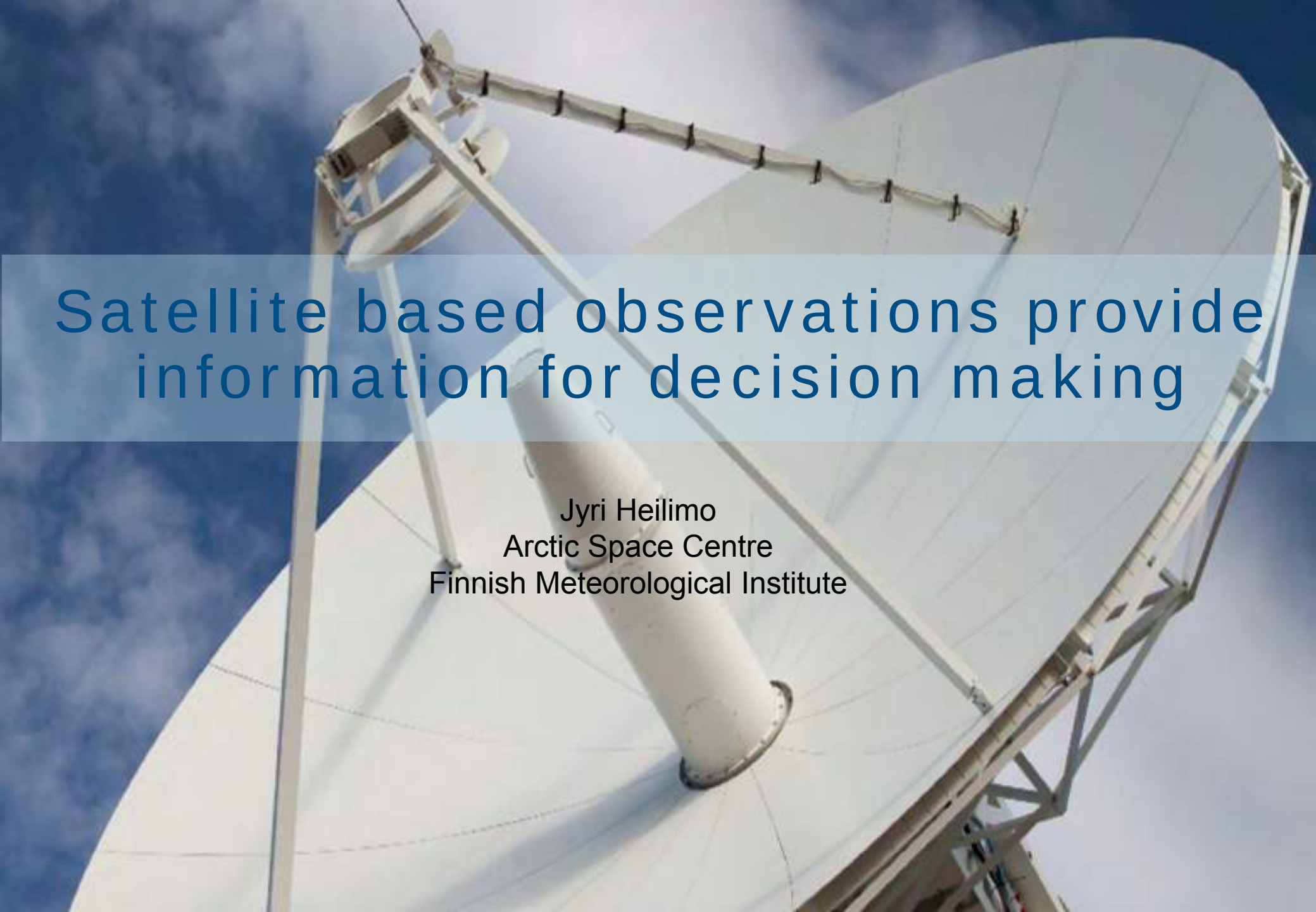


Satellite based observations provide information for decision making

Jyri Heilimo
Arctic Space Centre
Finnish Meteorological Institute

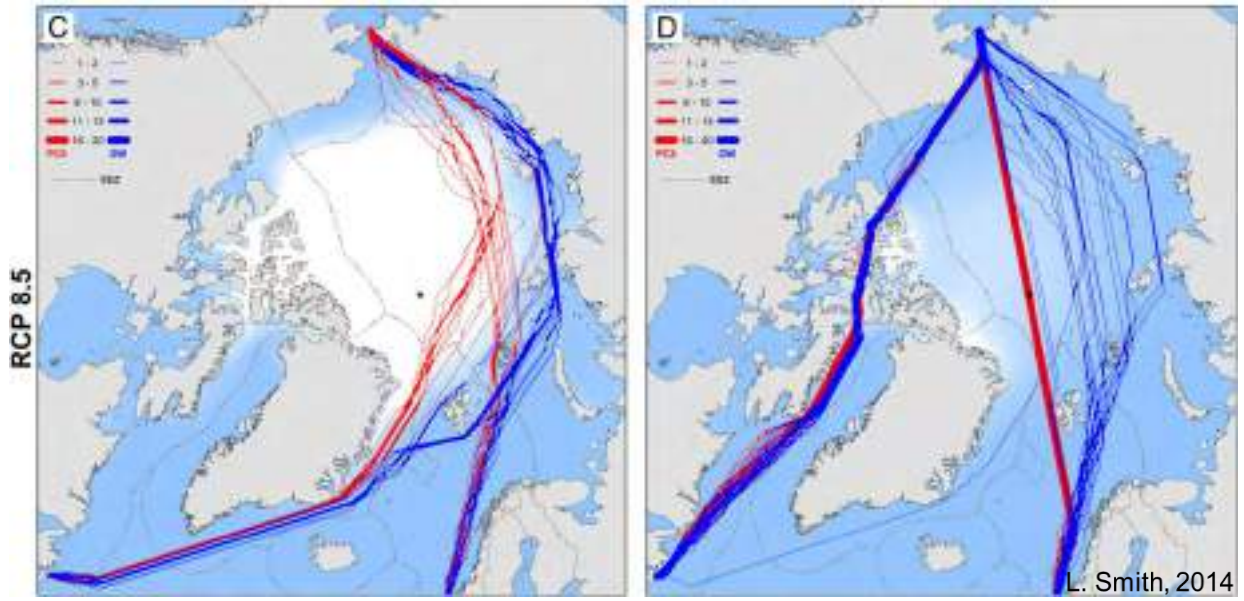
IPCC report and climate change

- Recent IPCC report laid down devastating figures of the impact of climate change and global warming.
- Urgent need to reduce carbon emissions to limit global warming to 1.5 degrees
- Warming in the Artic is 2-3 times stronger compared low or mid latitudes
- Balance of human activity will inevitably move towards higher latitudes

- Spaceborne observations in high latitudes becomes more and more important to support educated decissions to mitigate the challenges we will face

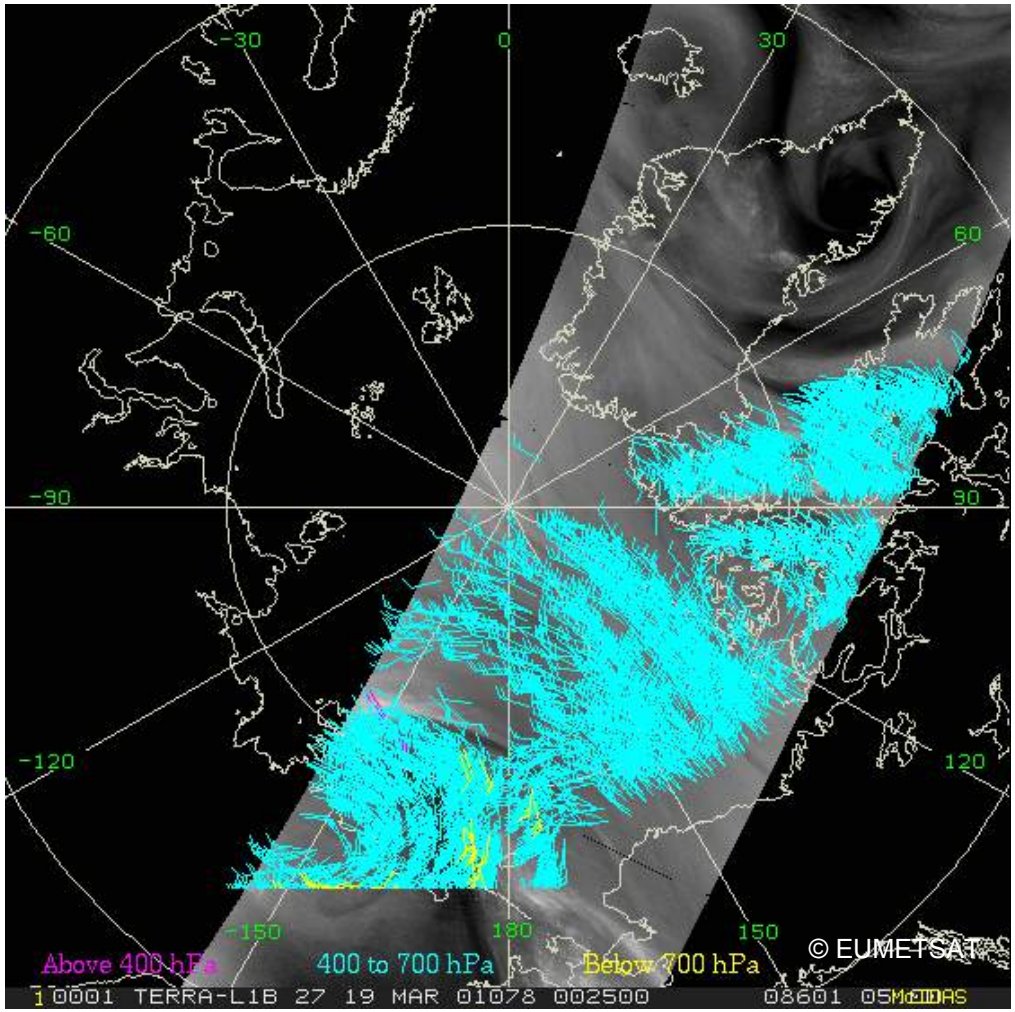
Challenges in navigation in the Arctic

- Positioning
- Weather forecasting
- Situational awareness
- Environment monitoring
- Search and rescue
- Disaster management
- Communication



Arctic Sea Routes September 2006 - 2059

Challenges in weather forecasting in the Arctic



Challenges in positioning in the Arctic

- GNSS systems do not work in same accuracy as in mid-latitudes
- *SBAS is impeded* due geometrical disadvanges
- Ionospheric effects further reduce GNSS positioning accuracy

- Geostationary communication not usable in high latitudes
- Ground based communication network not dense enough

Challenges in situational awareness in the Arctic

Light purple line = coastline or fast ice edge

A = compact ice, 10-30 cm thick

B = very close ice, 10-30 cm

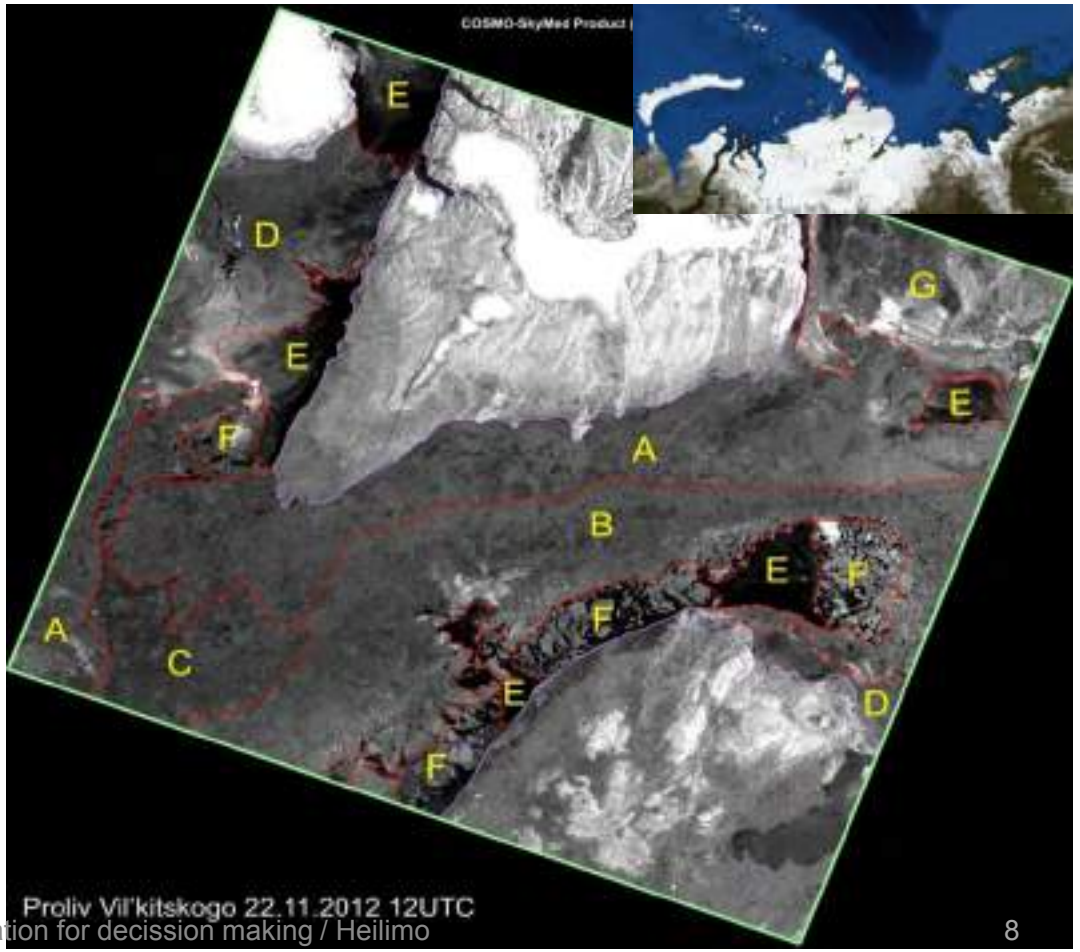
C = thick very close ice, 10-15 cm

D = new ice, < 10 cm

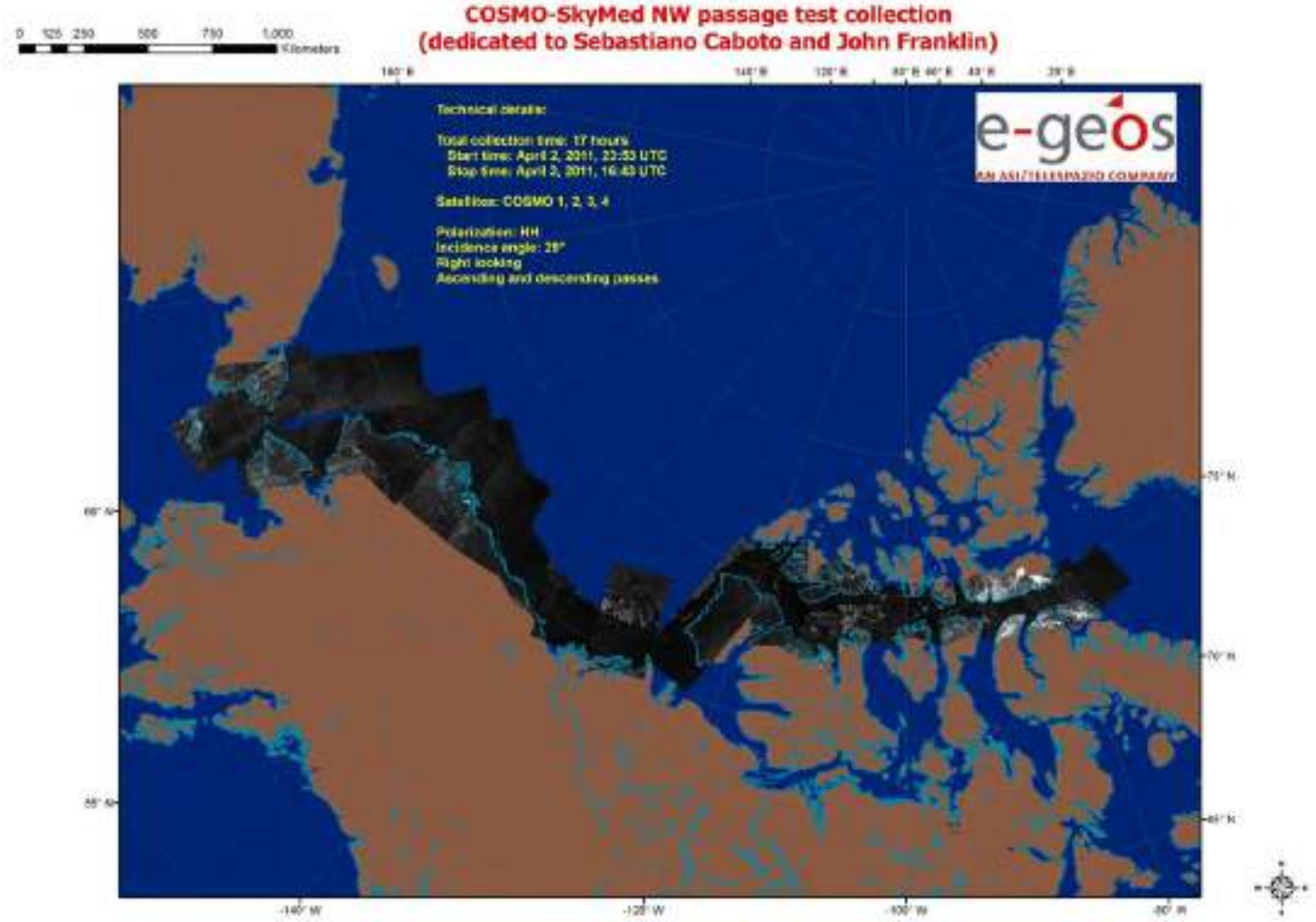
E = open water or new ice, < 5 cm

F = close ice, 10-15 cm

G = consolidated ice, 10-30 cm, rafted



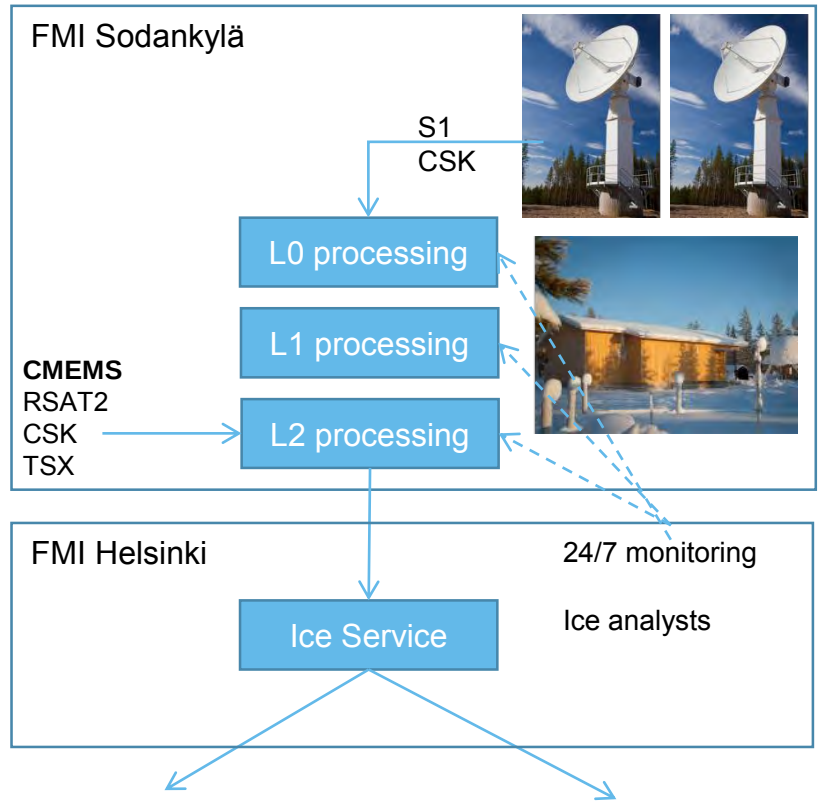
Satellite imaging of NWP

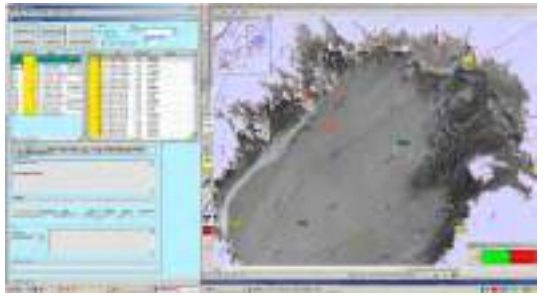


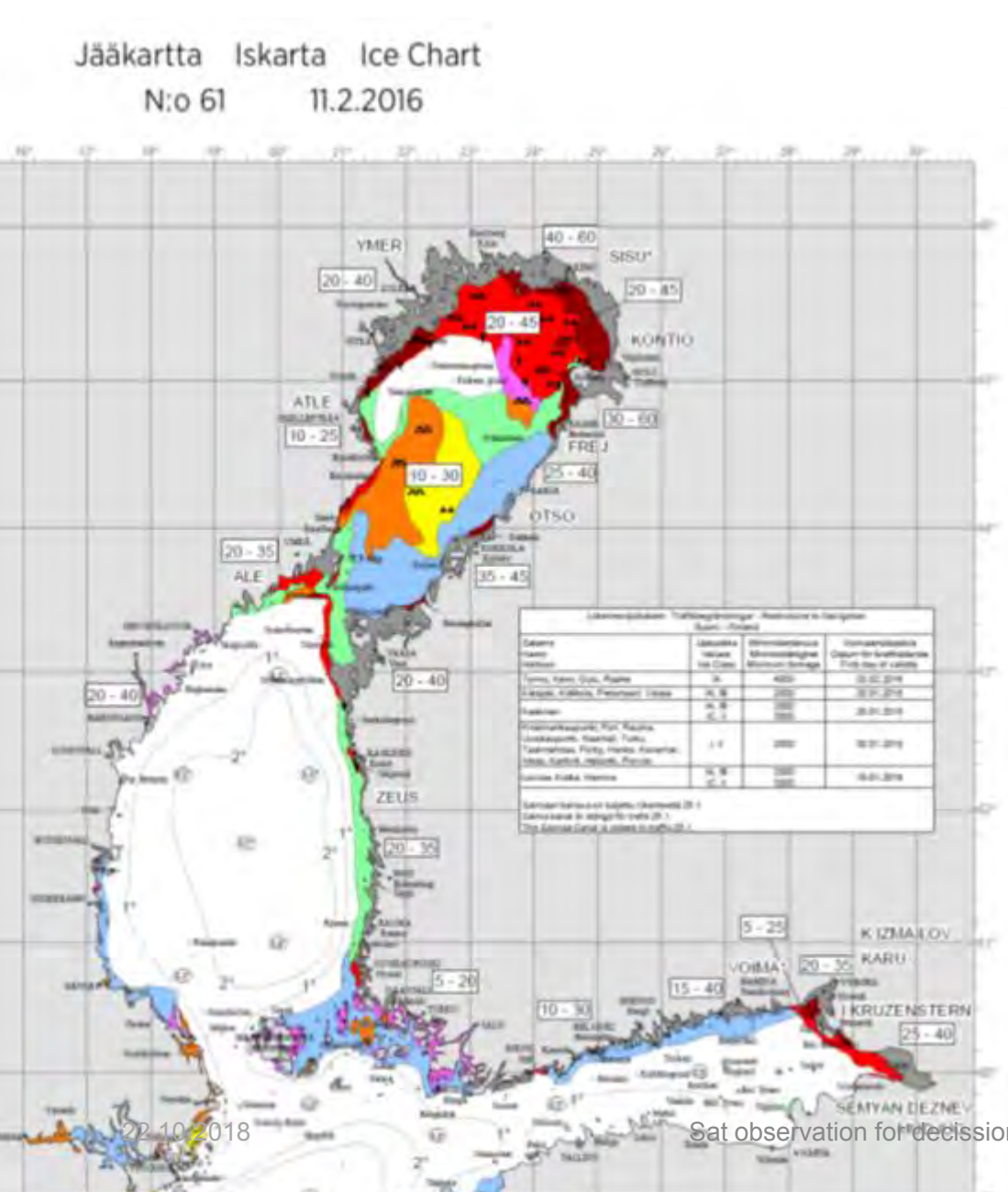
Baltic Sea Ice Monitoring

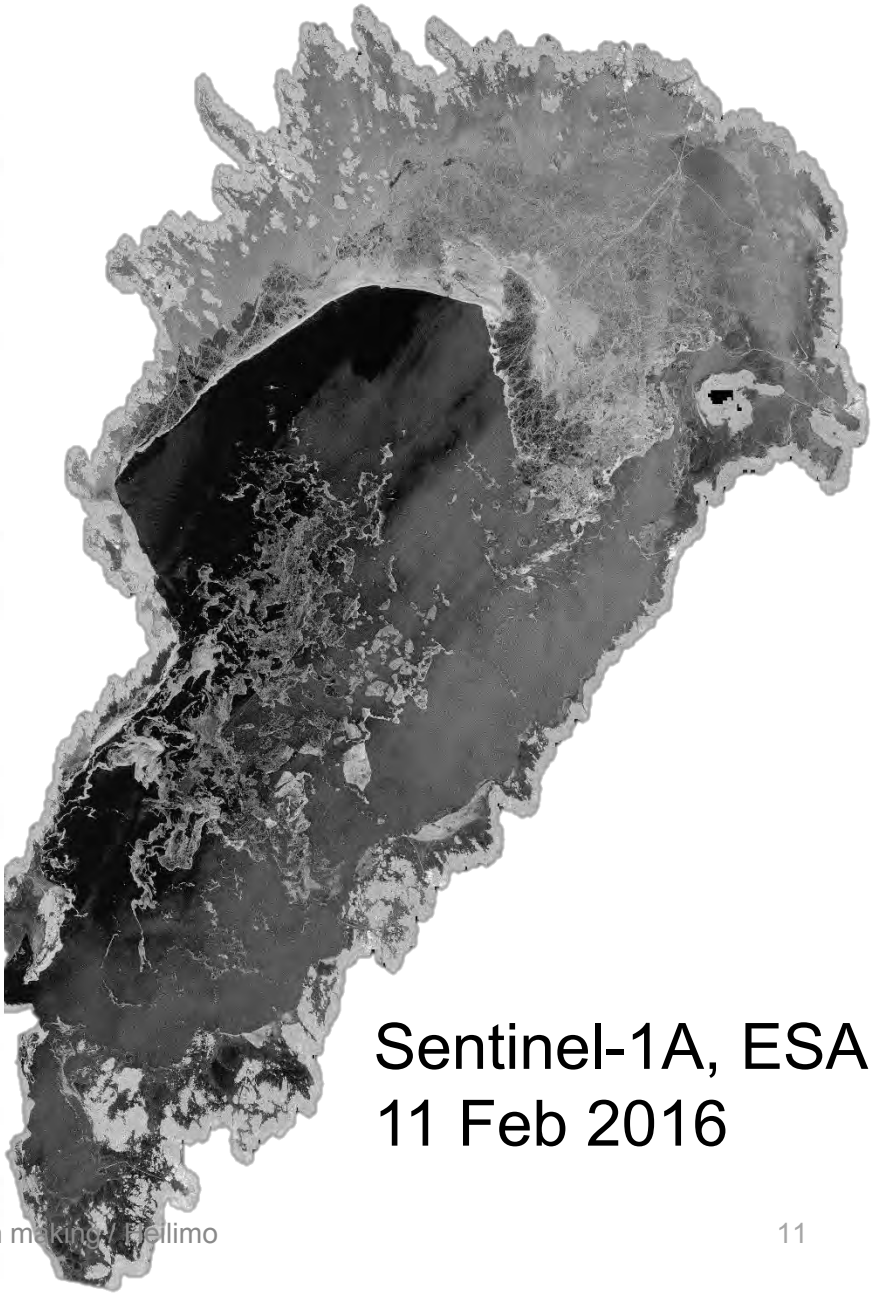
- Commercial and environmental needs
  - Finland is essentially an island
  - ~90% of Finland's import and export via sea routes
  - Gulf of Finland is one of the most busiest marine routes for oil transport
- Operative Service
  - Availability target 99.9%
  - Quasi-real-time / NRT needs
  - Daily products
- Customer:
  - Finnish Transport Agency
  - Finnish, Swedish, Estonian Ice breakers
- Operations:
  - Fully automated processing lines at Sodankylä
  - Operators and ice analysts in 2 shift
  - 24/7 monitoring of the processing lines

Data need:
- Sentinel-1 EW HH+HV pass-through
- Radarsat 2, Cosmo-Skymed, TerraSAR-X
- AOI: Baltic Sea
- Time: Nov – May





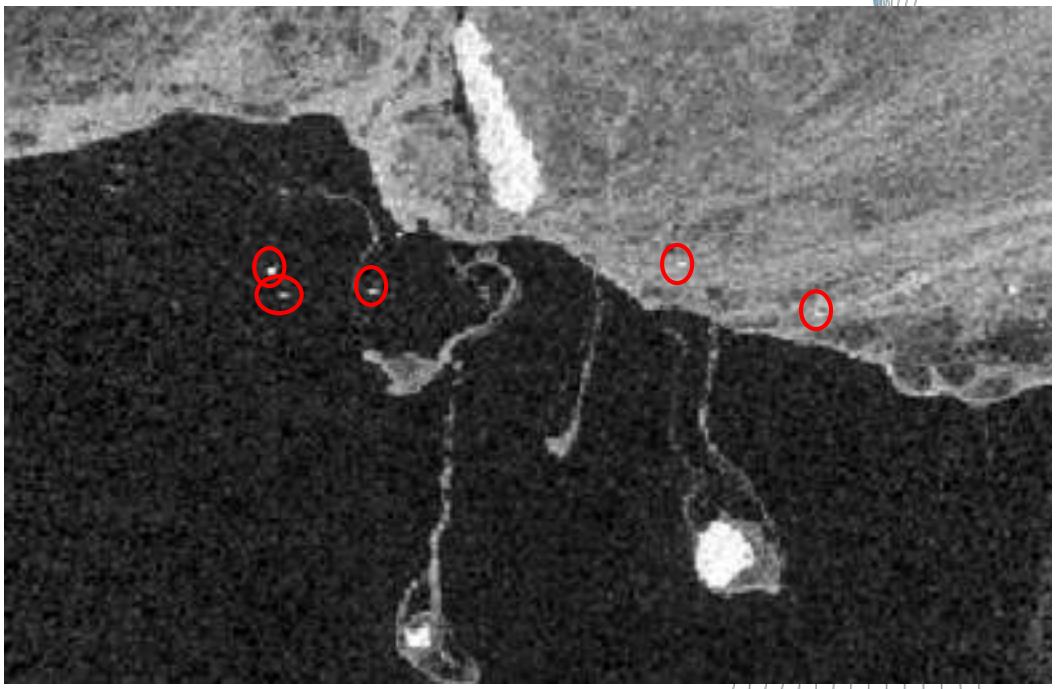




Sentinel-1A, ESA
11 Feb 2016

Vessel detection

- Satellite instruments can be used to detect vessels
  - Synthetic Aperture Radars are insensitive to weather and darkness
  - ”Missing” ships
  - Illegal fishing
  - Illegal migration / human trafficking
  - Border control
  - Search and rescue



Oil spill detection

- Gulf of Finland is one of the busiest shipping lanes in the World
- 200 - 300 oil spills detected annually
- Detection of oil spills can be improved with spaceborne SAR
  - 200 x 200 km coverage single image
  - Clouds or darkness does not affect detection
  - Complements airborne surveillance

Space weather and space situational awareness

Authorities: Hazards

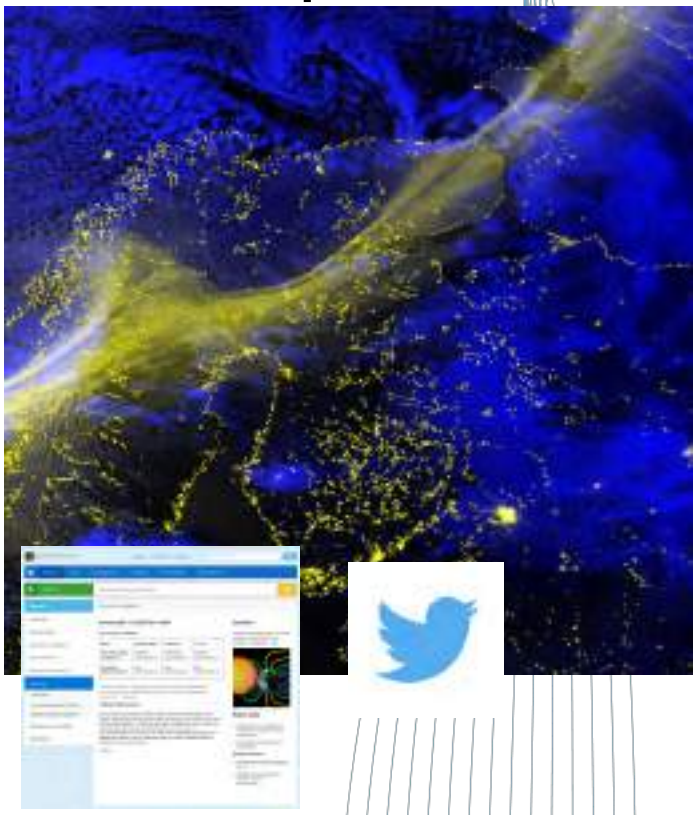
- Satellite and ground-based data
- Computer simulations
- Alerts and warnings

Weather and Security Duty Officer

On-call Space scientist

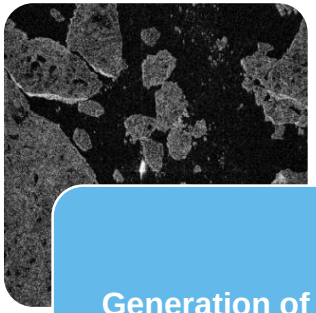
Tailored guidance

General public: Auroras

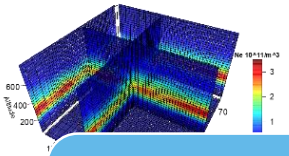


Improving navigation and safety in the Arctic Ocean

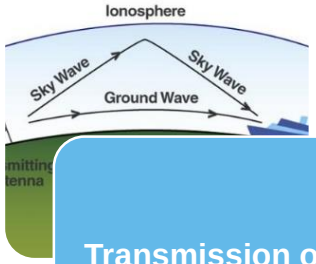
Satellite data reception



Generation of sea ice information



Space Situational Awareness



Transmission of compressed products

Water quality – River discharge

Water quality – Algae blooms

FINNISH METEOROLOGICAL INSTITUTE

OMI tropospheric NO_2

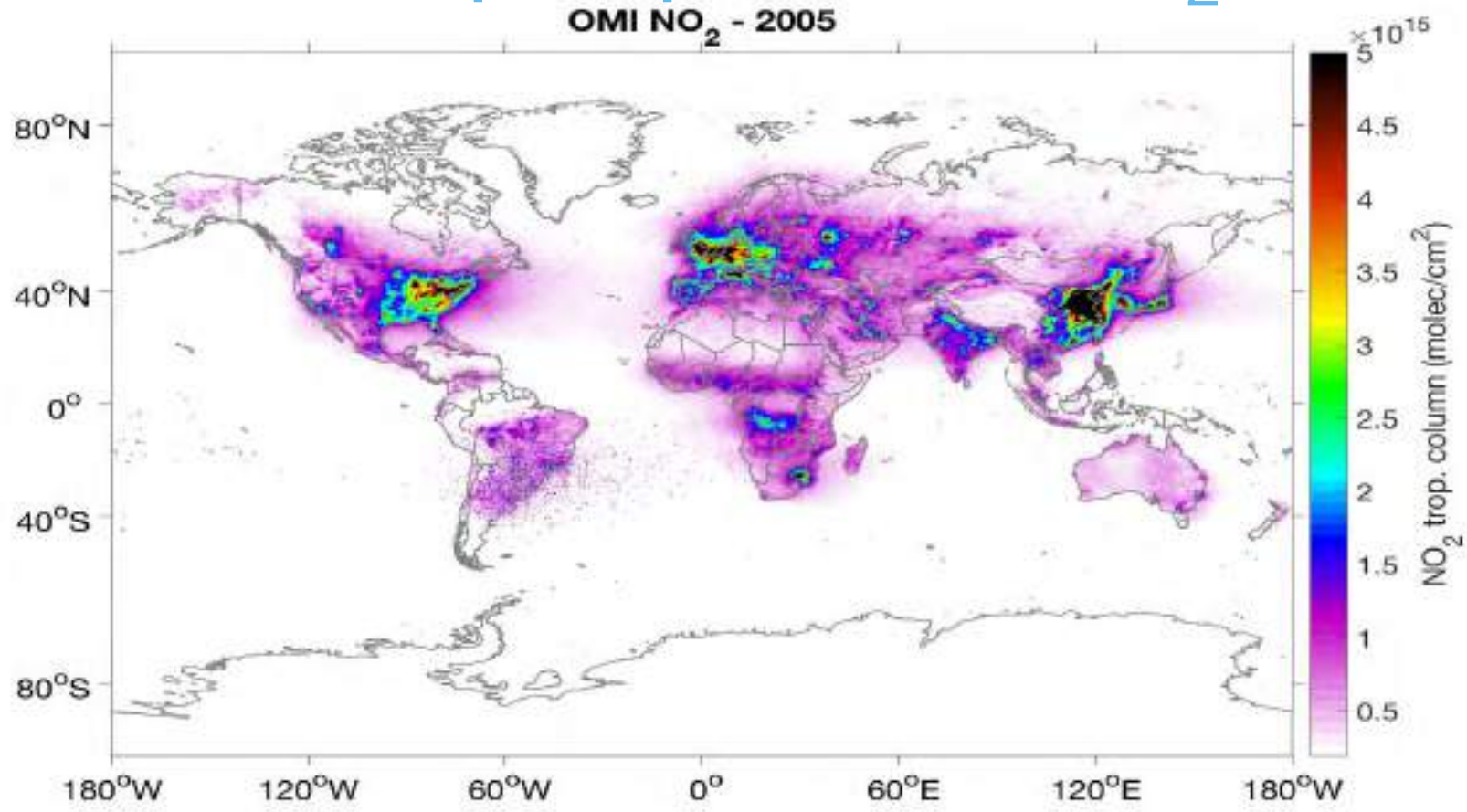
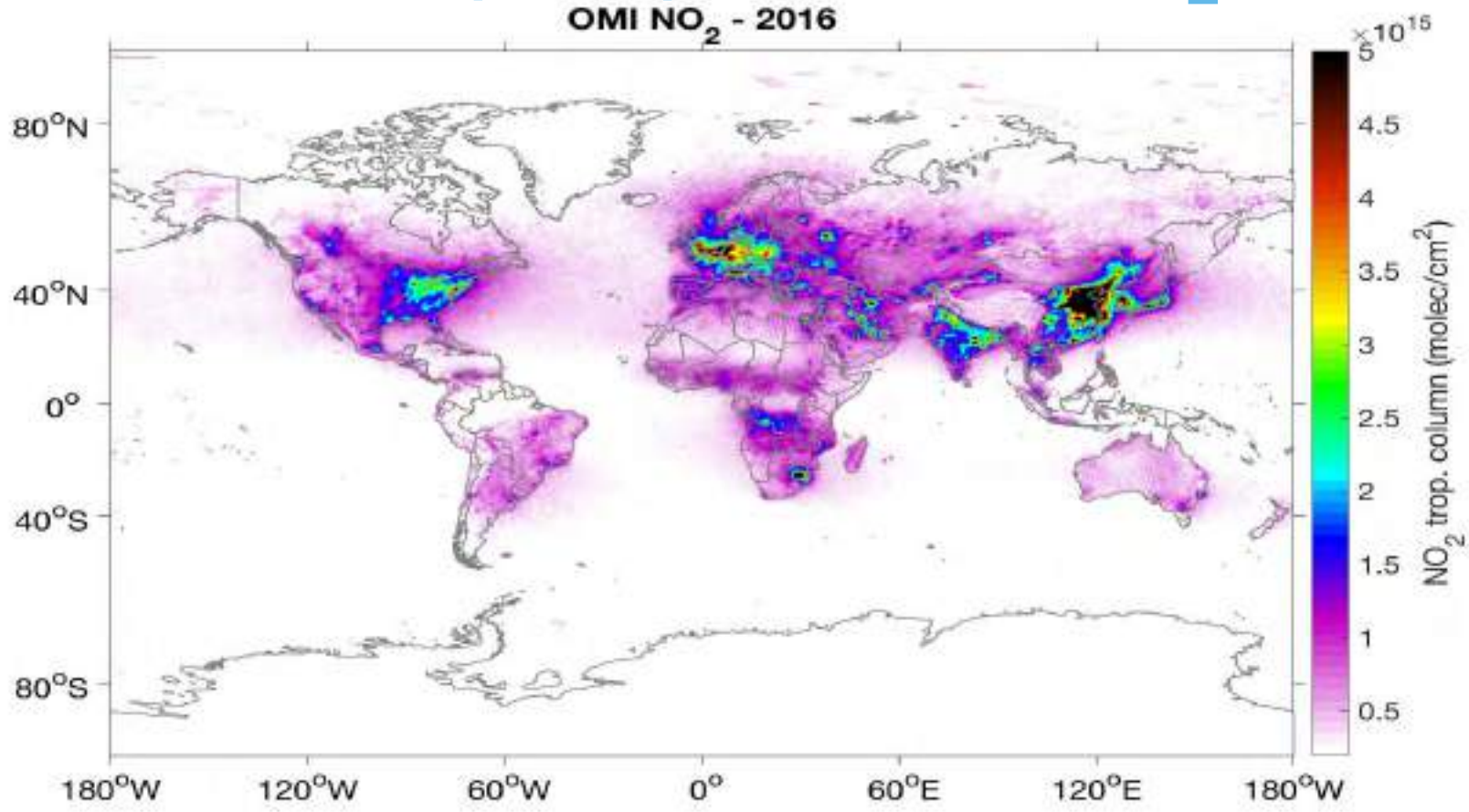


Figure: Iolanda Ialongo, Finnish Meteorological Institute

- NO_2 is a short-lived polluting gas, produced from fossil fuel combustion.
- Pollution decreased in USA and Europe as result of air protection policies, while increased in India and Middle-East because of the increasing industrial activities.
- In China polluting emissions started also decreasing a couple of years ago as consequence of new environmental policies.

FINNISH METEOROLOGICAL INSTITUTE

OMI tropospheric NO_2



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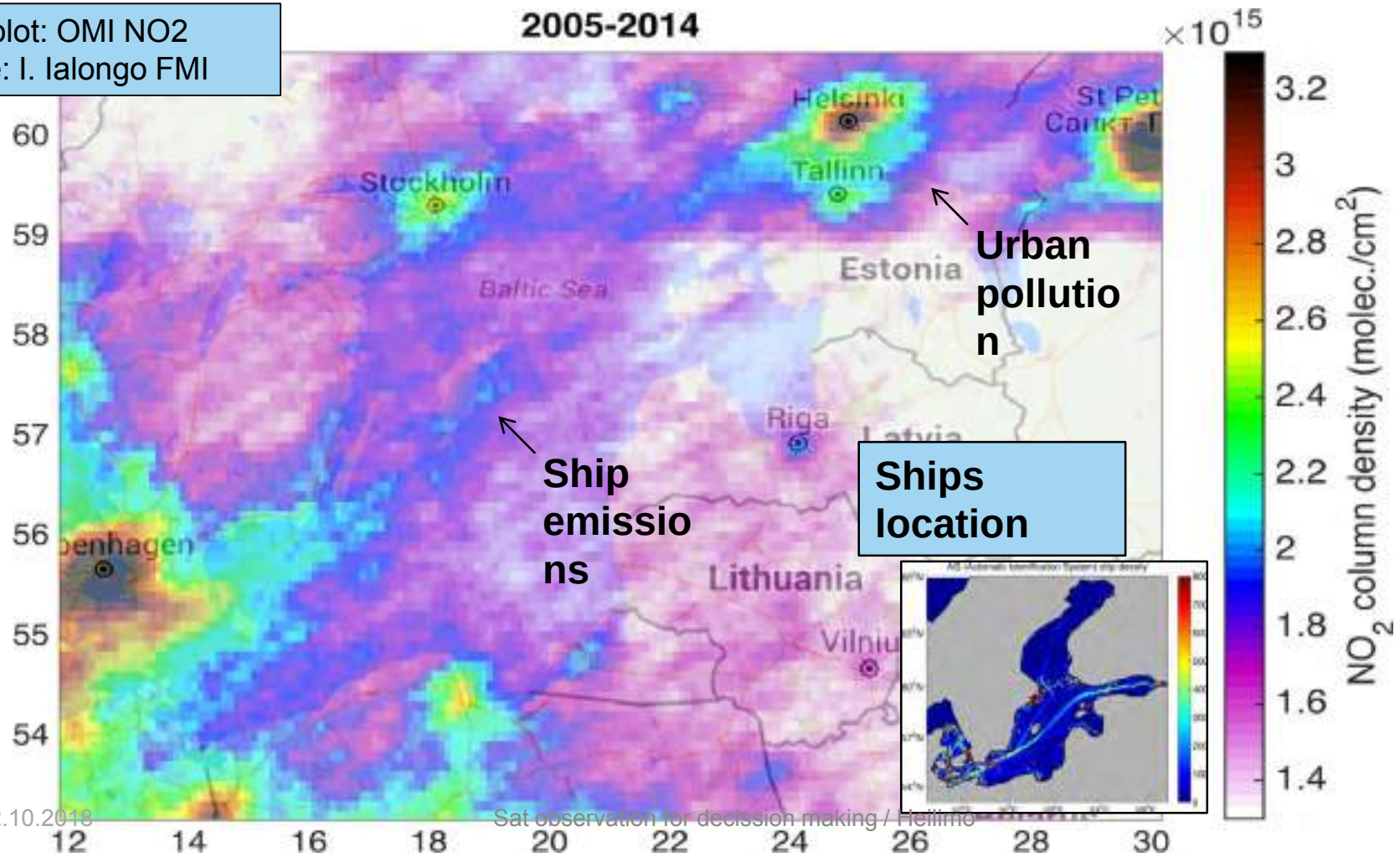
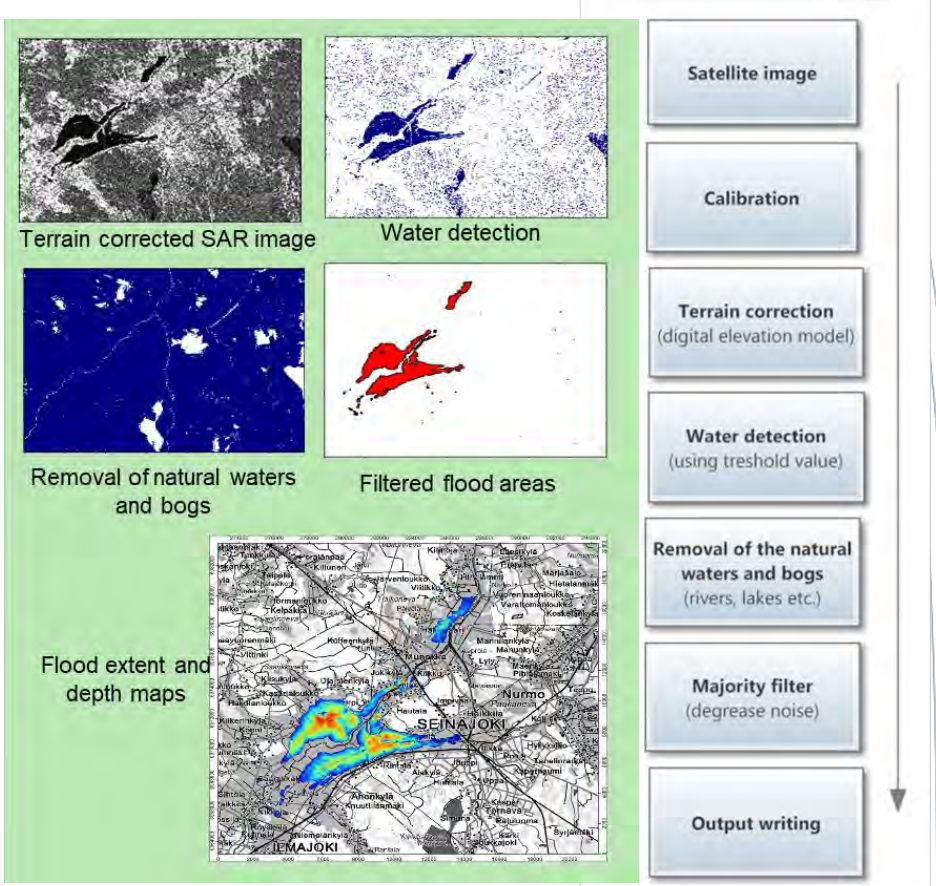
Monitoring Air Quality in the Baltic region: preparation for S5P exploitation

In the plot: OMI NO2
Source: I. Ialongo FMI

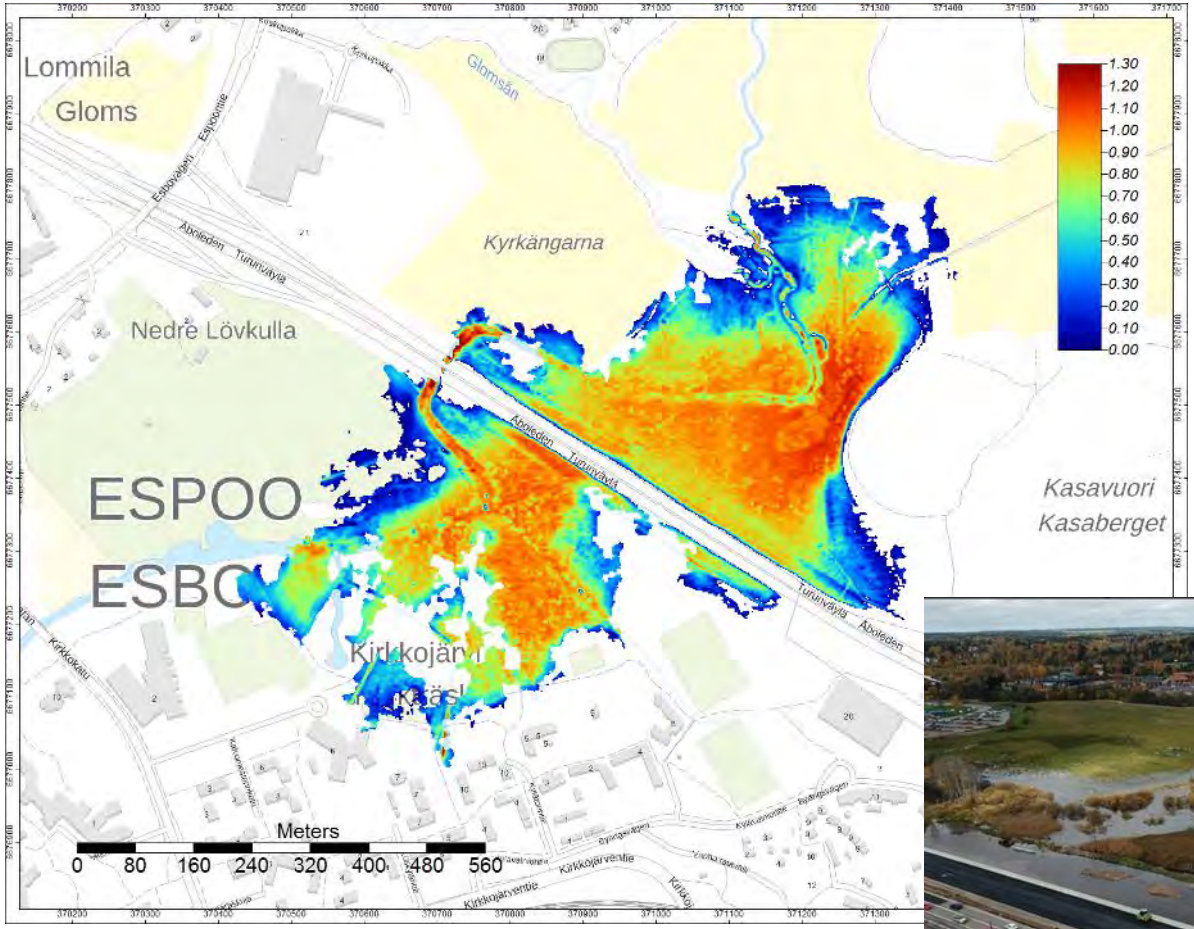


Flood detection and monitoring

- Annual flooding of rivers in Bothnia
  - Spring floods due snow melt
  - Autumn floods due heavy rains
- Operational service for regional authorities
  - Flood covered area, Flood depth
  - Forest floods

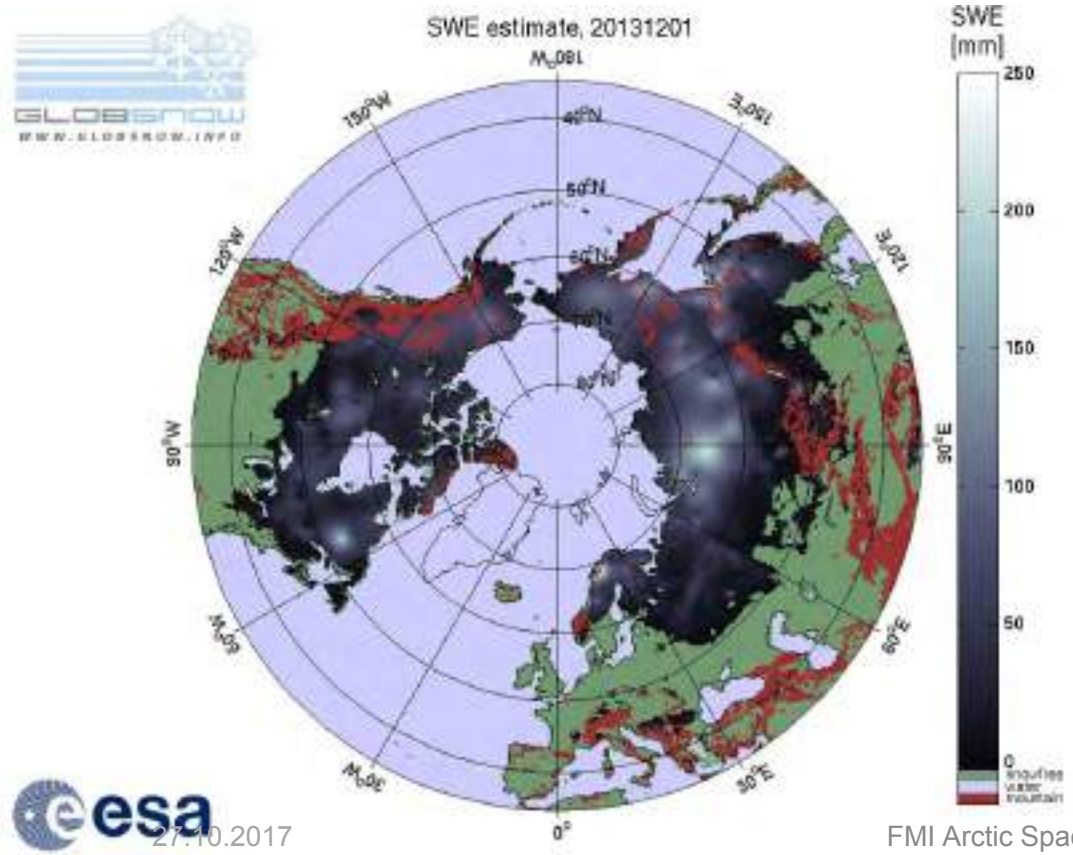


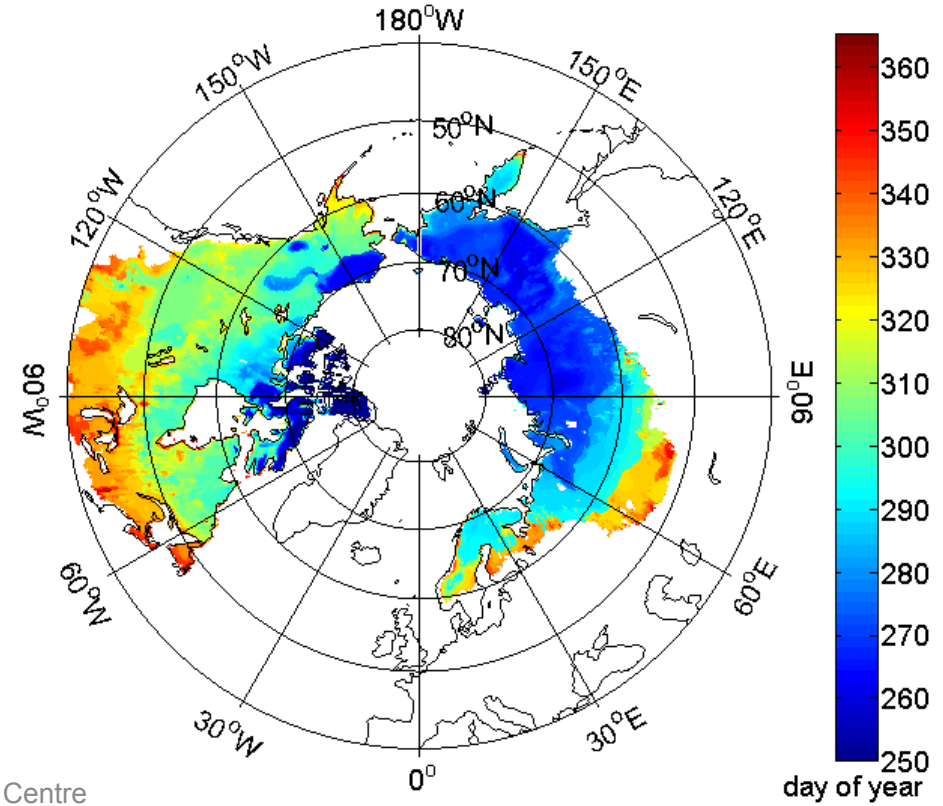
Autumn flooding at Espoo 2017



Snow cover and soil frost of the Northern Hemisphere from Microwave Radiometer Satellite Data

Snow mass (SWE) in 1 Dec. 2013 and the day of soil freezing in autumn/winter of 2013 using U.S. DMSP SSMIS and ESA SMOS satellite data



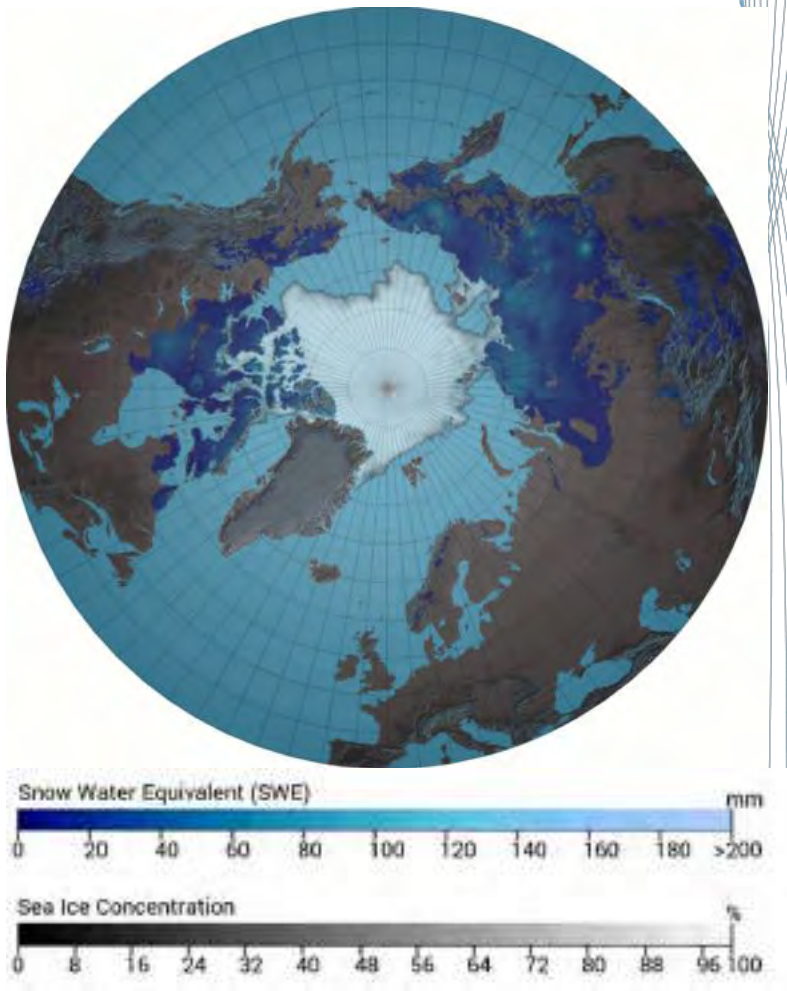


Snow and ice in the Arctic:

Spaceborne data-derived information for climate research and NRT-applications

- Atmospheric phenomena and their interaction with biosphere and cryosphere
- Snow covered area
- Snow water equivalent
- Seasonal frost / thaw
- Permafrost
- Sea ice
- Hydrology

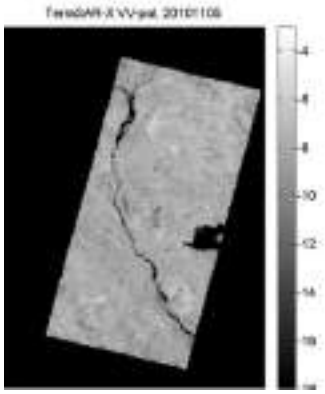
Snow Mass and Ice Cover (12 Oct. 2017-6 Dec. 2017)



DEVELOPING REMOTE SENSING CAPABILITIES

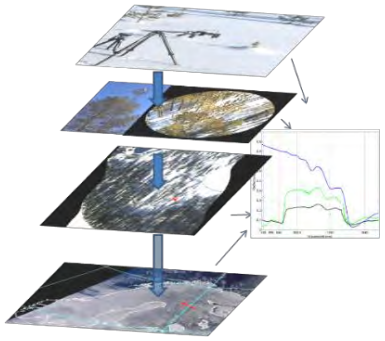
EXPERIMENTS

Campaign datasets, …

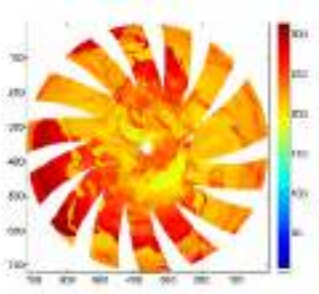


PHYSICS

…model development…

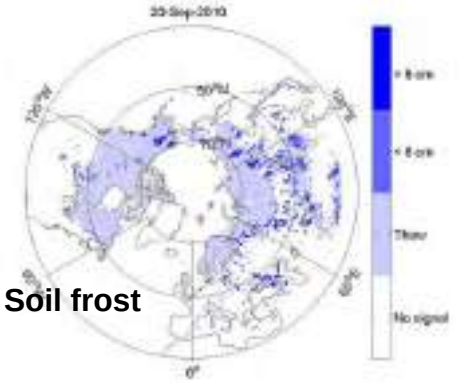


…for better understanding of satellite observations



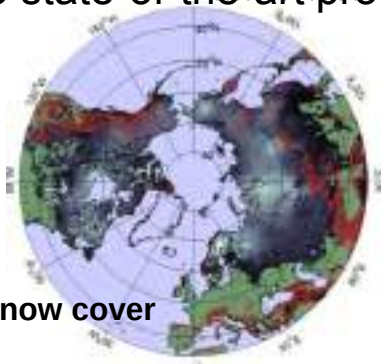
APPLICATIONS

From innovative prototypes…



Soil frost

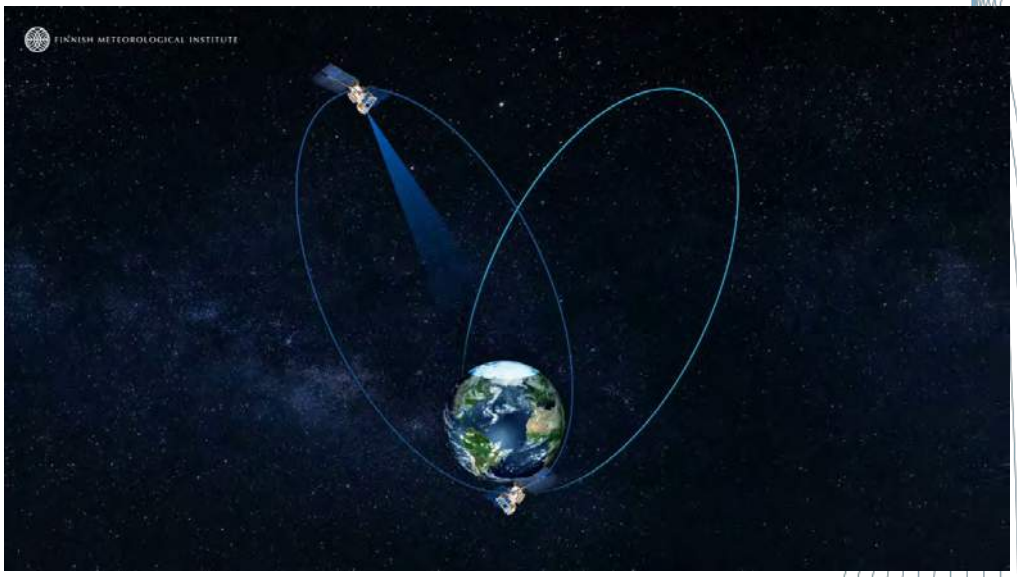
…to state-of-the-art products



Snow cover

Future needs for the Arctic – HEO Mission

- Improved imaging
  - Weather forecasts, winds
  - Sea state, Sea ice conditions
  - Snow and ice cover
- Improved positioning
  - Navigation in Arctic ocean
  - Arctic communities
  - Search and rescue
- Improved communication
  - Satellite communication
  - HF-communication
- Improved situational awareness
  - Space weather



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