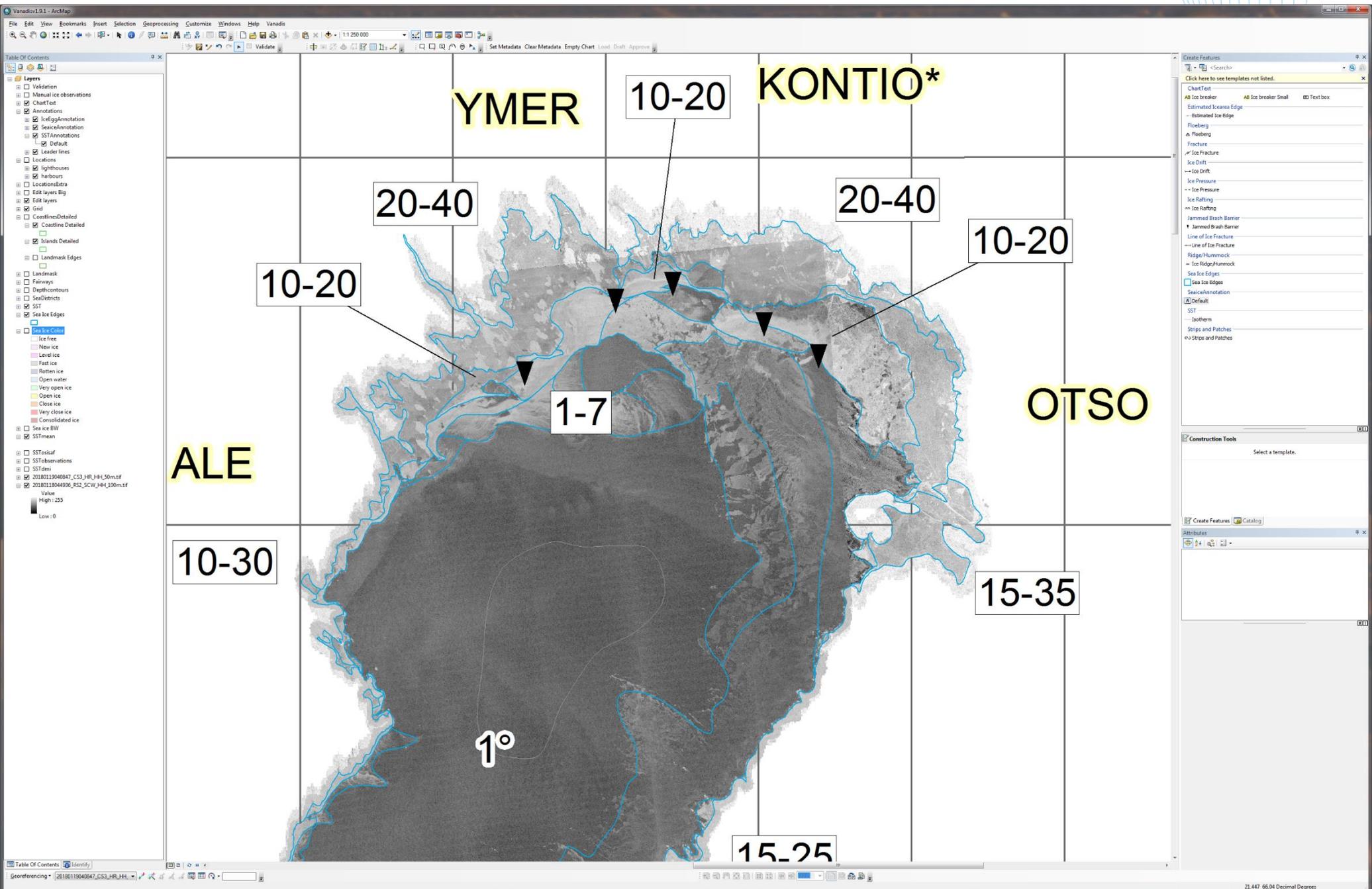




Vanadis

- GIS software tailored for ice situation analysis
- Vanadis consists of:
 - ArcGIS10
 - Vanadis extension to ArcGIS for easier data handling
 - Vanadis postGIS database
- Vanadis is used for:
 - Visualizing GIS data such as satellite images, SST data, observations
 - Creating ice analysis (polygons)
 - Visualization of analyzed ice conditions:
Creating the ice chart
- Several automatic outputs from Vanadis DB:
 - Gridded data: NetCDF
 - Statistics, cvs
 - Sub-basin ice charts, pdf
 - Sigrid-3
 - S-411
 - Copernicus CMEMS products





ALE

YMER

KONTIO*

OTSO

10-20

20-40

10-20

20-40

10-20

1-7

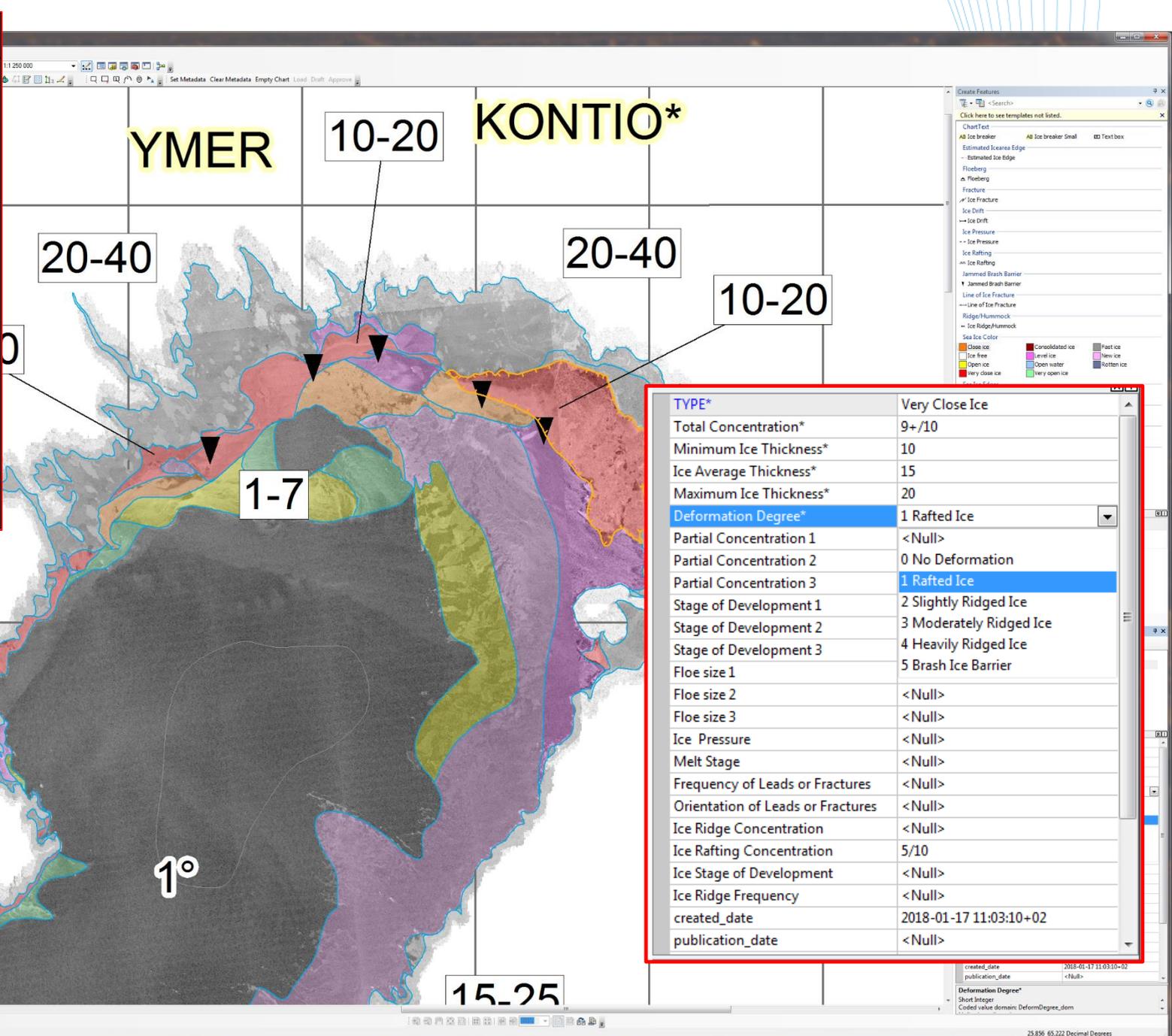
10-30

15-35

15-25

1°

Ice type Istyp Jäättyppi	Concentration Koncentration Peittävyys	Symbols Symboler Merkinnät
Ice free Isfritt Avovesi	-	Jammed brash barrier Stampsivall Sohjovyö
New ice (< 5 cm) Nylis (< 5 cm) Uusi jää (< 5 cm)	7 - 10/10	Rafted ice Hopskjuten is Päällekkäin ajautunut jää
Nilas, grey ice (5-15 cm) Tunn jämn is (5-15 cm) Ohut tasainen jää (5-15 cm)	9 - 10/10	Ridged or hummocked ice Vallar eller upptornad is Ahtaunut tai ryykköitynyt jää
Fast ice Fastis Kiintojää	10/10	Strips and patches Strängar av drivis Ajojäänauhoja
Rotten fast ice Rutten fastis Hauras kiintojää	-	Floe-bit, floeberg Isbumling Ahojää - tai ryykkiölautta
Open water Öppet vatten Avovesi	< 1/10	Fracture Spricka Repeämä
Very open ice Mycket spridd drivis Hyvin harva ajojää	1 - 3/10	Fracture zone Område med sprickor Repeämävyöhyke
Open ice Spridd drivis Harva ajojää	4 - 6/10	Estimated ice edge Uppskattad iskant Arvioitu jään reuna
Close ice Tät drivis Tiheä ajojää	7 - 8/10	Icebreaker (* coordinating) Isbrytare (* koordinerande) Jäänmurtaja (* koordinaattori)
Very close ice Mycket tät drivis Hyvin tiheä ajojää	9 - 9+/10	Water temperature isotherm (°C) Vattentemperaturisoterm (°C) Veden lämpötilan tasa-arvokäyrä (°C)
Consolidated ice Sammanfrusen drivis Yhteenjäätynyt ajojää	10/10	Mean water temperature Ytvattnets medeltemperatur Meriveden pintalämpötilan keskiarvo (1971 - 2000)
Ice thickness (cm) Istjocklek (cm) Jään paksuus (cm)		



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	<Null>
Partial Concentration 2	0 No Deformation
Partial Concentration 3	1 Rafted Ice
Stage of Development 1	2 Slightly Ridged Ice
Stage of Development 2	3 Moderately Ridged Ice
Stage of Development 3	4 Heavily Ridged Ice
Floe size 1	5 Brash Ice Barrier
Floe size 2	<Null>
Floe size 3	<Null>
Ice Pressure	<Null>
Melt Stage	<Null>
Frequency of Leads or Fractures	<Null>
Orientation of Leads or Fractures	<Null>
Ice Ridge Concentration	<Null>
Ice Rafting Concentration	5/10
Ice Stage of Development	<Null>
Ice Ridge Frequency	<Null>
created_date	2018-01-17 11:03:10+02
publication_date	<Null>

SSToisaf
 SSTobservations
 SSTdim
 20180119040847_CS3_HR_HH_50m.tif
 20180119044936_RS2_SCW_HH_100m.tif
 Value
 High: 255
 Low: 0

Create Features

Click here to see templates not listed.

Chart tool

Ice breaker
 Ice breaker Small
 Text box

Estimated Icearea Edge

Estimated Ice Edge
 Floeberg
 Fracture
 Ice Fracture
 Ice Drift
 Ice Pressure
 Ice Pressure
 Ice Rafting
 Ice Rafting
 Jammed Brash Barrier
 Jammed Brash Barrier
 Line of Ice Fracture
 Line of Ice Fracture
 Ridge/Hummock
 Ice Ridge/Hummock

Sea Ice Color

Consolidated ice
 Fast ice
 Ice free
 Level ice
 New ice
 Open water
 Rotten ice
 Very close ice
 Very open ice

created_date 2018-01-17 11:03:10+02
 publication_date <Null>

Deformation Degree*
Short Integer
Coded value domains DeformDegree_dom

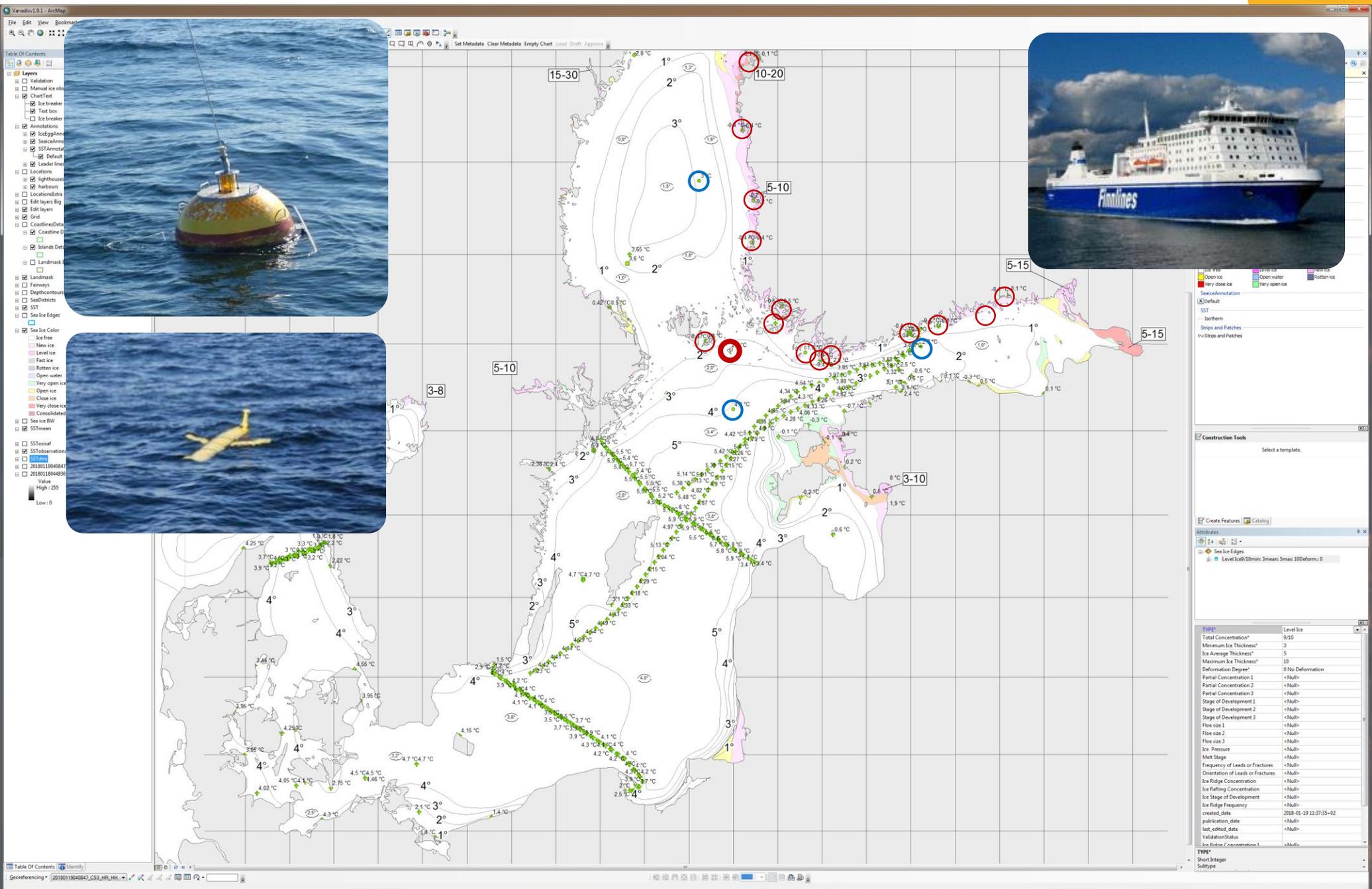


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- LocationsExtra
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- Edit layers
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- Coastline D
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- Landmark
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- Consolidated
- Sea ice BW
- SSTmean
- SSTtotal
- SSTobservations
- SST
- 20180119040847
- 20180119040836
- Value
- High: 255
- Low: 0

- Ice free
- Open ice
- Very close ice
- SeaIceAnnotation
- SST
- Isobath
- Strips and Patches
- Sea Ice Edges

Construction Tools

Select a template.

Create Features

Attributes

Sea Ice Edges
Level Ice/10min:3max:5max:10Deform:0

TYPE	Level Ice
Total Concentration*	9/10
Minimum Ice Thickness*	3
Ice Average Thickness*	5
Maximum Ice Thickness*	10
Deformation Degree*	0 No Deformation
Partial Concentration 1	<Null>
Partial Concentration 2	<Null>
Partial Concentration 3	<Null>
Stage of Development 1	<Null>
Stage of Development 2	<Null>
Stage of Development 3	<Null>
Flake size 1	<Null>
Flake size 2	<Null>
Flake size 3	<Null>
Ice Pressure	<Null>
Melt Stage	<Null>
Frequency of Leads or Fractures	<Null>
Orientation of Leads or Fractures	<Null>
Ice Ridge Concentration	<Null>
Ice Stage of Development	<Null>
Ice Ridge Frequency	<Null>
created_date	2018-01-19 11:37:35-02
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Ice Ridge_Concentration 1	<Null>

TYPE*

- Short Integer
- Subtype

DMI SST analysis (CMEMS)

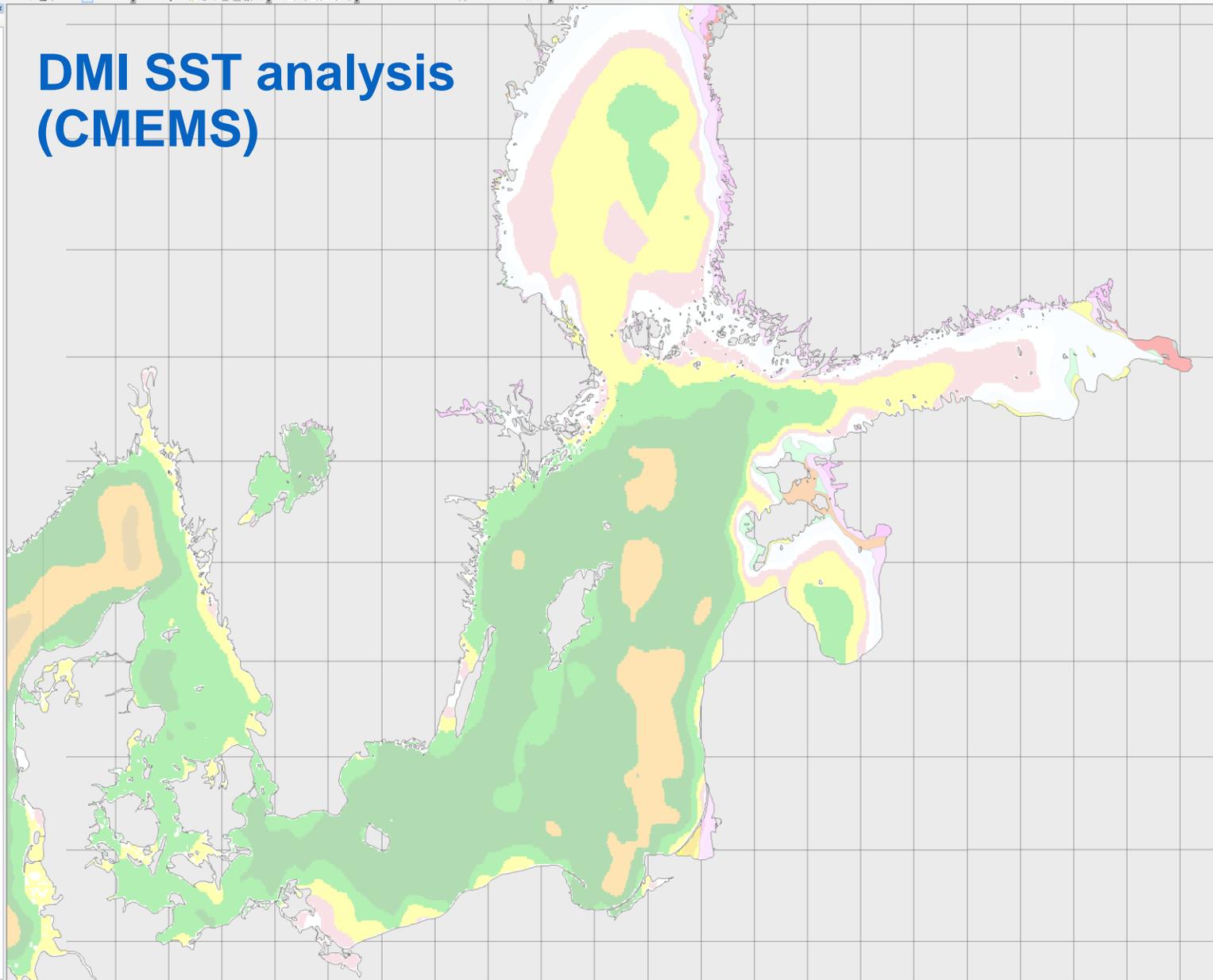


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 - Nebours
 - LocationsExtra
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 - Ice free
 - New ice
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 - Fast ice
 - Rotten ice
 - Open water
 - Very open ice
 - Open ice
 - Close ice
 - Very close ice
 - Consolidated ice
 - Sea ice BW
 - SSTmean
 - SSToissaf
 - SSToobservations
 - SSTmean
 - 20180119040847_CS3_HR_HH_50m.tif
 - 20180118044936_RS2_SCW_HH_100m.tif

Value
High: 255
Low: 0

Create Features

Click here to see templates not listed.

ChartText

- All Ice breaker
- All Ice breaker Small
- Text box

Floeberg

Fracture

- Ice Fracture
- Ice Drift
- Ice Pressure
- Ice Pressure
- Ice Rafting
- Ice Rafting

Jammed Brash Barrier

Jammed Brash Barrier

Line of Ice Fracture

Line of Ice Fracture

Ridge/Hummock

Ice Ridge/Hummock

Sea Ice Color

- Close ice
- Ice free
- Open ice
- Very close ice
- Consolidated ice
- Level ice
- Open water
- Very open ice
- Fast ice
- Sea ice
- Rotten ice

Strips and Patches

Strips and Patches

Construction Tools

Select a template.

Create Features Catalog

Attributes

- Sea Ice Edges
- Level Ice/10min:3mean:5mac:100Deform:0

TYPE	Level Ice
Total Concentration*	9/10
Minimum Ice Thickness*	3
Ice Average Thickness*	5
Maximum Ice Thickness*	10
Deformation Degree*	0 No Deformation
Partial Concentration 1	<Null>
Partial Concentration 2	<Null>
Partial Concentration 3	<Null>
Stage of Development 1	<Null>
Stage of Development 2	<Null>
Stage of Development 3	<Null>
Floe size 1	<Null>
Floe size 2	<Null>
Floe size 3	<Null>
Ice Pressure	<Null>
Melt Stage	<Null>
Frequency of Leads or Fractures	<Null>
Orientation of Leads or Fractures	<Null>
Ice Ridge Concentration	<Null>
Ice Rafting Concentration	<Null>
Ice Stage of Development	<Null>
Ice Ridge Frequency	<Null>
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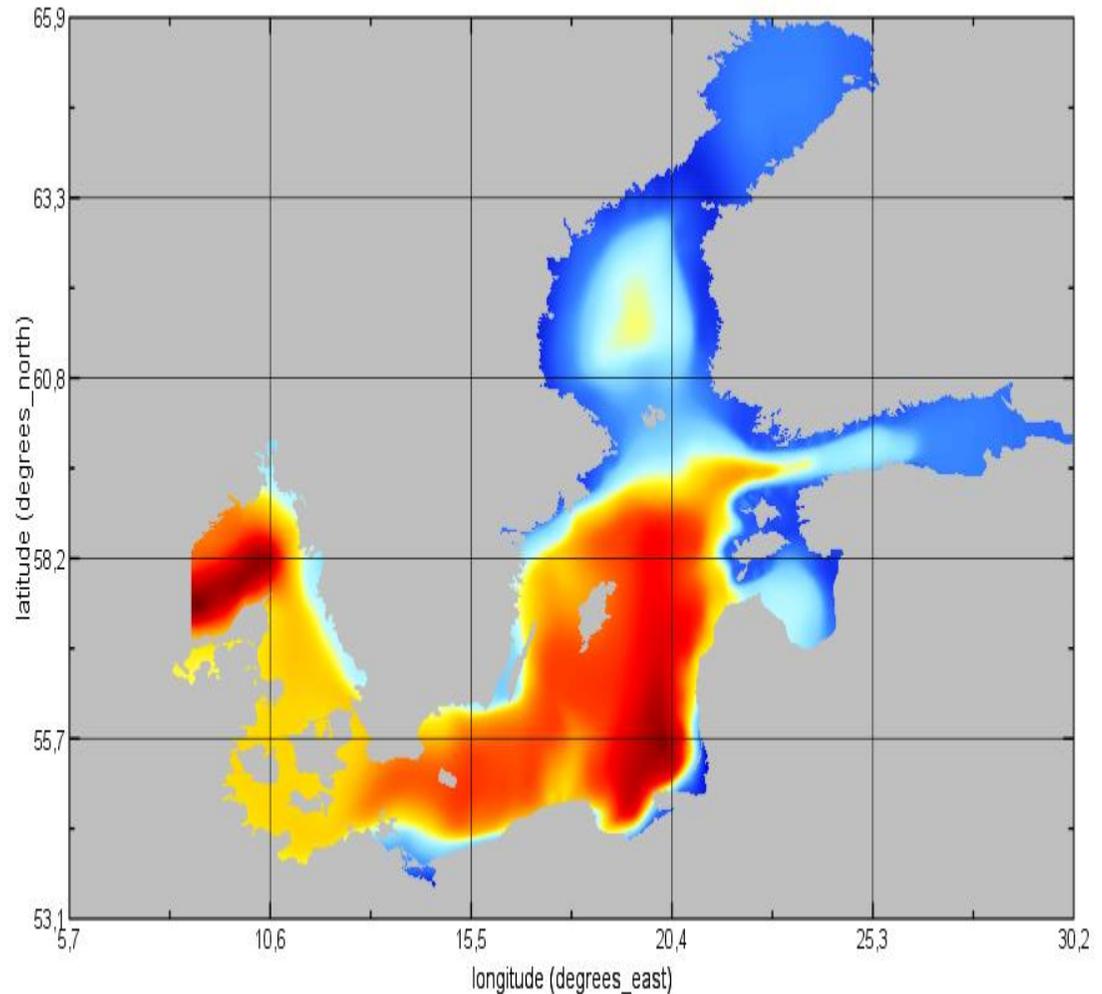
Short Integer

Subtype



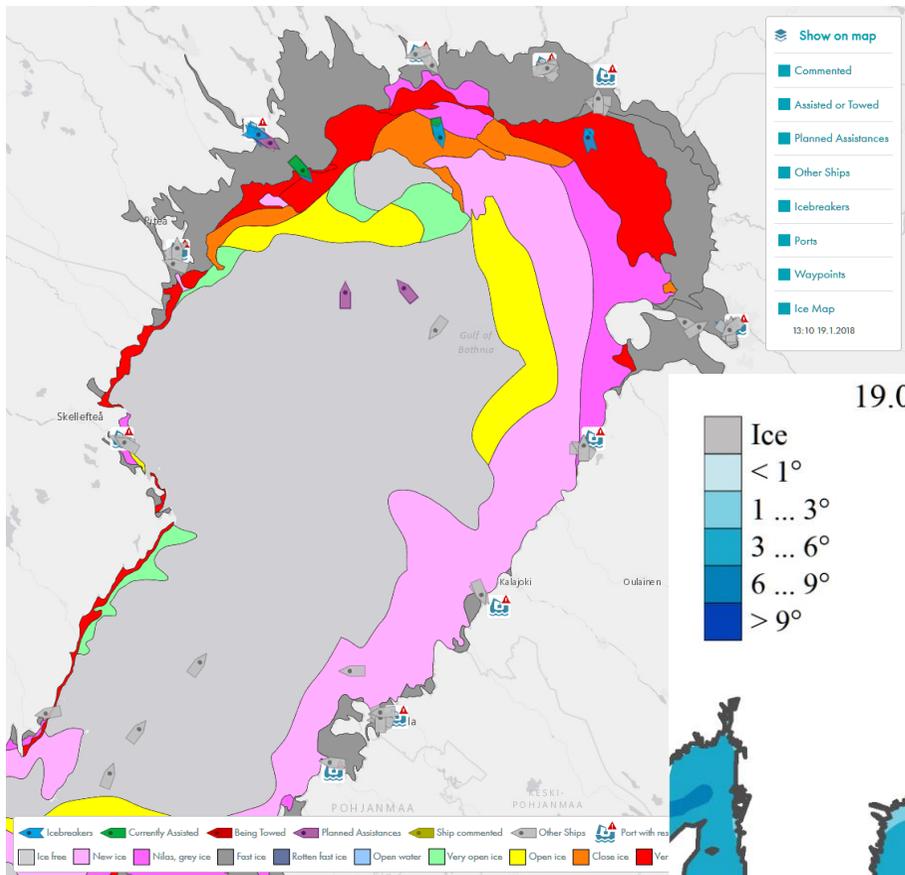
FMI SST analysis

- Interpolated from manually edited isotherms
- Resolution 1 nm
- NetCDF grid

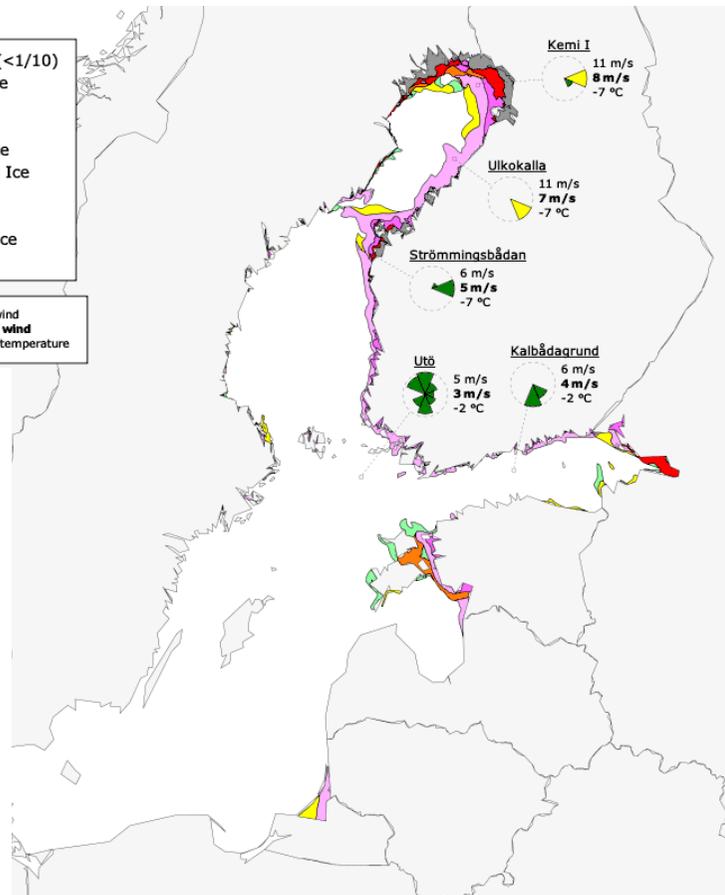
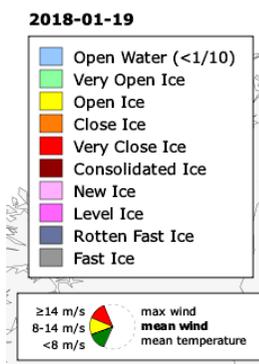




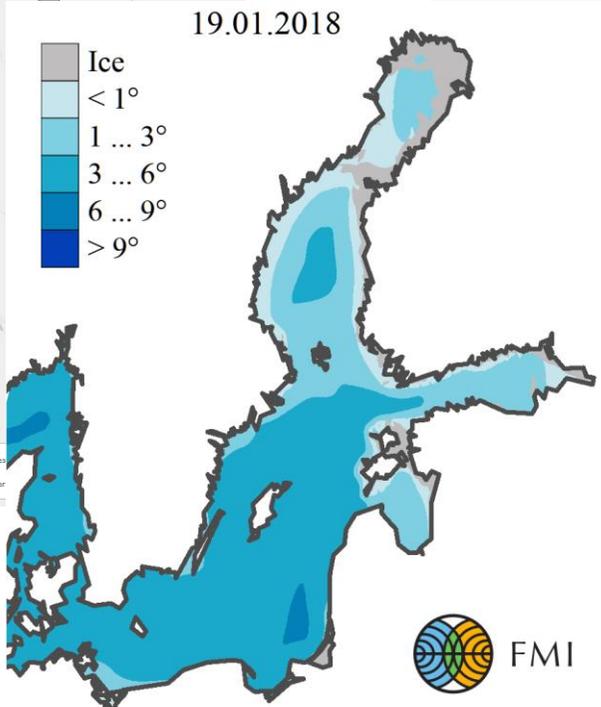
Derivatives of the ice chart data



Baltice.org

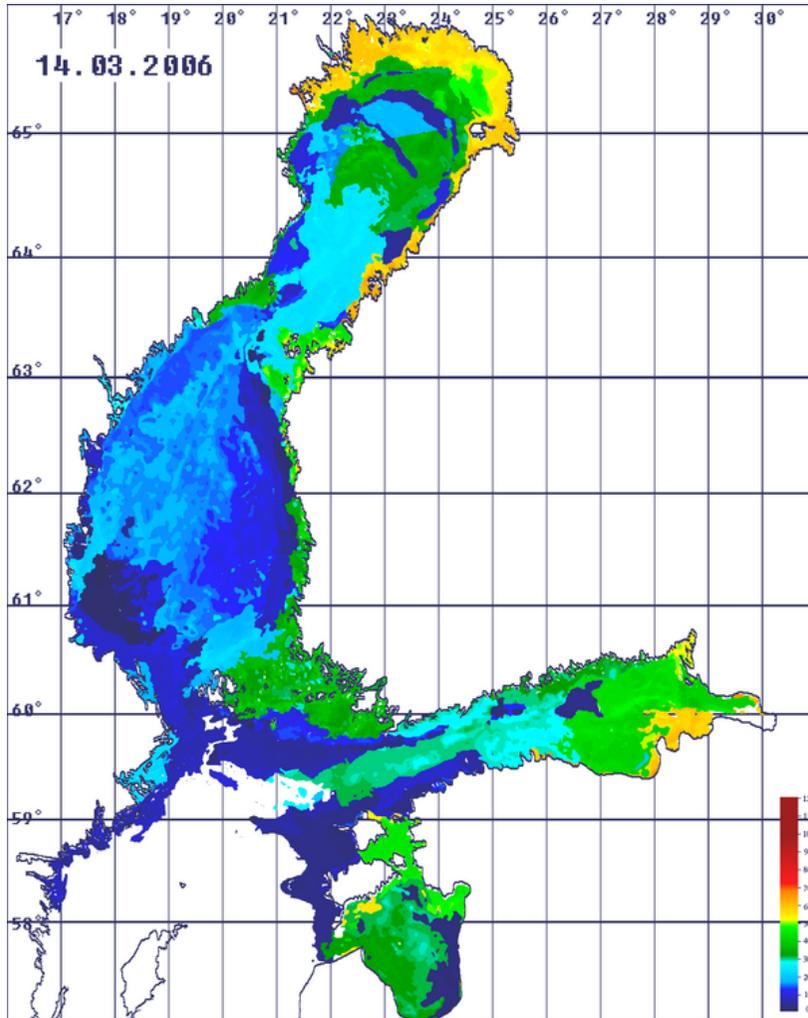


Finnish Traffic Agency





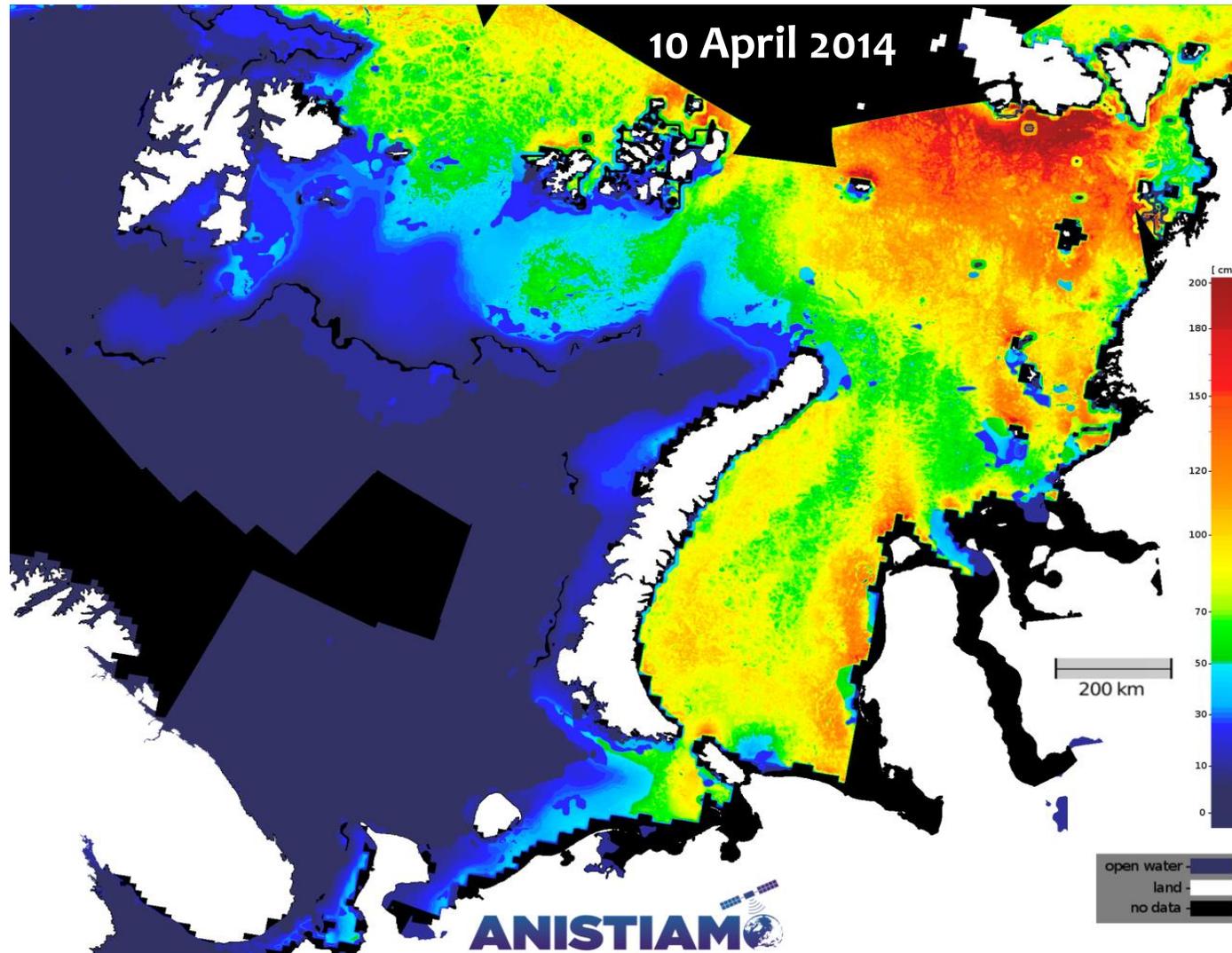
Ice Thickness Image



- ◆ Based on SAR image
- ◆ From ice chart:
 - * Level ice thickness range
 - * Degree of Deformation
- ◆ Spatial resolution 500m
- ◆ About 250 images (ice season 2005-06)
- ◆ Published when SAR data available
- ◆ CMEMS product
- ◆ Under development: Usage in Arctic waters



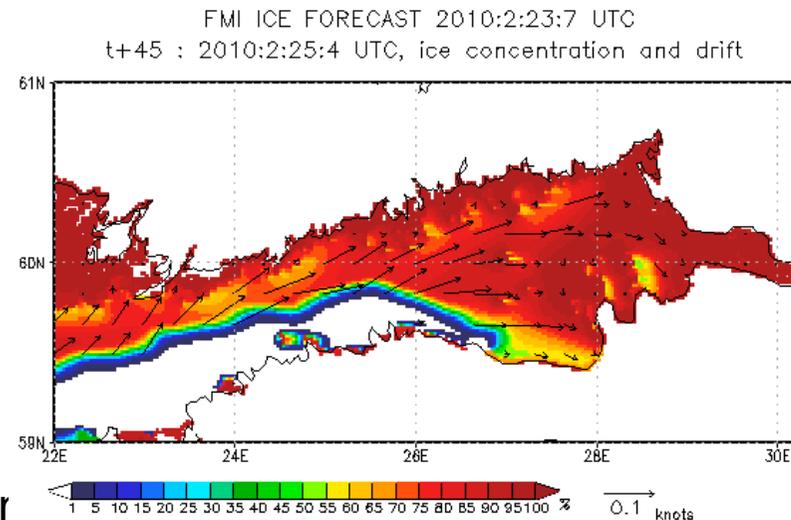
Sea ice identification by remote sensing methods





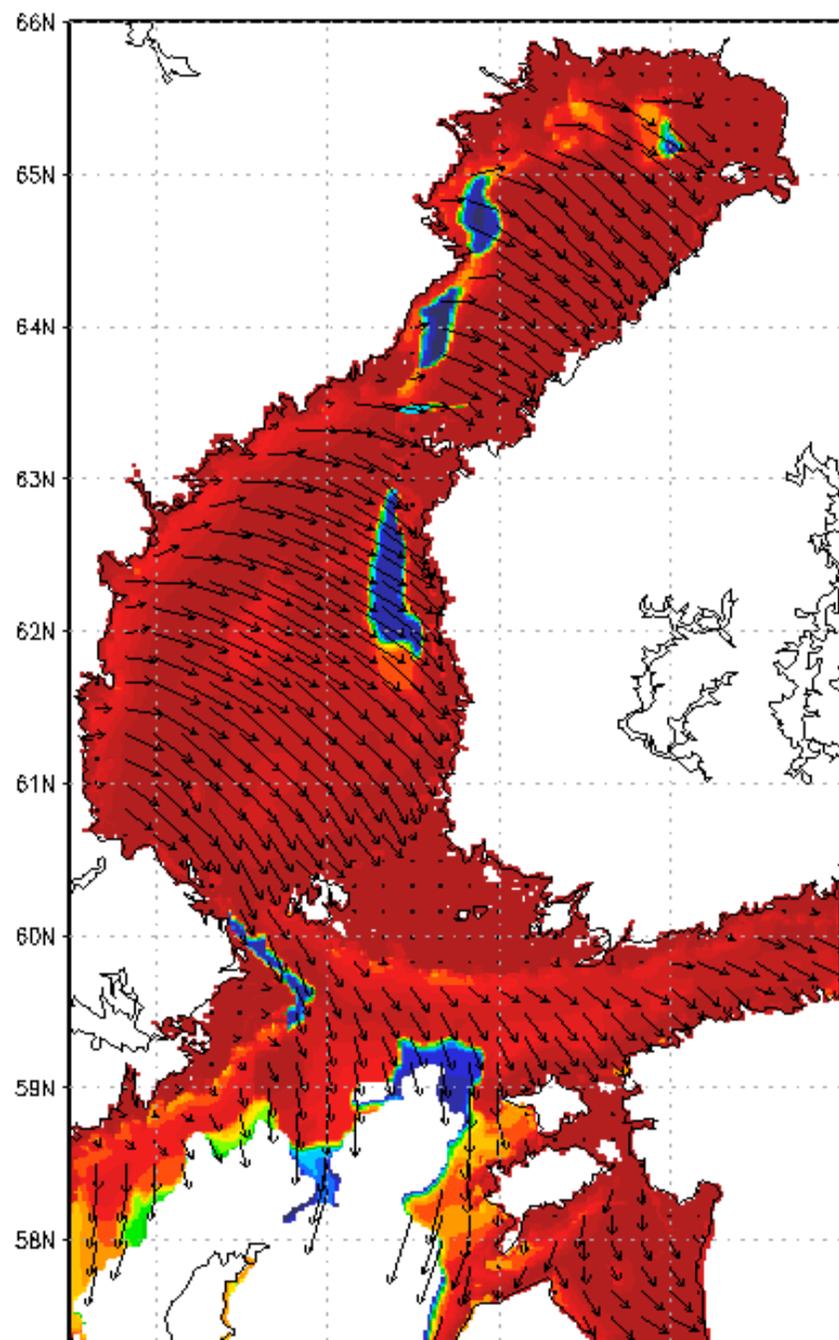
HELMI Ice Model

- HELsinki Multi-category Ice model
- Developed and implemented by Jari Haapala
- Parameters:
 - Drift field
 - Concentration
 - Mean ice thickness
 - Deformed ice thickness
 - Deformed ice fraction
 - Convergence field
 - Compressing region
 - Compression force (under validation)
- Weather forcing:
 - HIRLAM MEPS 54 h



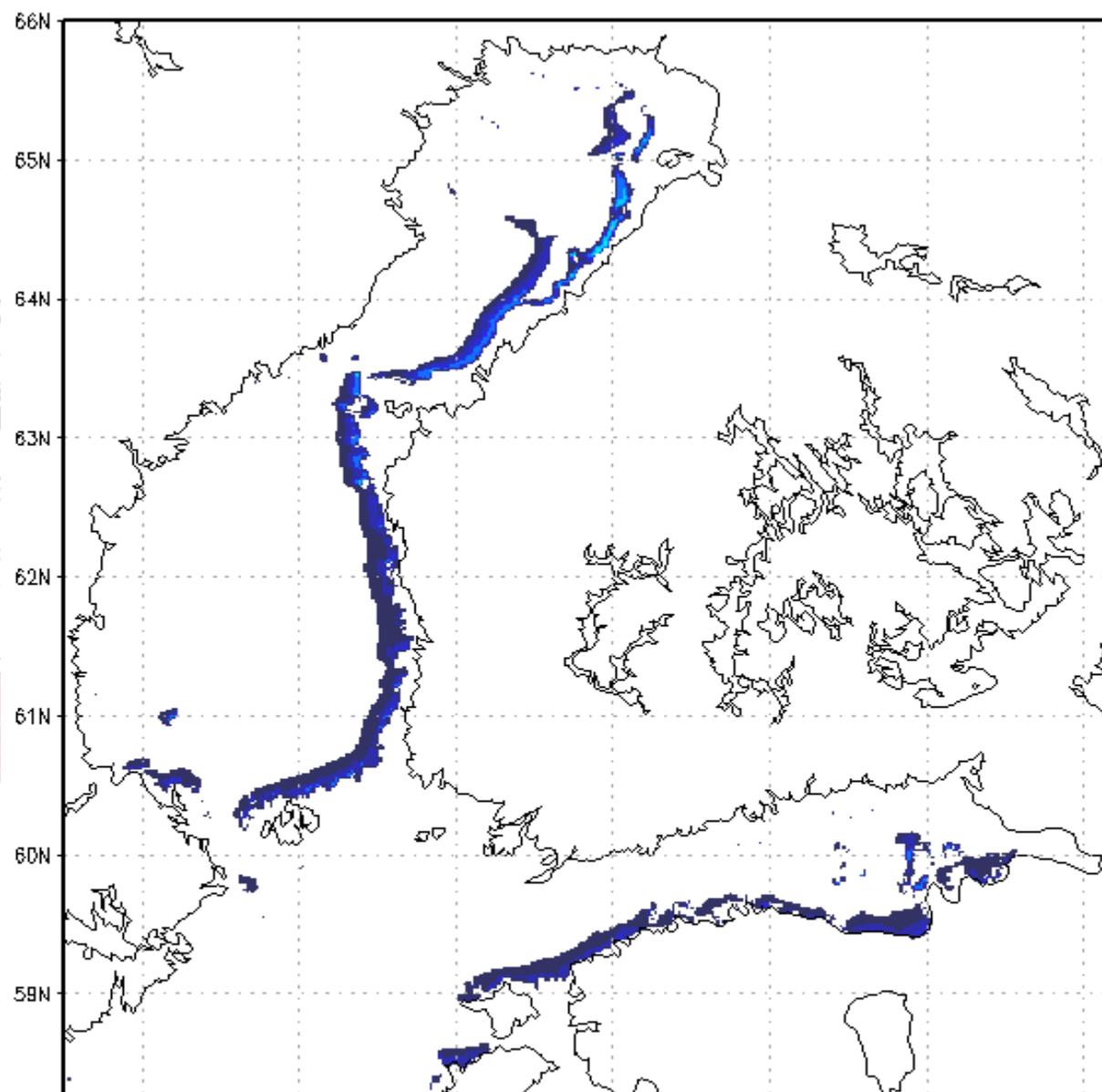
FMI ICE FORECAST 2010:3:9:7 UTC

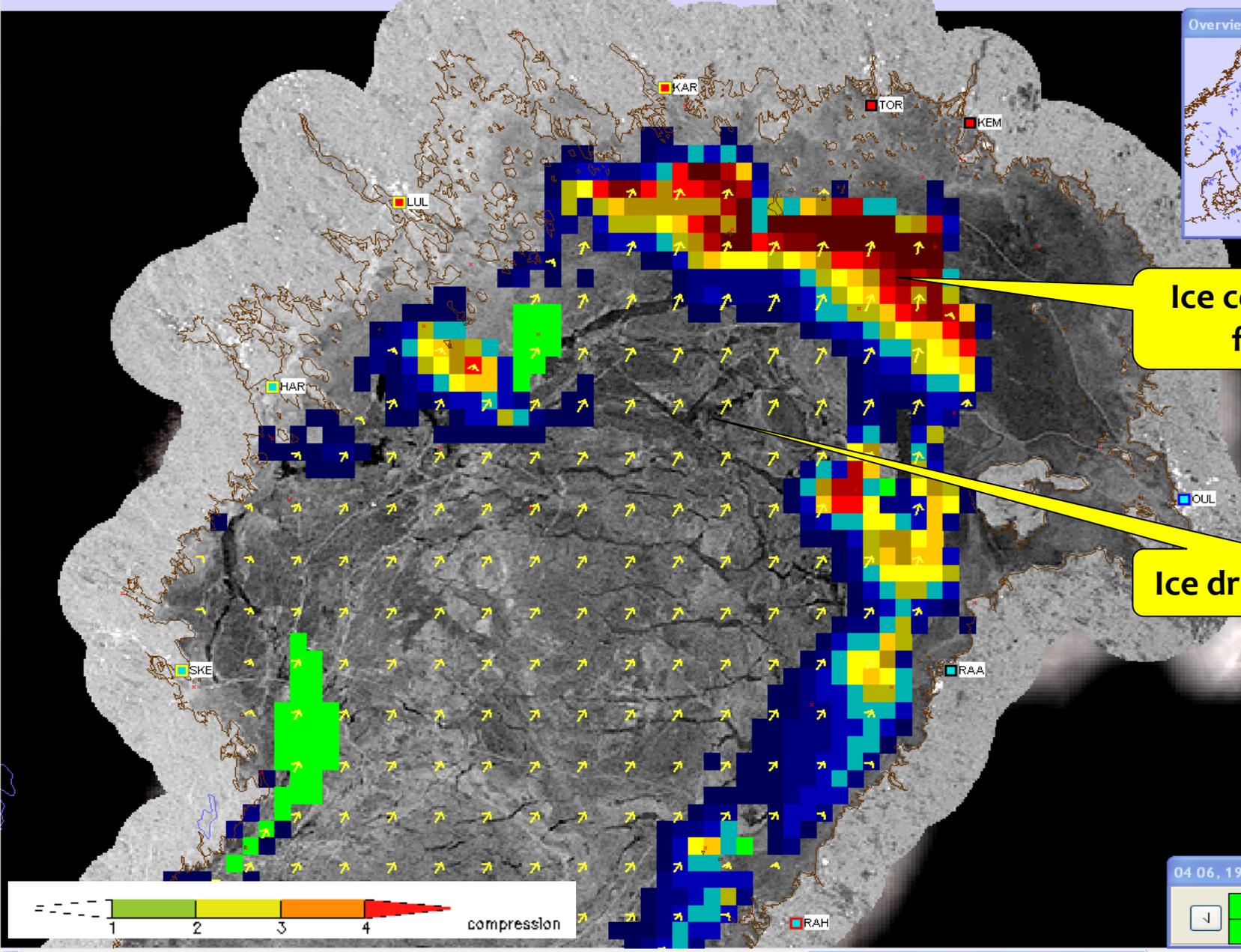
t+0 : 2010:3:9:7 UTC, ice concentration and drift



FMI ICE FORECAST 2010:3:9:7 UTC

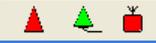
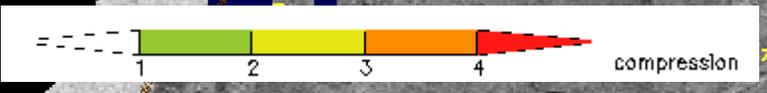
t+0 : 2010:3:9:7 UTC, compressive region





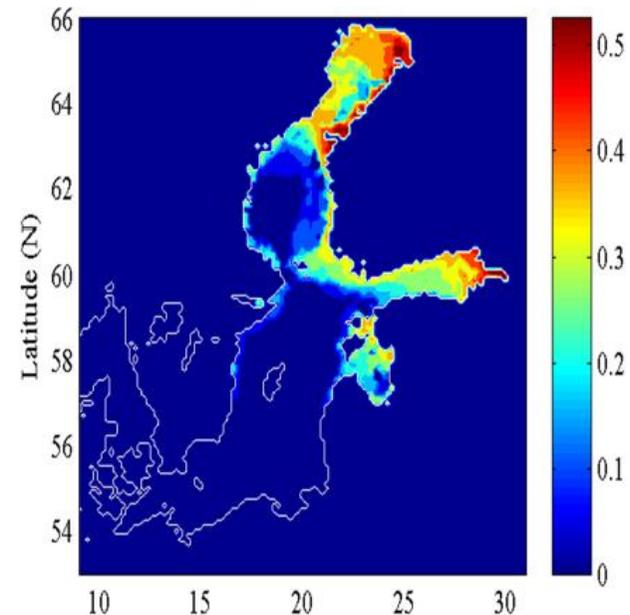
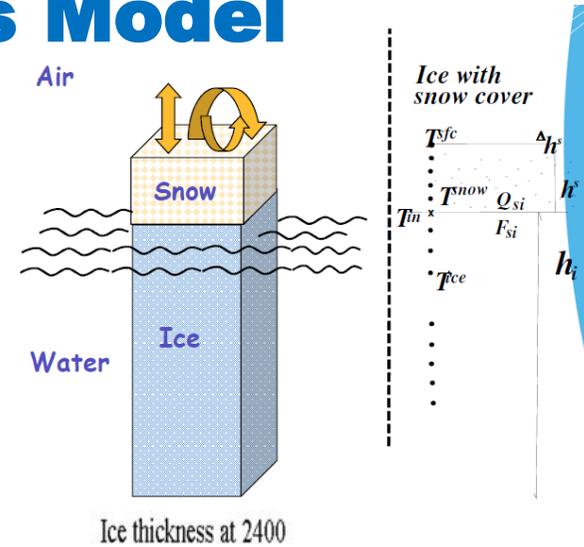
Ice compression forecast

Ice drift forecast



HIGHTSI Ice Thickness Model

- HIGH-resolution Thermodynamic Snow/Ice model
- One-dimensional
- Energy and mass balance
- Radiative/turbulent fluxes
- Feedback mechanisms (albedo)
- Melting/refreezing
- Snow to ice transformation
- Forcing:
 - Wind, Temperature, Humidity, Cloudiness, Precipitation (snow/liquid), Radiation fluxes, Oceanic heat flux





Summary

- Finnish-Swedish sea-ice and SST analysis is a QRT extensive compilation of all available data
- Manual analysis by ice and oceanography expert >> Quality Check
- State-of-the-art data handling and storage
- Distribution according to user needs
- Method could be extended to Arctic/Antarctic areas if logistic resources were available



Thank you!





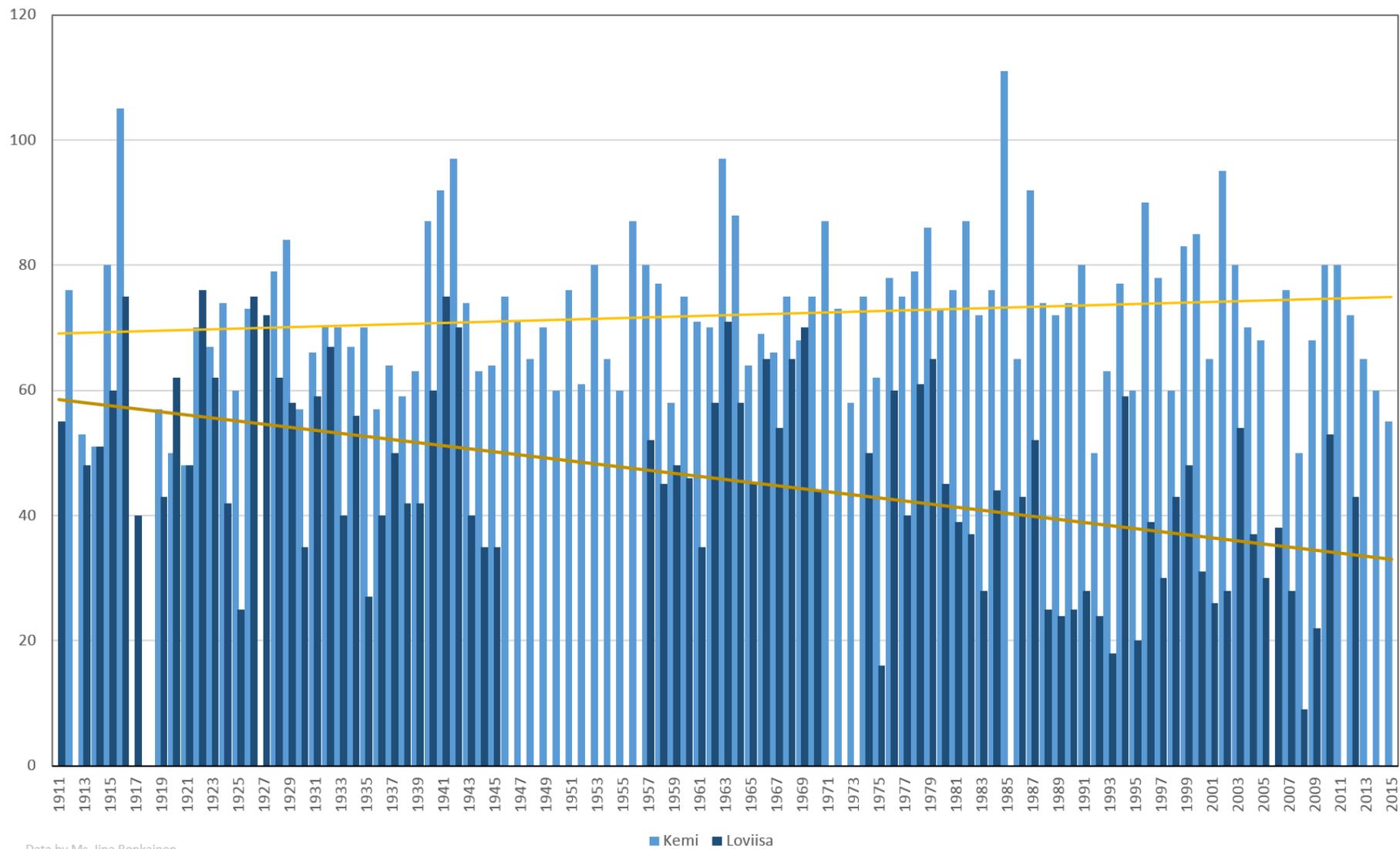
FMI Observations

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





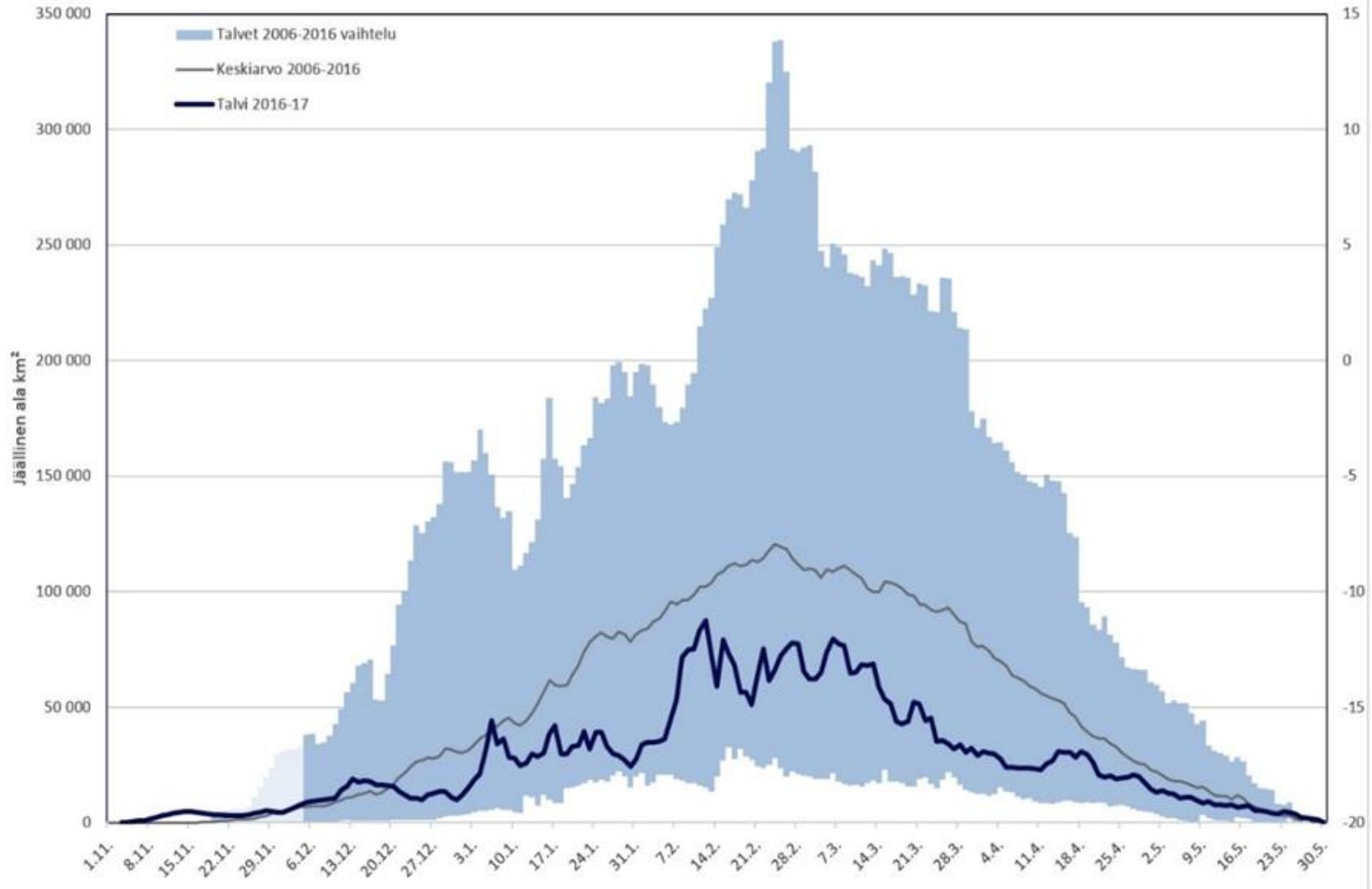
Tasaisen jään paksuus 1911-2015



Data by Ms. Iina Ronkainen



Jäätalven 2016-17 kulku

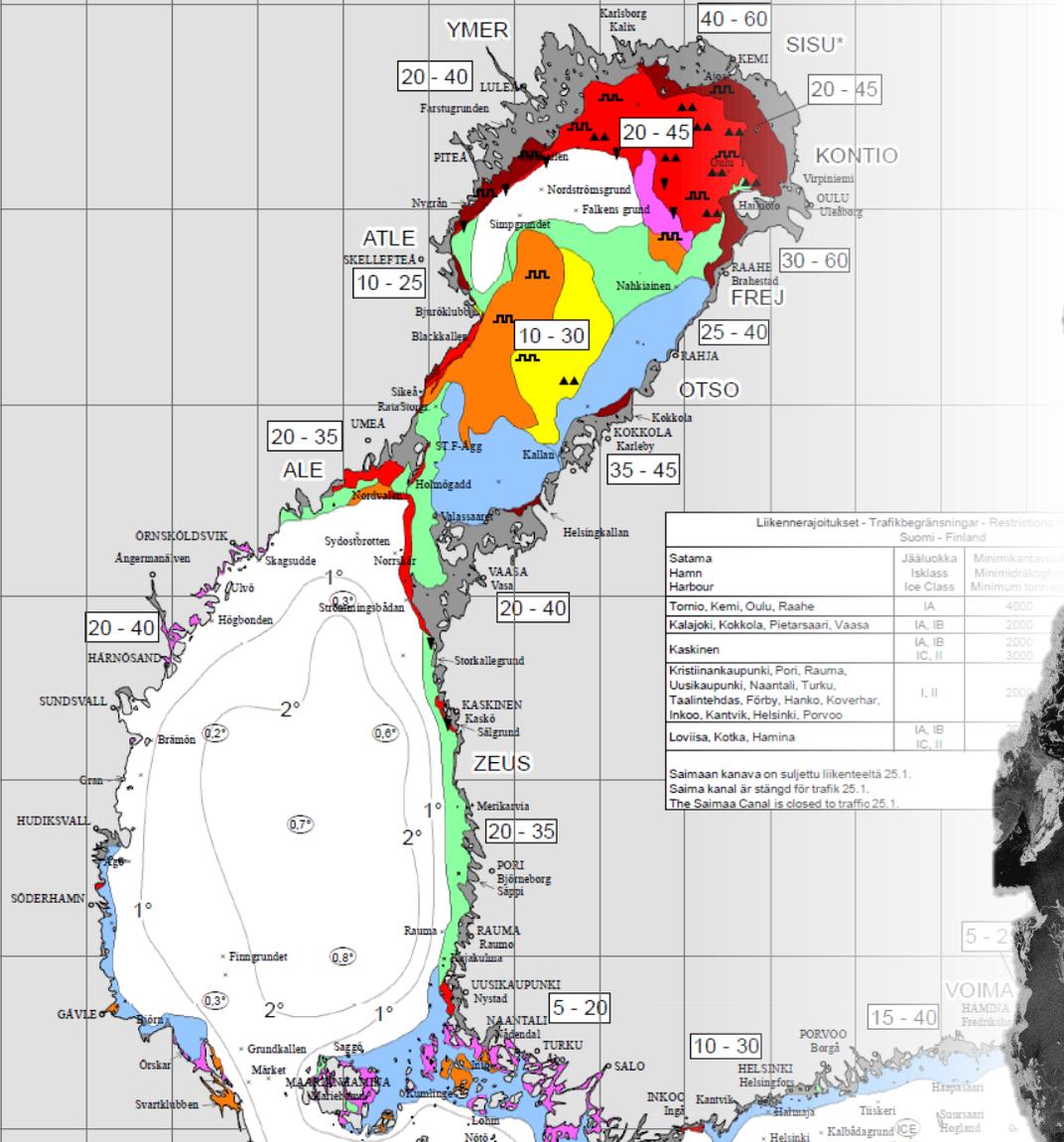


Jääkartta Iskarta Ice Chart

N:o 61

11.2.2016

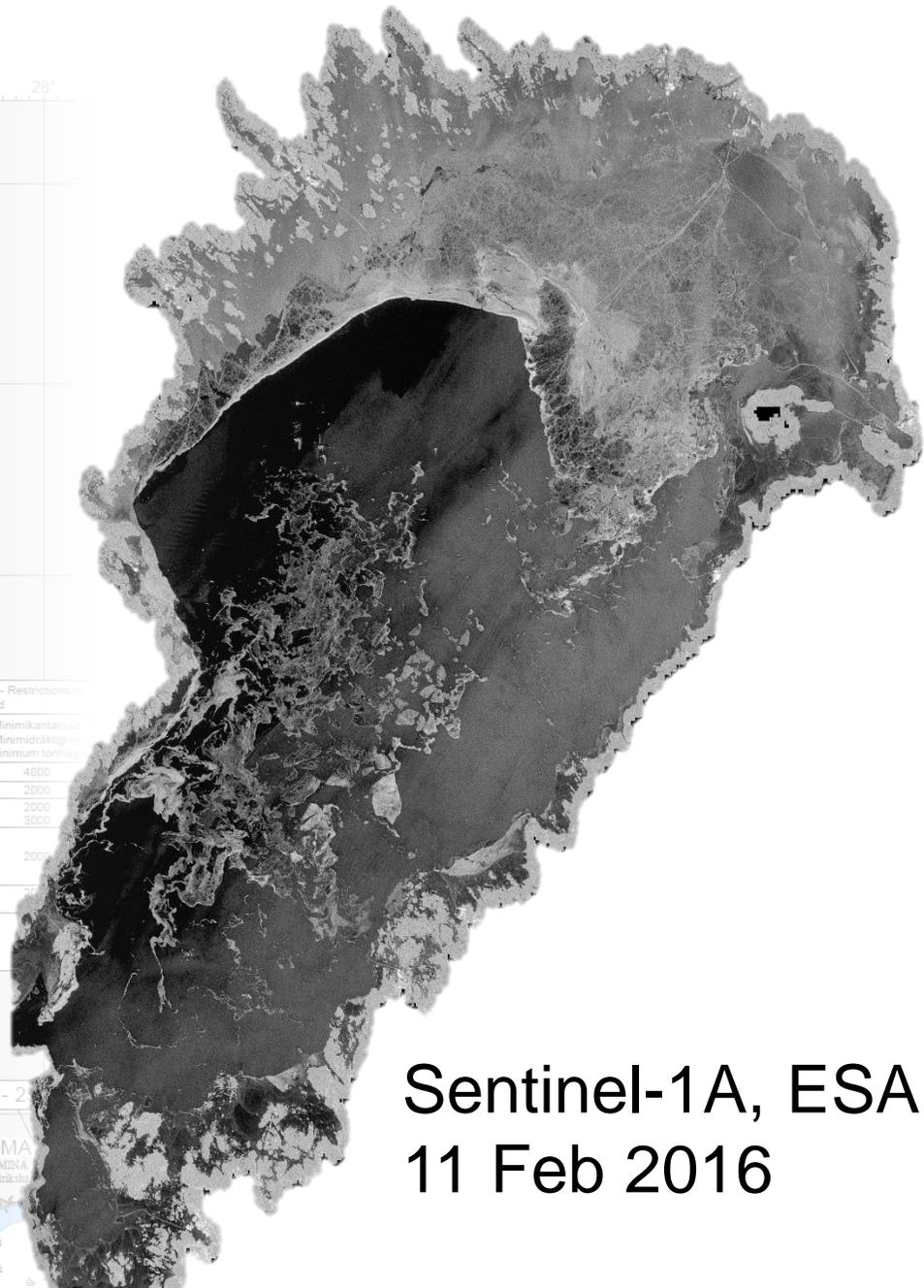
15° 16° 17° 18° 19° 20° 21° 22° 23° 24° 25° 26° 27° 28°



Liikenn rajoitukset - Trafikbegränsningar - Restrictions to traffic
Suomi - Finland

Satama Hamn Harbour	Jäätaluokka Isklass Ice Class	Minimikantavuus Minimum draught
Tornio, Kemi, Oulu, Raahe	IA	4000
Kalajo, Kokkola, Pietarsaari, Vaasa	IA, IB	2000
Kaskinen	IA, IB IC, II	2000 3000
Kristinankaupunki, Pori, Rauma, Uusikaupunki, Naantali, Turku, Taalinthdas, Förby, Hanko, Koverhar, Inkoo, Kantvik, Helsinki, Porvoo	I, II	2000
Loviisa, Kotka, Hamina	IA, IB IC, II	2000 3000

Saimaan kanava on suljettu liikenteeltä 25.1.
Saima kanal är stängd för trafik 25.1.
The Saimaa Canal is closed to traffic 25.1.



Sentinel-1A, ESA
11 Feb 2016