

Use cases with Copernicus data



BalticSatApps Copernicus User Uptake,
9.11.2018, Finnish Meteorological Institute, Helsinki

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- Smart cities and examples of city applications
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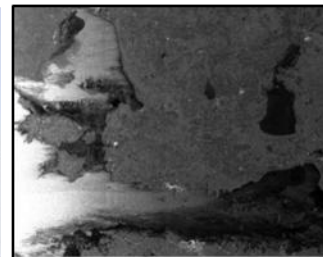
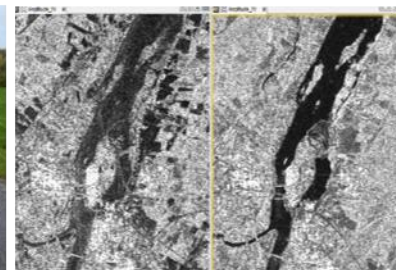
- Characteristics of Sentinel data

What information we can get from satellite data



Satellite data can give information about

- Air
 - Atmosphere composition
 - Air quality (traffic emissions)
- Ground
 - Flooding
 - Forest fires
 - Land usage
 - Changes in forest areas
 - Snow cover (SWE, FSC)
 - Frost
- Water areas (Sea, lakes)
 - Ice conditions
 - Ship emissions



What satellite data is utilized in the Finnish Meteorological Institute



Atmosphere composition and air quality

- NASAn A-train constellation (6 satellites)
- Aura OMI
 - Air quality (NO₂, SO₂, HCHO)
 - O₃
 - Aerosols (AAI)
- CALIOPlidar
 - Clouds
- Aqua MODIS
 - Aerosols
- OCO-2
 - Carbon dioxide
- Sentinel satellites (S5P: TROPOMI, S5 and S4)
 - S5P: also methane and carbon monoxide

Land information

- Sentinel satellites
 - S1: Snow cover, floods
 - S2: Snow cover, land use
 - S3: Snow cover, Forest fires
- COSMO-SkyMED
 - Flood
- SMOS-satellite
 - Frost

Water information (Sea, lakes)

- Sentinel satellites
 - S1: Sea ice
 - S2: Sea ice
 - S3: Sea ice
- COSMO-SkyMED, TerraSAR-X
 - Sea ice
- VIIRS
 - Ocean color, sea surface temperature
- MODIS
 - Sea surface temperature

Where to get satellite data

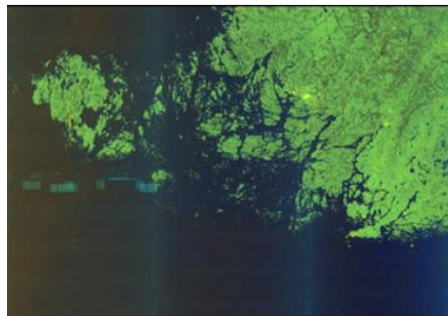


- Finnish Meteorological Institute has the National Satellite Data Centre, NSDC, that maintains **Finhub** (Finnish Data Hub System) system
<https://finhub.nsdcm.fmi.fi/#/home> where Sentinel data can be downloaded.
- Sentinel satellite data can be acquired also e.g. from the following places:
 - Copernicus Open Access Hub (<https://scihub.copernicus.eu/>) (previous ESA SciHub)
 - Google Earth Engine (<https://earthengine.google.com/>)
- Data from other possible satellites (images can be expensive)
 - COSMO-SkyMed: spatial resolution 1-100 m, temporal resolution 16 days
 - TerraSAR-X: spatial resolution 1-18 m, temporal resolution 11 days
 - MODIS ja VIIRS data from FMI's NSDC <http://nsdc.fmi.fi/data/data>

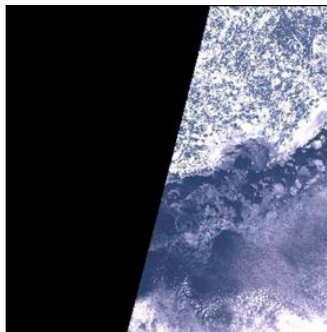
Examples of downloaded satellite data



Sentinel 1



Sentinel 2



Sentinel 3

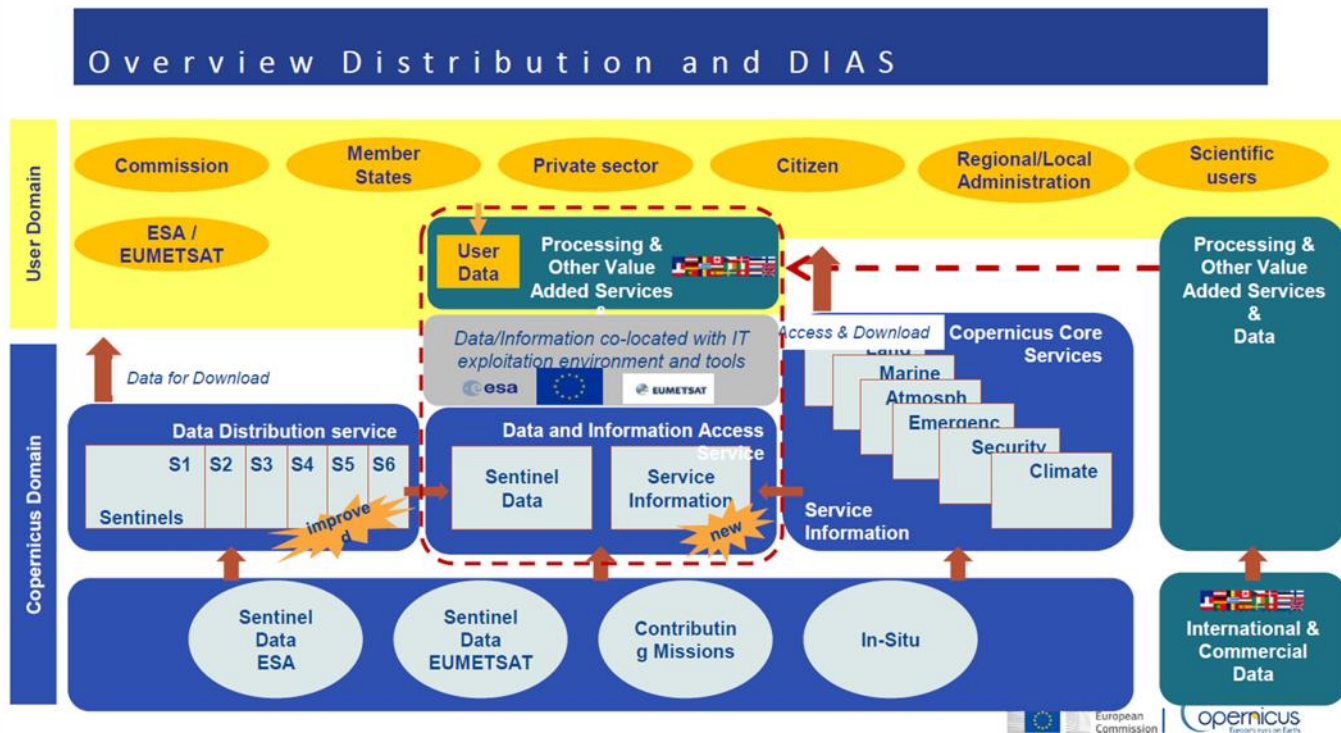


Copernicus-services



- Six thematic services (<http://copernicus.eu/main/services>), with products
 - **Atmosphere** (Copernicus Atmosphere Monitoring Service, CAMS) <https://atmosphere.copernicus.eu/> (Europe's air quality forecast etc.)
 - **Marine** (Copernicus Marine Environment Monitoring Service, CMEMS) <http://marine.copernicus.eu/> (marine products, trends etc.)
 - **Land** (Copernicus Land Monitoring Service, CLMS) <https://land.copernicus.eu/> (Global, Pan European and local; landcover/usage, urban atlas, CLC 2012, tree cover density 2015, hotspots)
 - **Climate** (Copernicus Climate Change Service, C3S) <https://climate.copernicus.eu/> (monthly maps to tell about the state of climate at that moment etc.)
 - **Emergency** (Copernicus Emergency Management Service, EMS) <http://emergency.copernicus.eu/> (EMS-map showing flooding, forest fires etc.)
 - **Security** (Copernicus service for security applications) <http://copernicus.eu/main/security> (preventing and preparing for crises)

Users of the services



- Commission
- ESA/EUMETSAT
- Member states
- Private sector
- Citizen
- Regional/Local Administration
- Scientific users

Atmosphere service



Atmosphere (Copernicus Atmosphere Monitoring Service, CAMS) <https://atmosphere.copernicus.eu/>

- European air quality and Forecast plots for the World (Aerosol optical depth, Carbon monoxide, UV-index forecast <https://atmosphere.copernicus.eu/global-forecast-plots>)

Use cases:

<https://atmosphere.copernicus.eu/use-cases>

Helps people and businesses to adapt to atmospheric conditions.

- In France:
 - [Mon Toit Solaire](#), web based tool, uses CAMS solar radiation information to help installing rooftop photo voltaic panels.
- In London and Riga:
 - [airTEXT](#), air quality forecasting service, uses CAMS Regional Ensemble air quality forecasts.
- In Australia:
 - [SunSmart](#), phone application, uses UV data from Copernicus to give alerts about UV radiation peaks.
- Lithuania, Latvia, Austria, Finland:
 - [PASYFO](#), a tool, uses CAMS forecasts of pollen levels, air quality and meteorological conditions to forecast personal allergy symptoms.

<https://atmosphere.copernicus.eu/pasyfo-forecasts-personal-allergy-symptoms>

Marine service

Marine (Copernicus Marine Environment Monitoring Service, CMEMS)

<http://marine.copernicus.eu/>

- Ocean products (160 products, e.g. seaice, salinity)
- Ocean monitoring indicators (sea level, sea ice, trends)
- Ocean state reports

Online tutorials: <http://marine.copernicus.eu/training/online-tutorials/>

Use cases:

<http://marine.copernicus.eu/markets/use-cases/>

- **Quiet oceans**, Ocean noise mapping using Copernicus Marine service temperature, Salinity and surface roughness products
- Finland: **Ice services in the Baltic Sea: land fast ice extent and thickness**, using CMEMS Baltic Sea products, Sentinel 1 data, sea ice thermodynamic model and in-situ data.



Land service

Land (Copernicus Land Monitoring Service, CLMS) <https://land.copernicus.eu/>

- **Global**
 - Vegetation (Land cover, NDVI, Leaf area index)
 - Energy (land surface temperature, surface albedo)
 - Water (lake surface temperature, water quality)
 - Cryosphere (Lake ice extent, snow cover extent, SWE)
 - Hotspots
- **Pan European:**
 - Corine Land Cover, CLC (forests, waterbodies, agriculture, wetland, artificial surfaces), High resolution layers
- **Local** (detailed land cover and use information and changes):
 - Urban atlas <https://land.copernicus.eu/local/urban-atlas/urban-atlas-2012>
 - Riparian zones
 - Natura 2000 sites
- Imagery and reference data
 - EU-DEM, EU-Hydro, Image mosaics



Land service

Use cases:

<https://land.copernicus.eu/user-corner/land-use-cases>

Helps to best manage the use of land and its impact.

- EEA (European Environment agency) **monitors urban environment** by using Urban atlas product.
- EEA makes a report about urban adaptation to climate change
- EEA makes **reports** about land use (Landscapes in transition: an account of 25 years of land cover change in Europe) and **about trends in soil moisture using Corine Land Cover data**.
<https://www.eea.europa.eu/data-and-maps/indicators/water-retention-4/assessment>
- EEA uses Riparian Zones data for reporting on "Green infrastructure and flood management".

Users of Land Service, In Finland: Agency for rural affairs (plant classification, shorten controlling time),
Finnish Environment Institute (water quality)



Climate service



Climate (Copernicus Climate Change Service, C3S) <https://climate.copernicus.eu/>

- Climate bulletins
 - Monthly maps to tell about the state of climate at that moment etc.
- Climate Data Store
 - Water quality indicators for Europe, Sea ice monthly and daily gridded data
 - Climate reanalysis
- Data in action
 - Demonstrator projects

Use cases:

<https://climate.copernicus.eu/node/101>

Helps to support scientists, businesses and policymakers by giving information about climate.

- Italy: **GECOsistema**, using C3S data to make projections on the future supply of water available for crops.
- **Vortex**, using reanalysis data to better plan windfarms.

Emergency service

Emergency (Copernicus Emergency Management Service, EMS)

<http://emergency.copernicus.eu/>

- EMS mapping (floods, fires, landslides etc.)
e.g. <http://emergency.copernicus.eu/mapping/#zoom=2&lat=23.77595&lon=-24.885&layers=00B0T>
- Early warning systems
 - European and Global Flood awareness system (EFAS&GloFAS)
 - European Forest Fire Information system (EFFIS)
- Drought Observatory (DO)

Use cases:

<http://emergency.copernicus.eu/>

- France: **Monitoring floods** caused by heavy rain by using Emergency Management Service. <http://emergency.copernicus.eu/mapping/ems/copernicus-emergency-management-service-monitors-floods-aude-france>
- Haiti: **Monitoring earthquakes** by using Emergency Management Service.



Security service

Security (Copernicus service for security applications)

<http://copernicus.eu/main/security>

Helps in preventing and preparing for crises

- Border and Maritime surveillance



Smart cities



- In Copernicus-program, it is also studied how cities could utilize satellite data in order to improve urban management and the quality of life.
- Smart city:
 - Urban area, that uses different kinds of sensors that are collecting electronic data.
 - The purpose is to get information to manage resources efficiently
 - The information is gathered from citizens and different kinds of sensors.
 - Smart city has environmentwise urban planning, energy efficiency and it supports sustainable development (low carbon, resource efficiency, intelligent services, inequality prevention and health).
- Some examples of city applications:
 - Air quality information-> helps with health related issues
 - Satellite data can be used to monitor air quality.
 - Allergic pollens : CAMS provides daily forecasts of pollen levels. At the moment, birch, olive and grass pollens are forecasted.
 - Change detection and influence on urban area (estimate damages after extreme weather events)
 - Flooding information-> helps in urban planning and managing flooding events
 - Light pollution, traffic management, housing provision, security, city-infrastructure modelling, urban planning, 3D modelling, digital city creation and carbon footprint can be services of a smart city. Also services related to tourism.
 - Planning of Climate change adaptation and mitigation in the city (Climate Change Services, C3S)
 - Urban planning, Monitoring green areas in the city (S2), Urban area extent and expansion, Monitoring of construction, Monitoring of cultural heritage, Land subsidence (SAR interferometry)

Examples of city applications

- Montpellier (France): Optimizing waste collection by using sensor and satellite connectivity <https://eu-smartcities.eu/news/cities-are-reaching-space-solve-urban-challenges-and-save-money>
- Salzburg (Austria): Development of mobility in the city. Electric busses, with satellite navigation.
- Trieste (Italia): Increasing citizen involvement. A system based on satellite navigation, where citizens can put and look at requests sent to the city to resolve problems (such as damaged lamps or leaking pipes)
- Praha (Czech): Monitoring land use from aerial- and satellite images.
- Oslo (Norway): Music festival caused lawn wear (Sentinel data), Land subsidence in railway network area
- Zurich (Switzerland): Sentinel ½ -data fusion for mapping ecosystem services of the city
- Amsterdam (Netherlands): Monitoring bridges and buildings using InSAR techniques and Sentinel 1 data

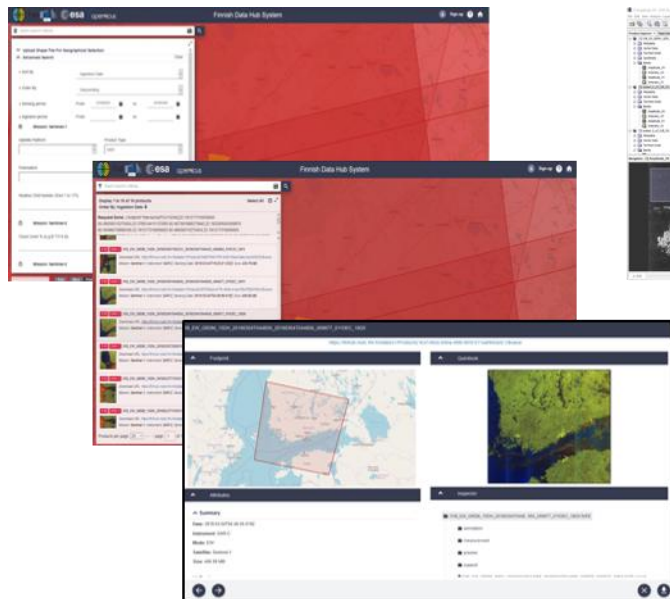


Example of ship detection

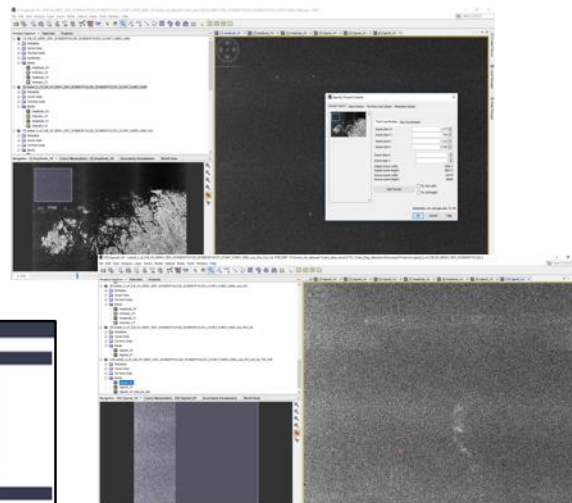
- Sentinel 1 data used, 24.8.2018,
S1B_IW_GRDH_1SDV_20180824T161226_20180824T161251_012407_016E01_6560.data



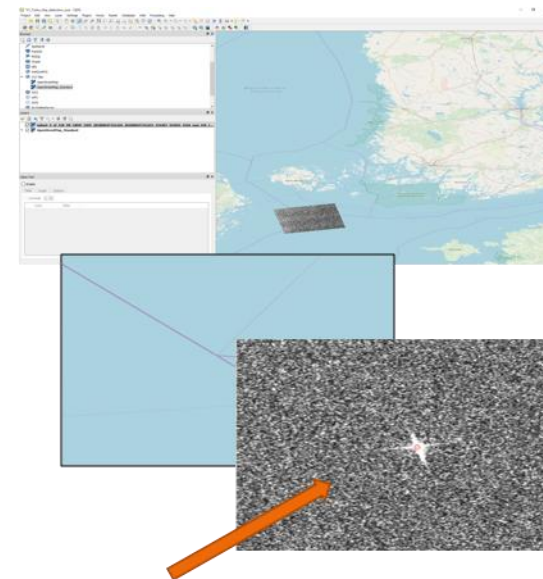
Finhub



SNAP

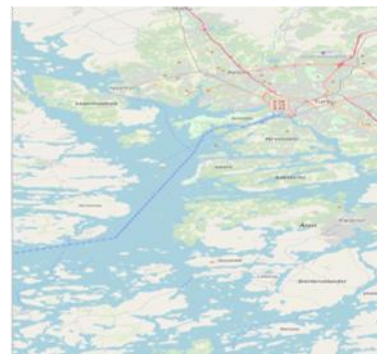
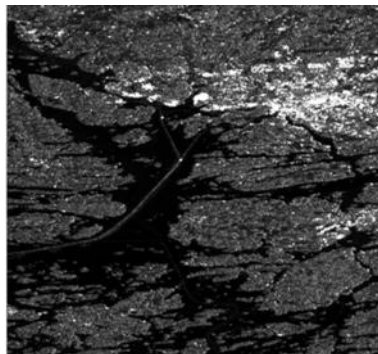


QGIS



Some examples

Sentinel 1 HH-polarisation image:



Turku 4.3.2018 *s1B_EW_GRDM_1SDH_20180304T044856_20180304T044956_009877_011DEC_18D0.SAFE*

Sentinel 2 RGB (Bands 4, 3, 2; Natural colors) image:



Turku 11.8.2018



Turku 10.9.2018



S2A_MSIL1C_20180811T095031_N0206_R079_T34VEN_20180811T120020.SAFE

S2A_MSIL1C_20180910T095031_N0206_R079_T34VEN_20180910T135526.SAFE

Katriina Veijola, Ali Arslan, Cemal Tanis,

26.12.2018 Finnish Meteorological Institute, BalticSatApps Copernicus User Uptake,

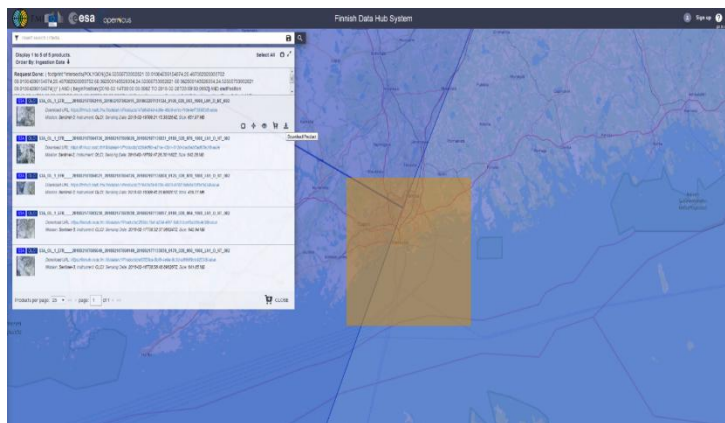
9.11.2018, FMI, Helsinki

Ocean colour with S3 data

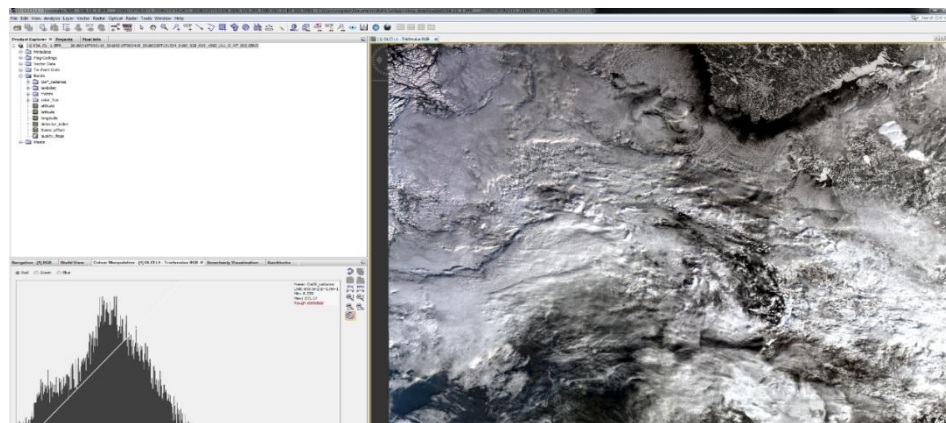


- Satellite data from Sentinel 3 OLCI instrument is used
 - Data is downloaded from Finhub
`SSA_OL_1_EFR____20180219T092115_20180219T092415_20180220T131324_0180_028_093_1980_LN1_O_NT_002.SAFE`
 - RGB image is made (Red: Oa08_radiance, Green: Oa06_radiance, Blue: Oa04_radiance).

Finhub



SNAP



Example of NDVI



- NDVI (normalized difference vegetation index)

- Sentinel 2 MSI data

- $$NDVI = \frac{I_{Ban} \frac{8A-Ban}{8A+Ban} \frac{d}{4}}{I_{Ban} \frac{d}{4}}$$

- Resolution 10 or 20 m

- Can be acquired every 5 days, depending on clouds

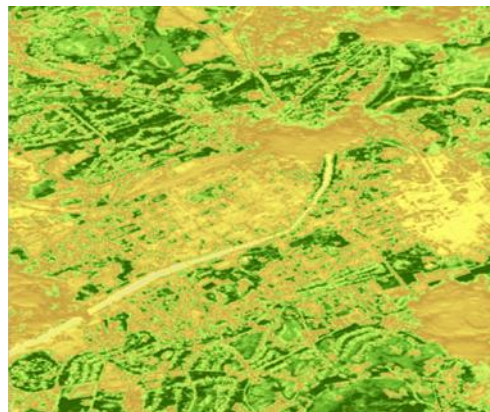
- NDVI tells about the amount of green vegetation and its health

- Values btw. -1 and 1; -1 (water), 1 (green), 0 (urban area)

- NDWI (normalized difference water index)

- $$NDWI = \frac{I_{Ban} \frac{8A-Ban}{8A+Ban} \frac{d}{11}}{I_{Ban} \frac{d}{11}}$$

- Resolution 20 m



S2A_MSIL1C_20180910T095031_N0206_R079_T34VEN_20180910T135526.data

Other examples



You can practice more by yourself

- Research User Support (RUS) <https://rus-copernicus.eu/portal/the-rus-library/learn-by-yourself/>
- It provides tutorials to use Sentinel data for different applications, such as:
 - Ship detection with Sentinel 1
 - Flood mapping with Sentinel 1
 - Burned areas mapping with Sentinel 2
 - Crop mapping with Sentinel 2
 - Ocean colour with Sentinel 3 OLCI
 - Land monitoring with Sentinel 3
 - Water bodies mapping from space
 - Land subsidence with Sentinel 1
 - Oil spill mapping with Sentinel 1
 - Active fire detection with Sentinel 3 SLSTR
 - Urban classification with Sentinel 1

RUS test cases vs. Sentinel data				
Test case	Sentinel 1	Sentinel 2 (MSI)	Sentinel 3	
			OLCI	SLSTR
Ship detection	X			
Flood mapping	X			
Burned areas mapping		X		
Crop mapping		X		
Ocean colour			X	
Land monitoring			X	
Water bodies	X	X		
Land subsidence	X			
Oil spill mapping	X			
Active fire detection				X
Urban classification	X			

- There are shown the steps how to process the data.

Thank you!

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Characteristics of Sentinel satellites



Sentinel Satellite	Spatial resolution	Temporal resolution	Launch	Instrument	Applications
S1	9-40m	6 days	1A: 3.4.2014 1B: 25.4.2016	Radar, C-band	Monitoring ice and ships, Oil spills, Ocean winds
S2	10 m, 20 m, 60 m	5 days	2A: 23.6.2015 2B: 7.3.2017	MSI: Optical, multispectral (high resolution)	Water quality, Changes in forests, Monitoring agriculture
S3	300-1200 m	< 2 days (OLCI) < 1 day (SLSTR, at the equator)	3A: 16.2.2016 3B: 25.4.2018	OLCI: Optical (moderate resolution, 300m) SRAL: Altimetry SLSTR: Radiometer etc.	Ocean colour, Water quality, Sea surface temperature, Monitoring burning areas
S4	8 km	60 minutes	Meteosat Third Generation mukana, 2022	UVN: spectrometer etc.	Atmosphere
S5P	7-68 km	1 day (13:30 local solar time)	13.10.2017	TROPOMI: spektrometer	Atmosphere, Air quality, Climate, Ozone, UV
S5	7.5-50 km	1 day	With Metop-SG satellite, 2021	UVNS: spectrometer etc.	Atmosphere
S6		10 days	2020	Altimetry	Sea surface height