

Use of Satellite SAR observations integrated in Arctic maritime situational awareness

Hans Eilif Larsen

Kongsberg Satellite Services (KSAT)



KONGSBERG

200

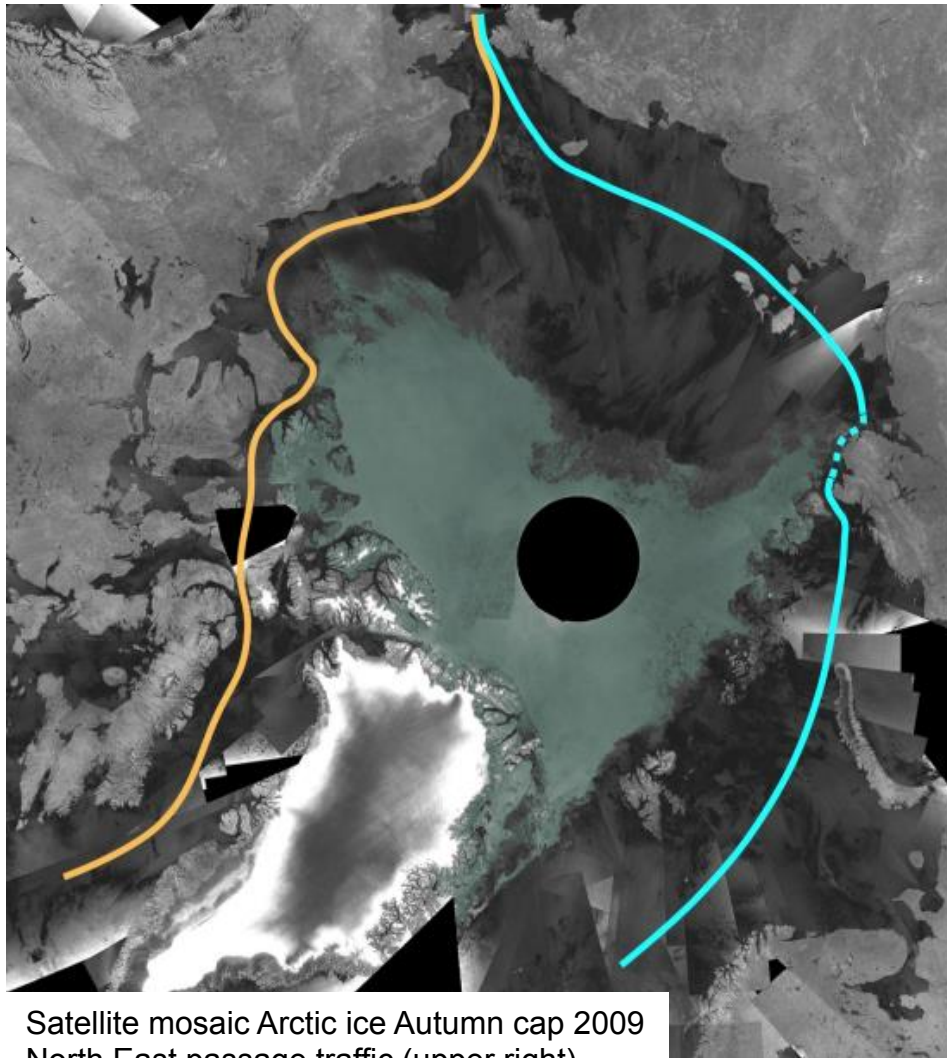
Kongsberg Satellite Services

- **World leading provider within our business area**
 - Satellite Ground station Network and services
 - Maritime monitoring and surveillance services using satellite data
- **Supports 85 satellites, 18000 passes/month**
- **Worldwide customer base**
- **Turnover 2014 ~60 Meuro, 140 employees**
- **HQ in Tromsø, Norway**
- **Operates 9 ground station facilities including both in Northern Arctic (Svalbard and Tromsø) and in Antarctica**
- **24/7/ 365 operations**



Tromsø city

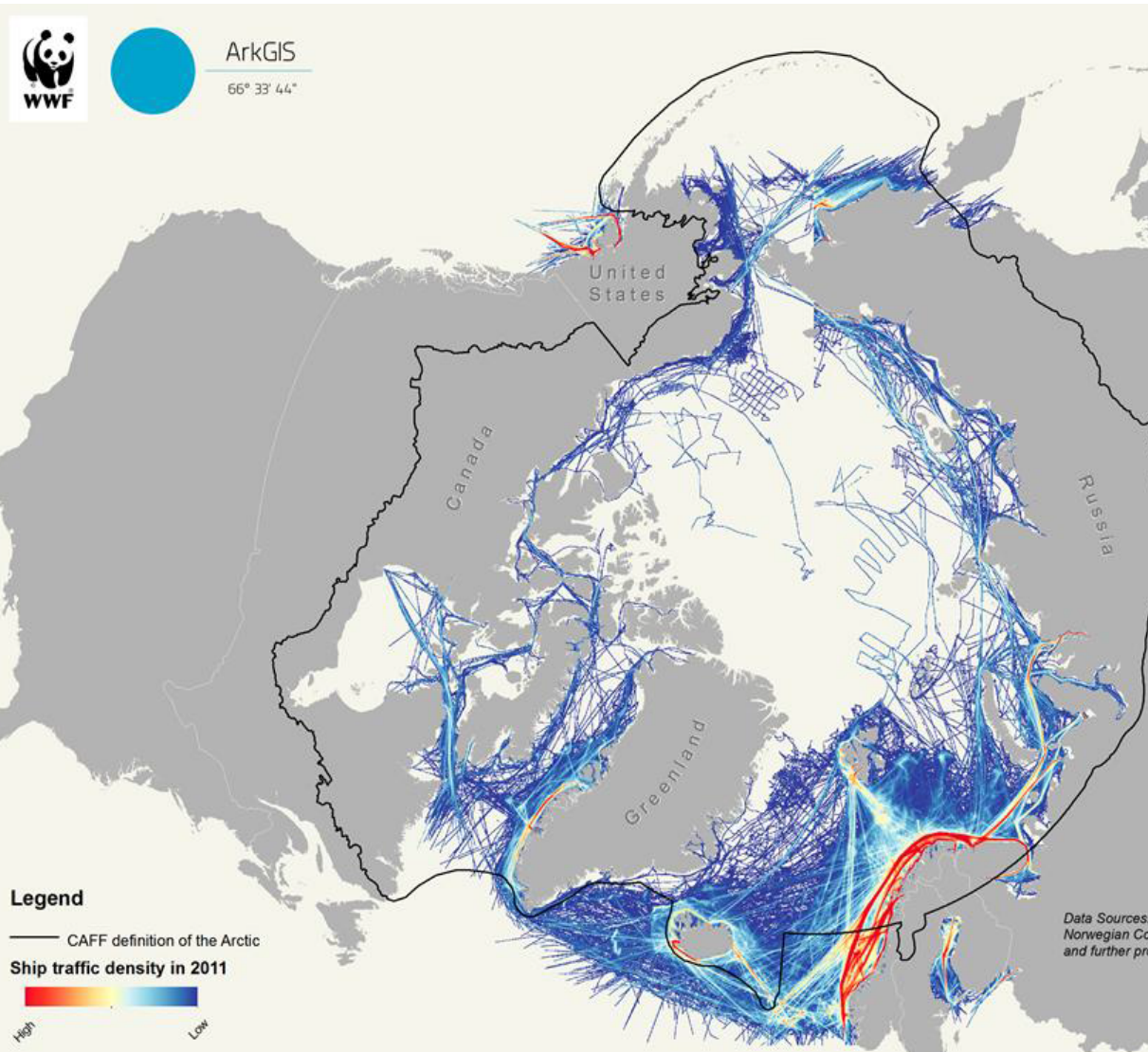
Changing ice conditions, new opportunities



Satellite mosaic Arctic ice Autumn cap 2009
North East passage traffic (upper right)
Arctic drilling (lower right)



Arctic Vessel Traffic



ArcticSat project

- ESA funded feasibility study
- ArcticSat concept aimed to improve situational awareness in the Arctic
- Kick-off: 03.03.2014
- Duration: 14 months
- Core group



Situational Awareness in the Arctic

Depends on critical applications of space technologies

1. Effective communications

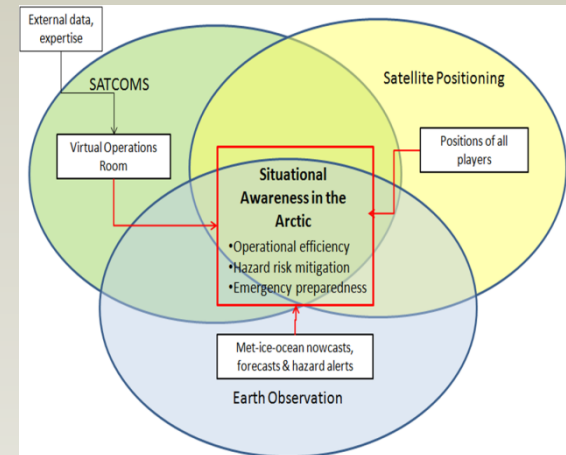
- to enable a complete virtual view of operations and effective decision making, effectively mitigating the remoteness of the activities.

2. Access existing observed and forecasted met-ice-ocean conditions over the field of operations

- potential hazards and dynamic risk assessment

3. Monitor the positions of all players

- deployed and monitored effectively for situational awareness
- safety, emergency preparedness



SITUATIONAL AWARENESS IN THE ARCTIC

- **Communication Awareness**

- *Non-Geostationary satellites*
- *Geostationary satellites*
- *Earth Observation*
- *Terrestrial communication systems*

- **Information and Data Awareness**

- *Integrity on information; Poor ENC coverage and ice chart; Dynamic risk assessment (DRA)*

- **Navigational Awareness**

- **Emergency Response Awareness**

- *Limited SAR resources; Unfit emergency preparedness equipment*

- **Environmental Awareness**

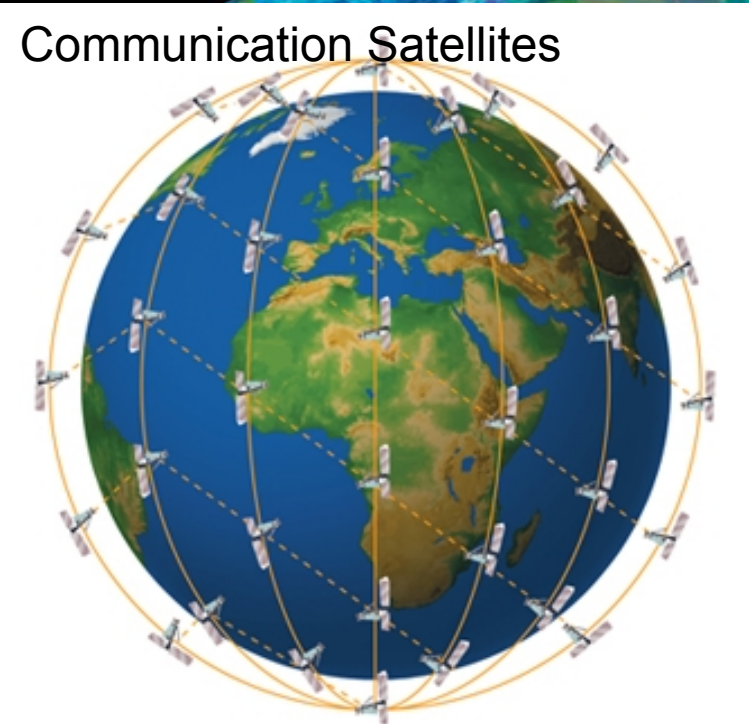
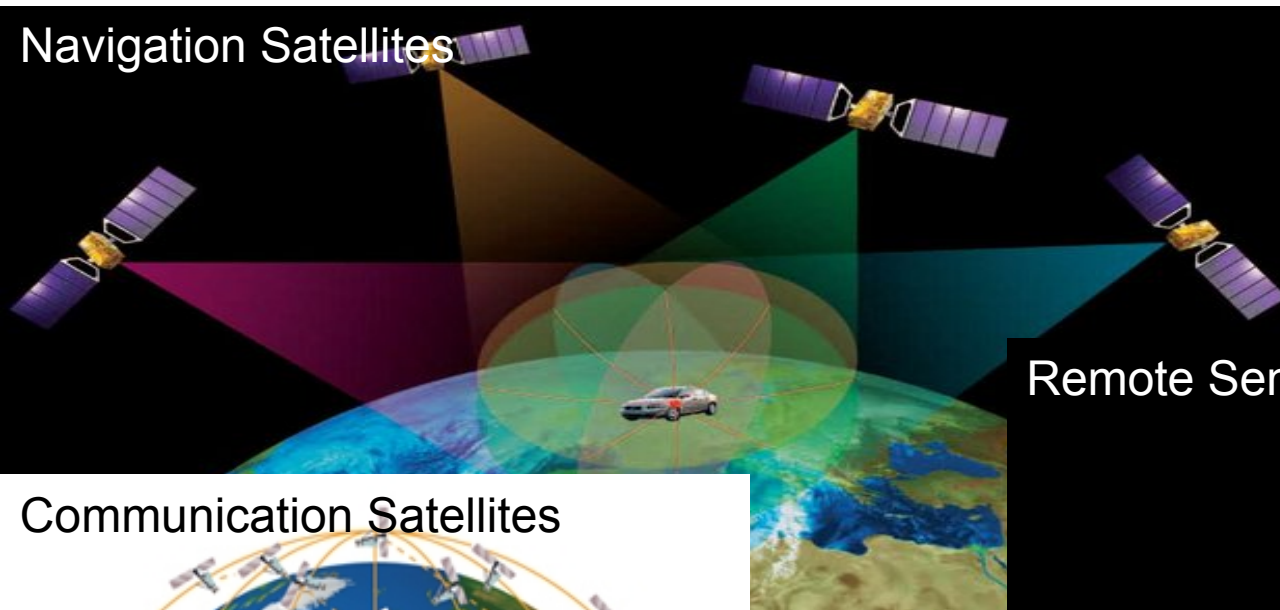
- *Harsh weather; Visibility; Remoteness;*
- *Icing on equipment; Solar activity.*

- **Regulatory Awareness**

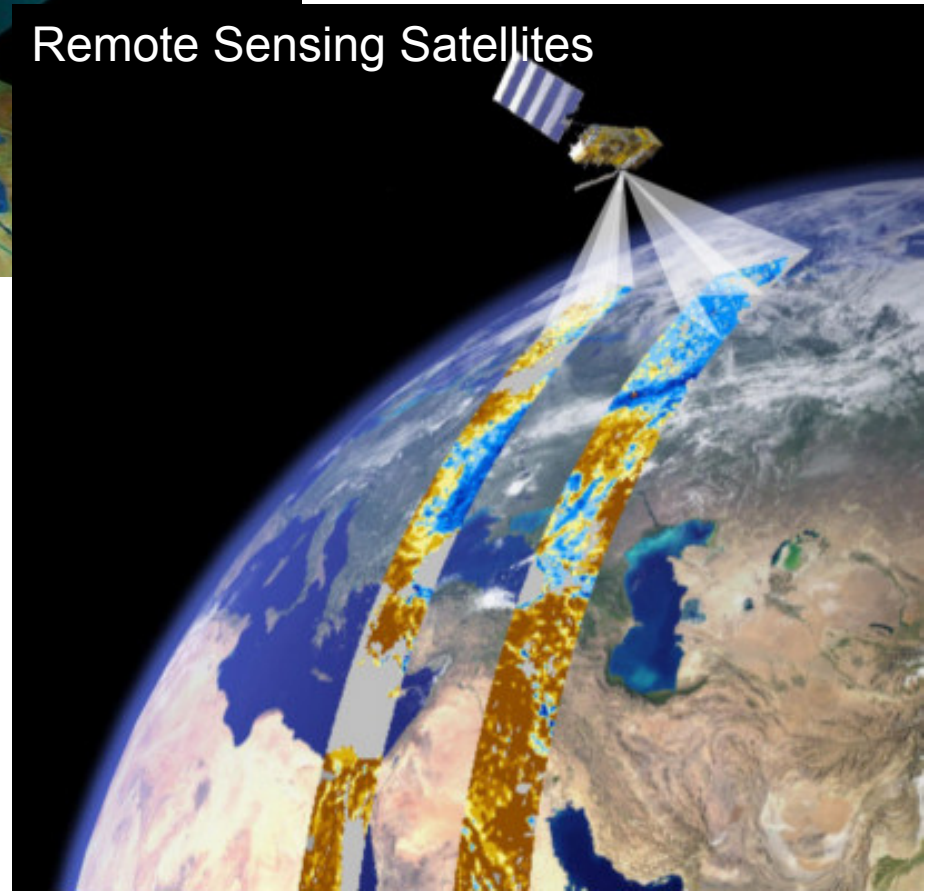
- *Untrained personnel; Lack of international regulations; Requirements and new roles for VTS*



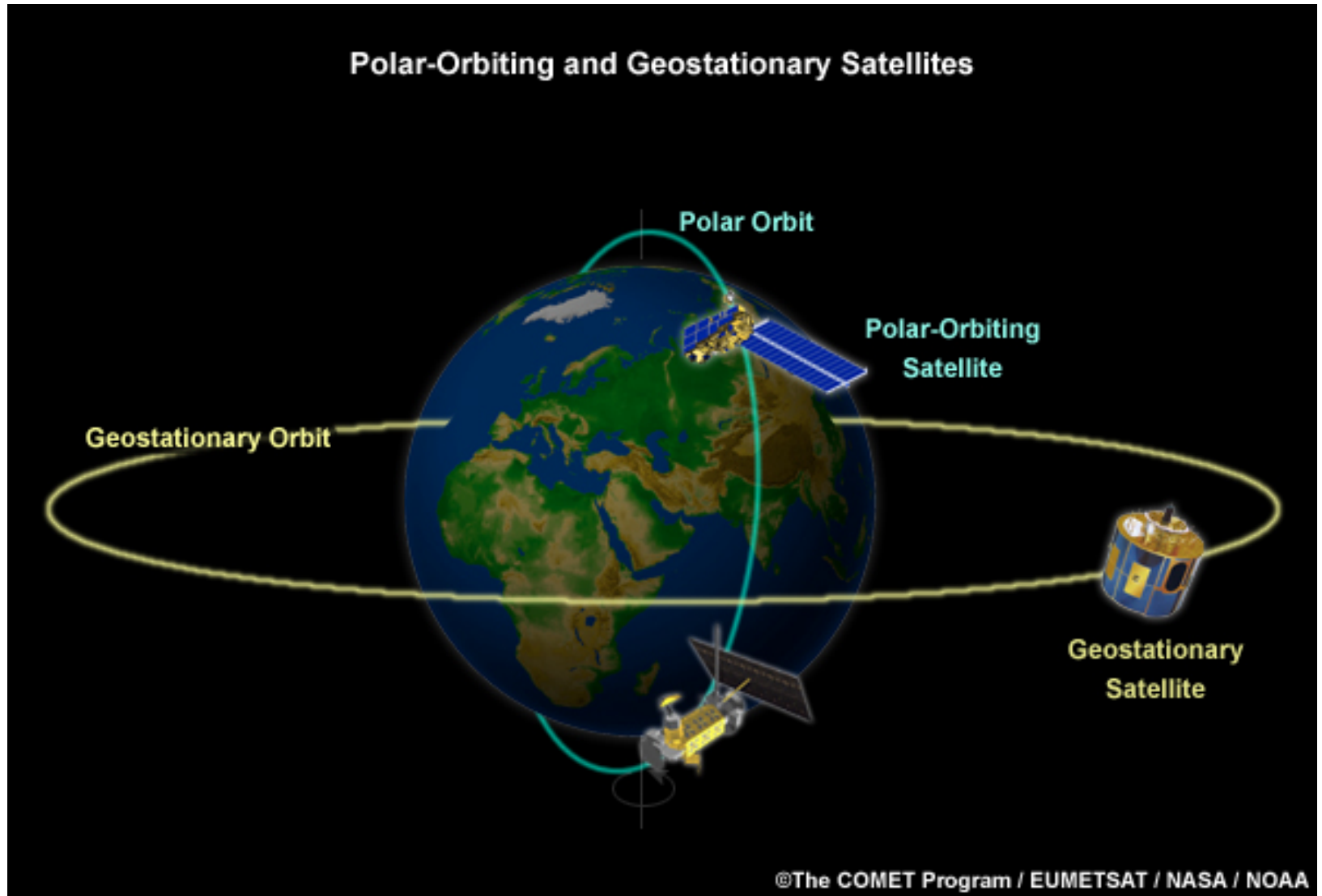
Satellites



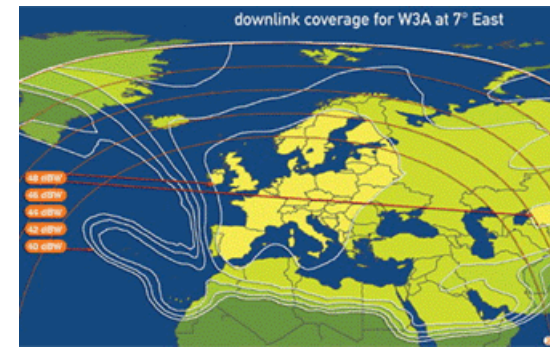
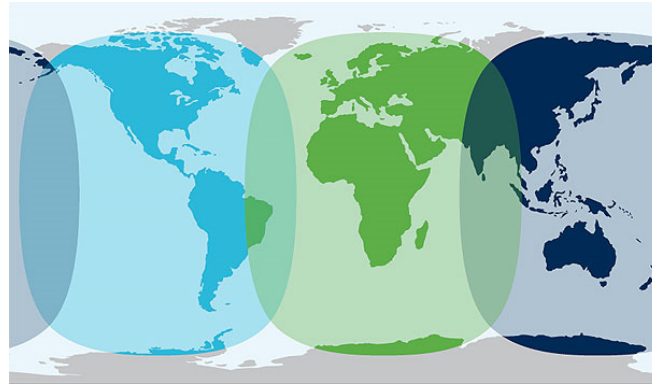
Remote Sensing Satellites



Satellite Orbits



Communication Satellite Alternatives



Iridium CS / OpenPort

True Global Coverage
2,4-128 Kbit/s

Inmarsat FleetBroadband

App. 75° S - 75° N
150-432 Kbit/s

VSAT example

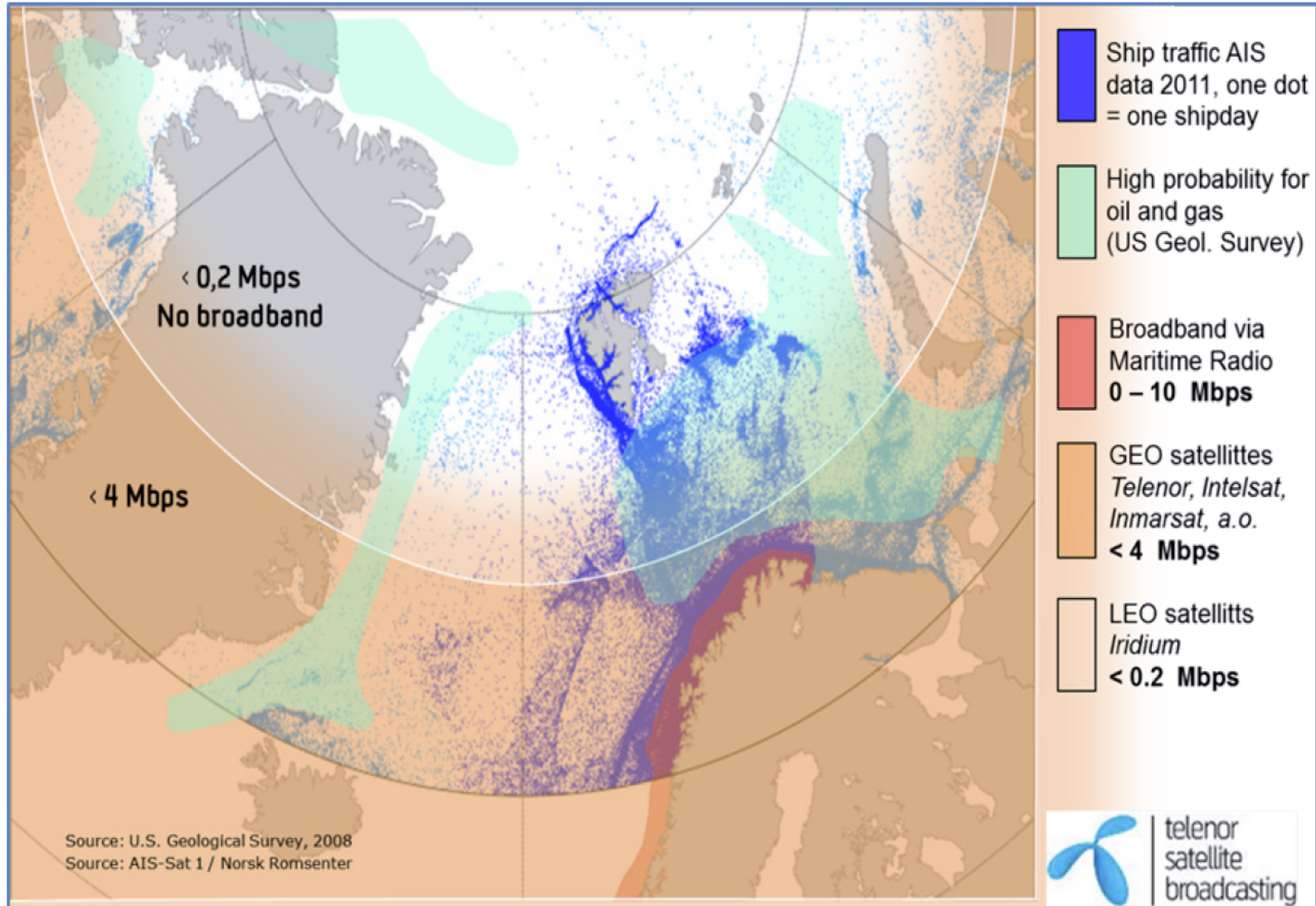
Varies - 60° S - 75° N
128-1024 Kbit/s (Normal Subscriptions)

Polar Orbit

Geostationary Orbit

In general low bandwidth, for users in Arctic also less reliable links

Ship traffic, O&G - and available telecom



User needs

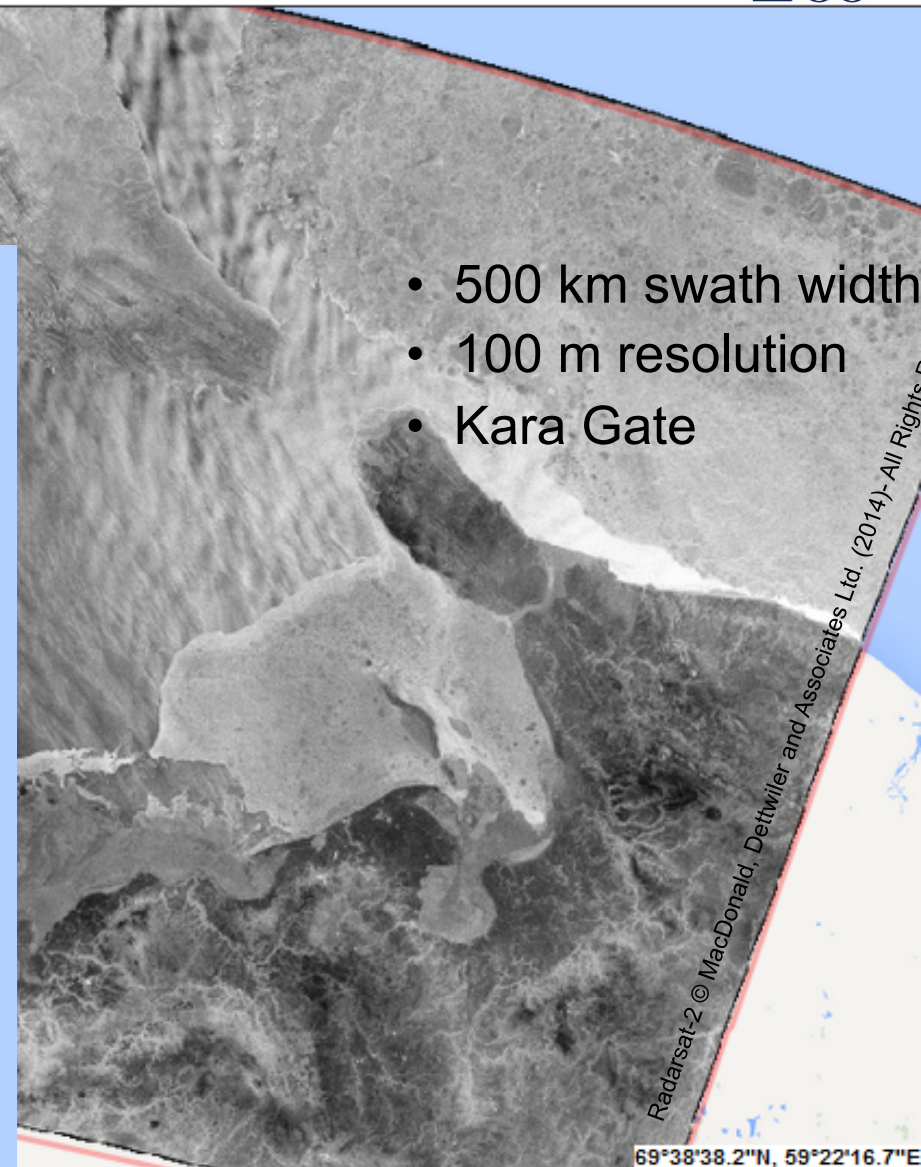
- actors involved in Arctic operations (onboard/land)

- All operational information into a single view (COP) for all ships taking part in a defined operation, e.g. incident
- Optimized distribution of prioritized and adapted data to low bandwidth
- Near Real Time **ice monitoring** based on satellite imagery
 - Ice edge, ice bergs and floes, ice concentration, leads, etc.
 - NRT-acquisition
 - NRT detection (analysis) of sea ice,
- similar need for **oil spills** and **vessels**
- Forecast drift of detected ice, objects and oil spills
- Vessel traffic monitoring, including vessel detection without AIS-signal

Remote Sensing Satellites - Radar



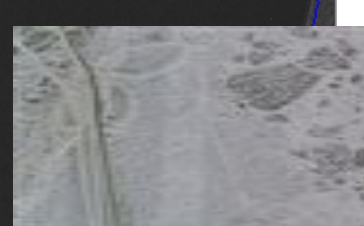
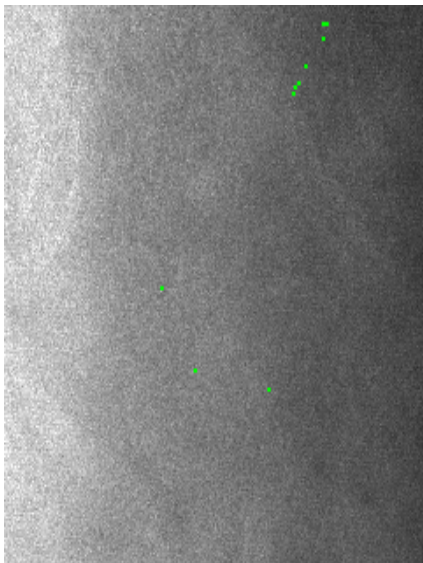
- 30 km Swath width
- 3 m resolution



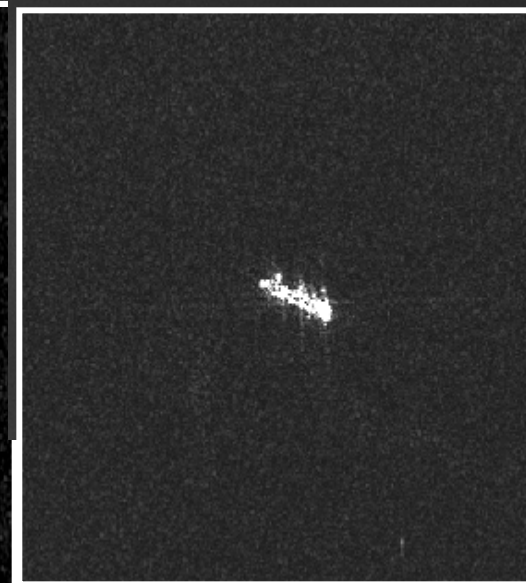
- 500 km swath width
- 100 m resolution
- Kara Gate

69°38'38.2"N, 59°22'16.7"E

Satellite tradeoff: Coverage vs resolution



20 km swath optical
0,5 m resolution



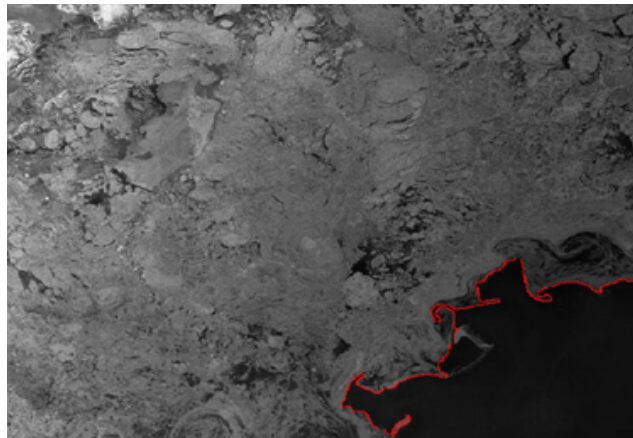
by KSAI, 2009

Satellite-based Services – Arctic

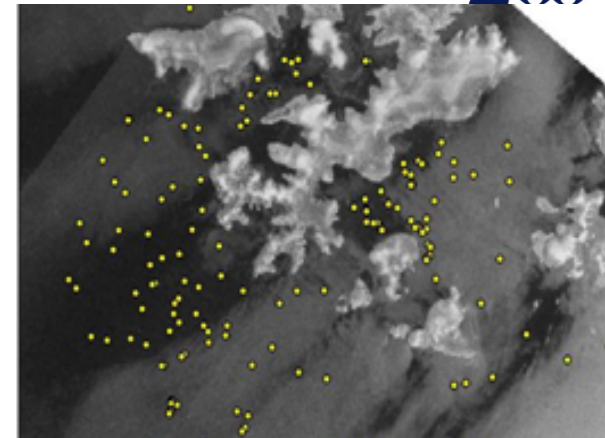
- Elements of situational awareness



OIL SPILL/SEEPAGE DETECTION



ICE EDGE DETECTION



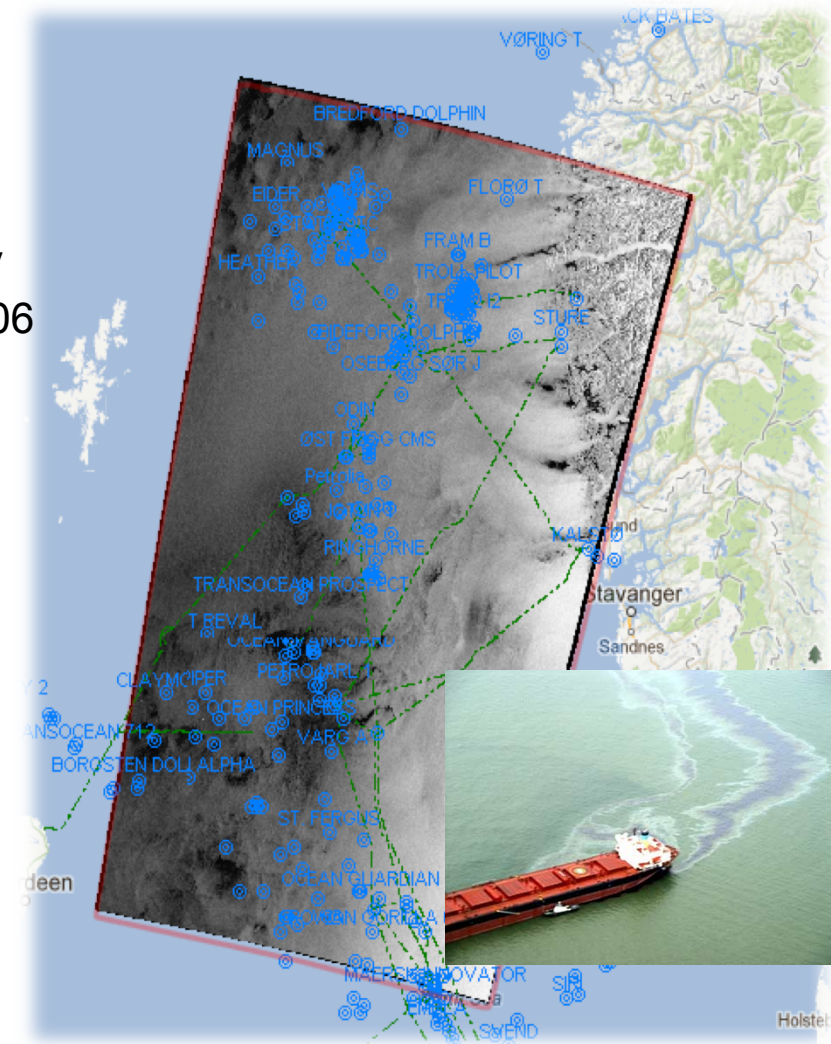
OBJECT DETECTION



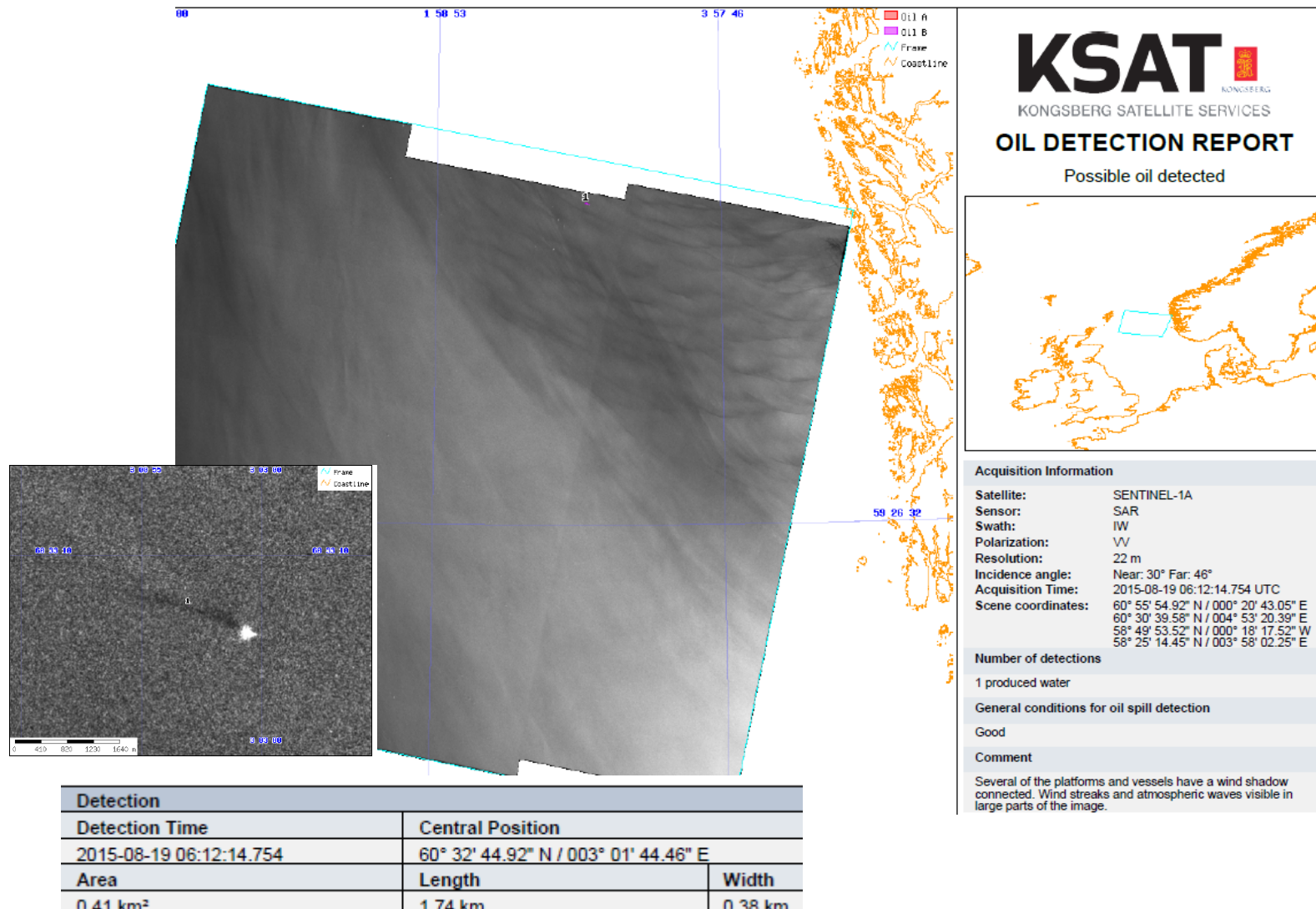
- 24/7 – 365
- Fast Access/
Delivery

Global Oil spill Monitoring - Using SAR (Radar)

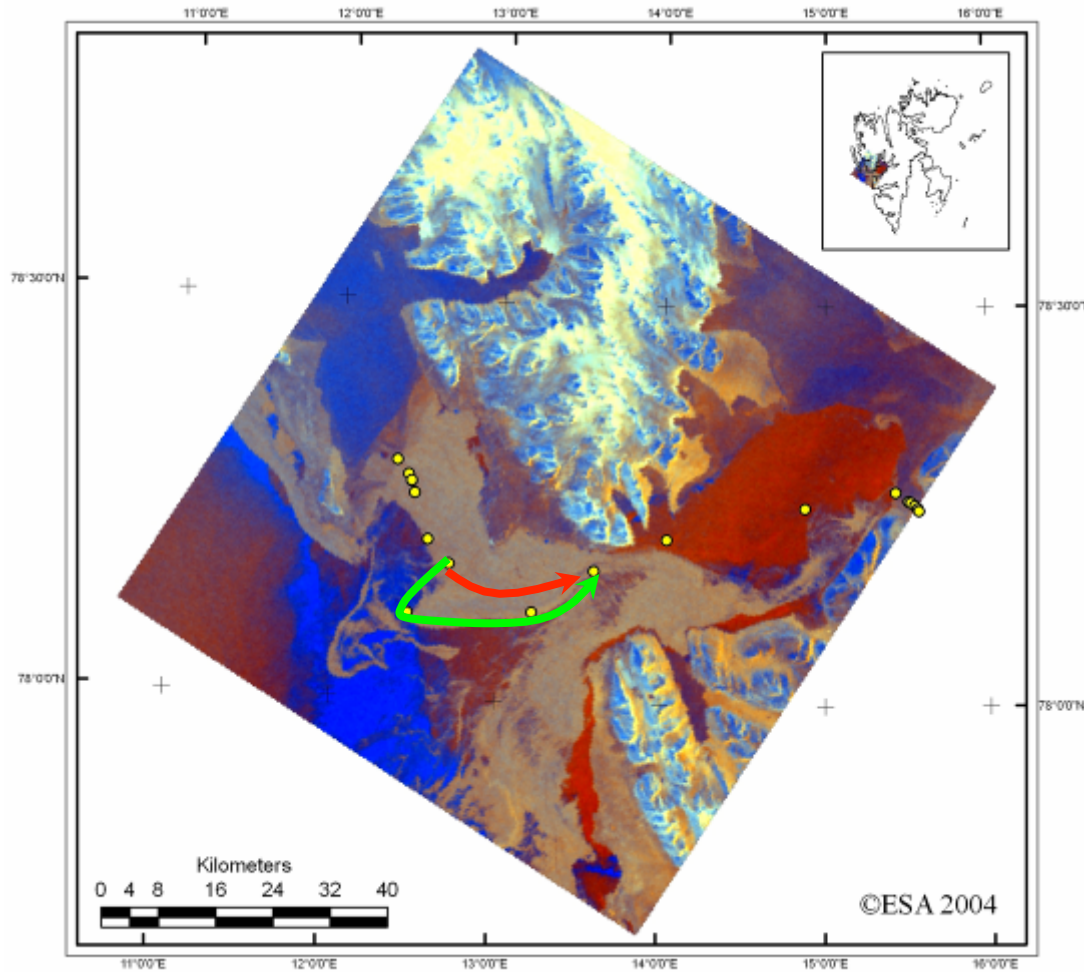
- First KSAT multimission operational EO service
 - Used operationally for 20 years
 - EMSA, national authorities, offshore industry
 - Pan-European EMSA CSN service since 2006
- Information to users < 15-60 minutes
- Cover large geographical areas
- Light independent, through clouds
- Detects small leaks
- 24/7 Operational Team



First Sentinel-1A NRT Oil spill detection



Ship routing in Arctic waters



Planned route through ice

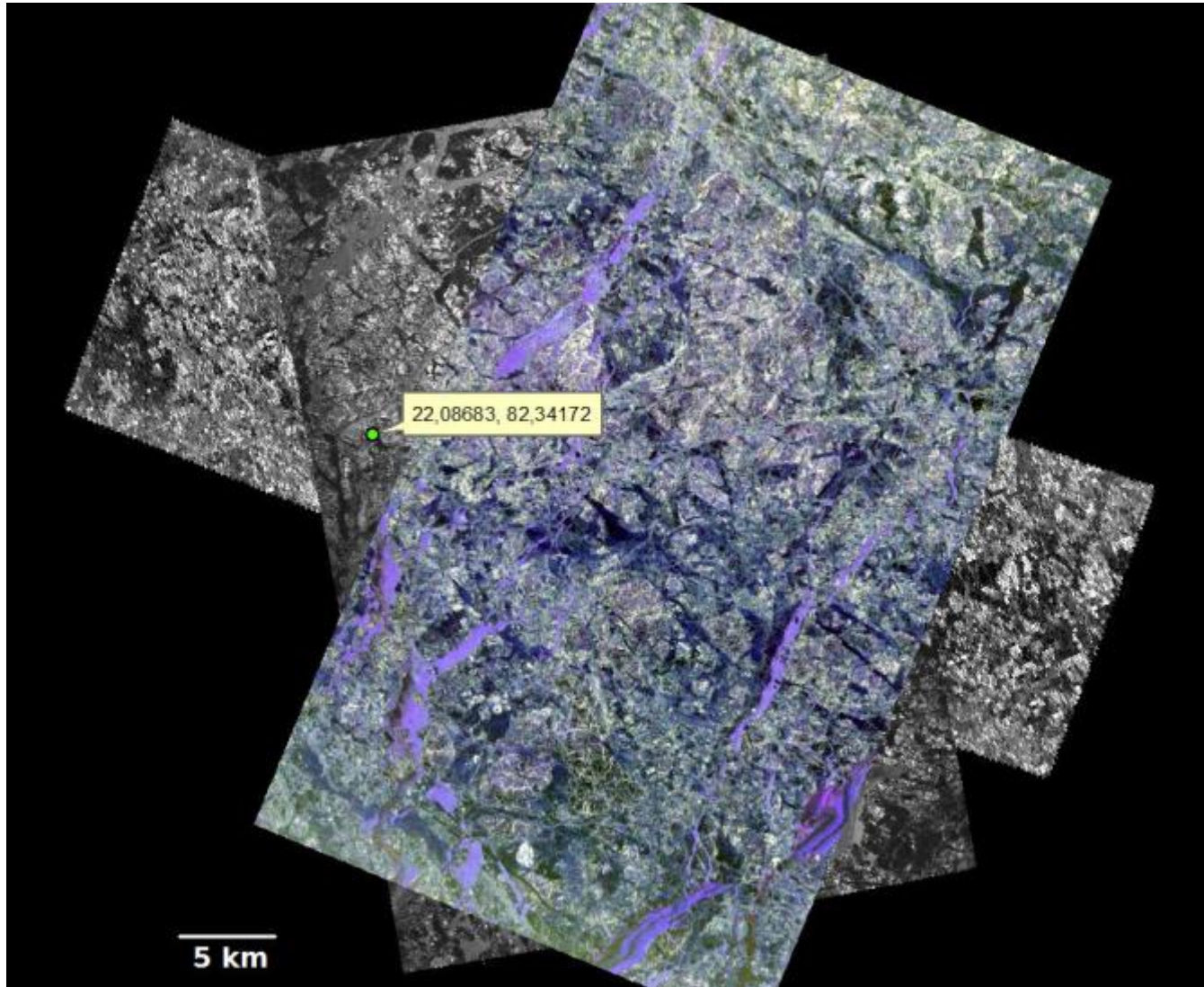
6 hours

Actual route around the ice

3 hours

Navigation in ice

- Supporting Arctic R&D cruise



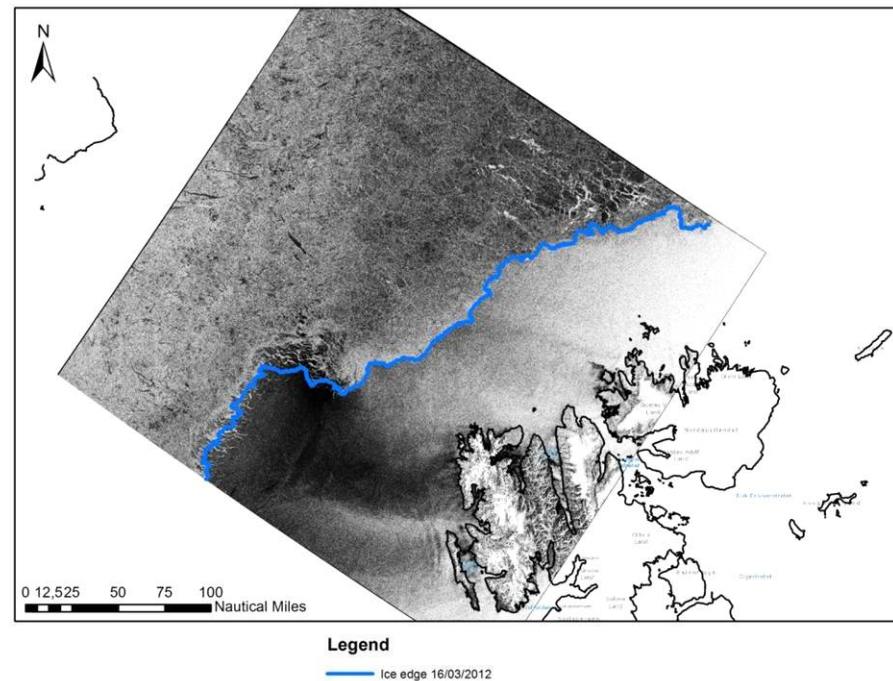
22.mars 2015.
Lowest: TSX
stripMap dual-pol

Mid: CSK Himage,
HH-pol

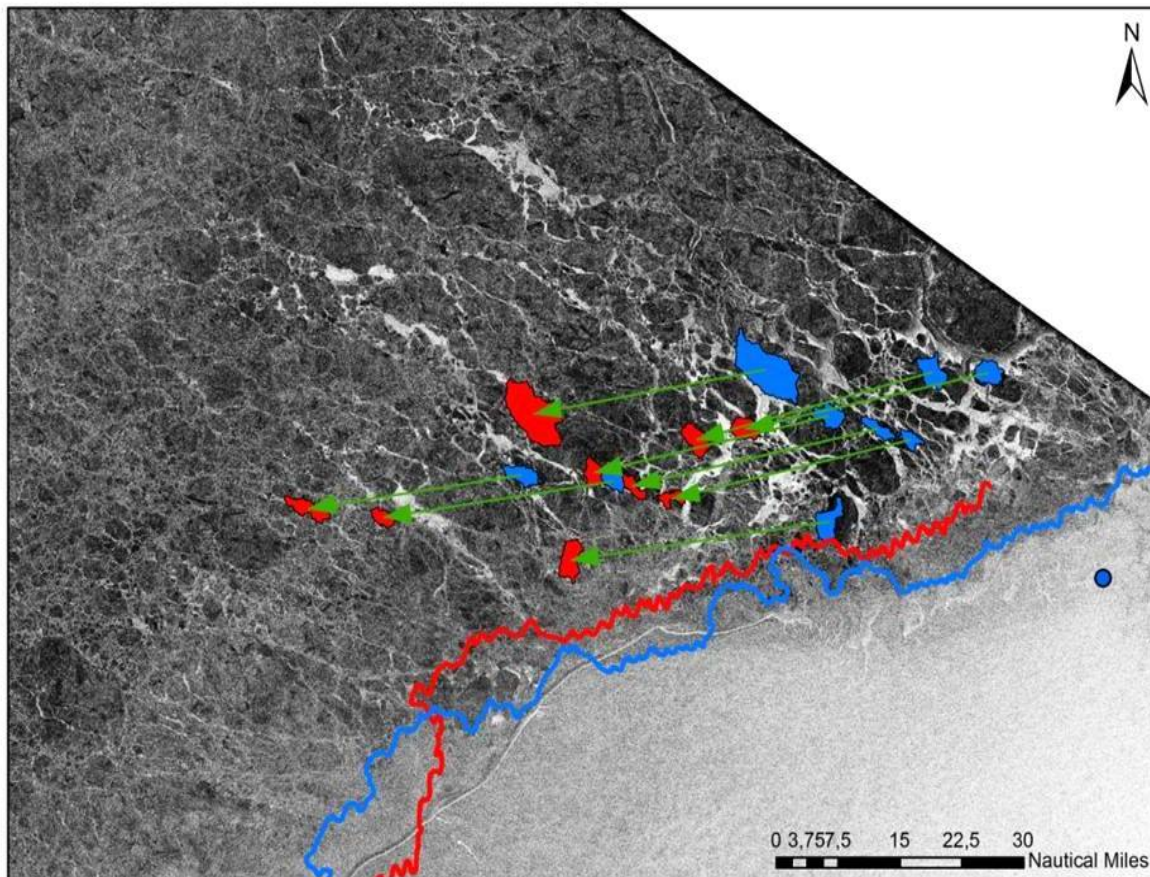
Upper: RS2 Quad-
pol scene.

Ice edge detection

- Proprietary algorithm and process for automated ice edge detection
 - Ready within 10 minutes after image processing
 - High resolution (100 Meter)
 - Draws a "very open drift ice" line (met.no, NIC and DMI terminology)
- Characteristics:
 - Fast delivery
 - Frequent delivery (24/7)
 - Not weather dependent
 - High-resolution
 - Accurate
 - Small files for transfer over low bandwidth



Ice monitoring



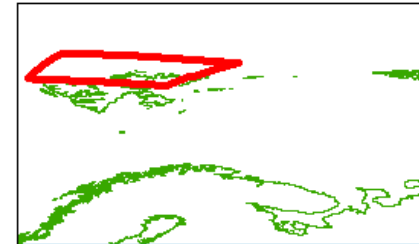
Legend

-  Ice movement 16/03/2012 - 19/03/2012
-  Ice edge 16/03/2012
-  Ice edge 19/03/2012
-  Ice floes 16/03/2012
-  Ice floes 19/03/2012

Ice edge movement in the Arctic

KSAT 







MET.NO Ice Chart,
May 20, 2015 – 14:00



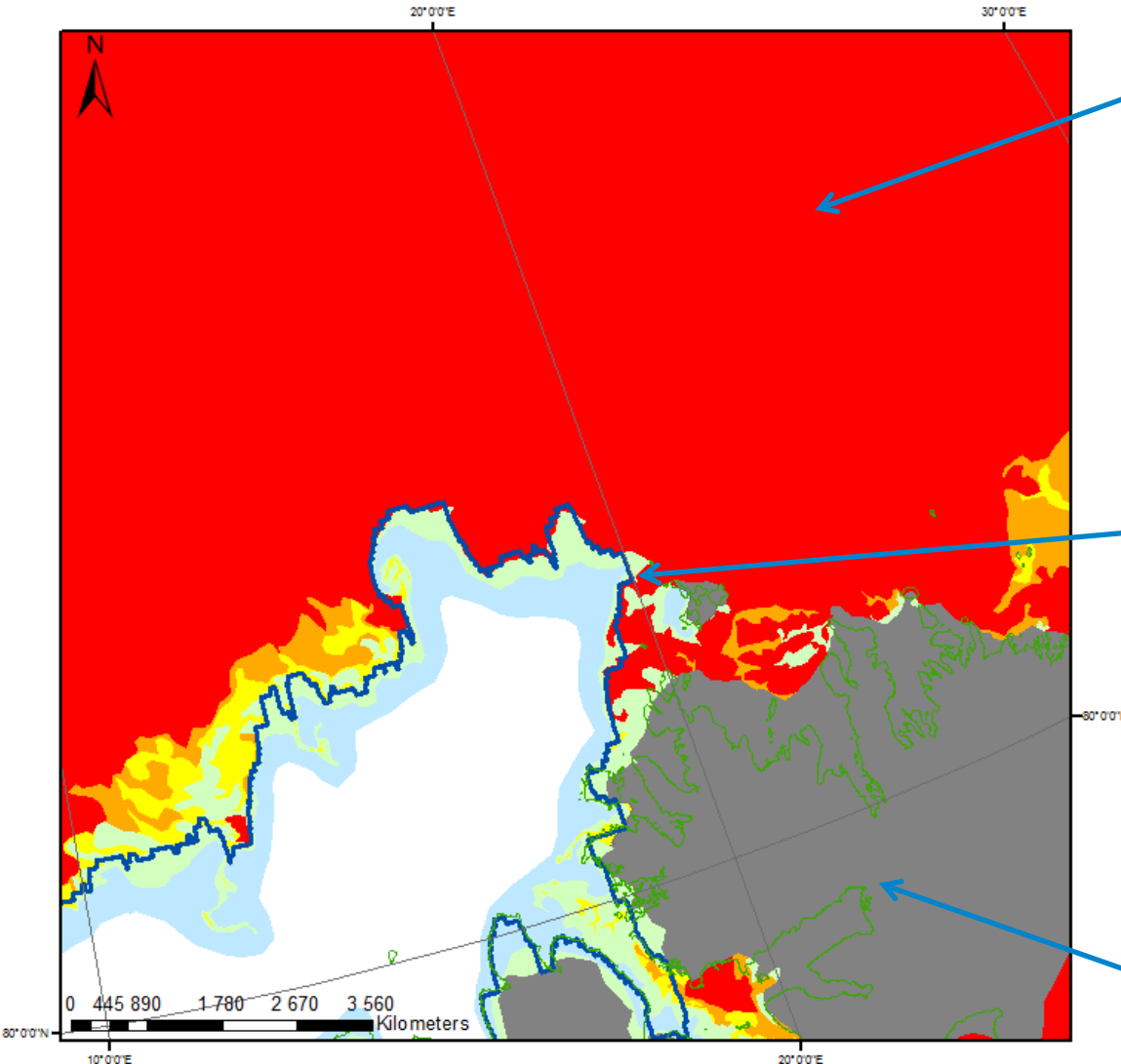
KSAT Ice Edge Line,
May 21, 2015 - 06:05

Legend

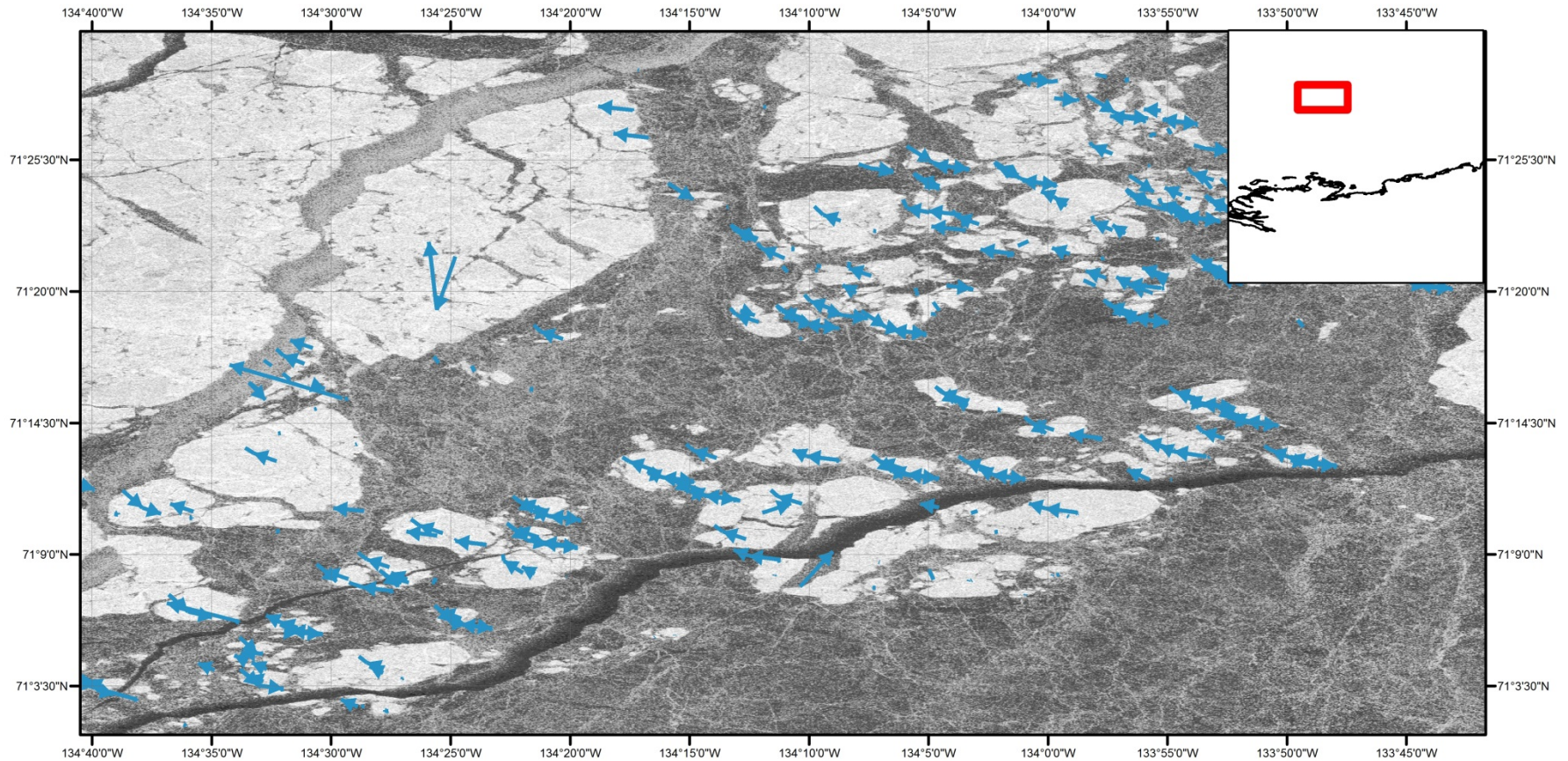
ICE_TYPE

-  Fast Ice
-  Very Close Drift Ice
-  Close Drift Ice
-  Open Drift Ice
-  Very Open Drift Ice
-  Open Water

NEW MET.NO Ice Chart,
May 21, 2015 –14:00



Ice tracking 2011



CSKS2_GEC_B_WR_04_HH_RD_SF_20110305031519_20110305031533

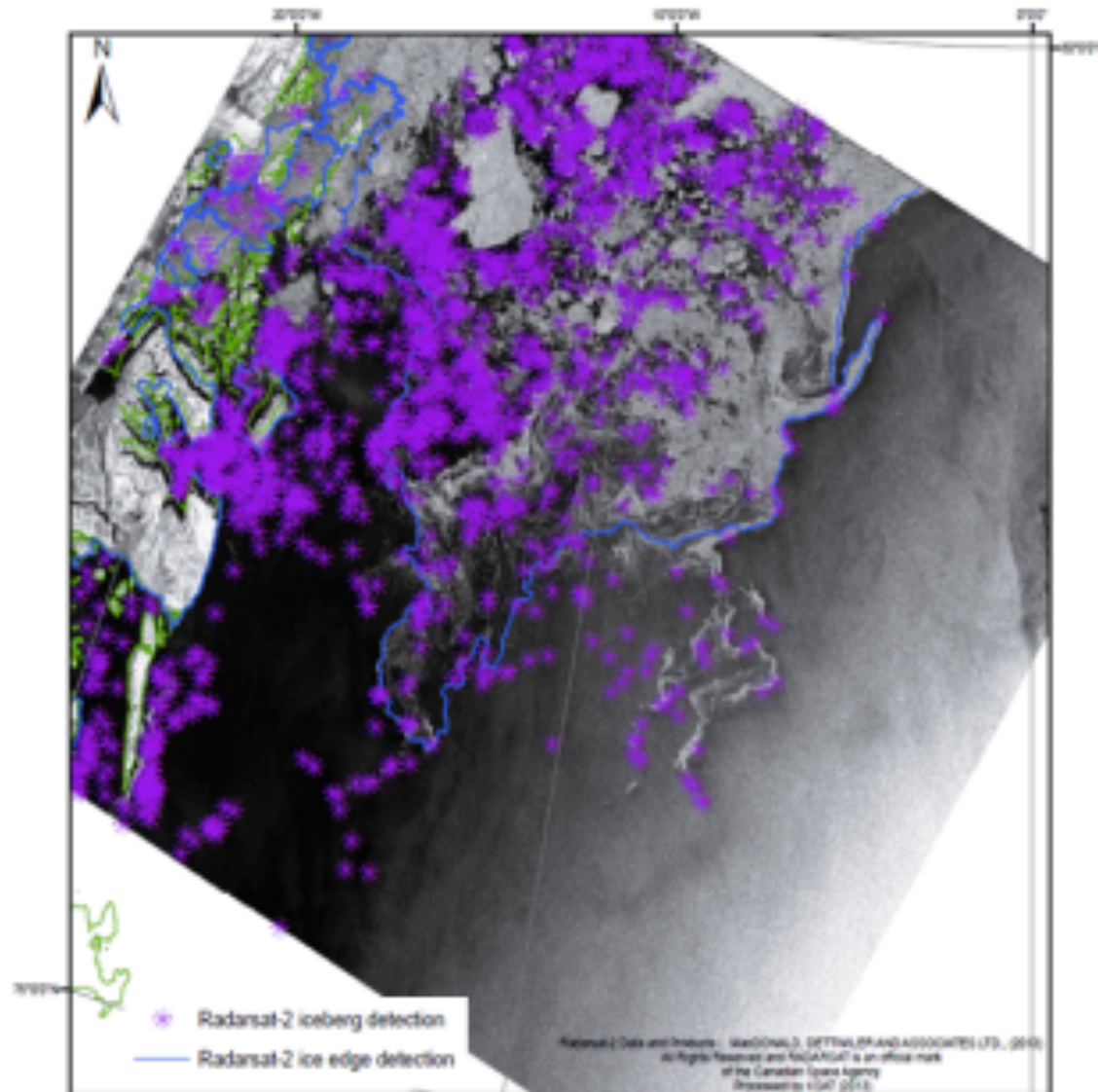
(c) Telespazio 2011

Legend

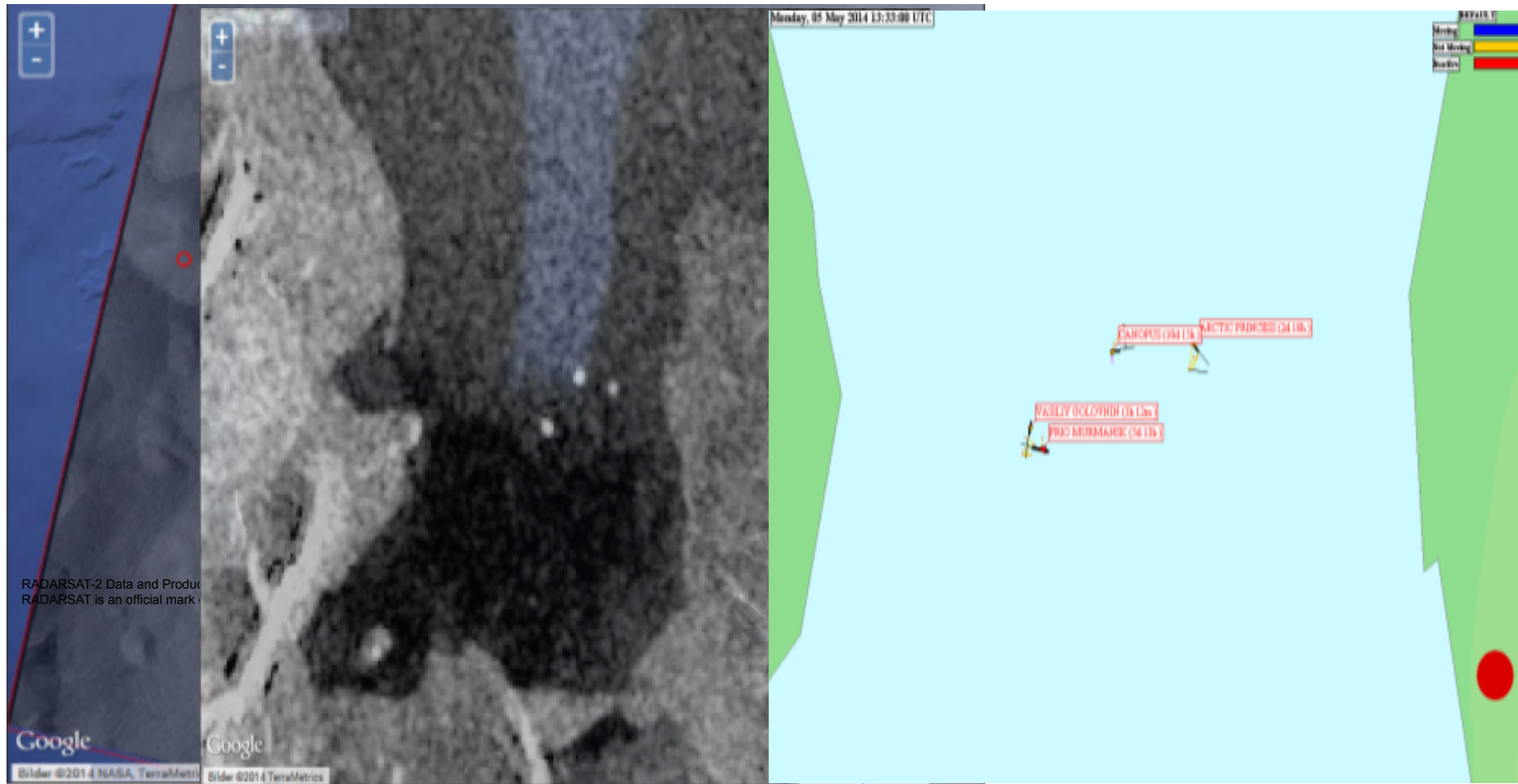
→ 2011.03.05 03:15 - 2011.03.11 05:03

0 1 2 4 6 8
Nautical Miles

Iceberg and ice edge detection based on SAR



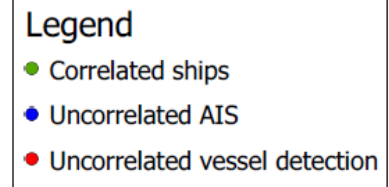
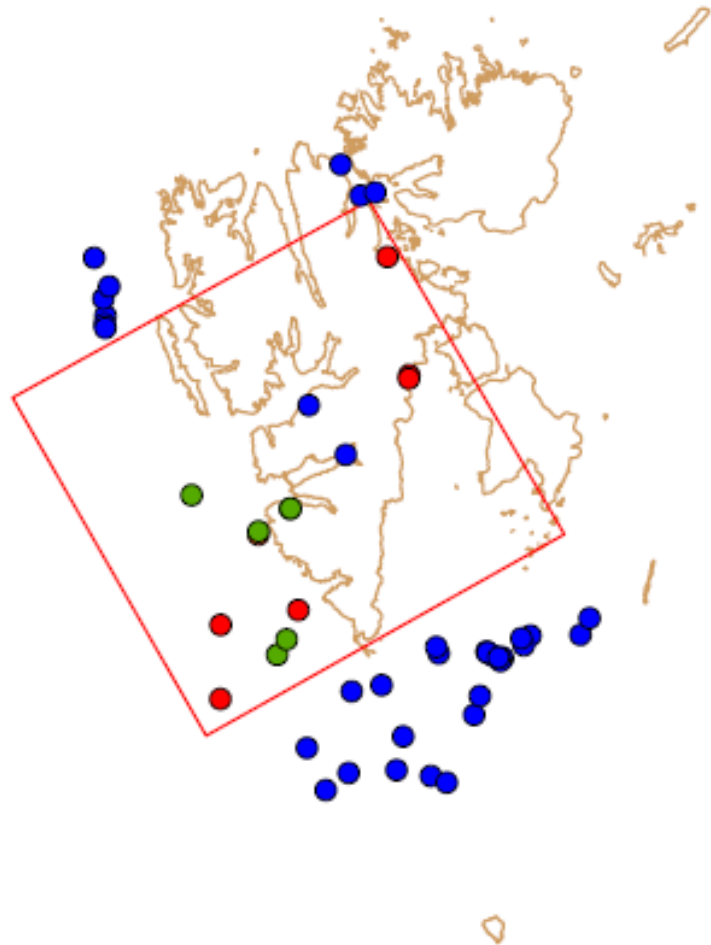
Satellite vessel detection and identification



- Large area activity monitoring and AOI/target identification
- Targeted data collection and multisource identification (imagery+AIS)
- High resolution data (optical) identification

Radar based ship detection

- Correlated with AIS

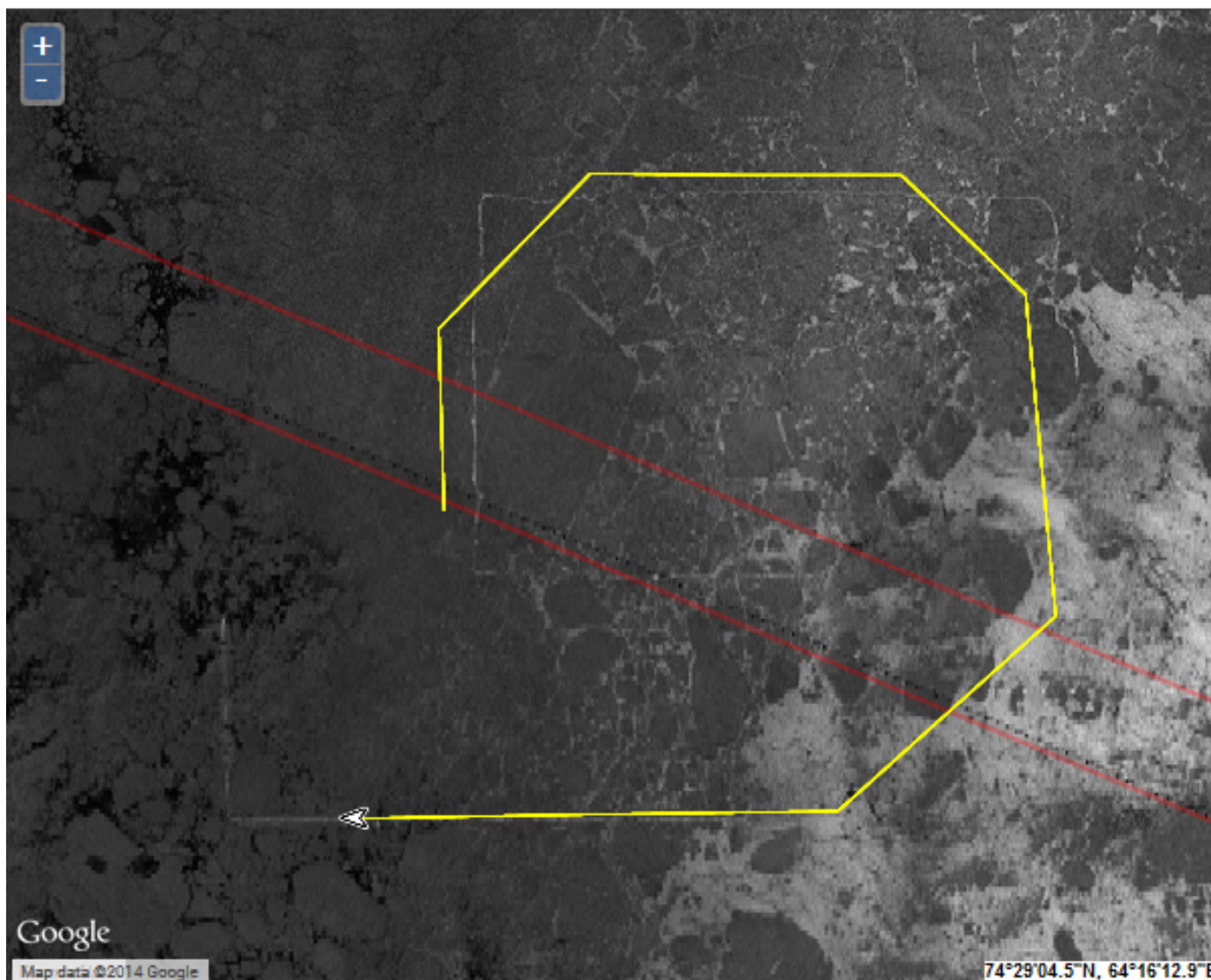


Correlation with AISSAT-1 and LuxSpace - 28/11/2012 (asc)

AIS and SAR images

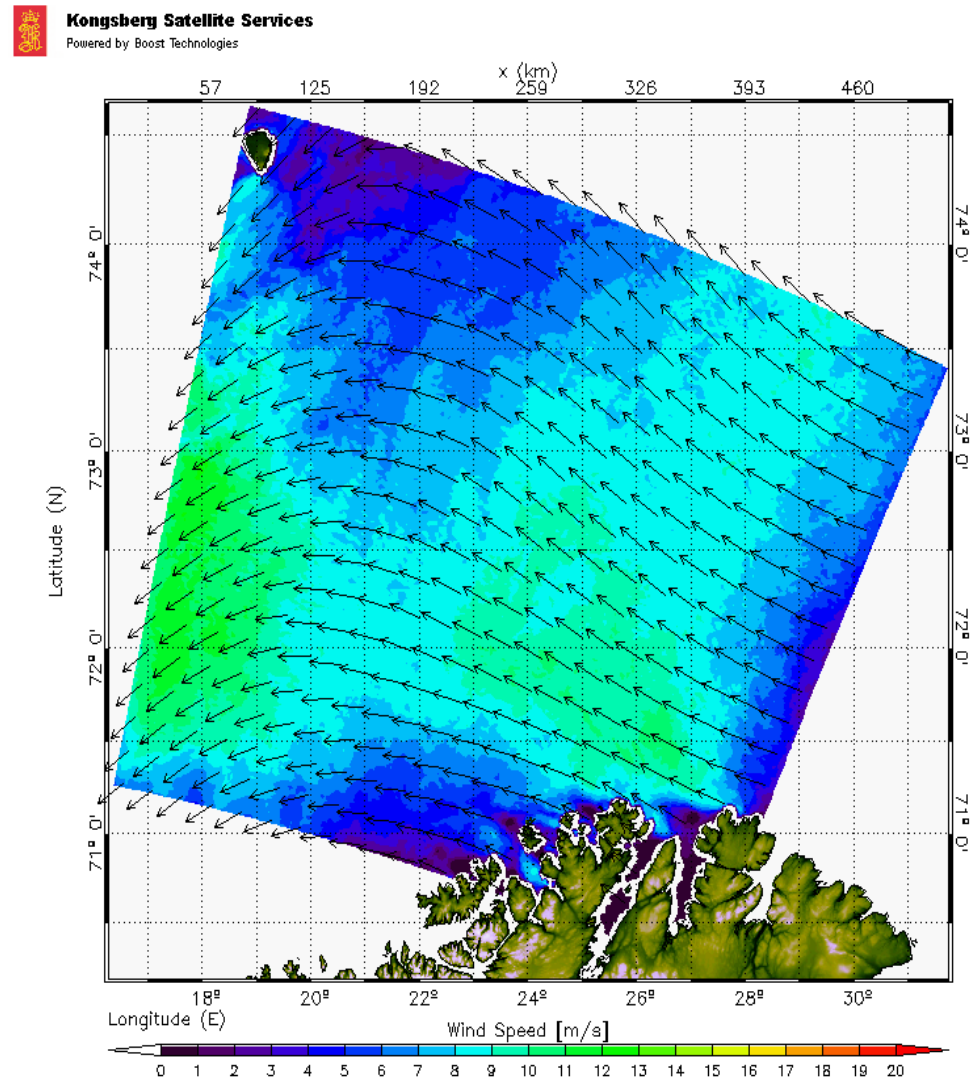


AIS vessel and track



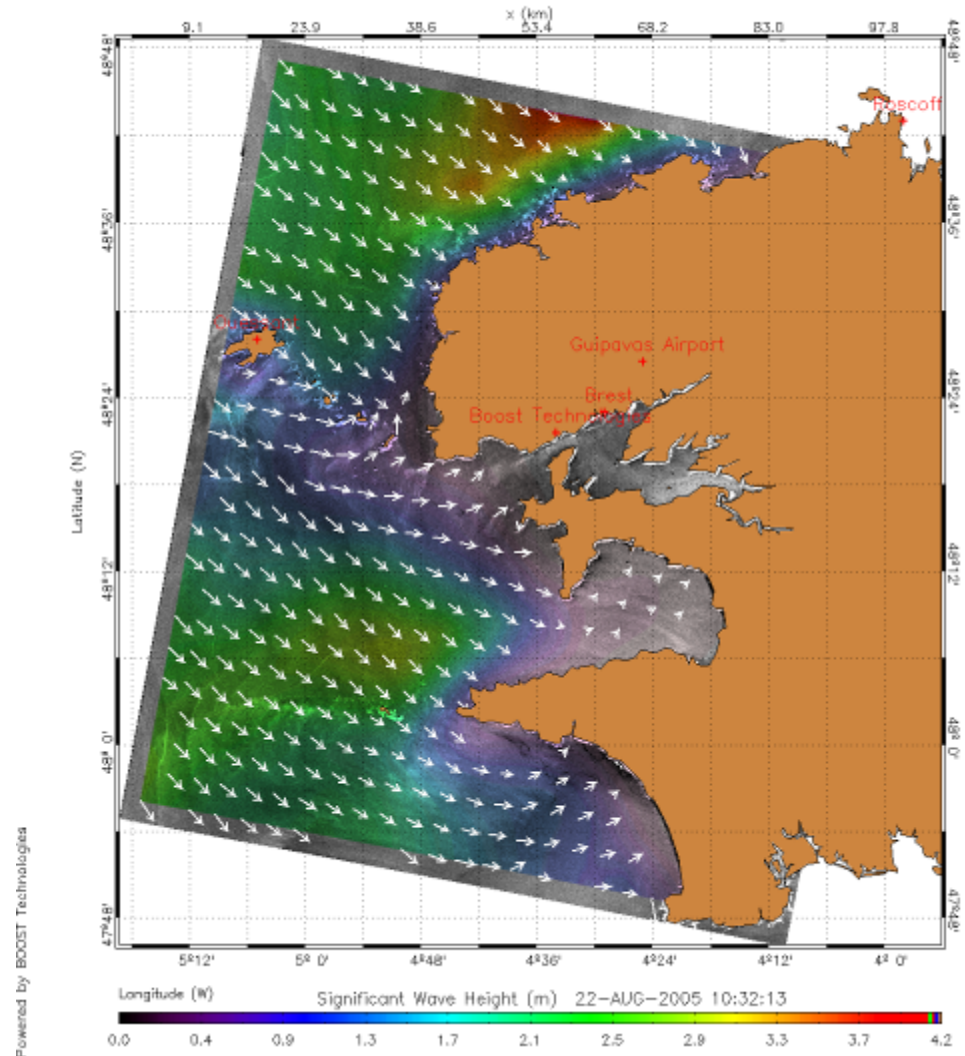
Satellite derived wind information

- High Resolution wind information available
- 1 km x 1 km resolution
- Accuracy 2 m/s (wind speed), 25° (direction)
- Windmaps generated from 15,000 Radar images since 2008

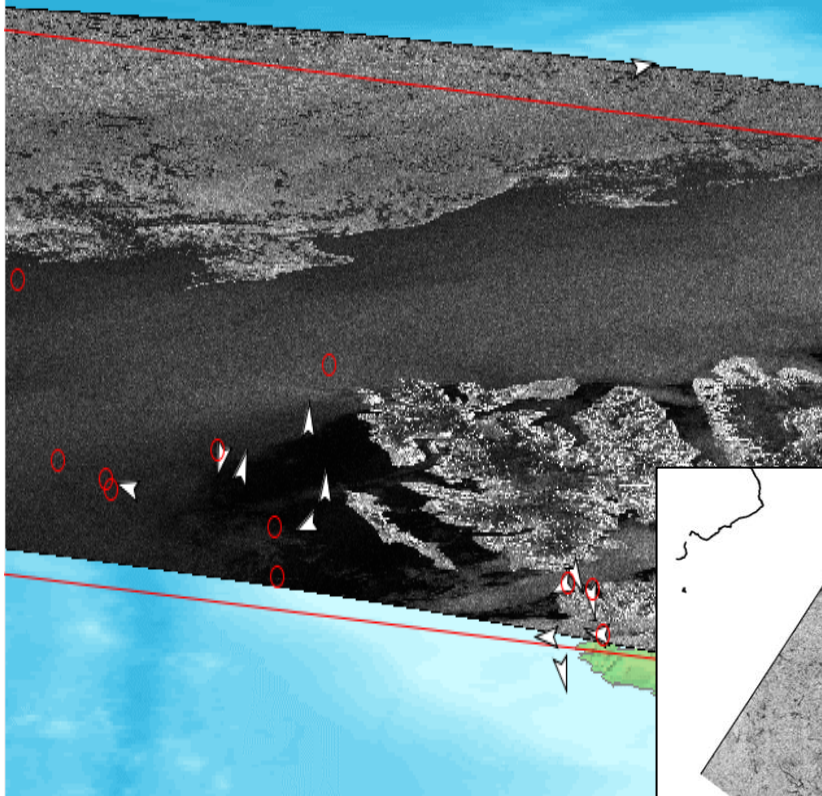


Waves retrieval from SAR

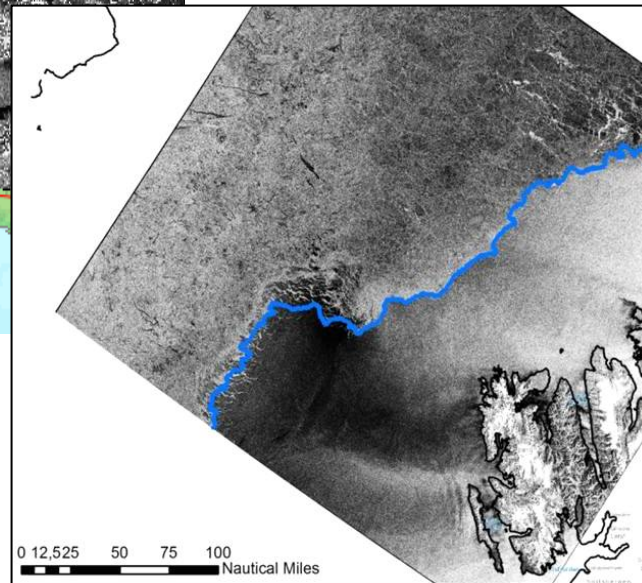
- Long waves (swell systems) are visible on SAR images because they modulate the backscattered signal
- Products : swell fields
 - Available information
 - Significant wave height
 - Wavelength (*)
 - Dominant direction (*)
 - (*) depends upon type of SAR products
- Validation activities
 - Error on SWH Less than 40 cm in 50 % of cases
 - $\Pr[\epsilon(\text{SWH}) < 40\text{cm}] = 50\%$
- Limitation:
 - Azimuthal cut-off increase with respect to R/V ratio and wind speed



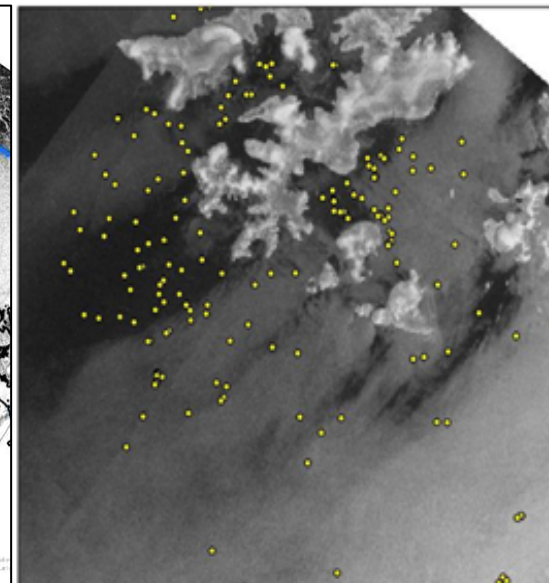
Arctic Situational Awareness



Vessel detection & identification



Ice edge detection



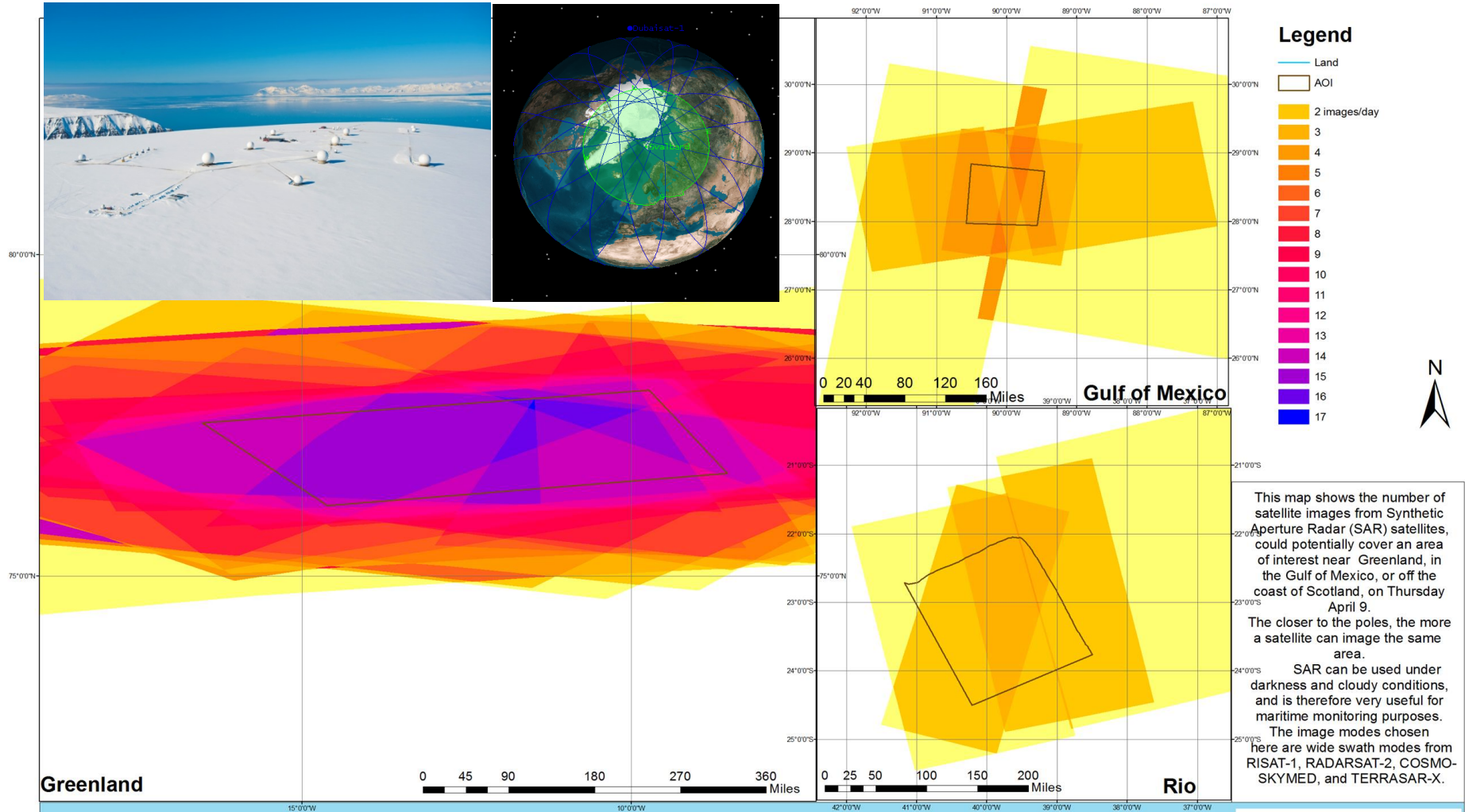
08:39 UTC 18th August 2004
Objects – Ice bergs

- "Object" detection, identification & tracking
 - General vessel traffic and operations safety
 - Activity monitoring e.g for resource utilisation
 - Extended security (national sovereignty)
- Challenge
 - Detect small objects
 - Discriminate/Identify various objects
 - Target identity

Polar Orbiting and Revisit Frequency

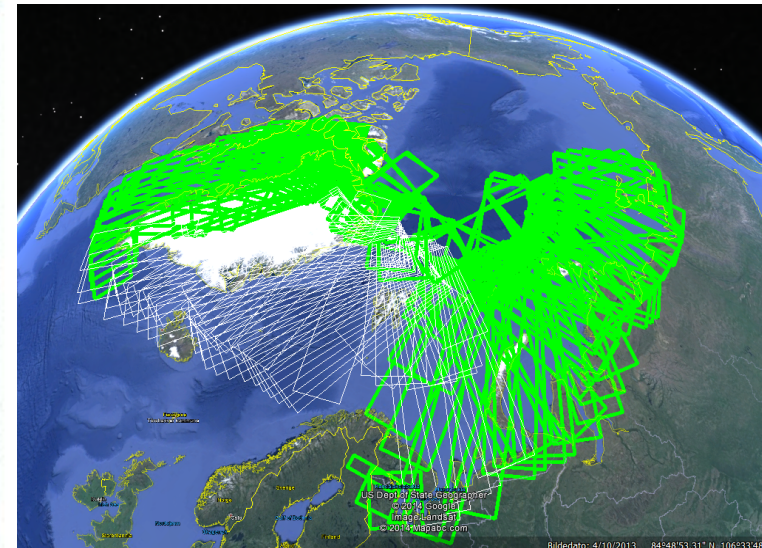
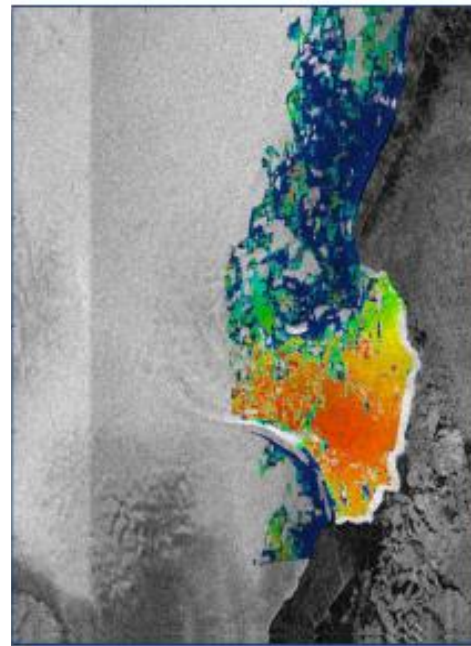
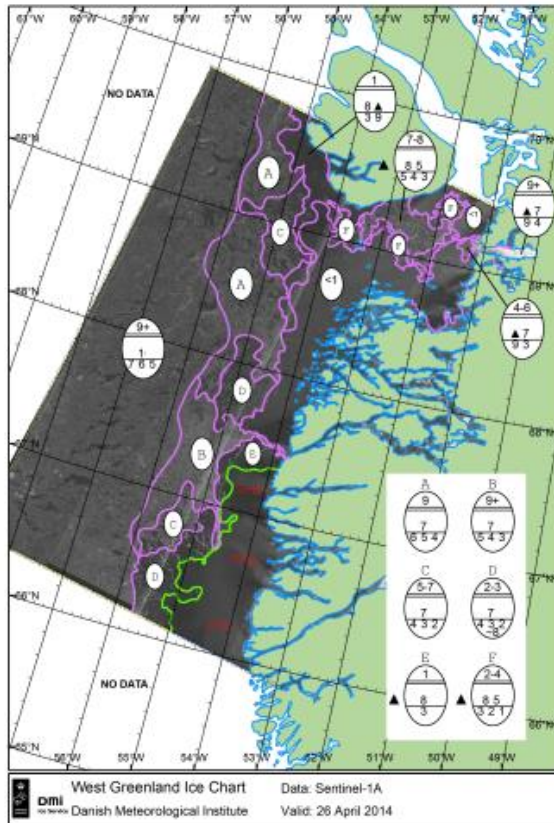


KONGSBERG



How many images can I get over my area in one day?

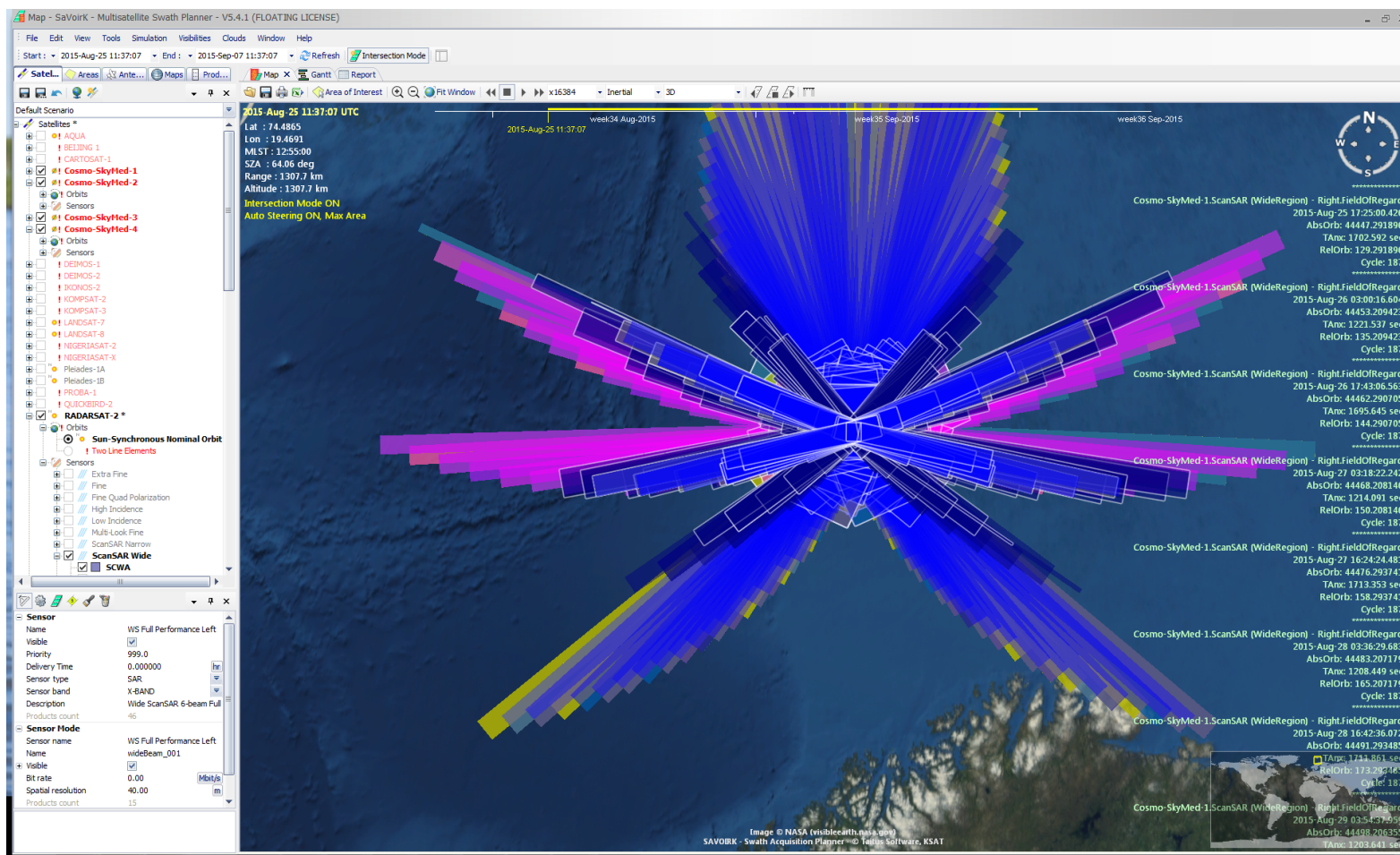
Copernicus: Sentinel-1 examples



European Copernicus program:

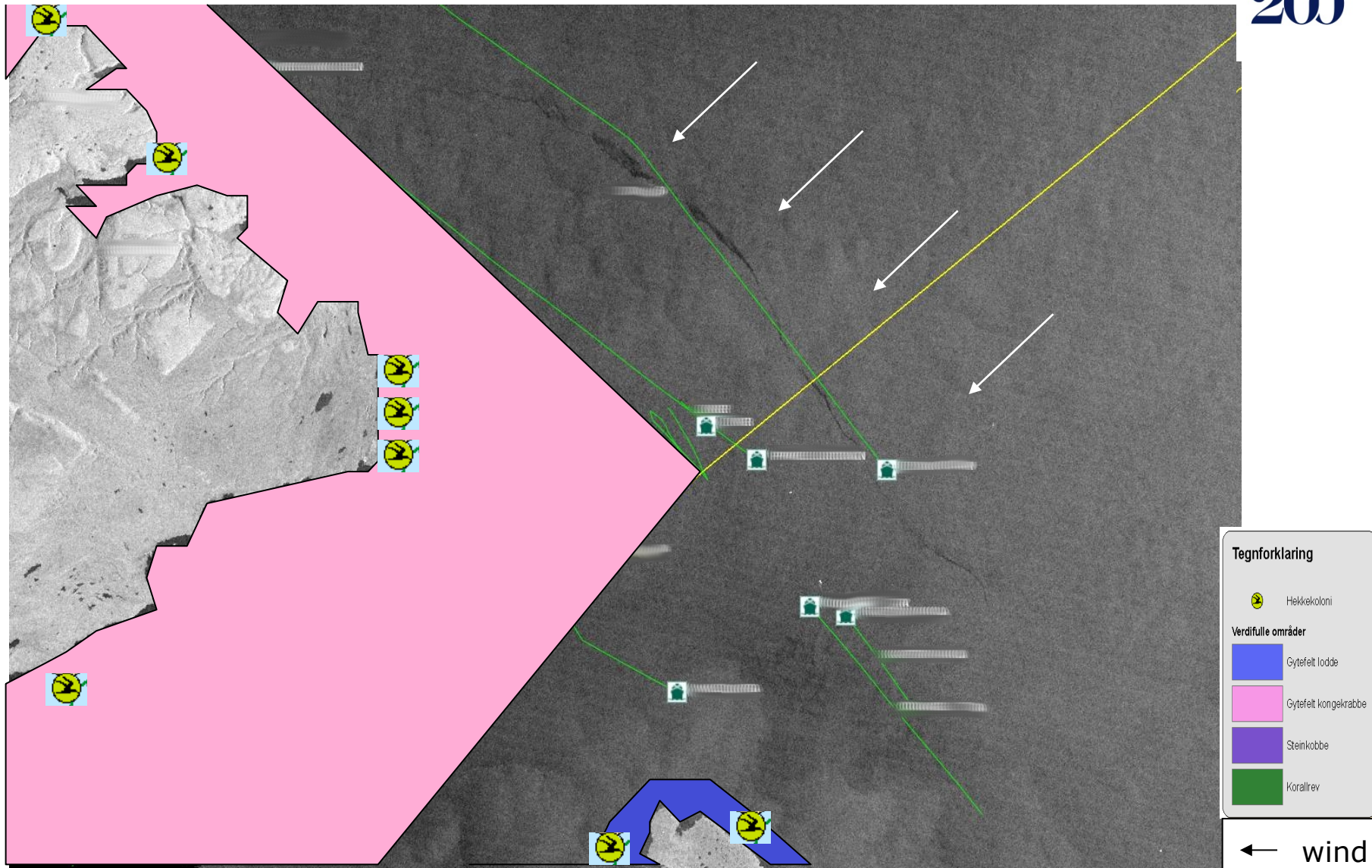
- First satellite Sentinel-1 launched April 2014
- Operational since 23. September
- Examples: Ice charting, ice movement, coverage, oil spills

KSAT SAR-MultiMission (S-1A, RS2, TSX, CSK1-4)



Bjørnøya / Barents Sea - 12 day cycle;

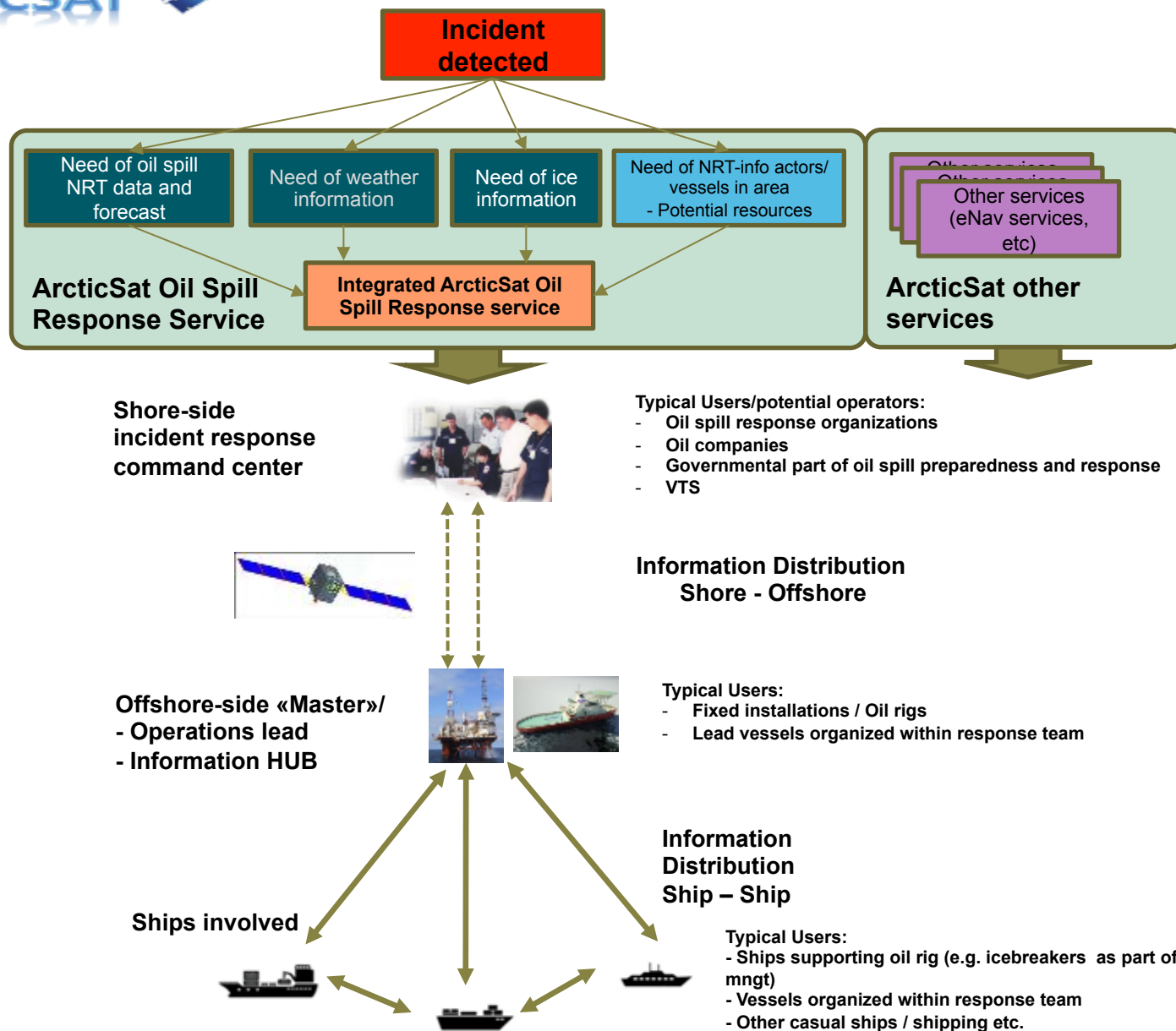
Operational use: Integrated service information

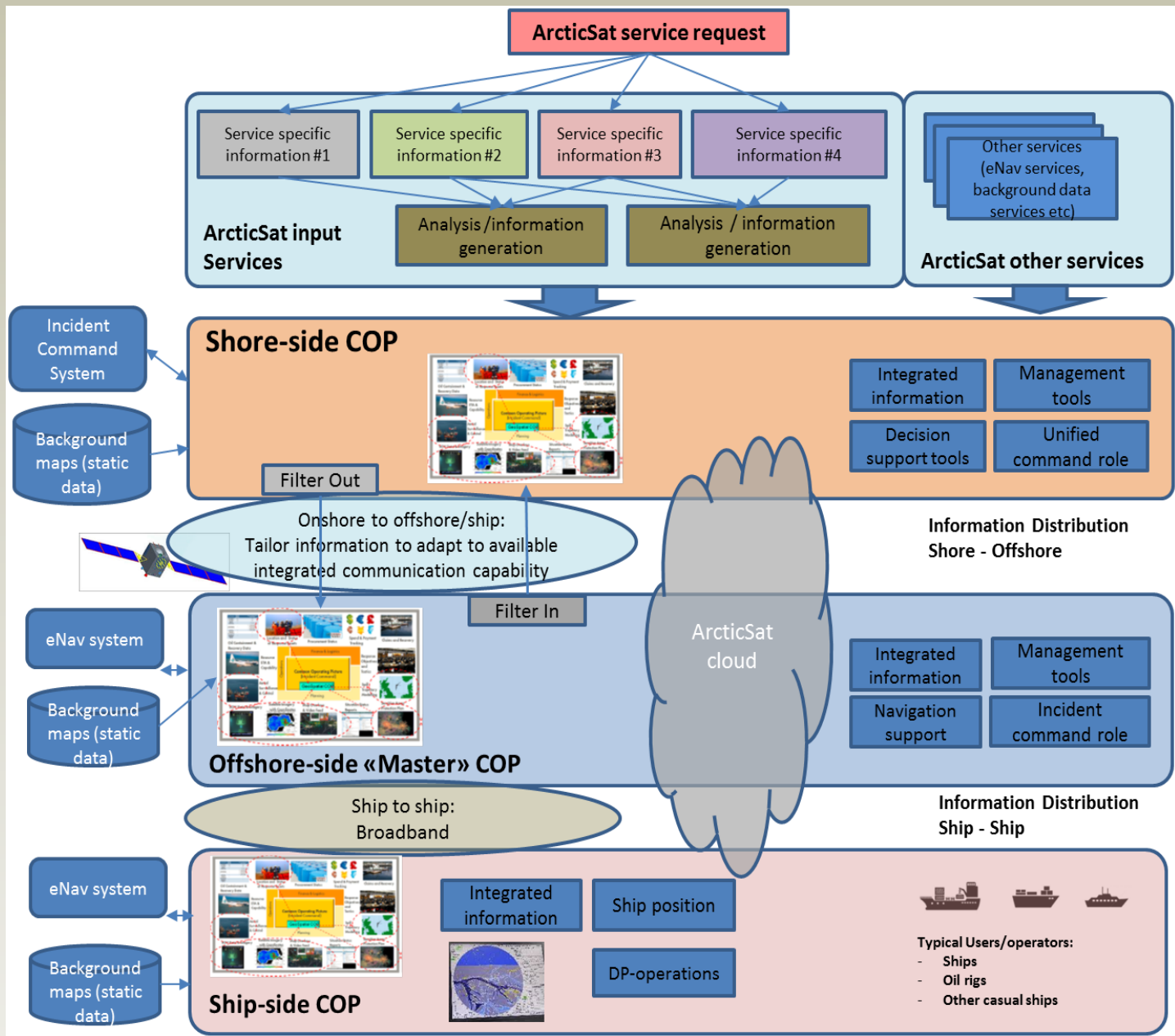


Common Operating Picture (COP)

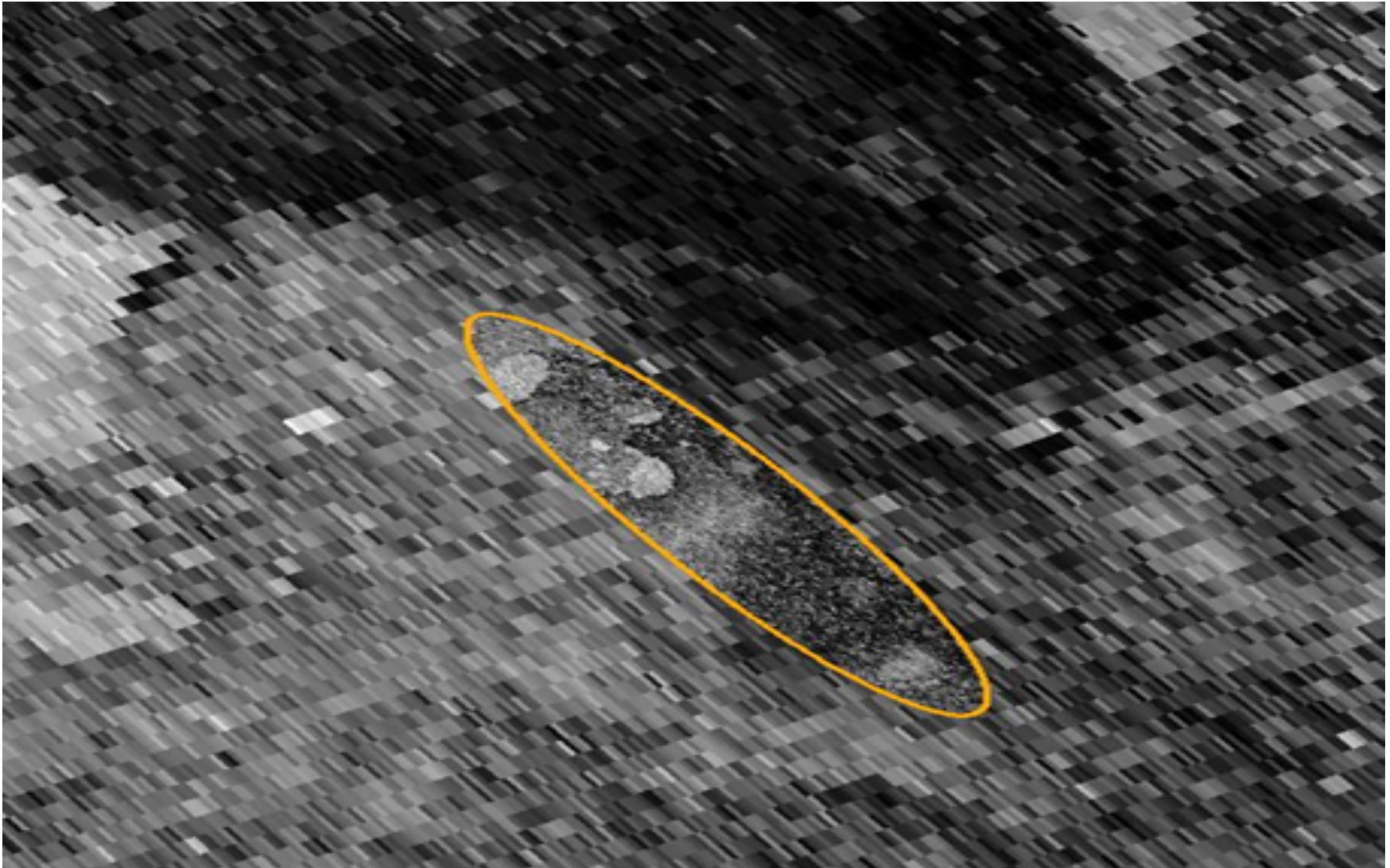
- As basis of decision support

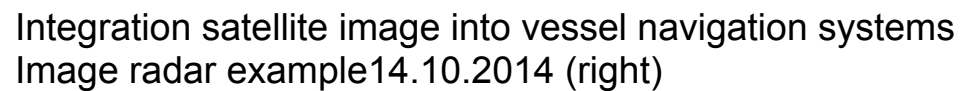




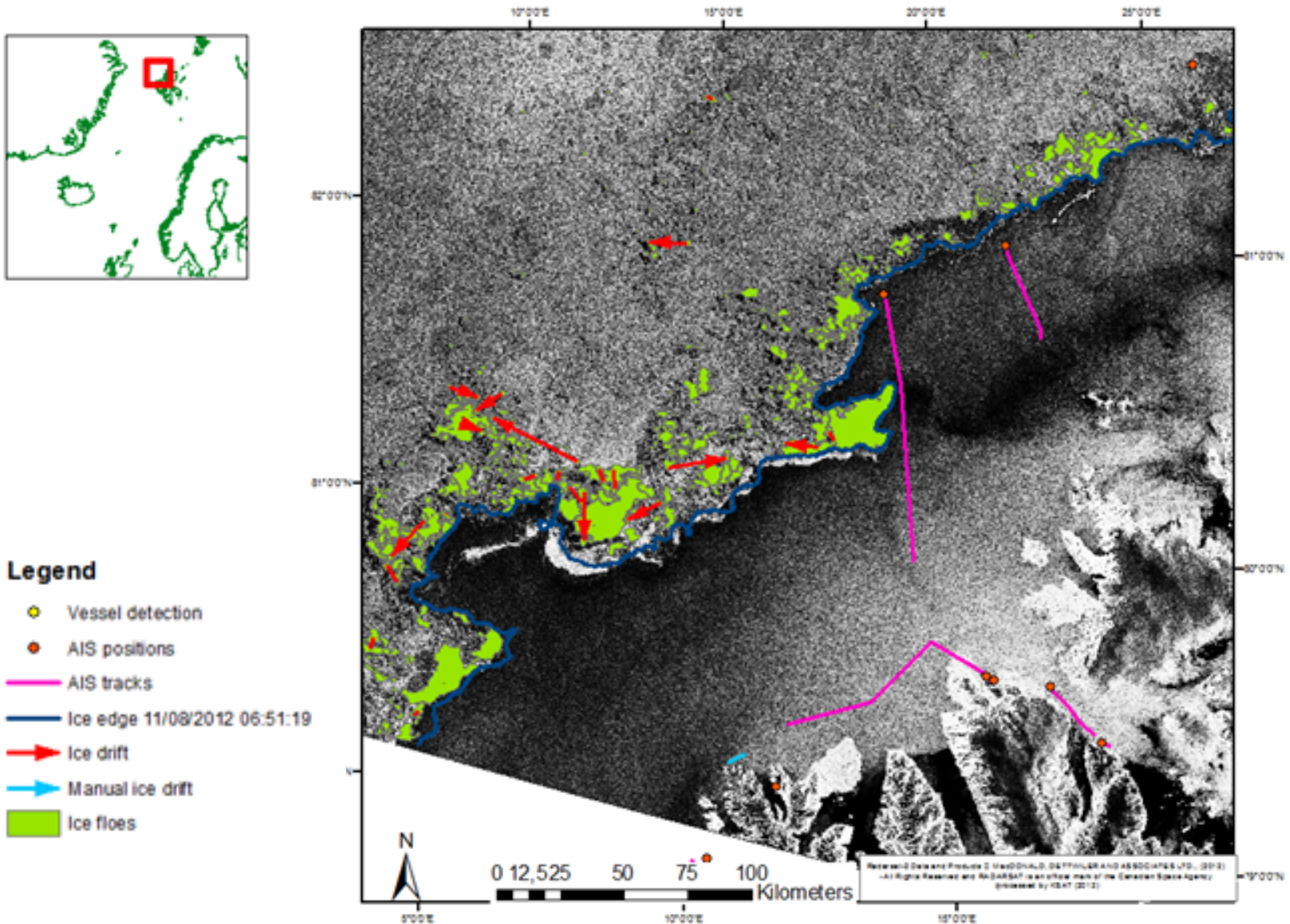


Clip – zip – ship





Integrated monitoring in the Arctic





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Kongsberg Satellite Services Delivery Portal

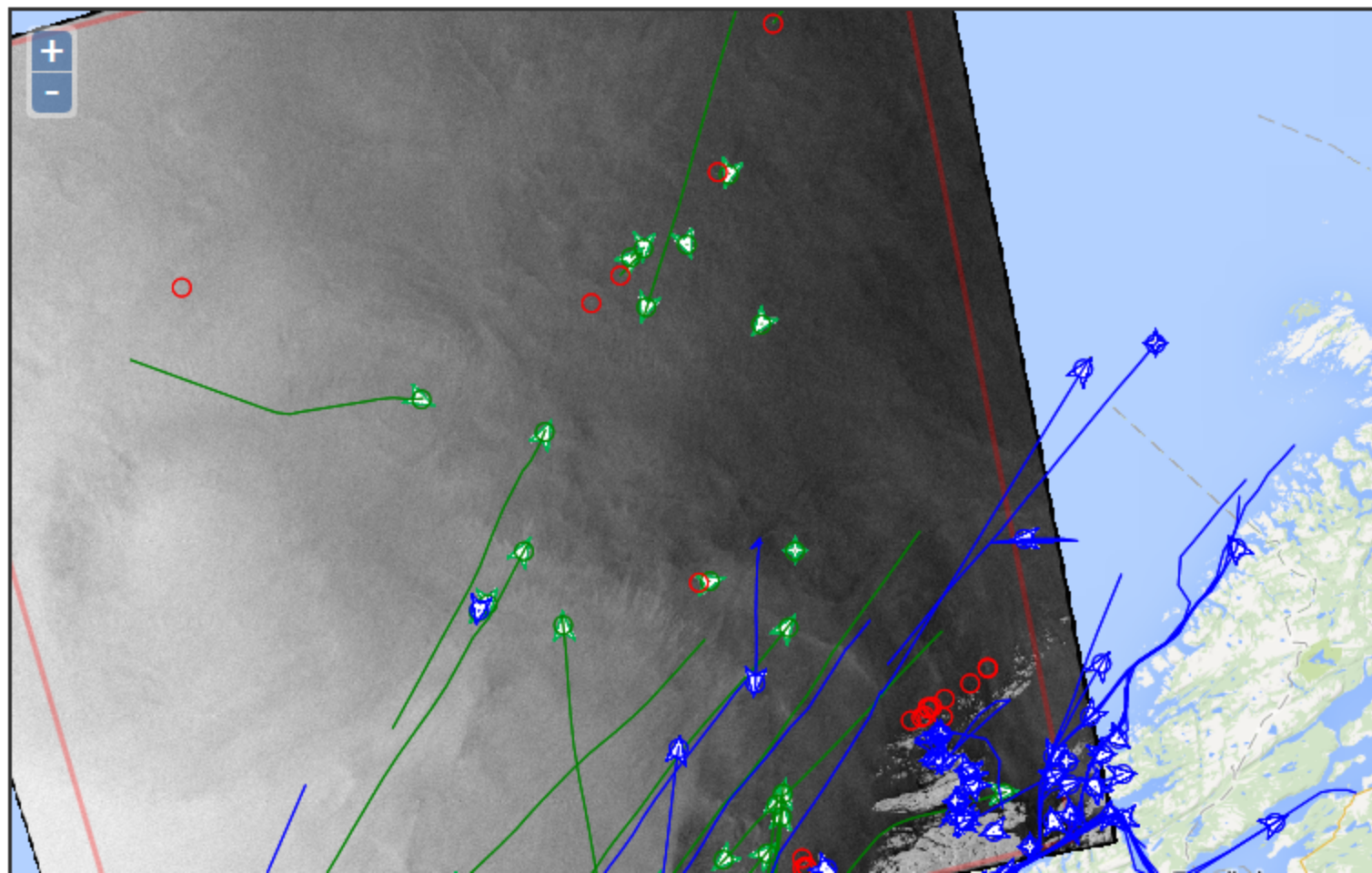
[Summary](#) [Oil spill detection](#) [Vessel detection](#) [AIS](#) [Flerbruk](#) [My orders](#) [Delivery Monitor](#) [Documents](#) [Site information](#)**Search****Change map baselay**☐ Satellite map ☒ Roadmap**Offshore installation**☐ Check to show offshore o**Features for the activ**

Image	Detected information
<input checked="" type="checkbox"/> Image	<input type="checkbox"/> Vessel SAR
	<input type="checkbox"/> Vessel (AIS)
	<input type="checkbox"/> Track (AIS)

Number of products:

- ☐ RADARSAT-2 2014-1
- ☐ RADARSAT-2 2014-1
- ☐ RADARSAT-2 2014-1
- ☒ RADARSAT-2 2014-1
- ☐ RADARSAT-2 2014-1

Thank you for your attention!

