

New opportunities in satellite remote sensing for hydrological and environmental applications ESA perspective

Radoslaw Guzinski

About me



- 2010 – 2014: PhD from the University of Copenhagen
 - Remote sensing and evapotranspiration
- 2012 – 2015: Working in a remote sensing consulting company
 - Software development and physically based models
- 2016 – 2018: Research Fellow at ESA
 - Evapotranspiration
 - Agricultural applications

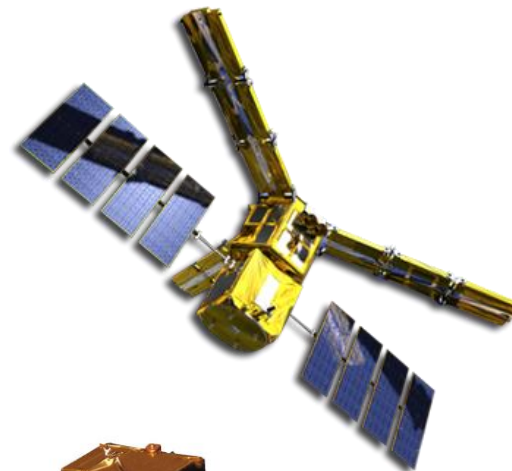
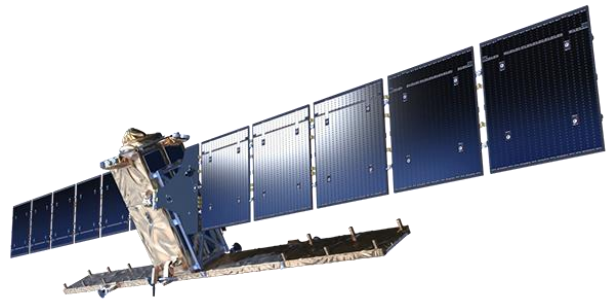


ESA facts and figures

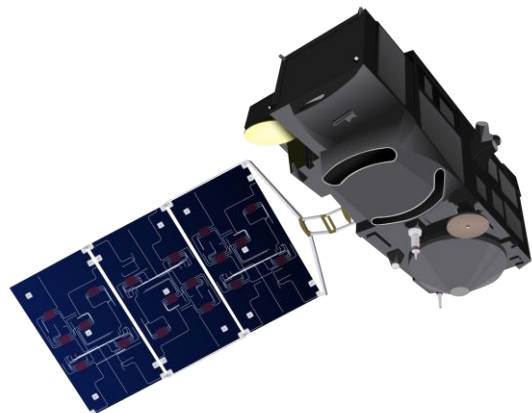


- Over 50 years of experience
- 22 Member States
- Eight sites/facilities in Europe, about 2300 staff
- 5.75 billion Euro budget (2017)
- Over 80 satellites designed, tested and operated in flight

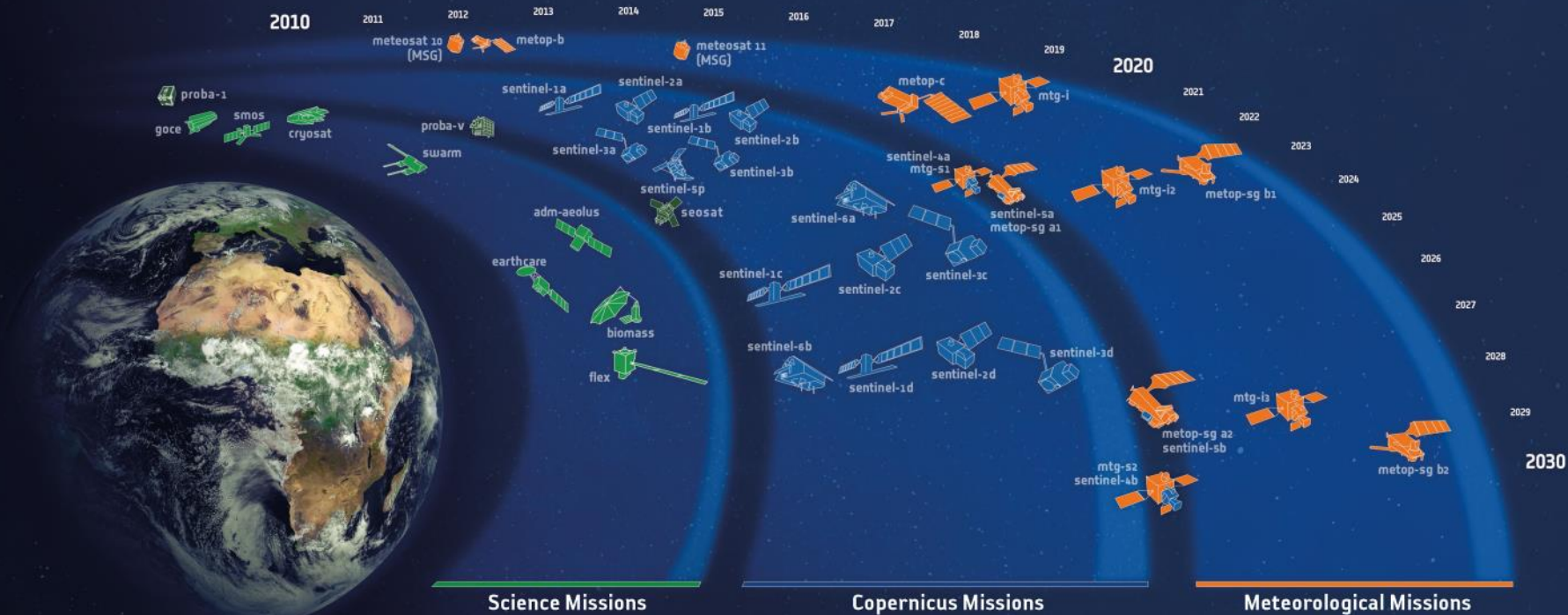




Sensors










→ ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Copernicus Space Component: the dedicated Sentinels ...

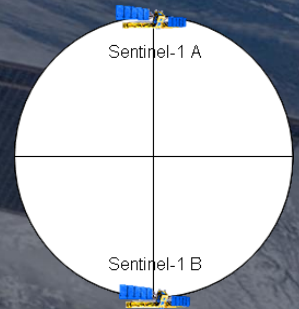


	S1A/B: Radar Mission	3 Apr 2014/25 Apr 2016
	S2A/B: High Resolution Optical Mission	23 June 2015/7 March 2017
	S3A/B: Medium Resolution Imaging and Altimetry Mission	16 Feb 2016/2018
	S4A/B: Geostationary Atmospheric Chemistry Mission	2021/2027
	S5P: Low Earth Orbit Atmospheric Chemistry Mission	2017
	S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission	2021/2027
	S6A/B: Altimetry Mission	2020/2025

Sentinel-1: Copernicus radar imaging mission for ocean, land, emergency



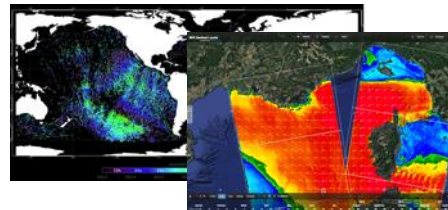
- Part of the Copernicus Programme led by the European Union
- Mission based on 2 identical satellites (S1A & S1B) and a highly performing ground segment
- Main satellites characteristics:
 - C-band Radar instrument
 - Instrument duty cycle of 25 min/orbit in HBR modes and 75 min/orbit in LBR (Wave)
 - Sun-synchronous orbit at 693 km altitude
 - Inclination: 98.18°
 - 7 years lifetime, consumables for 12 years
 - Mean LST: 18:00h at ascending node
 - 12-day repeat cycle at Equator (6 days with 2 satellites)
- Instrument operations based on a predefined observation scenario
- Systematic data processing with open & free data access
- Gradual increase of the mission operational capacity from the S1A launch up to the mission constellation routine operations



Sentinel-1 applications

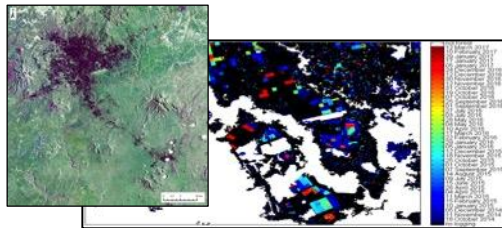
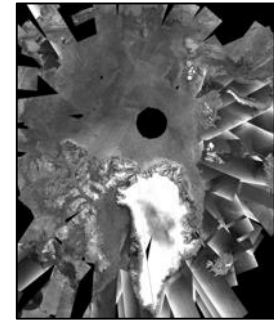


Maritime surveillance: oil spill monitoring, ship detection, illegal fisheries, etc.

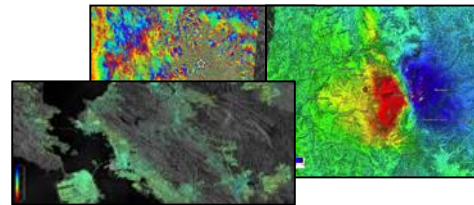


Sea state: wind, wave

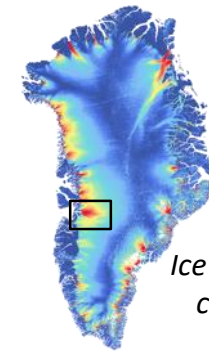
Sea ice and iceberg monitoring



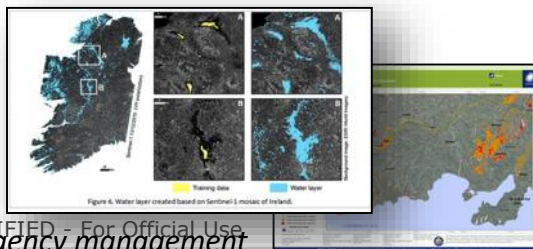
Land use, agriculture, forestry, logging, land classification, urban planning



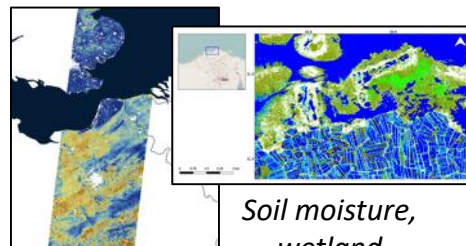
Ground deformation: subsidence, landslides, earthquakes, volcanoes, infrastructure monitoring



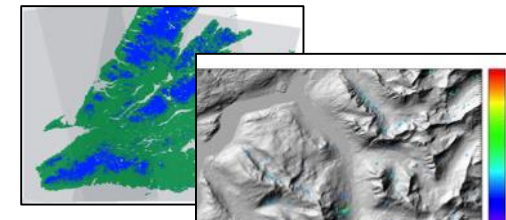
Ice sheets, glaciers, climate change



Emergency management



Soil moisture, wetland



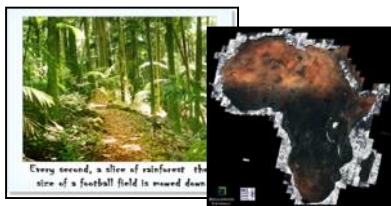
Snow, permafrost, avalanches, ...

Sentinel-2: General Features



- Optical **high resolution multispectral** mission
- Twin satellite constellation with wide imaging swath: fast repetition, systematic “carpet mapping” image acquisition
- **5 days revisit time** at equator (with two satellites)
- **13 spectral bands** VIS-NIR-SWIR

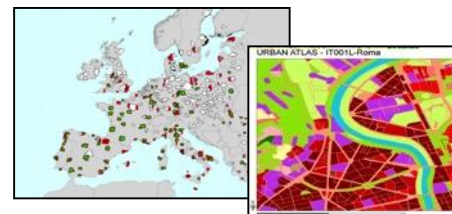
Sentinel-2 applications



Forests & Carbon, Vegetation monitoring

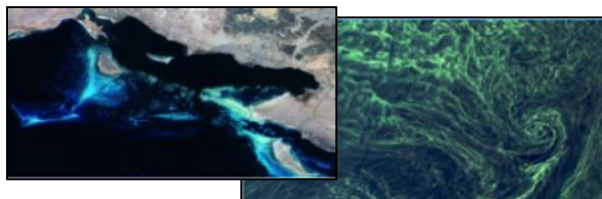
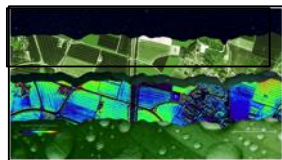


European land cover, human impact, high resolution layers

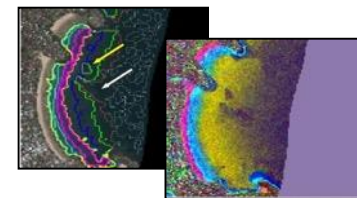


Regional to Urban Applications

Agriculture, fluorescence & biophysical parameters



Water quality, Wetlands

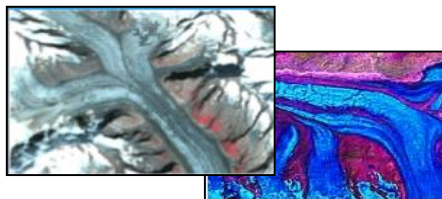


Coastal zones/bathymetry



Emergency management

ESA UNCLASSIFIED - For Official Use



Glaciers & ice



Geology & geomorphology

SENTINEL-3 mission overview

- Operational mission in high-inclination, low Earth orbit
- Full performance achieved with 2 satellites in orbit (S-3A,-3B)

Optical Mission Payload providing

- ❑ Sea and land color data, through **OLCI (Ocean and Land Color Instrument)**
- ❑ Sea and land surface temperature, through the **SLSTR (Sea and Land Surface Temperature Radiometer)**

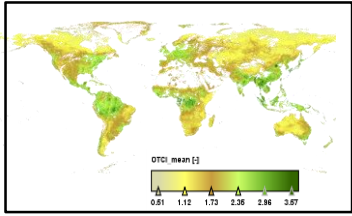
Topography Mission Payload providing

- ❑ Sea surface topography data, through a Topo P/L including a **Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL)**, a bi-frequency **MicroWave Radiometer (MWR)**, and a **Precise Orbit Determination (POD)** including
 - **GNSS Receiver**
 - **DORIS**
 - **Laser Retro-Reflector**

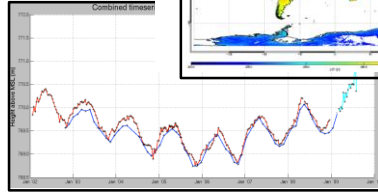
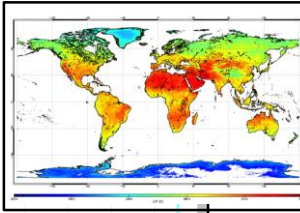
In addition, the payload design will allow

- ❑ Data continuity of the Vegetation instrument (on SPOT4/5),
- ❑ Enhanced fire monitoring capabilities, river and lake height, atmospheric products

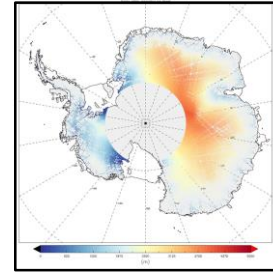
Sentinel-3 applications



Agriculture, vegetation monitoring

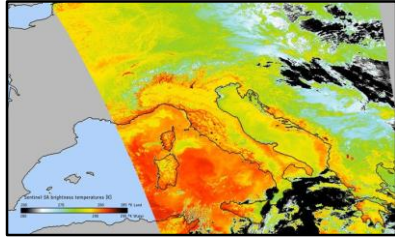
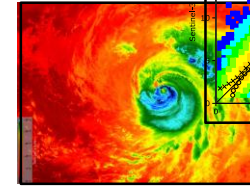
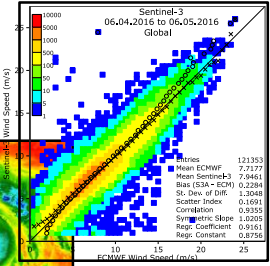


Water resource management

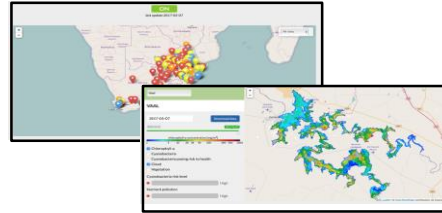


Climate research

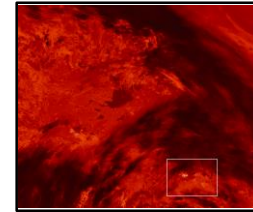
Weather forecasting & NWP



Climate monitoring, numerical modelling and mesoscale analysis

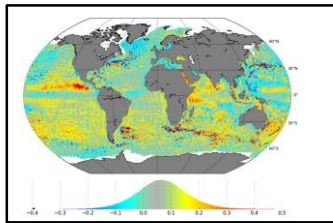


Inland water quality



Fire monitoring

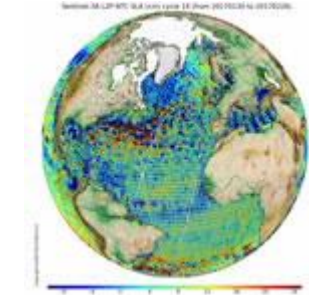
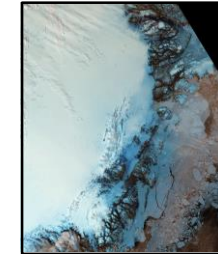
Ship routing: maritime safety



Fisheries: Harmful algal bloom/marine biology/global ocean primary production



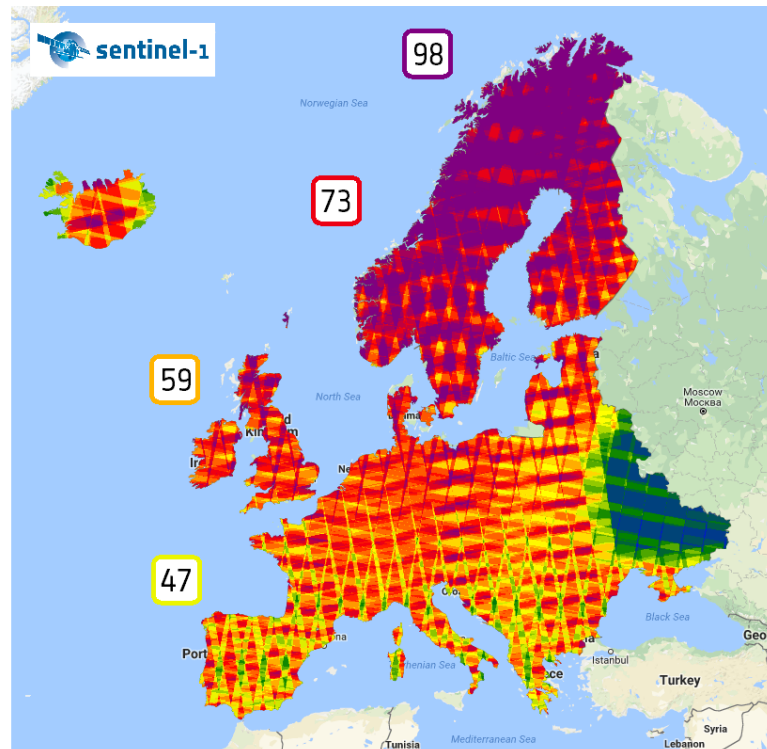
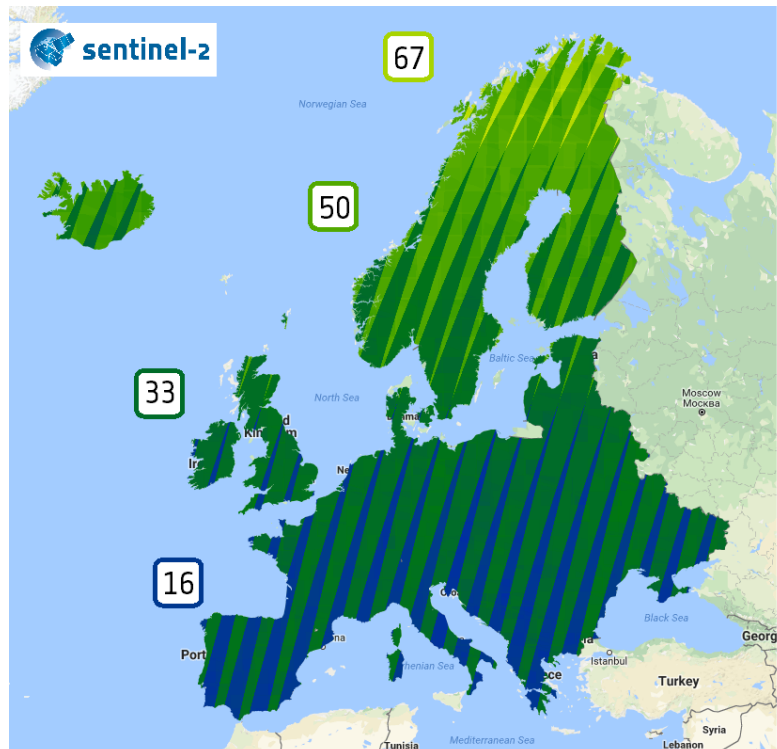
Snow and Ice



Mesoscale ocean circulation, currents, tides



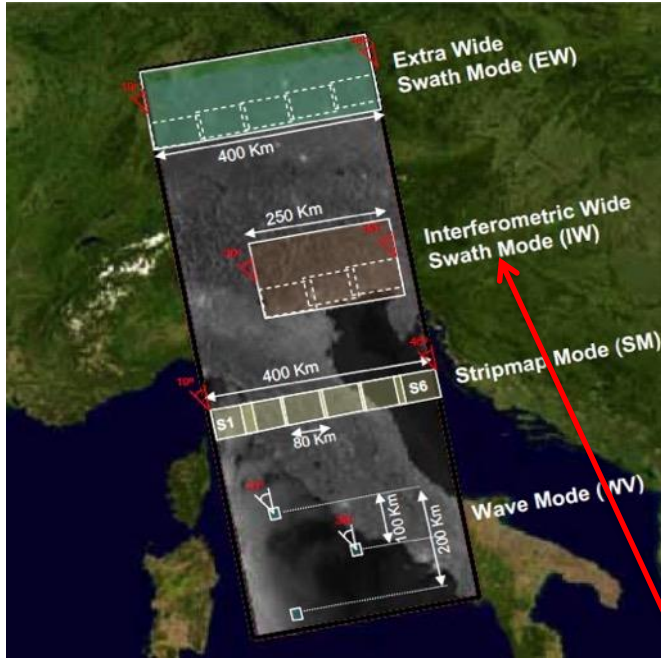
Copernicus – higher temporal resolution



Data capture from Sentinel-2 (left) and Sentinel 1 (right) over a three-month period - July, August and September, in 2017.

Copernicus – higher spatial resolution

Sentinel-1



EW

IW

SM

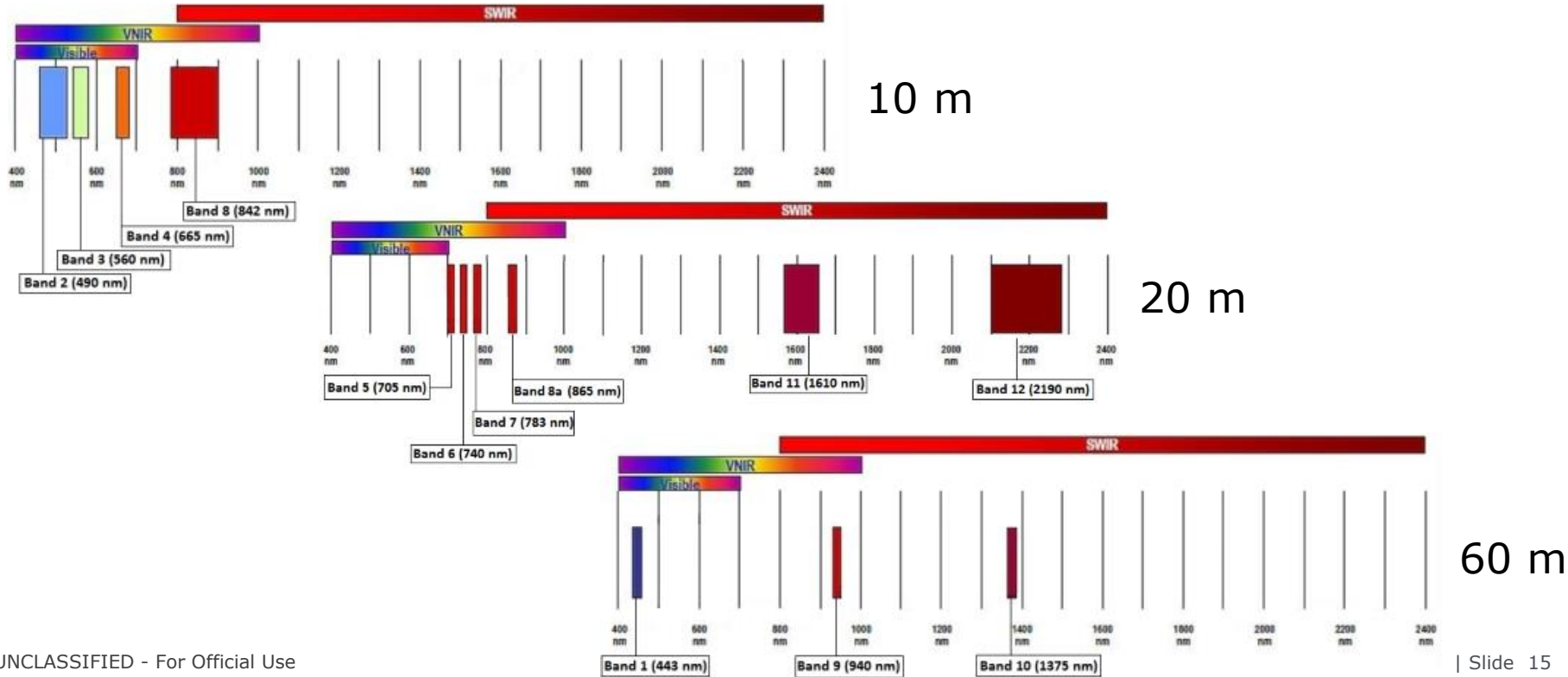
WV

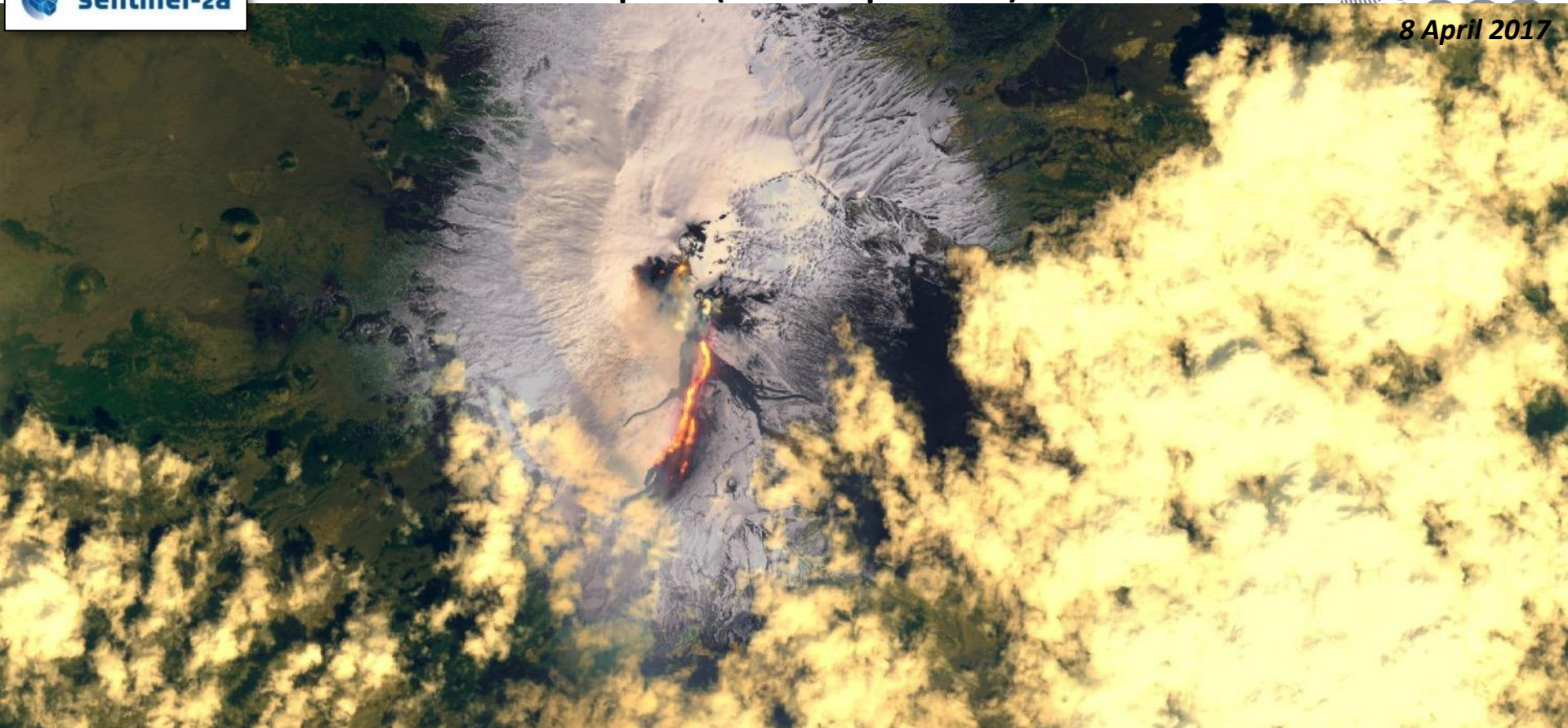
GRD Level 1 product resolution	Swath Width	Polarisation
50m (3 ENL)	> 400 km	HH+HV or VV+VH
20m (5 ENL)	> 250 km	HH+HV or VV+VH
9m (4 ENL)	> 80 km	HH+HV or VV+VH
50m (140 ENL)	20 x 20 km ² at 100 km spacing	HH or VV

IW: main mode over land and coastal areas

Copernicus – higher spatial resolution

Sentinel-2





Images generated using EO Browser → <http://apps.sentinel-hub.com/eo-browser>

Copernicus – higher spectral variety

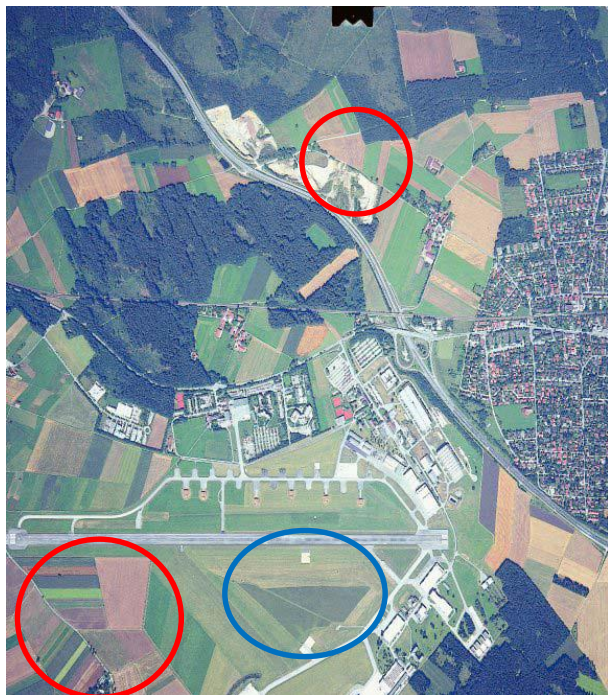


- Sentinel-1
 - Dual polarisation: HH+HV or VV+VH
- Sentinel-2
 - 13 spectral bands
 - 3 in red edge
- Sentinel-3
 - OLIC – 21 spectral bands
 - SLSTR – 3 thermal channels – including for fire detection



Complementarity between sensors

Optical

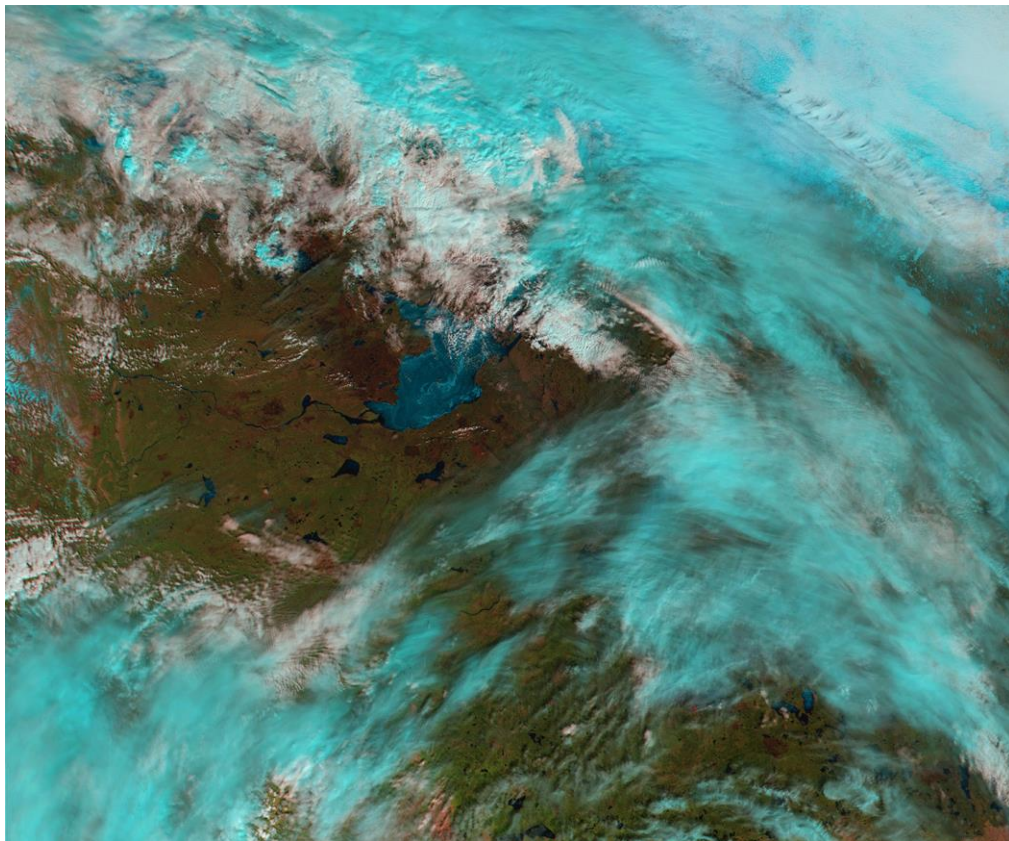


SAR



*Oberpfaffenhofen Airfield
(L-Band, representation of
Pauli)*

Complementarity between sensors



Fort McMurray wildfires - 2016

Sentinel-3 Optical and Thermal data

Contains modified Copernicus Sentinel data (2016)/processed by ESA/STFC-RAL Space, [CC BY-SA 3.0 IGO](https://creativecommons.org/licenses/by-sa/3.0/)

Copernicus – other features



- Free and open access data policy
- High quality
 - Accurate geolocation
 - Improved signal to noise ratio
 - Higher radiometric resolution
- Long-term planning
 - At least until 2030 in current configuration
 - Followed by second generation Sentinels



Copernicus Space Component Expansion



- Six potential missions:
 - High Spatio-Temporal Resolution Land Surface Temperature (LST) Monitoring Mission
 - HyperSpectral Imaging Mission
 - Anthropogenic CO2 Monitoring Mission
 - Polar Ice and Snow Topographic Mission
 - Passive Microwave Imaging Mission
 - L-Band SAR Mission
- Timeline:
 - 2017 – 2018: Mission requirements finalized and feasibility studies
 - 2019: Mission selection
 - 2025-2026: Launch



High spatio-temporal resolution thermal mission

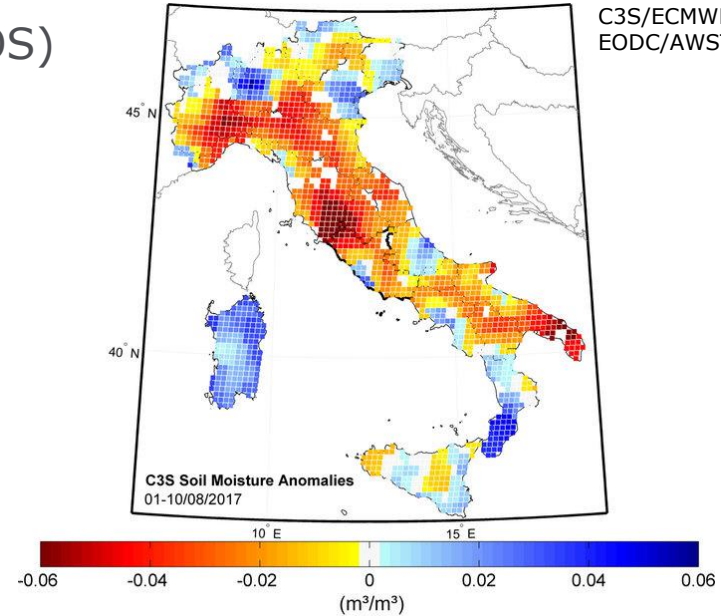


- Objectives:
 - To support monitoring evapotranspiration (ET) rate at European field scale
 - Water use efficiency
 - To support mapping and monitoring the soil composition
 - Mineralogy (silica) and organic matter
 - To support a range of additional services benefitting from TIR observations
 - Urban heat island, high-temperature events, permafrost monitoring
- Preliminary specifications:
 - 30 – 50 m spatial resolution
 - 1 – 5 days temporal resolution
 - Land surface temperature uncertainty below 1 – 1.5 K
 - Early afternoon overpass



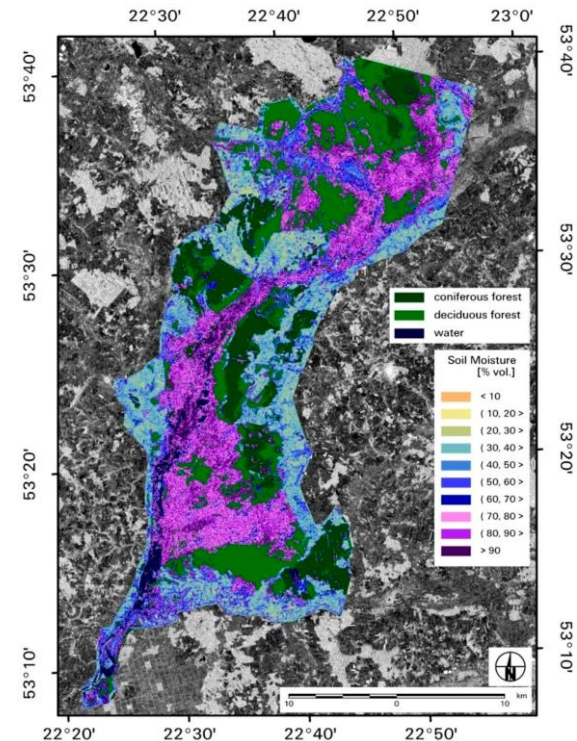
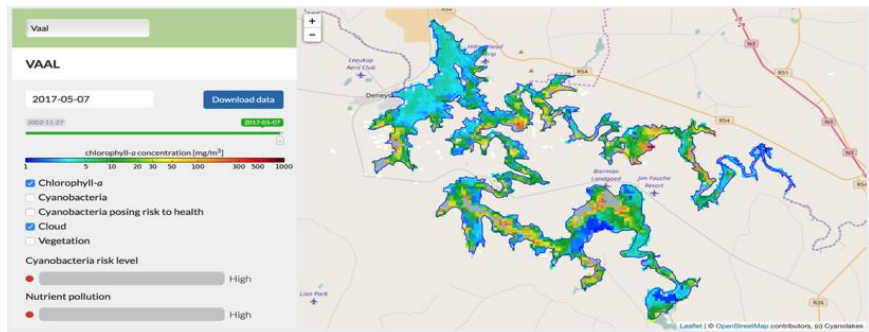
Earth Explorers

- Soil Moisture and Ocean Salinity (SMOS)
 - Soil moisture
- CryoSat-2
 - Ice thickness
- Fluorescence Explorer (FLEX)
 - Fluorescence, photosynthesis
- Biomass
 - Biomass in forests





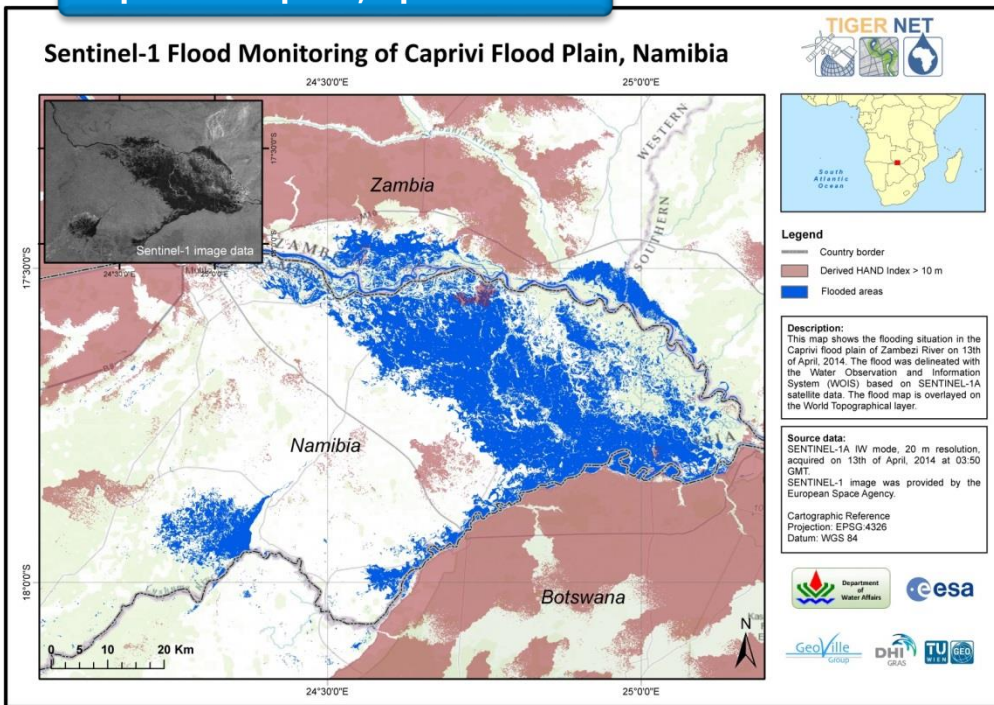
Applications



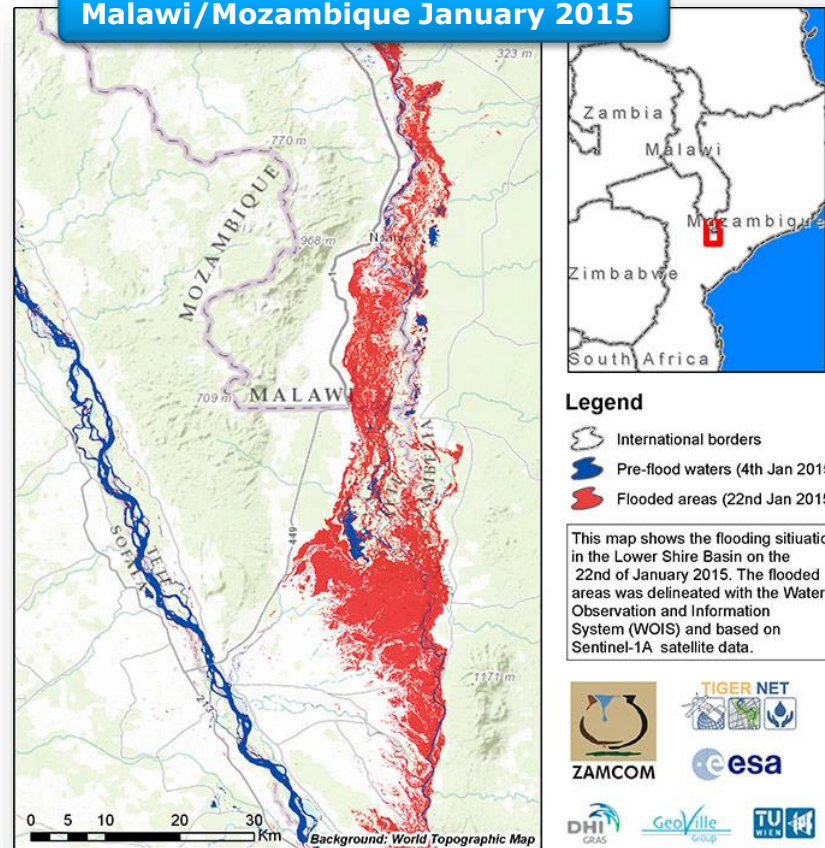
Flood/water extent mapping – Sentinel-1

Caprivi floodplain, April 2014

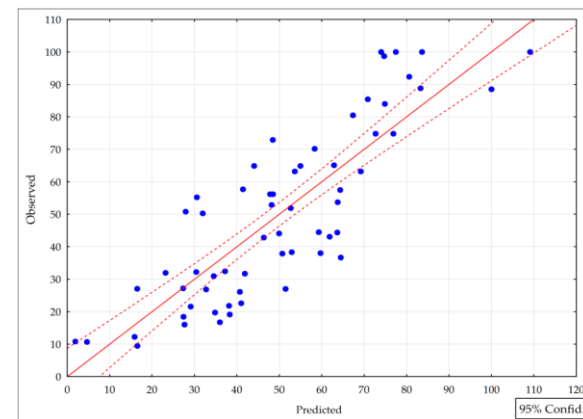
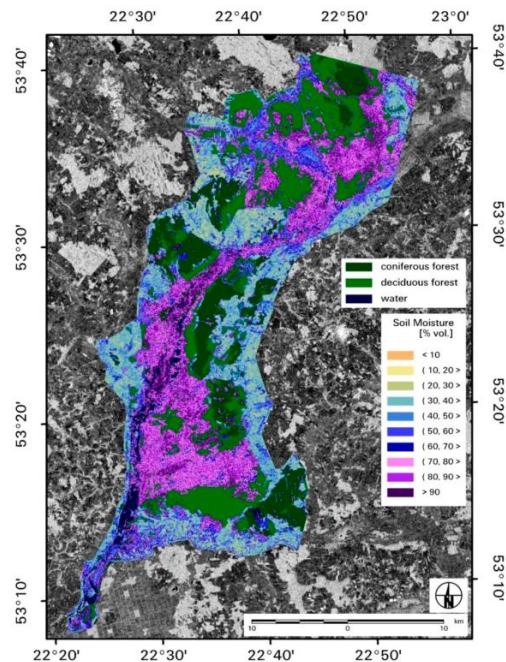
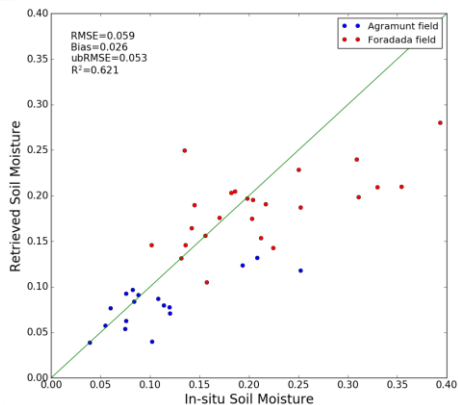
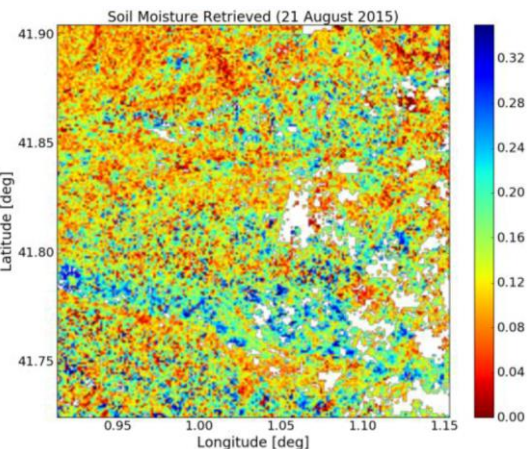
Sentinel-1 Flood Monitoring of Caprivi Flood Plain, Namibia



Malawi/Mozambique January 2015



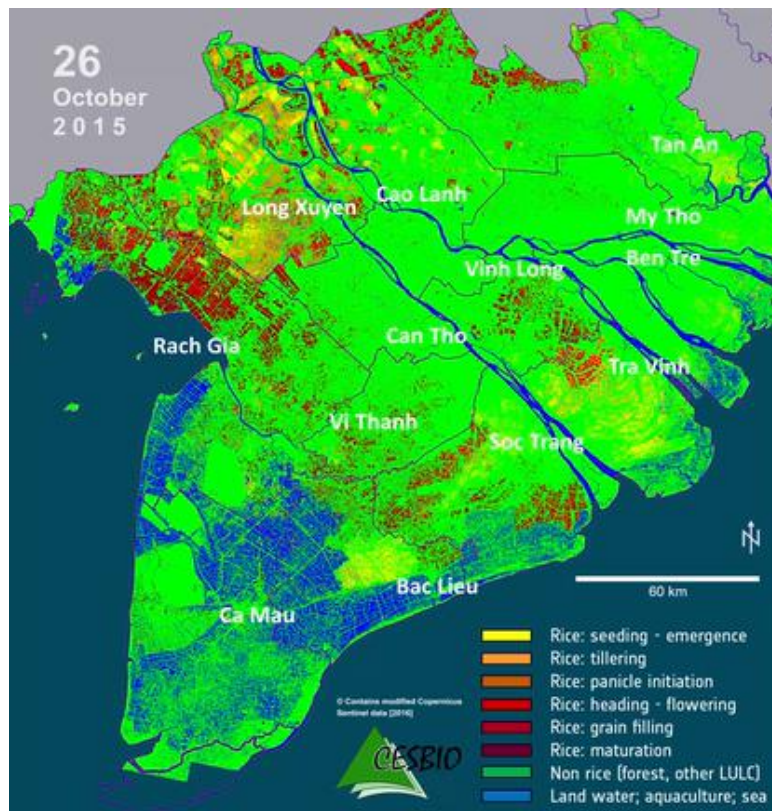
Soil moisture – Sentinel-1



Dabrowska-Zielinska et al. (2016), Assessment of Carbon Flux and Soil Moisture in Wetlands Applying Sentinel-1 Data

Gao et al. (2017), Synergetic Use of Sentinel-1 and Sentinel-2 Data for Soil Moisture Mapping at 100 m Resolution

Rice growth monitoring – Sentinel-1



Contains modified Copernicus Sentinel data (2015–16)/CESBIO/ESA DUE GEO-Rice Innovator project

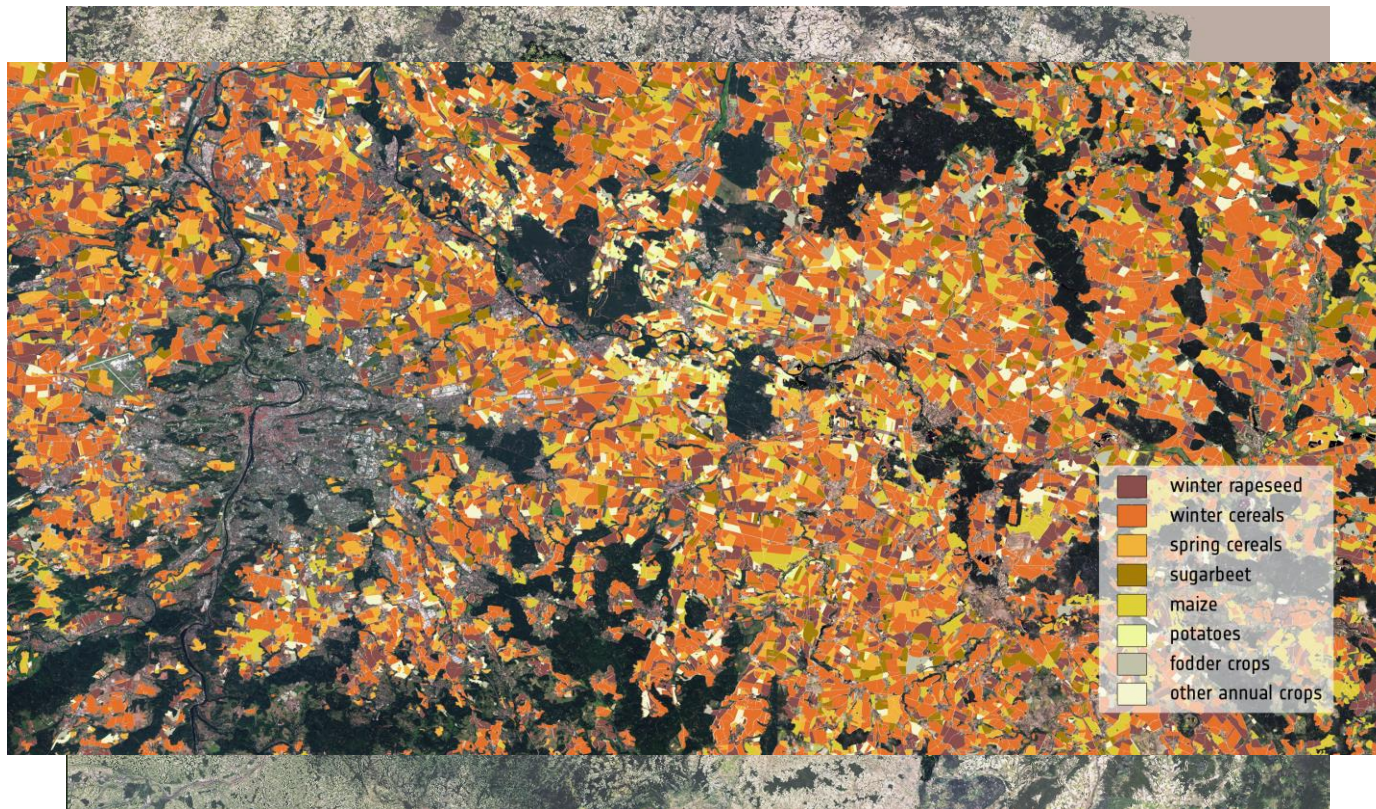
Agricultural monitoring – Sentinel-2



Contains modified Copernicus Sentinel data (2016), processed by ESA, CC BY-SA 3.0 IGO



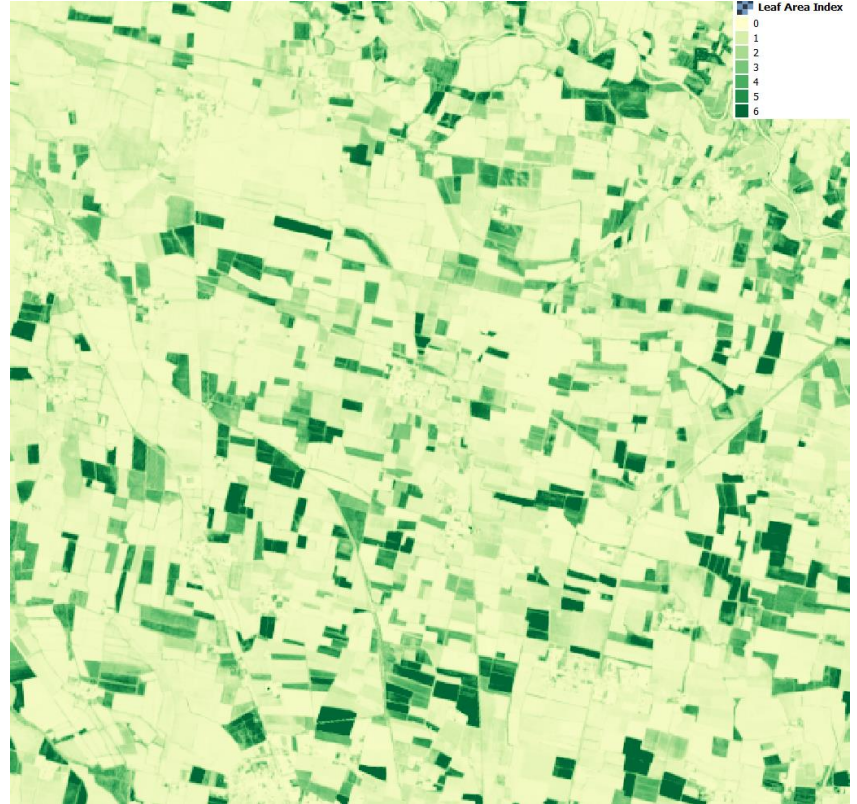
Crop type mapping – Sentinel-2



<http://www.esa-sen2agri.org>

DUE Sentinel-2 for Agriculture project; contains modified Copernicus Sentinel data (2015), CC BY-SA 3.0 IGO

Biophysical parameters – Sentinel-2



Contains modified Copernicus Sentinel data (2017)



Lake water quality – Sentinel-2



Furesø - 2017-06-19

Chlorophyll Concentration

mg/m³

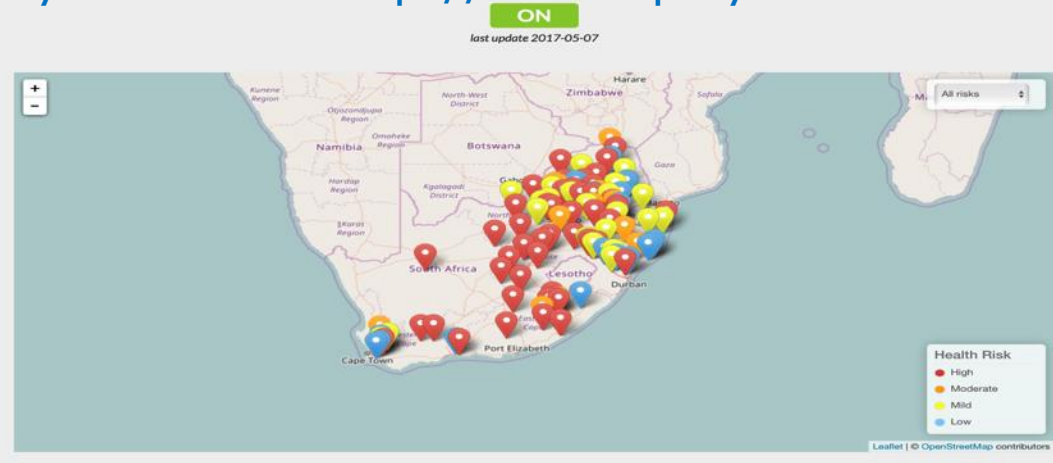


0 1 2 3 4 km

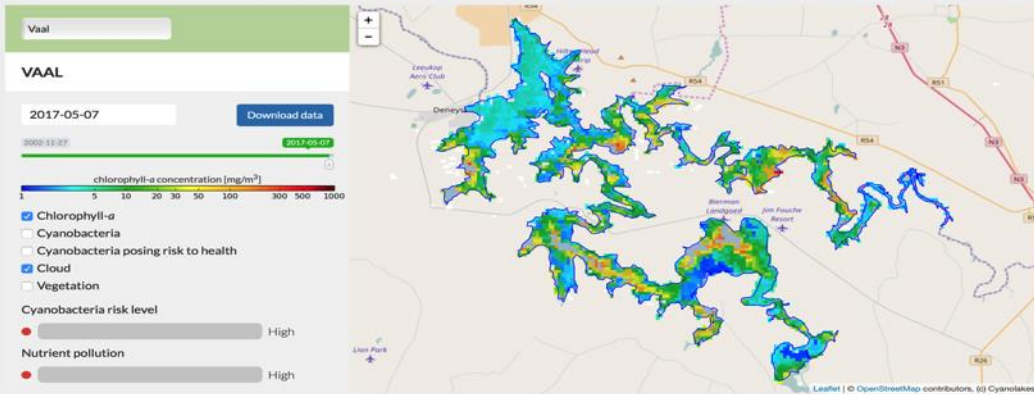


Contains modified
Copernicus Sentinel
data (2015), CC BY-
SA 3.0 IGO

Inland water quality – Sentinel-3 CyanoLakes: <http://eonemp.cyanolakes.com>



- ❑ CyanoLakes: winner of Copernicus Masters Ideas Challenge in 2014
- ❑ **Integration of Earth Observation into the National Eutrophication Monitoring Service (EONEMP)** provided by CyanoLakes (Pty) Ltd, funded by the Water Research Commission of South Africa.
- ❑ Service based on MERIS data (10 year archive) and **OLCI** data (live since April 2017)
- ❑ **Monitoring and reporting on eutrophication** (via chlorophyll-a estimates) and cyanobacteria blooms in lakes/reservoirs in South Africa.

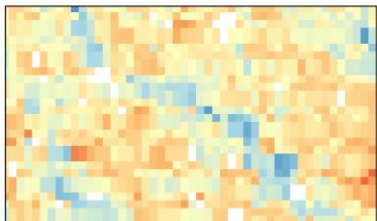


Evapotranspiration modelling – Sentinel-2 & -3



Evaporation - Po Valley - 2017.05.17 10:30 AM

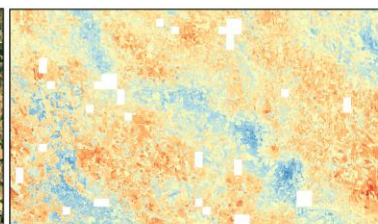
Sentinel-3
Evaporation



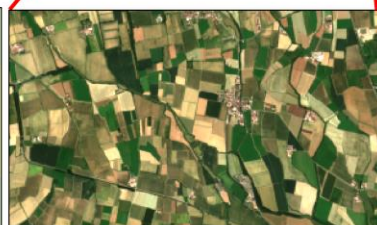
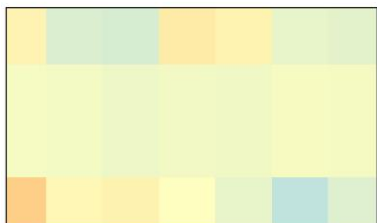
Sentinel-2
True Colour Composite



Sentinel-2
Evaporation



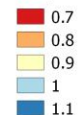
0 5 10 15 20 km



0 1 2 3 km

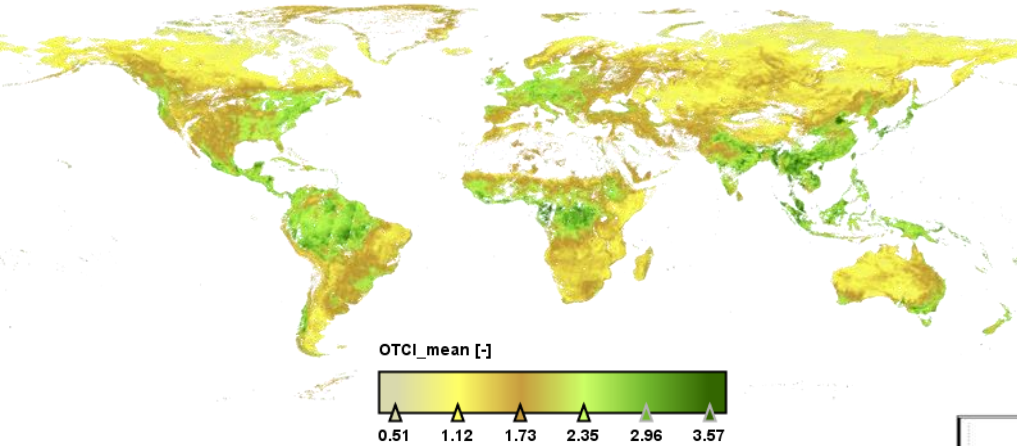


Evaporation (mm/h)



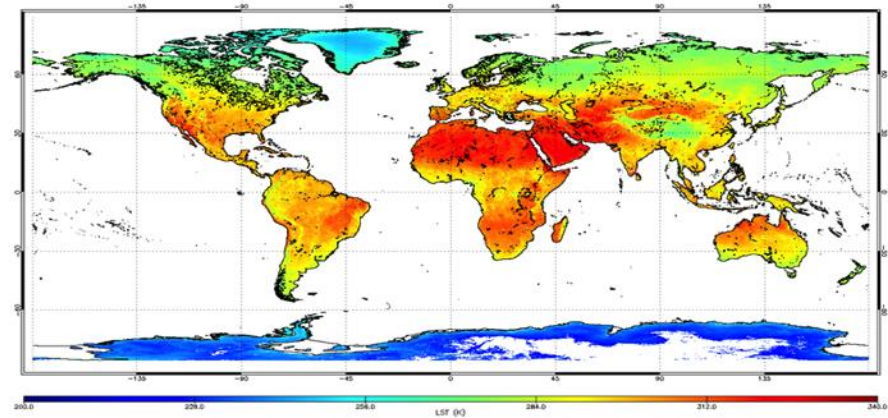
Contains modified
Copernicus Sentinel
data (2017)



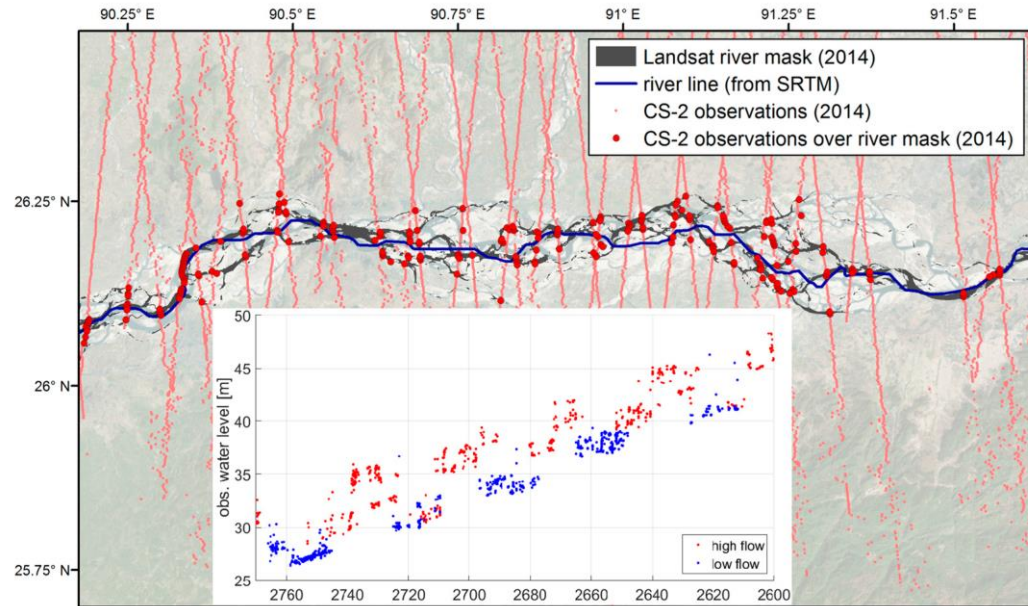
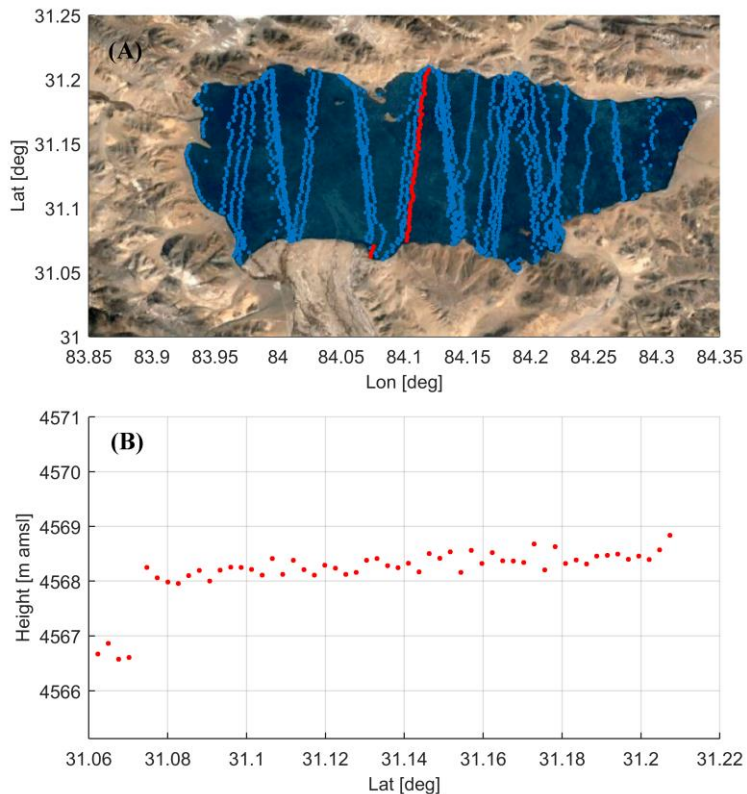


OLCI Terrestrial Chlorophyll Index (global mean, 20-23 September 2016). Credit: Sentinel-3 MPC

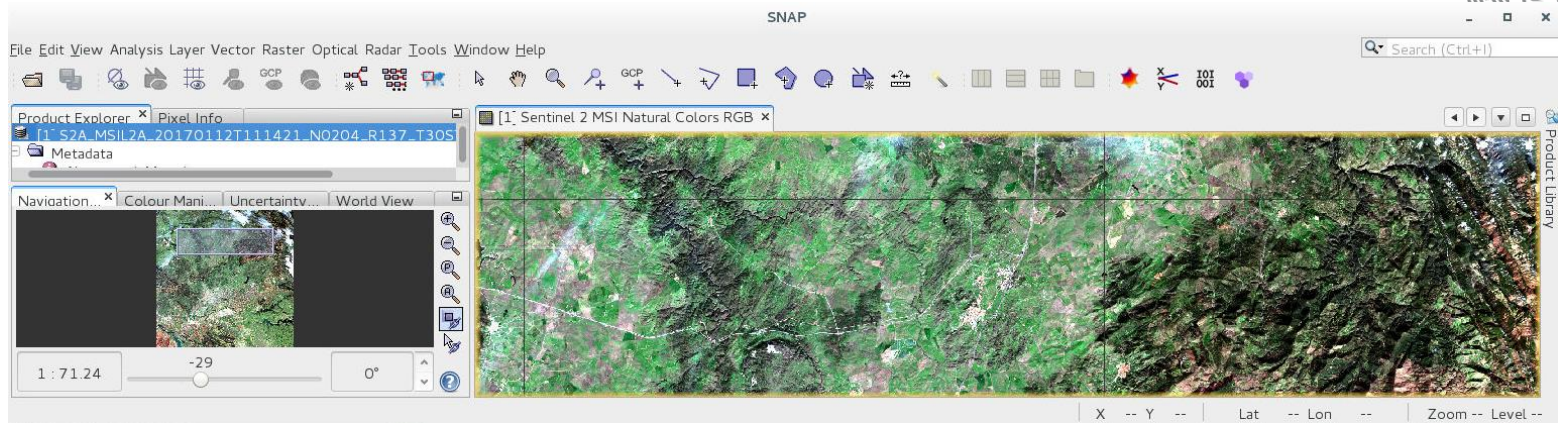
SLSTR Land Surface Temperature monthly composite for September 2016. Credit: D. Ghent, University of Leicester.



Water level – Sentinel-3



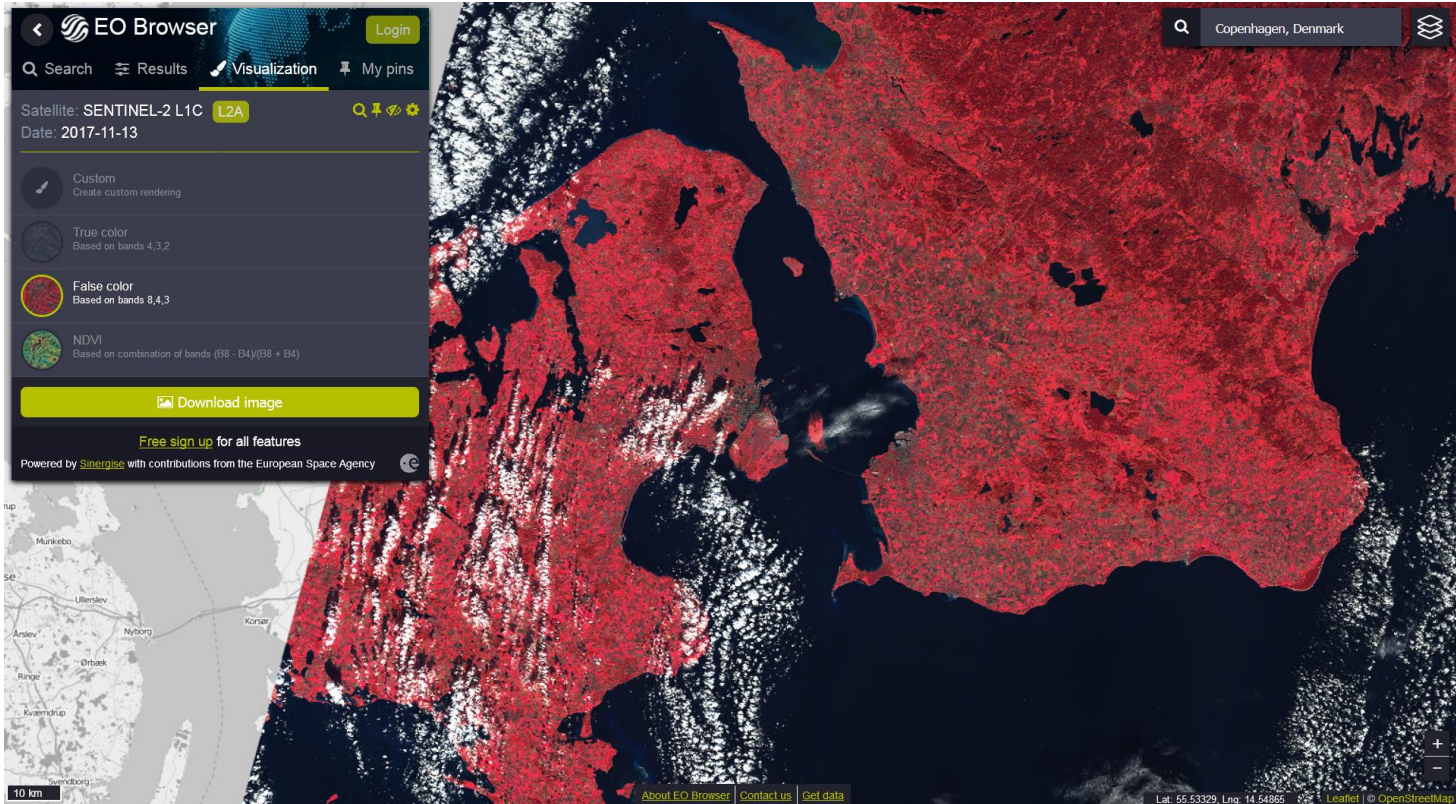
Jiang et al. (2016), CryoSat-2 Altimetry Applications over Rivers and Lakes



Tools



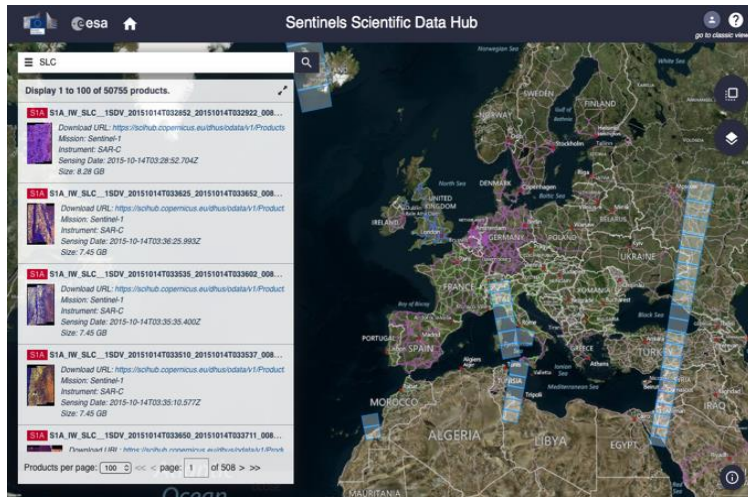
<http://apps.sentinel-hub.com/eo-browser/>



Open Sentinel Data Access @ ESA



- ESA offers free access for all users to Sentinel products: most recent as well as complete long term archive
- Any user can **self-register** at <http://scihub.copernicus.eu/>
- ESA delivers on 24/7 basis **Near Real Time** products (3 hours from sensing) as well as Non Time Critical products (24 hours from sensing)



ESA Data Hub provides an
OPEN SOURCE Web interface

Users can set own scripts to
automatically search, filter
and download products



Sentinel Application Platform (SNAP)



- Toolboxes for Sentinels 1, 2 and 3
- Sentinel-1:
 - Radar pre-processing
 - Radar image stacking
- Sentinel-2:
 - Atmospheric correction (Sen2Cor)
 - Radiometric Indices
 - Biophysical parameters retrieval
- Sentinel-3:
 - Water quality retrieval



DIAS: Data Information Access Service

The Copernicus Cloud

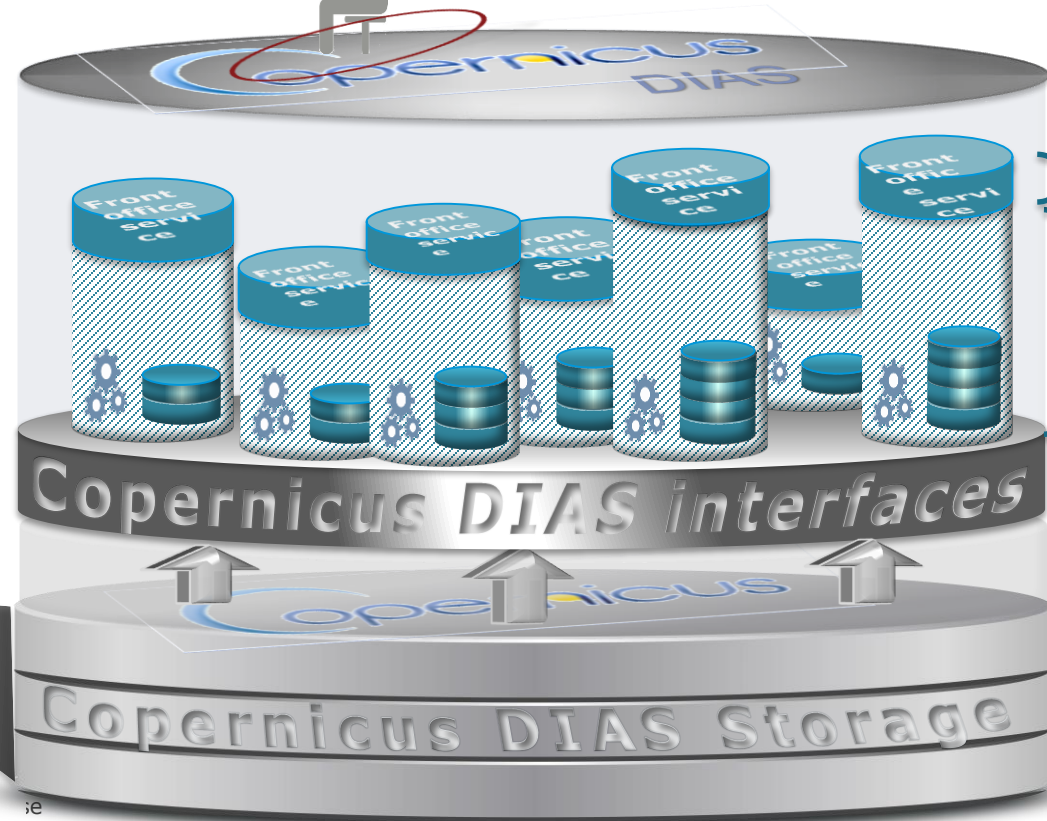


DIAS Provider: In charge of DIAS Back-Office Services & Interfaces operations

Data Sources:
Copernicus Data & Information,
Sentinels Core Products, ...



End user: User of the third-parties services



DIAS
Front-office

Third-Party user
interface

Third-Party
resources



**DIAS
Provider**



Third-Party

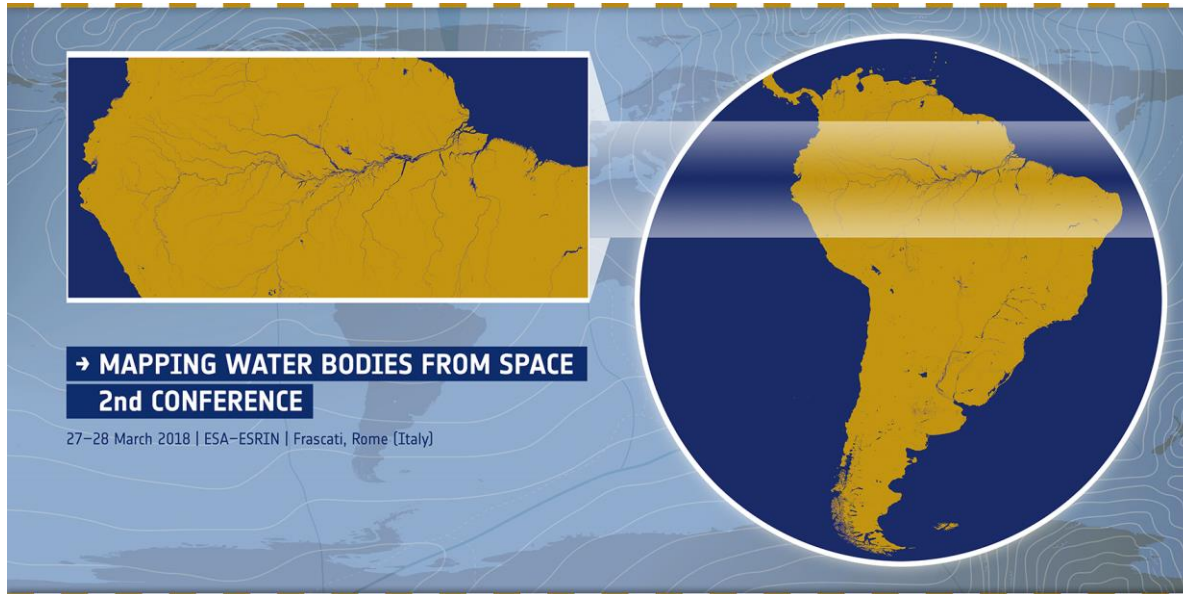
ie

- Ready for operations (KO + 6months) not later than Q2-2018 assuming successful negotiation
- 3.5 years of operations, with the aim to reach the service self-sustainability by the end of the contract
- IPRs & confidentiality protection

- For now...
 - IPT Cloud Poland
 - ESA Open Science Earth Observation Call - <https://earth.esa.int/aos/oseo>
 - Supported until May 2018

Mapping Water Bodies From Space conference

- Mostly water body mapping
- Also other applications – water quality, etc.
- <http://mwbs2018.esa.int/>



Thank you

