

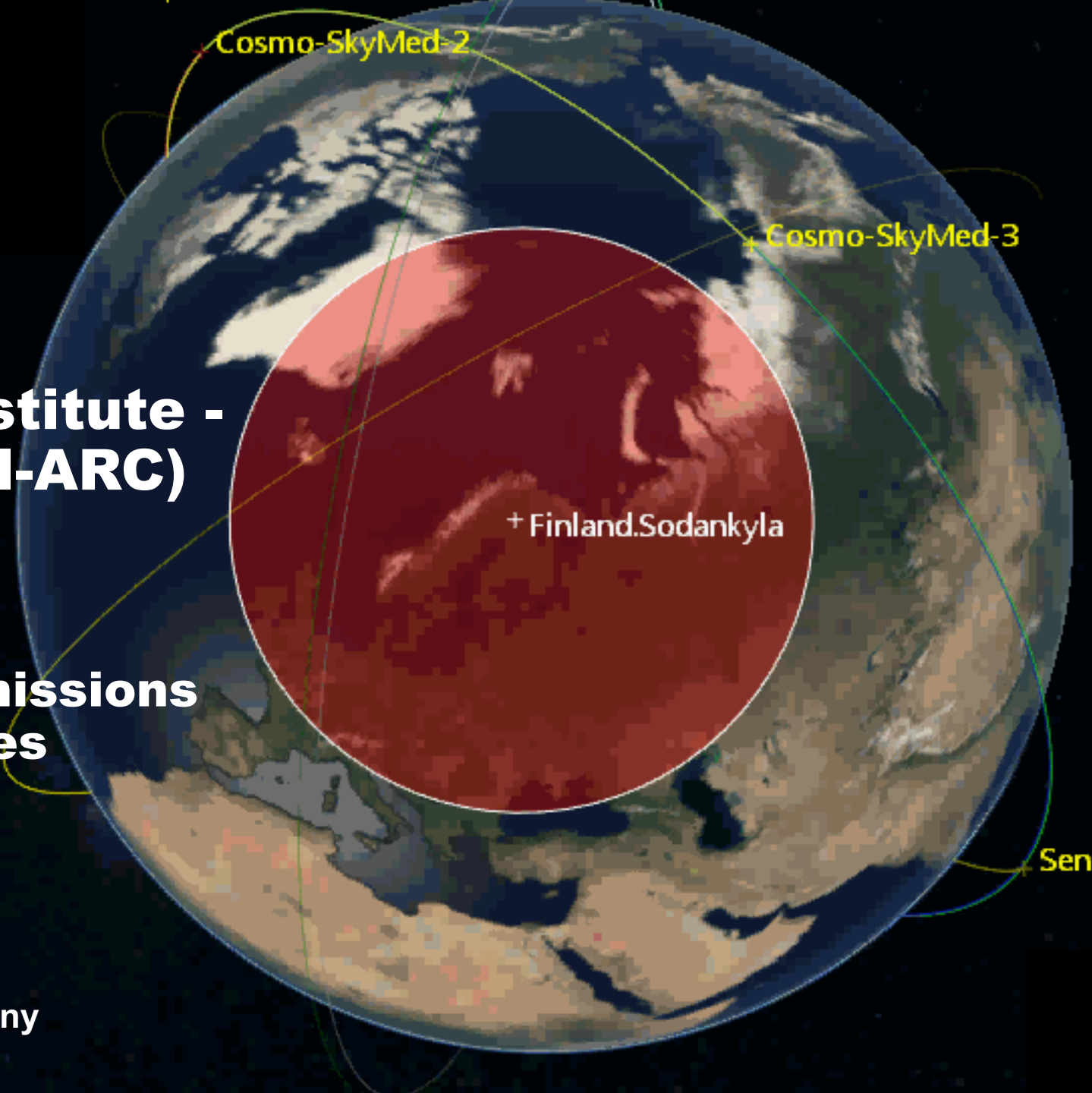


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Finnish Meteorological Institute - Arctic Space Centre (FMI-ARC)

Current and future satellite missions and CSPP based services

Timo Ryyppö
CSPP Users' Group Meeting, Darmstadt, Germany





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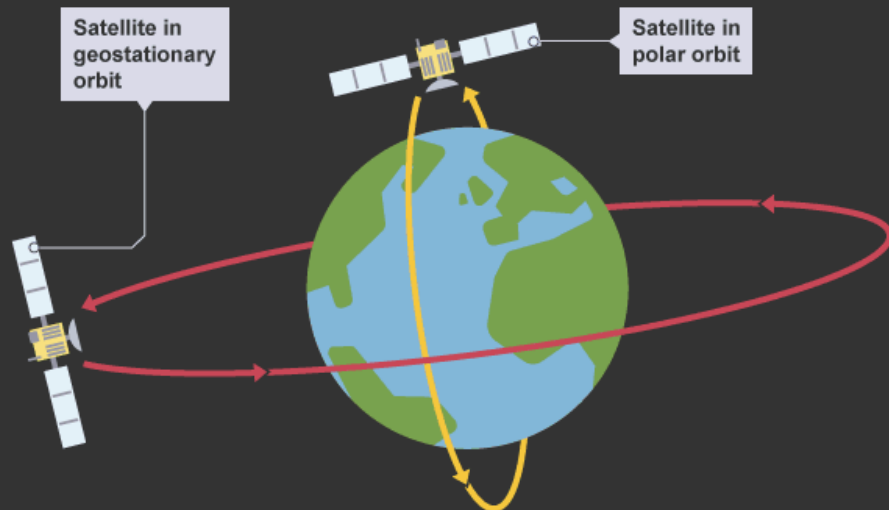
Content

- Introduction of FMI-ARC ground station
 - Infrastructure and service
- CSPP based products and services
 - History and current situation
- Future plans and discussion



Northern location as a strength

Station	LAT (deg)	Passes/day (max 14)
FMI-ARC Sodankylä, Finland	67,4	10
Svalbard, Norway	78,2	14
Matera, Italy	40,6	6
Mbarara, Uganda	-0,6	4



FMI-ARC infrastructure

- SOD01 (2.4 m X-band)
 - Decommissioned in mid 2021
 - Mainly used for Terra, Aura, and NPP
- SOD02 (7.3 m X-band) and SOD03 (7.3 m X/S-band)
 - Shared schedule, either antenna can be used for all missions
 - Expect S-band (SOD03 only)
 - Taken into operations in 2011 and 2017, respectively
- SOD04 and SOD05 (3.7 m X/L-band)
 - Multi-mission capability in X/L-band
 - Taken into operations in 2021 and 2022, respectively
- On-site data centre
 - Redundant heating, ventilation, air conditioning systems, and UPS. In addition, backup generator
 - FMI hosted cloud and storage services
 - On-premises Amazon Simple Storage Service (S3)
 - Virtual servers next to data





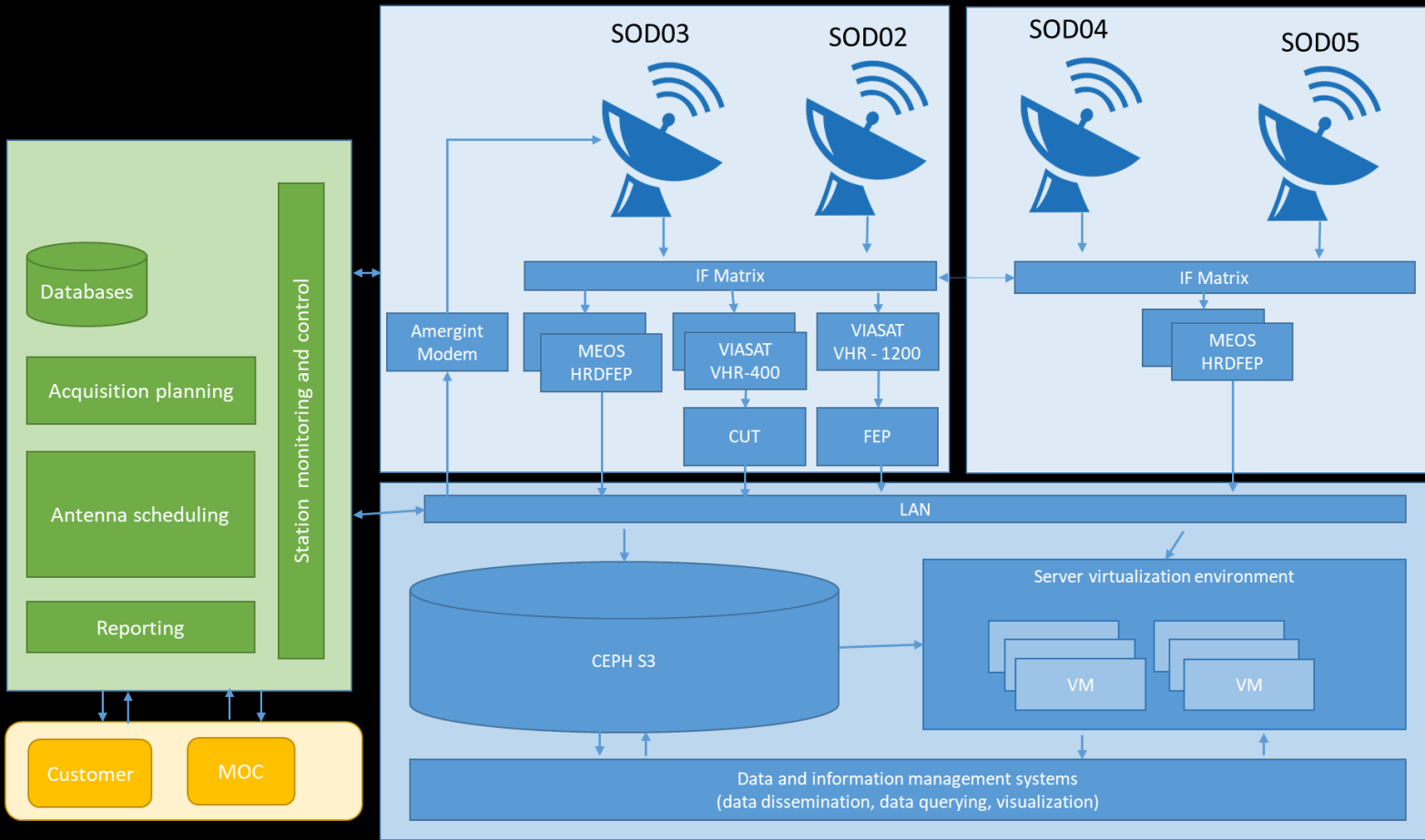
FMI-ARC satellite missions

- On-demand activities:
 - HaiYang-2B/C
 - Wind products from scatterometer data for EUMETSAT
 - Cosmo-SkyMed and Cosmo-SkyMed Second Generation
 - Sea ice monitoring for Copernicus Marine Environment Monitoring Service (CMEMS)
 - PAZ and KOMPSAT-5
 - Radio occultation data for NOAA
- Direct Broadcast:
 - X-Band: NPP, NOAA-20, NOAA-21
 - L-Band: MetOp-B/C, Arctic Weather Satellite (prototype for EPS-Sterna constellation)
 - Planned: MetOp-SG 1A/B
 - Usage: Sea ice monitoring, atmospheric composites and gases, active fires, weather service



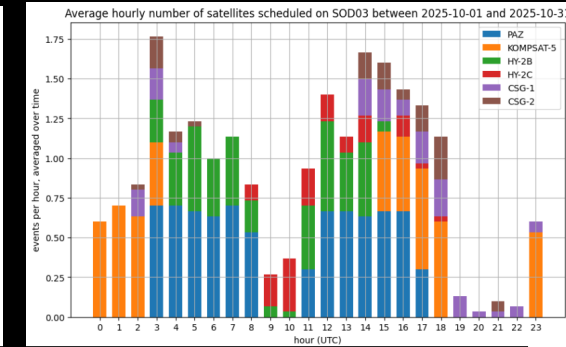
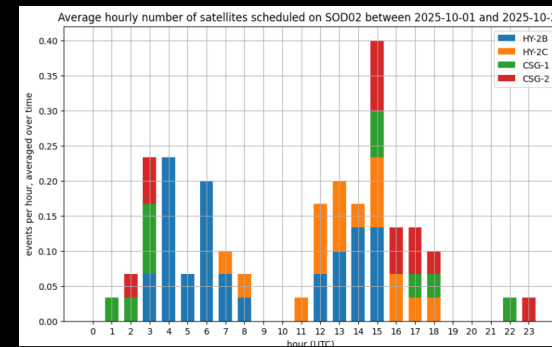
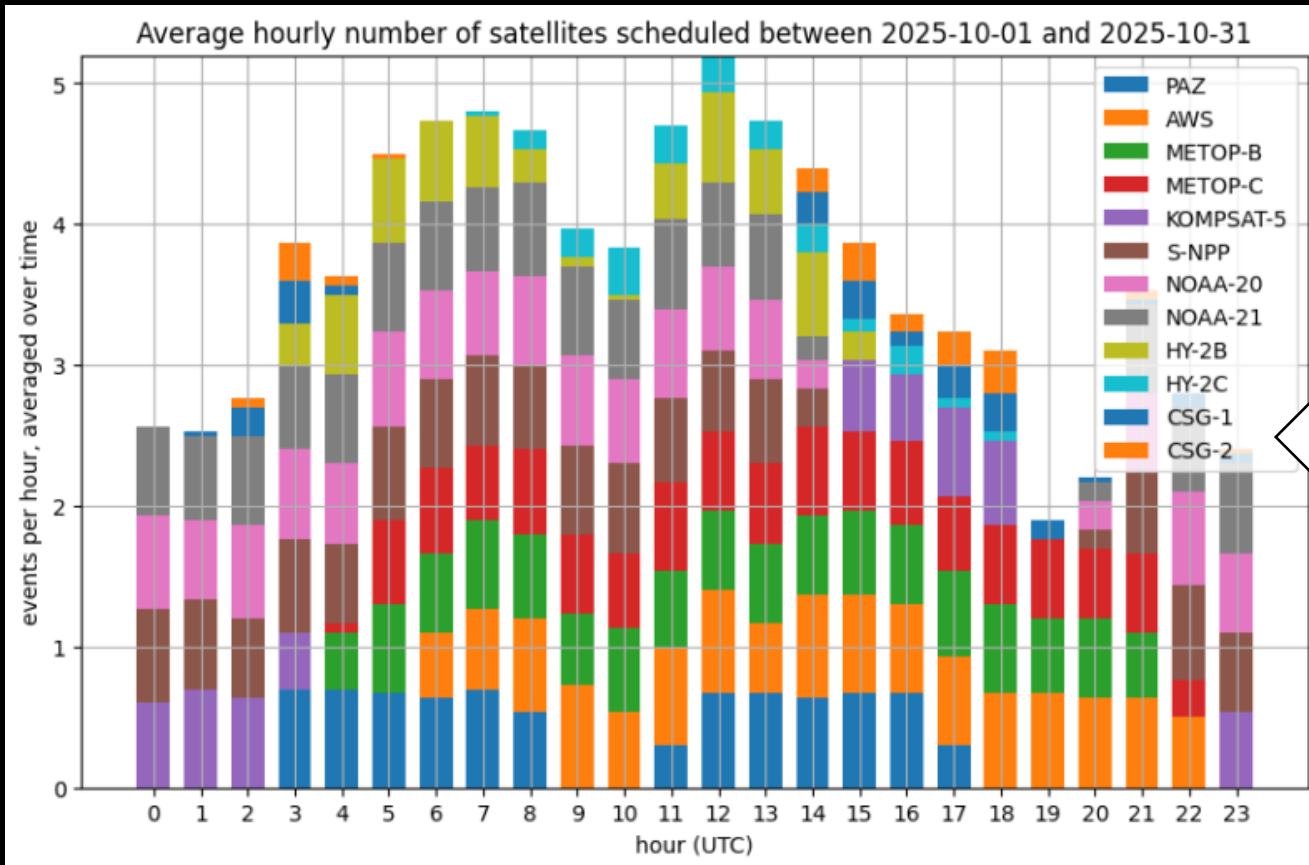
Concept of operations

- Antennas work as pairs
 - Redundancy, flexibility
- Matrix style approach
 - No limitations to output
 - Bypassing defective components

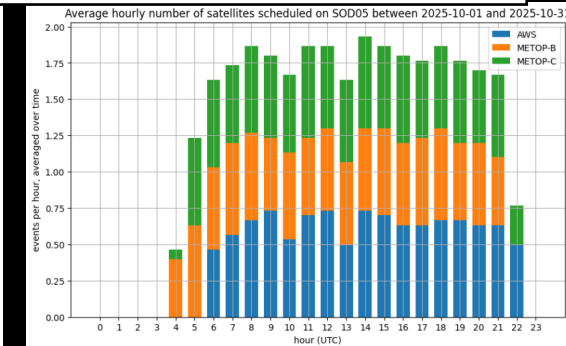
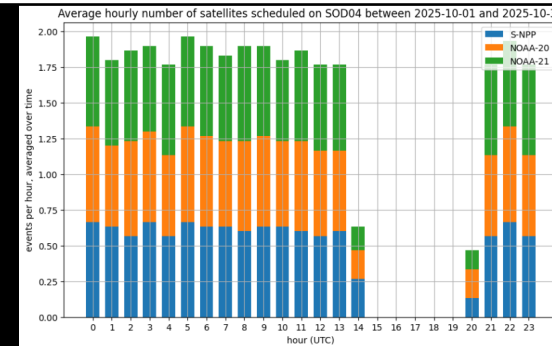


Scheduled passes

- ~80 passes/day → 30 000/year



Individual antennas vs. total





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CSPP BASED PRODUCTS AND SERVICES



History of CIMSS/SSEC products at FMI-ARC

- International MODIS and AIRS Processing Package (IMAPP) used from 2008 until May 11th, 2024
 - MODIS/Terra and Aqua products
- Community Satellite Processing Package (CSPP) used since 2012
 - FMI started as a beta tester
 - Used for VIIRS L1, active fire and cloud products
 - User friendly software, turn-key installation



SNPP and JPSS missions

- SNPP from 2012/03 onwards
 - First Suomi NPP image using CSPP software was processed by FMI on March 5th, 2012
- NOAA-20 from 2018/01 onwards
- NOAA-21 from 2023/04 onwards
- Reception of all visible passes (~30/day)
 - Highest priority in schedule
- Near-real time processing using RT-STPS and CSPP software
 - Sea ice monitoring, atmospheric composites and gases, active fires, weather forecast, public outreach



FMI-ARC 's satellite-based wildfire services



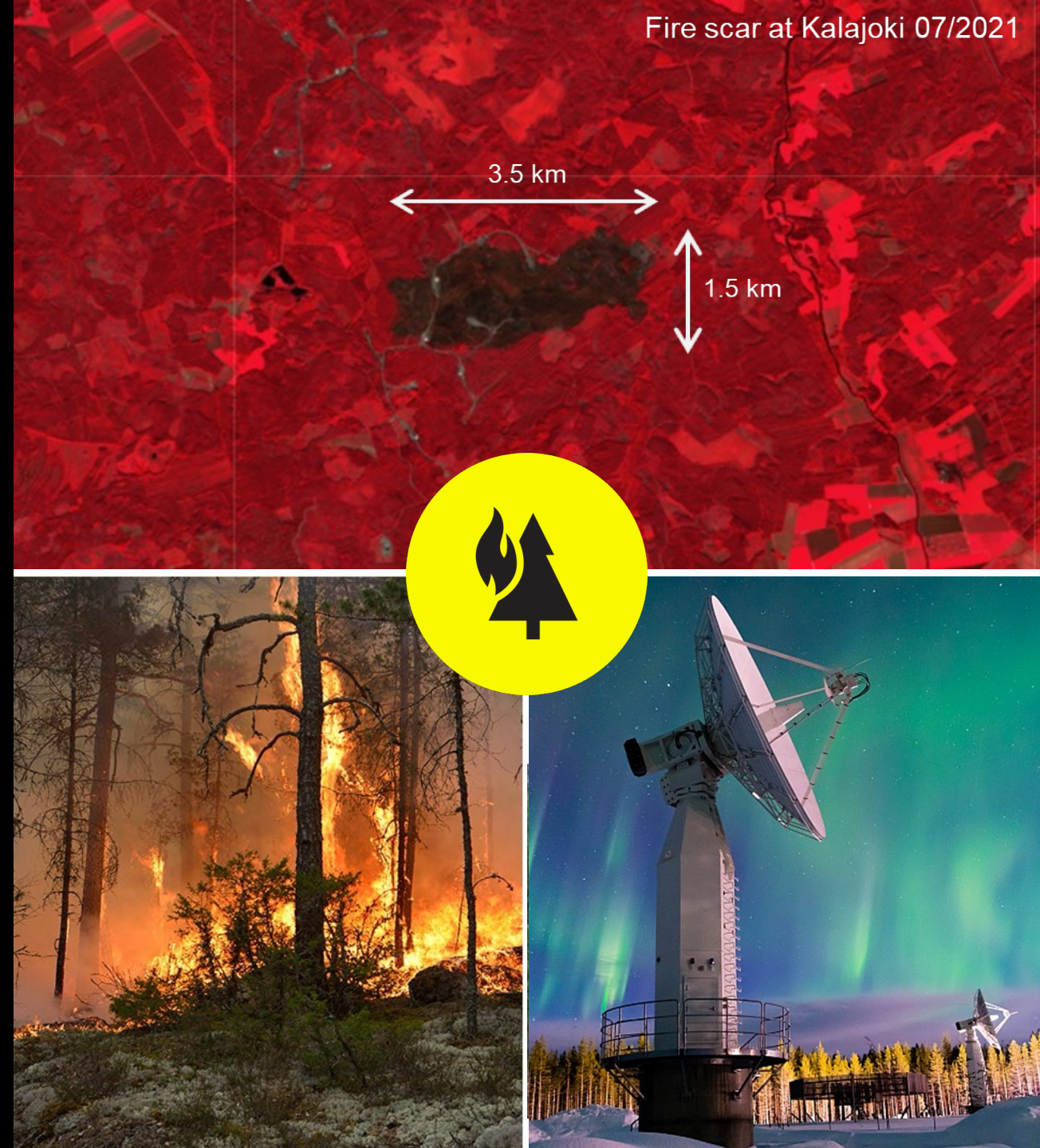
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Satellite based forest fire service

- Operational national service for Ministry of Interior
- Satellite data reception at Sodankylä
- Fully automatic hot-spot processing
 - Based on CSPP SDR and Active Fire
- Filtering of known false alert locations
 - Metal smelters, greenhouses, sun glints over sea
- Automatic notifications to fire and rescue services
- Several first alerts of forest fires every year



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Fire scar at Kalajoki 07/2021

3.5 km

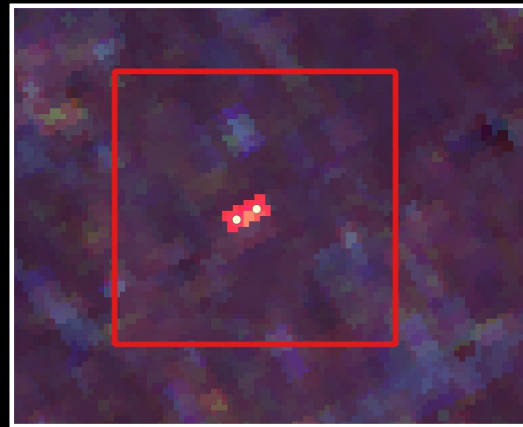
1.5 km

Kalajoki forest fire, Finland 2021

Start of the fire 26th of July ~13:30 LT
First alert to fire department 13:55 LT
First units arrive to target ~14:20 LT



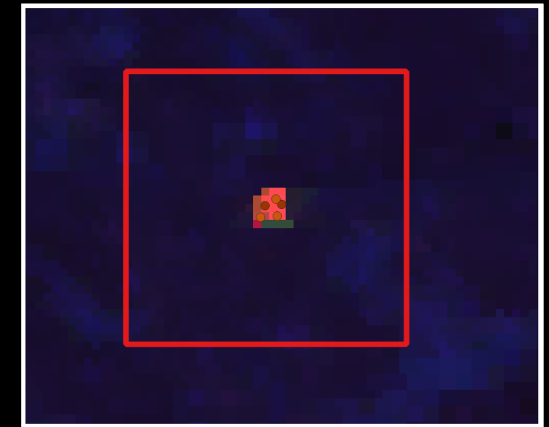
13:49 LT
1 fire pixel
FPR: 6 MW



13:54 LT
2 fire pixels
FRP: 6-10 MW



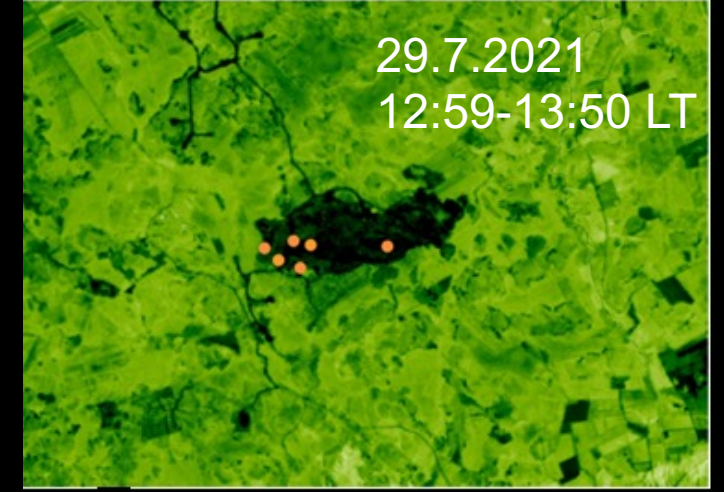
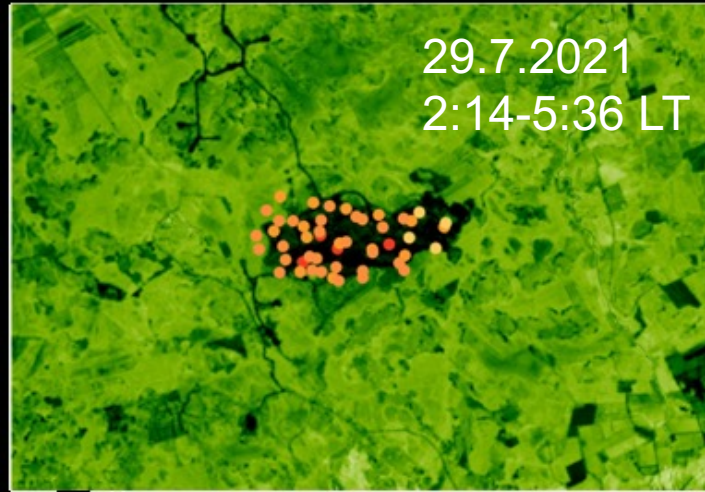
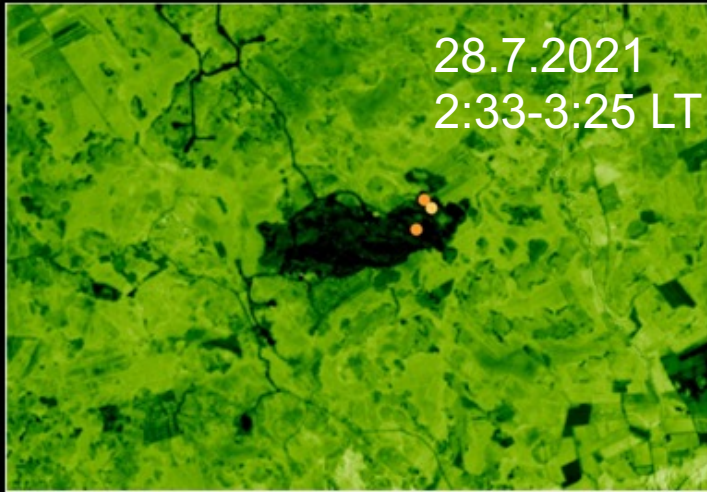
14:39 LT
5 fire pixels
FRP: 23-34 MW



15:36 LT
5 fire pixels
FRP: 27-40 MW



Kalajoki forest fire, Finland 2021



Background: Sentinel 2
RGB image showing burned
area on 29th of July

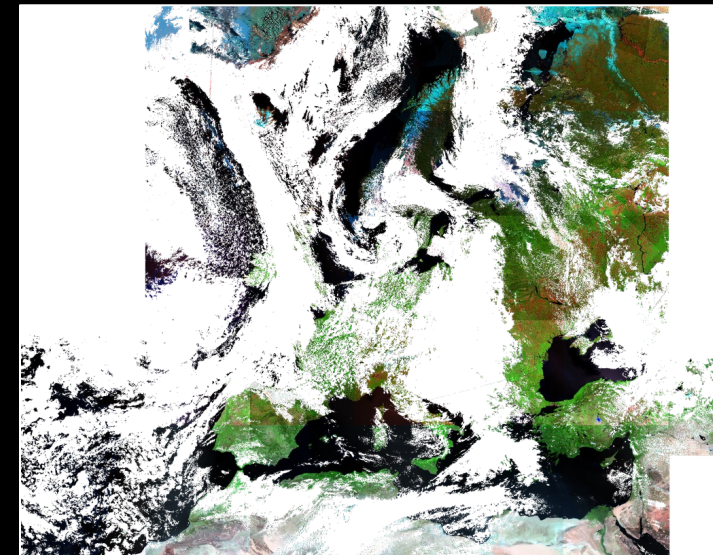
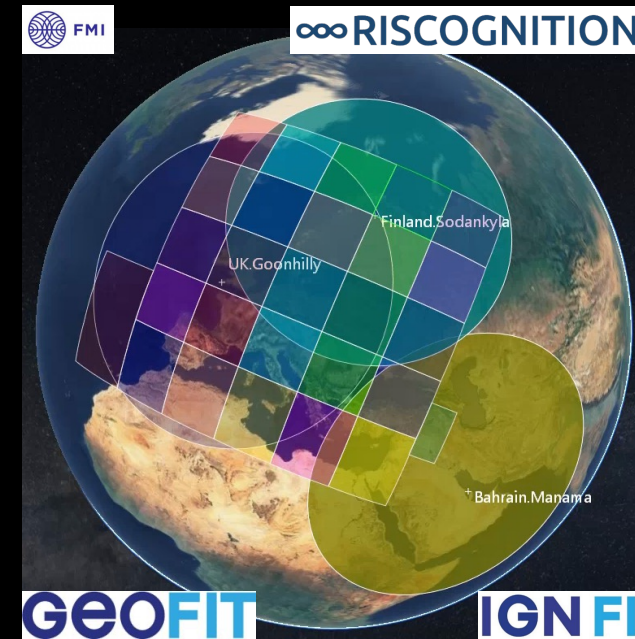
On-top: Active Fire satellite
product showing fire pixels
and their radiative power

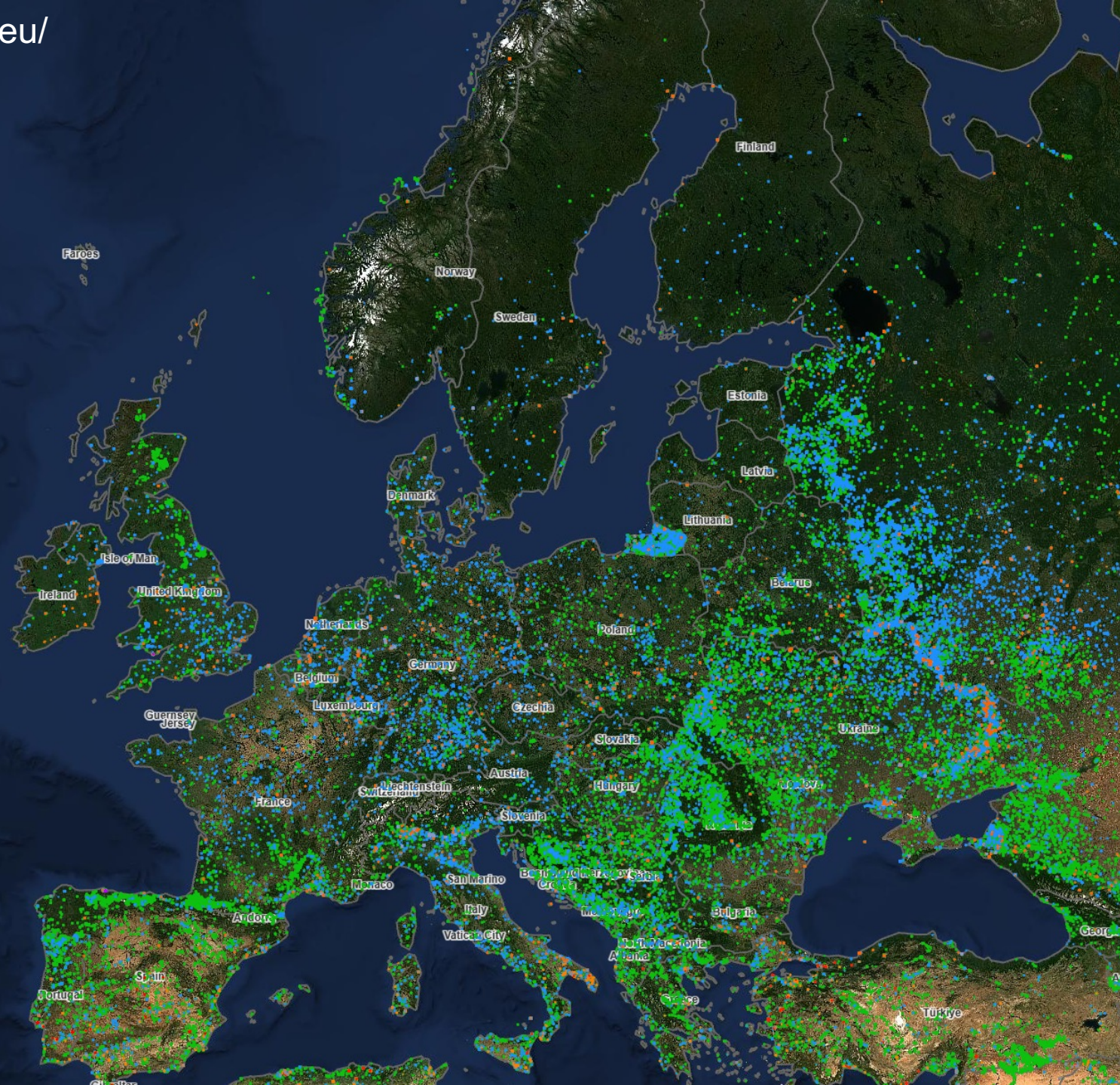
Fire Radiative Power (MW)


- 0,5 – 1,5
- 1,5 – 5
- 5 – 10
- 10 –

European Forest Fire Information System (EFFIS)

- The service is part of Copernicus EMS (Emergency Management Service)
- The service provides information on active wildfires and the extent of the fire area, as well as an impact assessment of fire damage
- Distributed ground stations
 - FMI is responsible for Northern part of Europe
- Satellites: Terra, Aqua, Suomi NPP, NOAA-20
- Processing software:
 - CSPP SDR (L1) Active Fire, and ATMOS (clouds)
 - Daily mosaics created with in-house Python tools





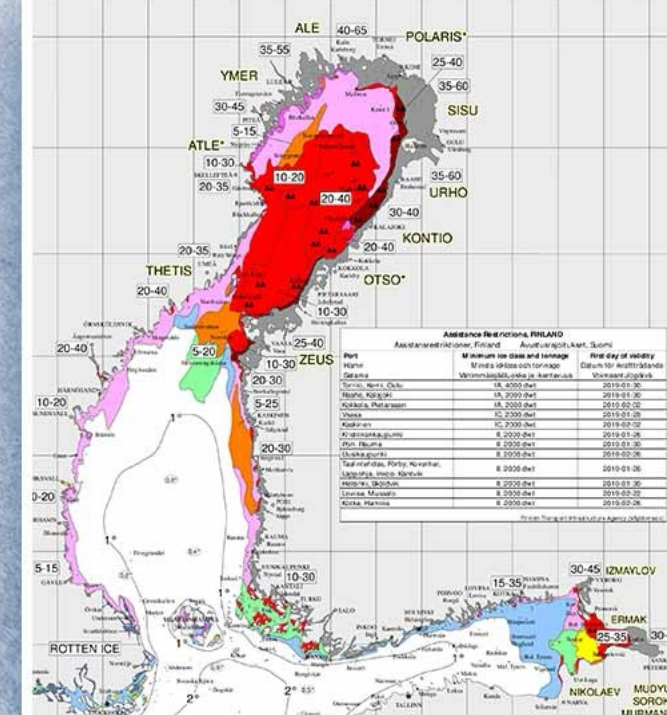
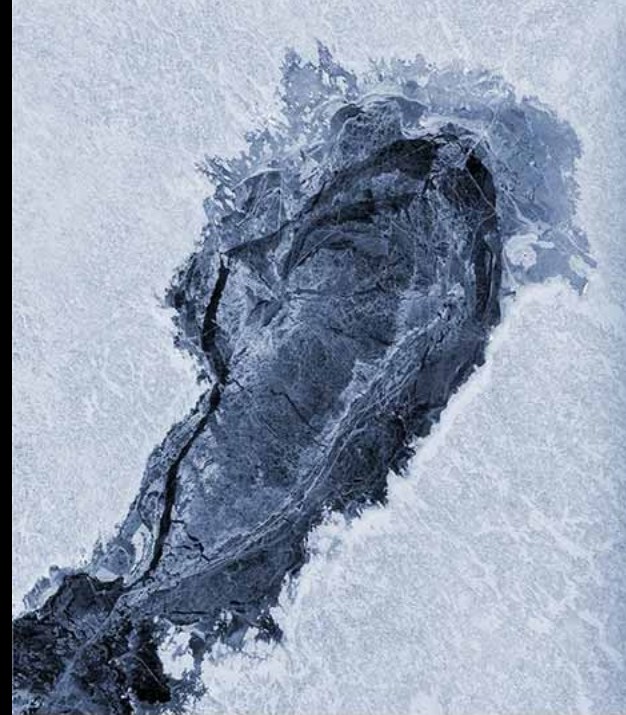
 Legend

VIIRS (all)

- <=6 hours (VIIRS Suomi)
- >6 & <=12 hours (VIIRS Suomi)
- >12 & <=24 hours (VIIRS Suomi)
- Last 7 Days (VIIRS Suomi)
- Last 30 Days (VIIRS Suomi)
- Fire Season (VIIRS Suomi)
- <=6 hours (VIIRS Noaa-20)
- >6 & <=12 hours (VIIRS Noaa-20)
- >12 & <=24 hours (VIIRS Noaa-20)
- Last 7 Days (VIIRS Noaa-20)
- Last 30 Days (VIIRS Noaa-20)
- Fire Season (VIIRS Noaa-20)
- <=6 hours (VIIRS Noaa21)
- >6 & <=12 hours (VIIRS Noaa21)
- >12 & <=24 hours (VIIRS Noaa21)
- Last 7 Days (VIIRS Noaa21)
- Last 30 Days (VIIRS Noaa21)
- Fire Season (VIIRS Noaa21)

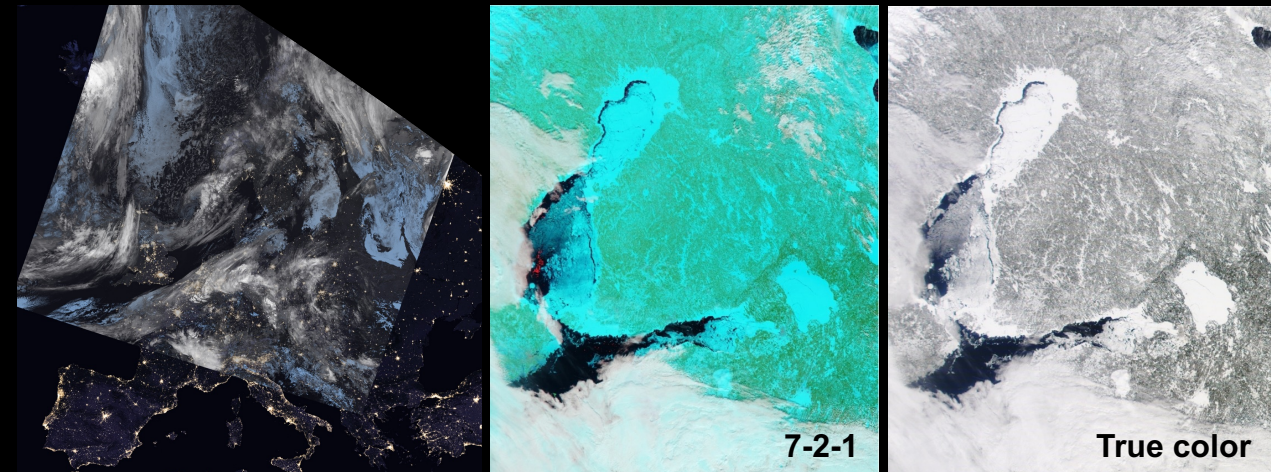
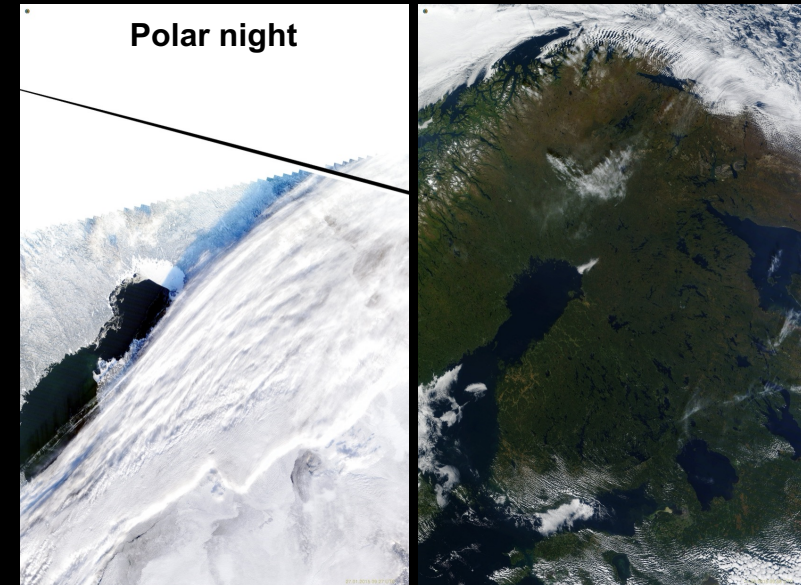
Baltic Sea Ice Monitoring

- 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 busiest marine routes for oil transport
 - Annual economic impact €24m and €116m (EARSC2015)
- Operational 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 at Helsinki
 - 24/7 monitoring of the processing lines



Optical Baltic Sea Ice Monitoring

- Radar images are expensive and not evenly available throughout the day
- Optical images useful especially during the spring
 - Statistically less clouds, polar night is over
- Optical instruments have more channels (wavelengths) compared to radars
 - VIIRS Day-Night Band and thermal emission bands for night-time observations
- L1 processing with CSPP SDR, visualization with **PyTROLL**
 - Many CSPP Polar2Grid functionalities are provided by Pytroll libraries



Satellite based flood monitoring

- Currently based on synthetic aperture radars (SAR)
- October 2012: Tests and validation for open areas (no forests)
- April 2013: Operative service for open areas
- May 2014: Tests and validation for forested areas
- Spring 2015: Operative service covering open and forested areas



Kokemäenjoki, April 2013

Hannu Vallias



Marjatta Nummijärvi

Kauhajoki, October 2012

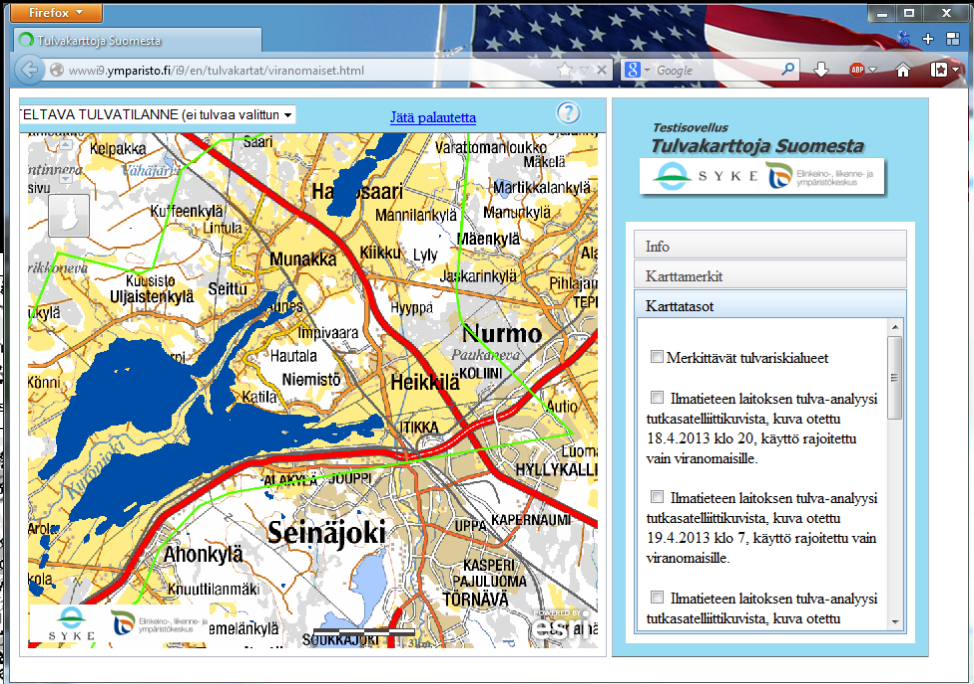
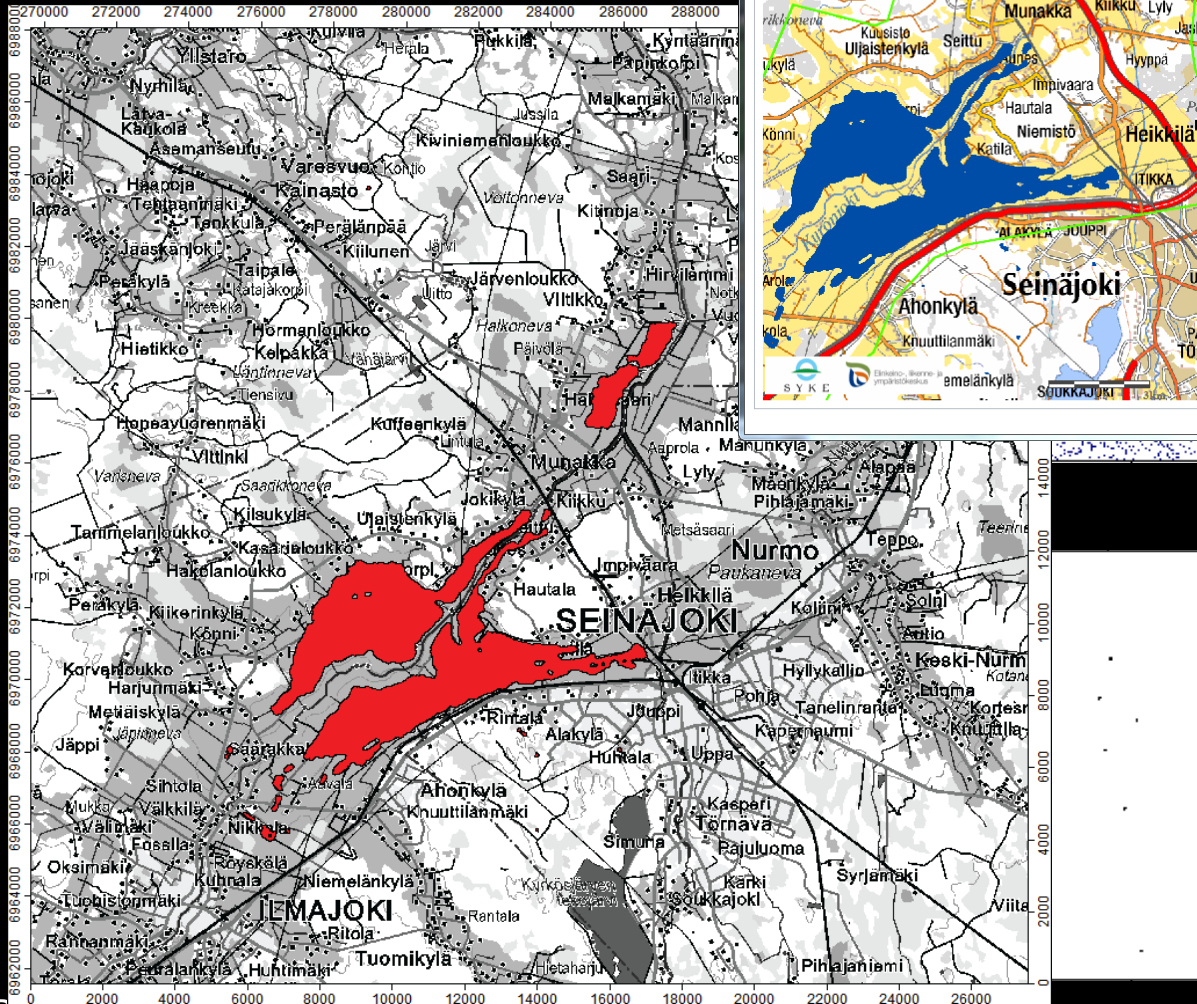


Kittilä, May 2014

Kaukosen vesihuolto-osuuskunta



Flood mapping



Water detection
(using treshold value)

Removal of the natural
waters and bogs
(rivers, lakes etc.)

Majority filter
(degrease noise)

Output writing

CSPP Flood Detection to help

Currently in Finland

- Airborne flood detection
 - Price: 18 000 € / flight
 - Latency: 3-4 days
 - Resolution: Max. 30 cm
 - Weather dependant
- SAR-based flood detection
 - Price: 3 000 €
 - Latency: 4 hours
 - Resolution: 3-5 m
 - No weather or lighting dependency

CSPP Flood Detection

- Pros.
 - High revisiting rate for VIIRS data
 - Can help to identify areas where to focus with SAR and planes
 - Active monitoring of the floodplain
 - Low price
 - NPP, NOAA-20 and NOAA-21 already scheduled and processed
- Cons.
 - Low resolution
 - Finland has lots of small rivers and lakes





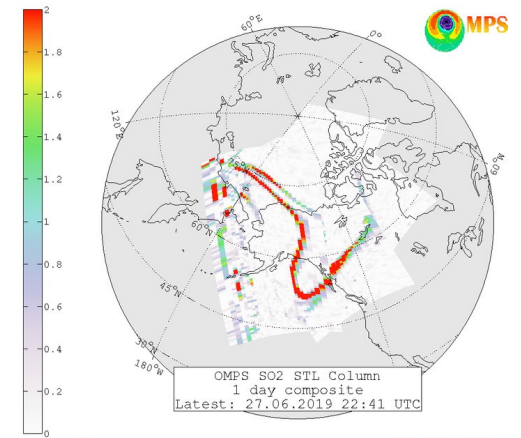
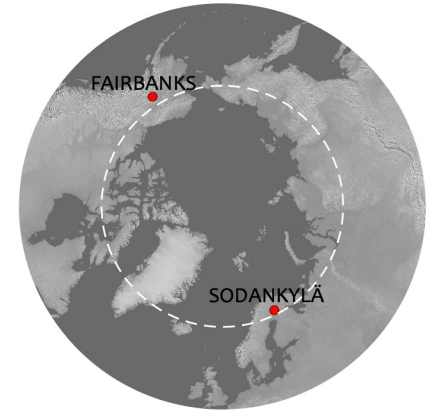
FMI

SAMPO service

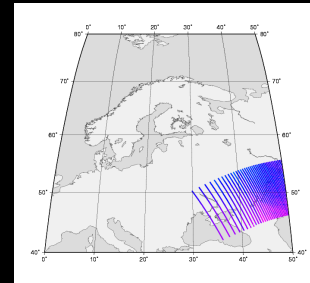
sampo.fmi.fi

Satellite Measurements from Polar Orbit

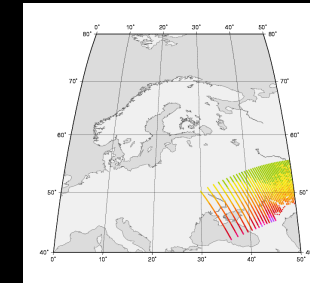
- SO₂, O₃, aerosols and UV radiation within 15 minutes from the measurement
- Europa, North Atlantic, Polar Ocean, Canada/Alaska, northern Siberia.
- Distribution: NASA, NOAA, KNMI, SACS, and EUMETSAT EUMETCast
- Data reception at Sodankylä (OMPS) and Fairbanks/Alaska (OMPS).
- Co-operation with NASA Direct Readout Laboratory and Disasters project, University of Fairbanks.



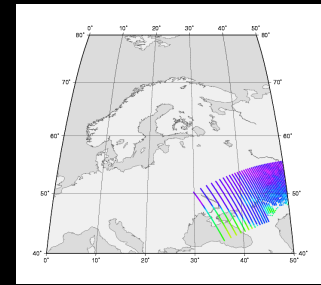
SAMPO service



Cloud fraction



UV index



O3 column

- Started in 2004 as OMI Very Fast Delivery (VFD)
 - Direct Broadcast (DB) data from Ozone Monitoring Instrument (OMI) onboard Aura
- Currently
 - DB data from Ozone Mapping and Profiler Suite (OMPS) onboard NPP and NOAA-20
 - Processing with International Planetary Observation Processing Package (IPOPP)
 - NASA Direct Readout Laboratory (DRL) has ended IPOPP development, and the software is frozen and archived
- CSPP SDR can create OMPS L1
 - L2 products missing -> Geoff Cureton's presentation *OMPS Level 2 Ozone and Sulfur Dioxide Products in CSPP LEO* on Thursday



CSPP User's Group Meeting topics

- User needs for future satellite missions including distribution of data
- General issues affecting the direct broadcast community



Lack of Sentinel-3 Direct Broadcast

- The Copernicus Sentinel-3 (S3) satellite mission is designed to measure sea-surface topography, sea and land surface temperature, and ocean and land surface color
 - S3A and S3B in orbit
 - S3C and S3D planned launches 2026 and 2028
 - Medium resolution optical instruments like MODIS and VIIRS
- Near-Real Time (NRT) definition: Data available ≤ 3 hours of sensing
 - S3A/B have no Direct Broadcast capability but a need for, for example, active fires
 - Push and influence from the community to add DB capability





Contact information:

Timo Ryyppö

Head of Sodankylä Satellite
Data Centre

Finnish Meteorological Institute
Arctic Space Centre
Tähteläntie 62
FIN-99600 Sodankylä
Finland

Tel: +358 50 5737 009

Email: timo.ryyppo@fmi.fi