THE COPERNICUS PROGRAMME

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"Earth Observation Showcase – Emerging Applications Powered by Innovative Technologies"

26th October 2017, Satellite Applications Catapult, Harwell

European Space Agency

What is Copernicus?

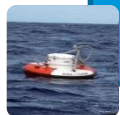**European response to global needs:**
- to manage the environment,
- to mitigate the effects of climate change and
- to ensure civil security

Space Component
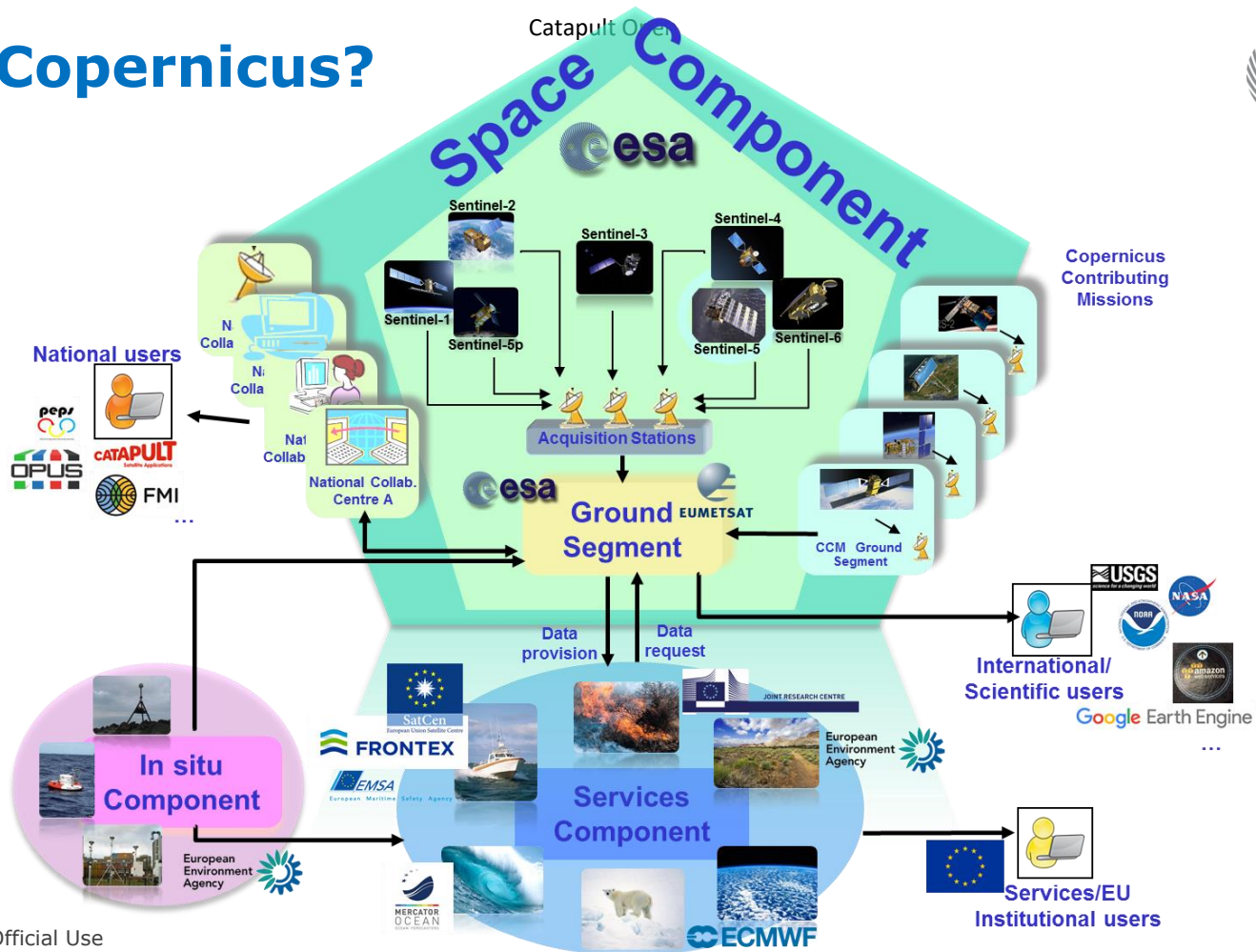
In-Situ Data

Services Component

European Space Agency

What is Copernicus?

Copernicus Users

Policymakers

Decision Makers

Start-Up Companies

Space Enthusiasts

Large Institutional User Organisations

Scientists

Students

Private Persons

Public Authorities

Value-Adding Companies

European Space Agency

Copernicus/GMES Facts & Figures

>100,000
Number of self-registered users (Open Data Hub)

6
service domains covered

2014
start of Copernicus operational phase

€ 10
of public return for every € 1 spent by the European tax payer on Copernicus

>€ 7 B
invested by ESA and EU till this day

€ 0
to pay for access to Sentinel data

20
new satellites & instruments specifically developed for the operational needs of Copernicus

83,000
jobs generated by Copernicus by 2030

European Space Agency

Copernicus Components & Competences

Coordinators:

Partners:

Overall Programme Coordination:

Space Component

Industries | Private companies

National Space Agencies | EUMETSAT

Services Component

Service operators: EMCWF, Mercator Océan, EEA, JRC, SatCen, EMSA and FRONTEX
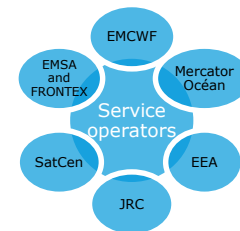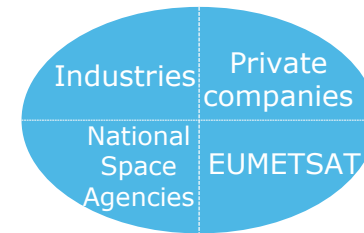
In-situ data are supporting the Space and Services Components

European Space Agency

Copernicus Services Component

European Space Agency

Copernicus Space Component: Role of ESA

➢ **Coordinator of overall Copernicus Space Component**

> ➢ Definition of overall architecture and plan for future evolutions
>
> ➢ Coordinating access to Copernicus missions from national, EUMETSAT and third party satellite owners

➢ **Development and procurement Agency for dedicated space infrastructure**

> ➢ Development of first spacecraft and Ground Segment
>
> ➢ Procurement of recurrent elements

➢ **Operator of Sentinel-1, Sentinel-2, Sentinel-3 (land) and Sentinel-5 precursor**

> ➢ EUMETSAT is operator of Sentinel-3 (marine), Sentinel-4, Sentinel-5 and Sentinel-6

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   13 Oct 2017

S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission   2021/2027

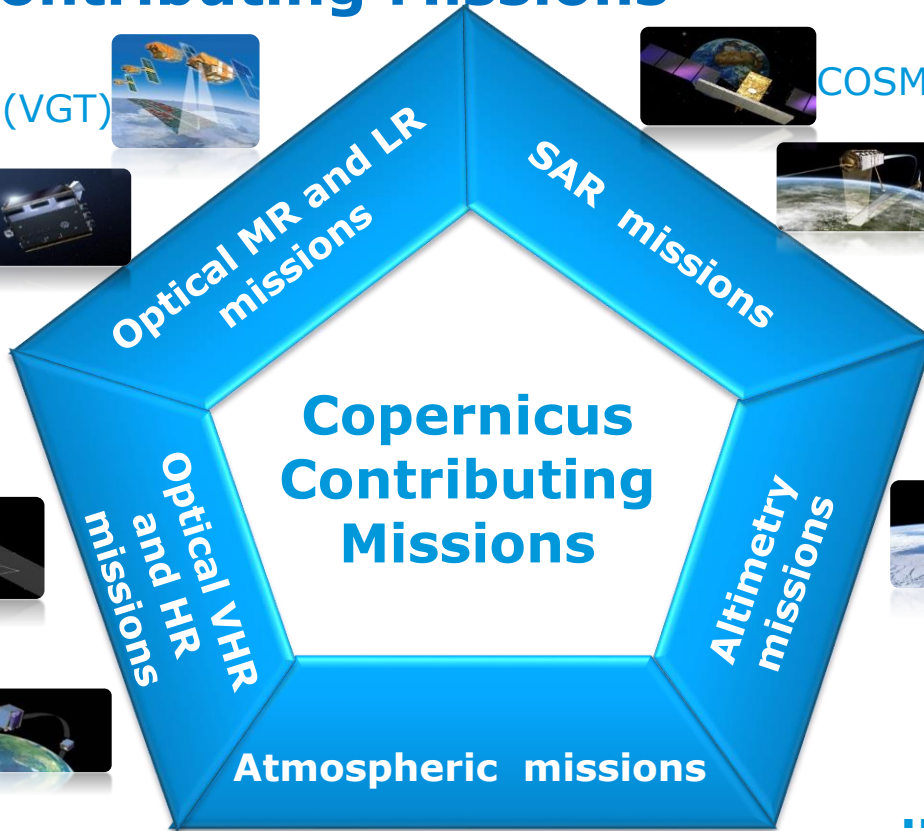**S6A/B:** Altimetry Mission   2020/2025

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... with a long-term operational perspective (with Next Gen)

2011   2014   2020   2030

Access to Contributing Missions

S-1 A/B/C/D

S-1 Next Generation

S-2 A/B/C/D

S-2 Next Generation

S-3 A/B/C/D

S-3 Next Generation

S-4 A/B (on MTG)

S-5 Precursor

S-5 A/B/C (on MetOp-SG)

S-6 A/B

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Copernicus Contributing Missions

esa

SPOT (VGT)

PROBA-V

COSMO-Skymed

Optical MR and LR missions
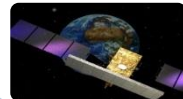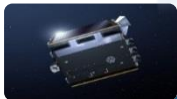
SAR missions

TerraSAR–X

Tandem-X

Radarsat

DMC
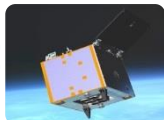
Pléiades

Deimos-2

RapidEye

SPOT (HRS)

Copernicus Contributing Missions

Optical VHR and HR missions

Altimetry missions
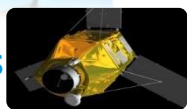
Cryosat

Jason

Atmospheric missions
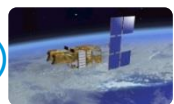
... and many more!

MetOp

Meteosat 2nd Generation

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Advantages of Sentinel Satellites

Fully operational system

Most comprehensive EO system in the world

Complementary to Contributing Missions

Free Sentinel data

Long-term observations
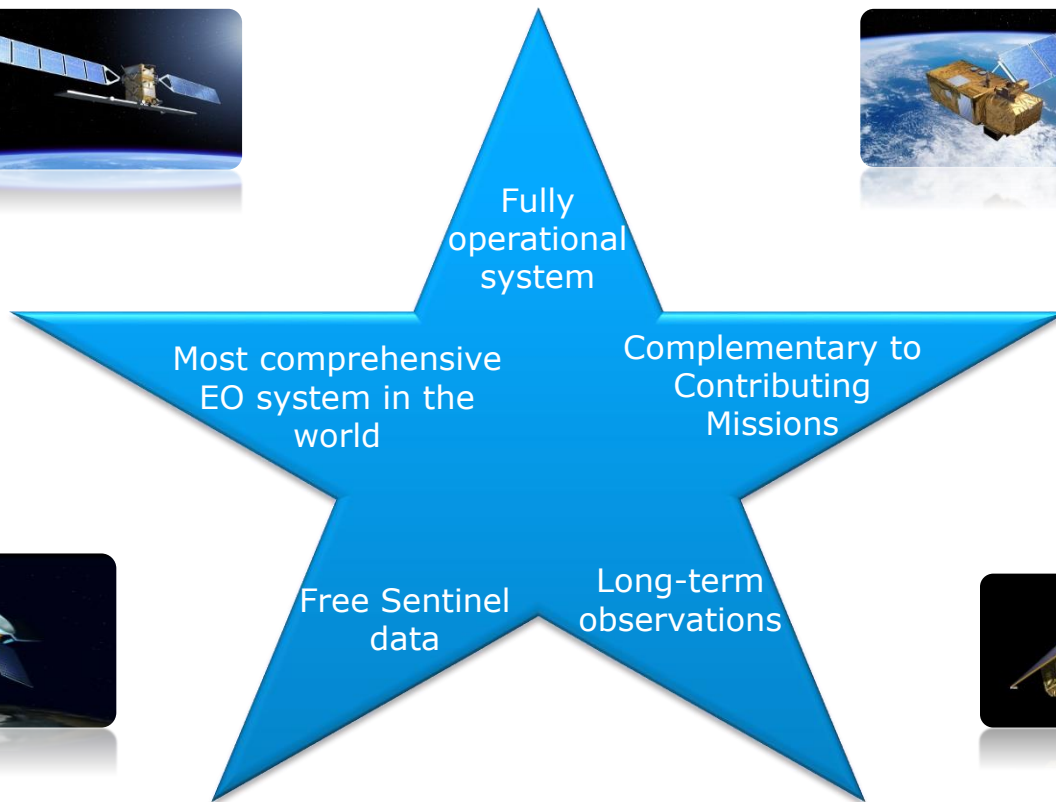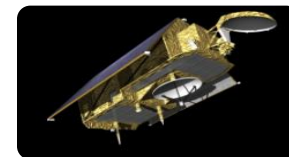
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First Generation Sentinels constellation

S-1

S-2

S-3

S-4

S-5

S-5p

S-6

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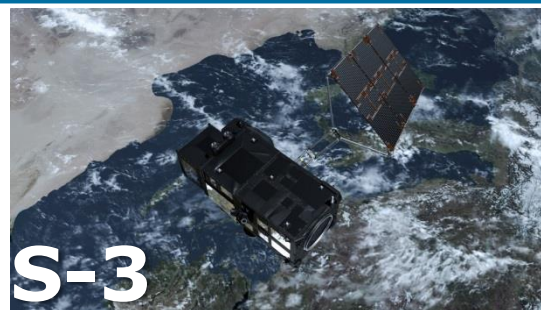
Sentinel-1 C-band SAR mission

Mission profile:

- **C-Band SAR** at 5.4 GHz, multi-polarisation
- Sun synchronous orbit at **693 km** mean altitude
- **250 km** swath width (Interferometric Wide-swath mode)
- **6 days** repeat cycle at Equator with 2 satellites
- **7 years** design life time, consumables for 12 years
- **4** nominal mutually exclusive operation modes

Mission objectives:
- ➢ Ice and marine, land monitoring
- ➢ Support to crisis management

Image Acquisition in Interferometric Wide Swath mode (IW)

Terrain **O**bservation by **P**rogressive **S**cans (TOPS)
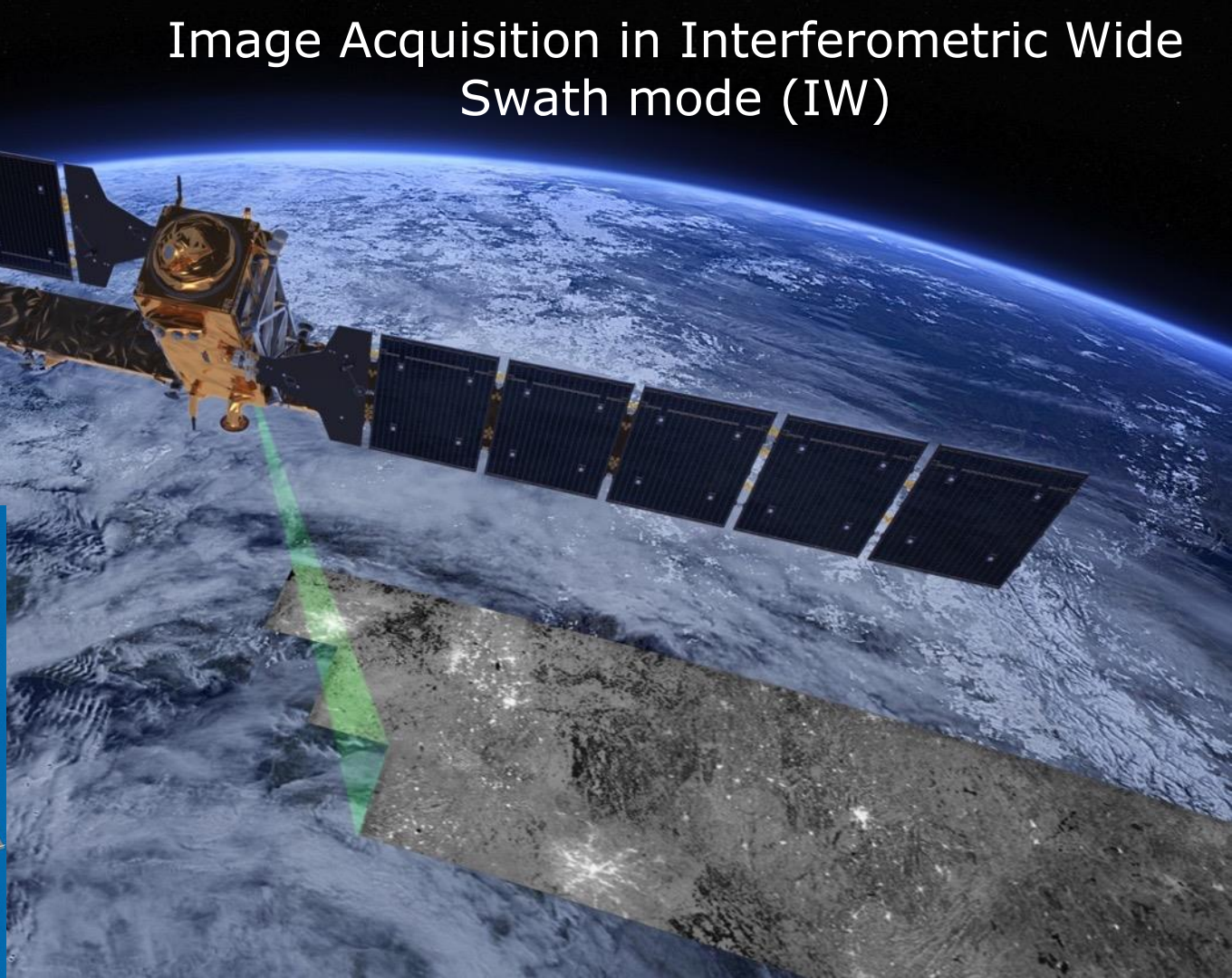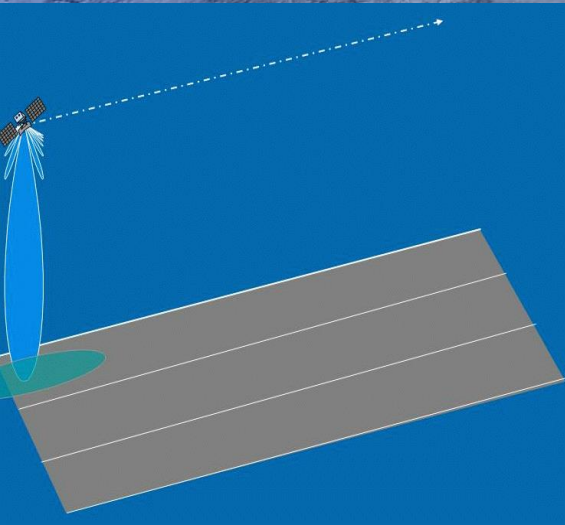
Sentinel-1 observation scenario
Main thematic domains & components

Land cover: agriculture, forestry, hydrology, etc.

Maritime surveillance

European coverage

Sea-ice, icebergs, lake-ice

Emergency

Calibration/validation

Ground deformation: Tectonic, volcanoes, landslides, subsidence… (InSAR applications)
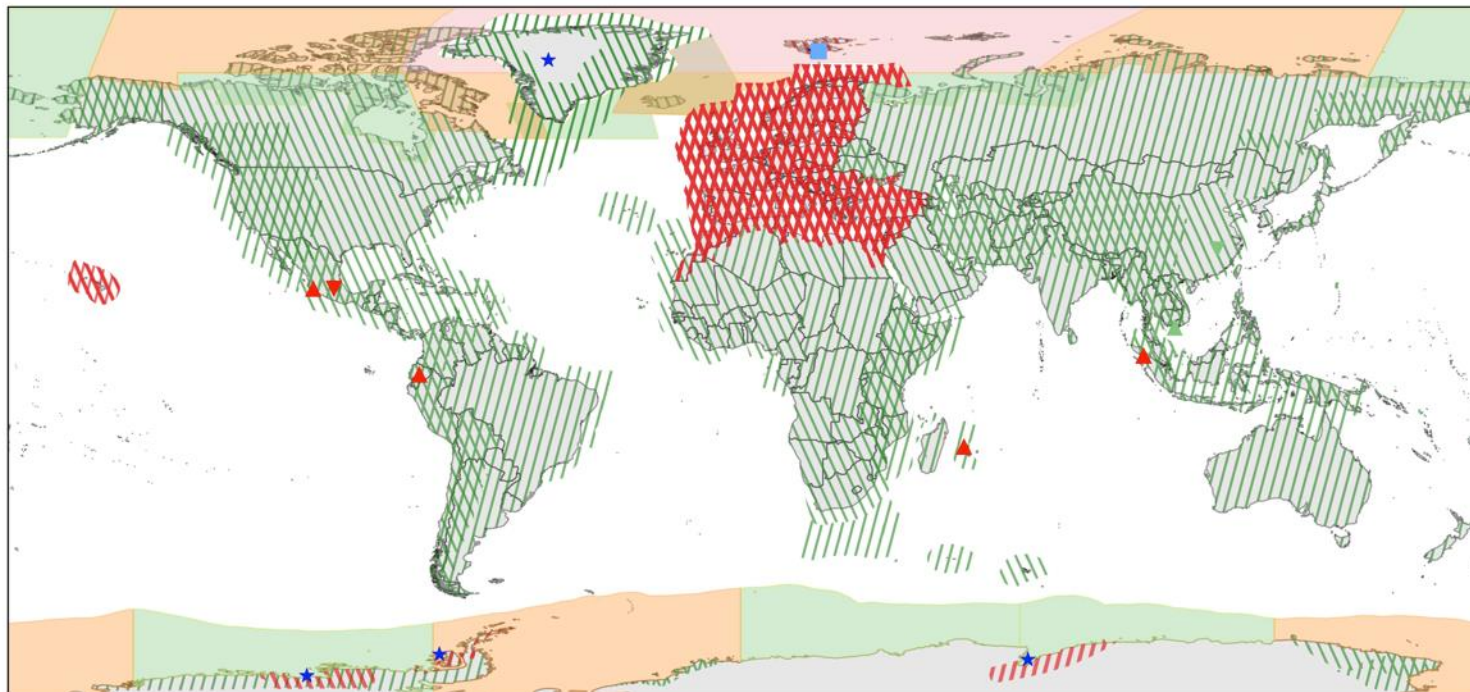
Security

Global land mapping

PR actions (infrequent)

Ice sheets, glaciers, permafrost, snow, etc

Sea state

European Space Agency

**Sentinel-1 Constellation Observation Scenario: Revisit & Coverage Frequency**

sentinel-1

esa

validity start: 05/2017

| PASS	REVISIT	FREQUENCY *	COVERAGE FREQUENCY **	REFERENCE DATA SITES (6d repeat)
ASCENDING	6 days	12 days	1 days	▲ Highly active volcanism
DESCENDING			1-3 days	▼ Fast subsidence
			2-4 days	▲ Short growth cycle, intensive agriculture
				▼ Fast changing wetlands
				★ Fast moving outlet glaciers
				■ Permafrost & glaciers

* coverage ensured from same, repetitive relative orbits
** coverage not considering repetitiveness of relative orbits

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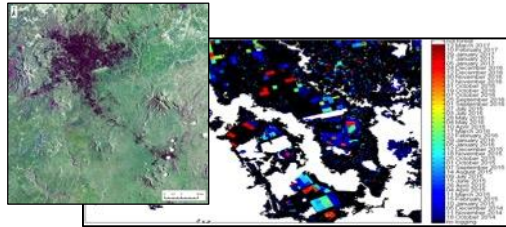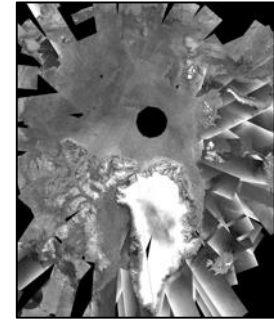# Sentinel-1 applications → ever increasing
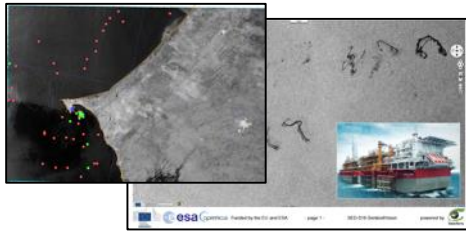
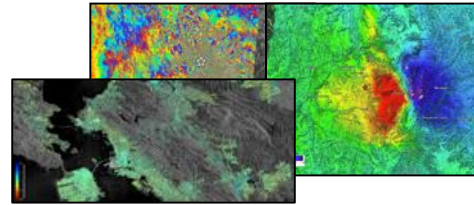*Maritime surveillance: oil spill monitoring, ship detection, illegal fisheries, etc.*
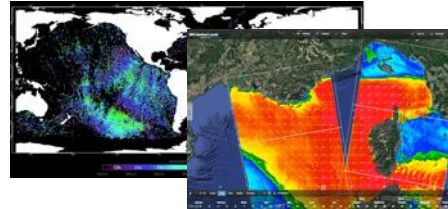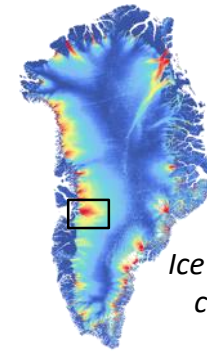
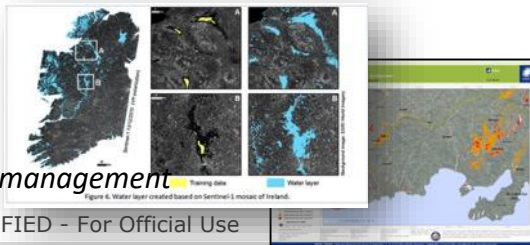*Sea state: wind, wave*

Sea ice and iceberg monitoring

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

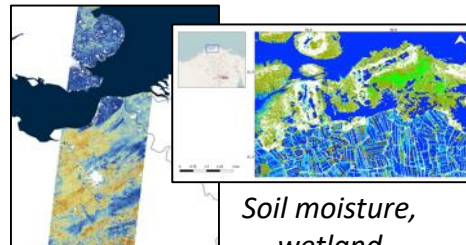*Ground deformation: subsidence, landslides, earthquakes, volcanoes, infrastructure monitoring*
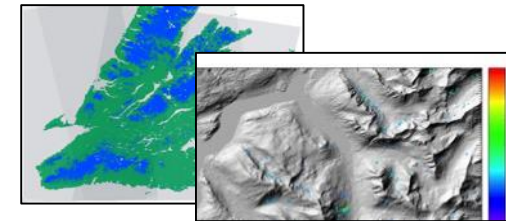
Ice sheets, glaciers, climate change

Emergency management

Soil moisture, wetland

Snow, permafrost, avalanches,…

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Regular Ice Charts based on Sentinel-1 imagery routinely generated by CMEMS

Greenland Ice Chart
Danish Meteorological Institute Valid: 03 May 2017, 12:00 UTC

Sea Ice Concentration Charts based on Sentinel-1 imagery routinely generated by CMEMS
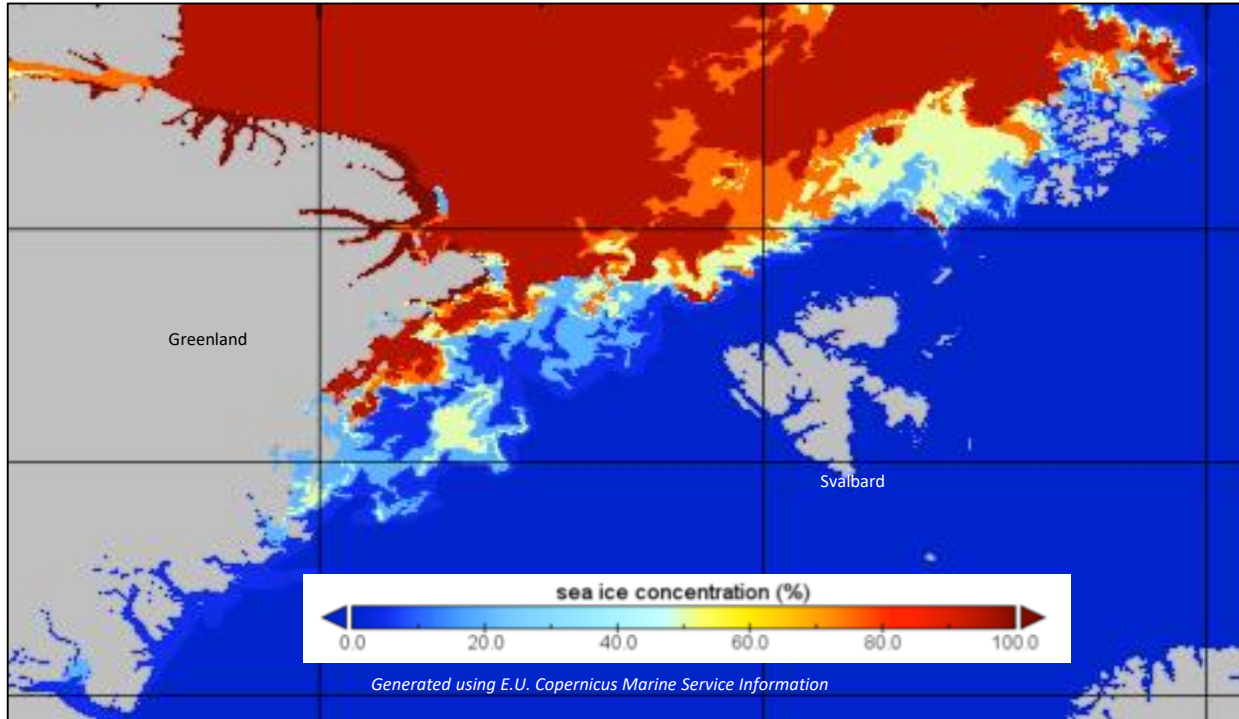
High resolution sea ice concentration charts (early September 2017)

The Copernicus Marine Environment Monitoring Service provides daily high resolution sea ice concentrations derived from Sentinel-1 mission data.
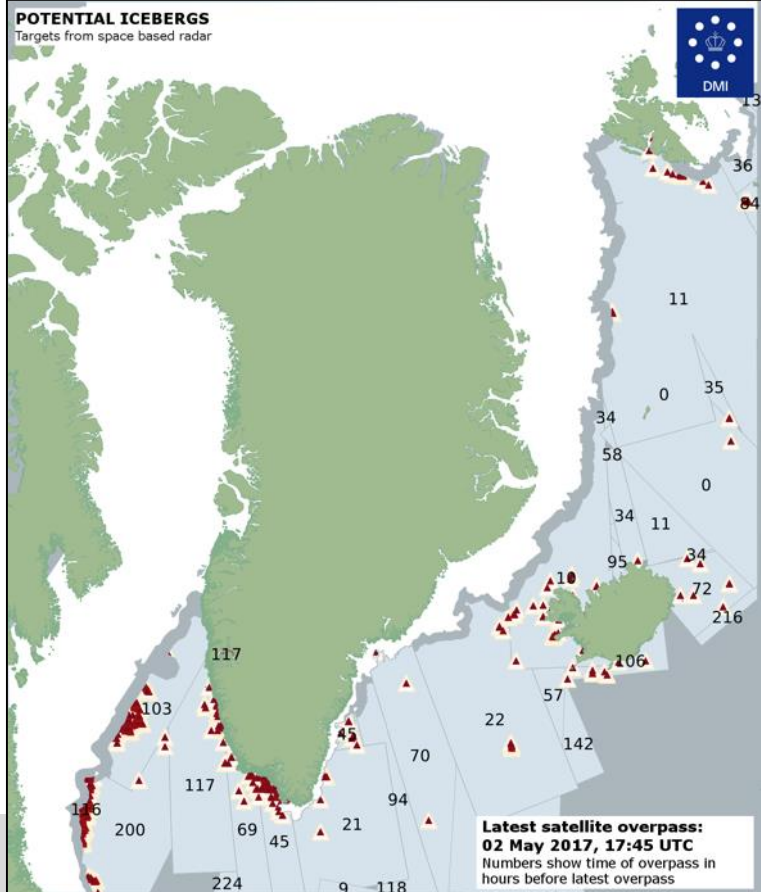
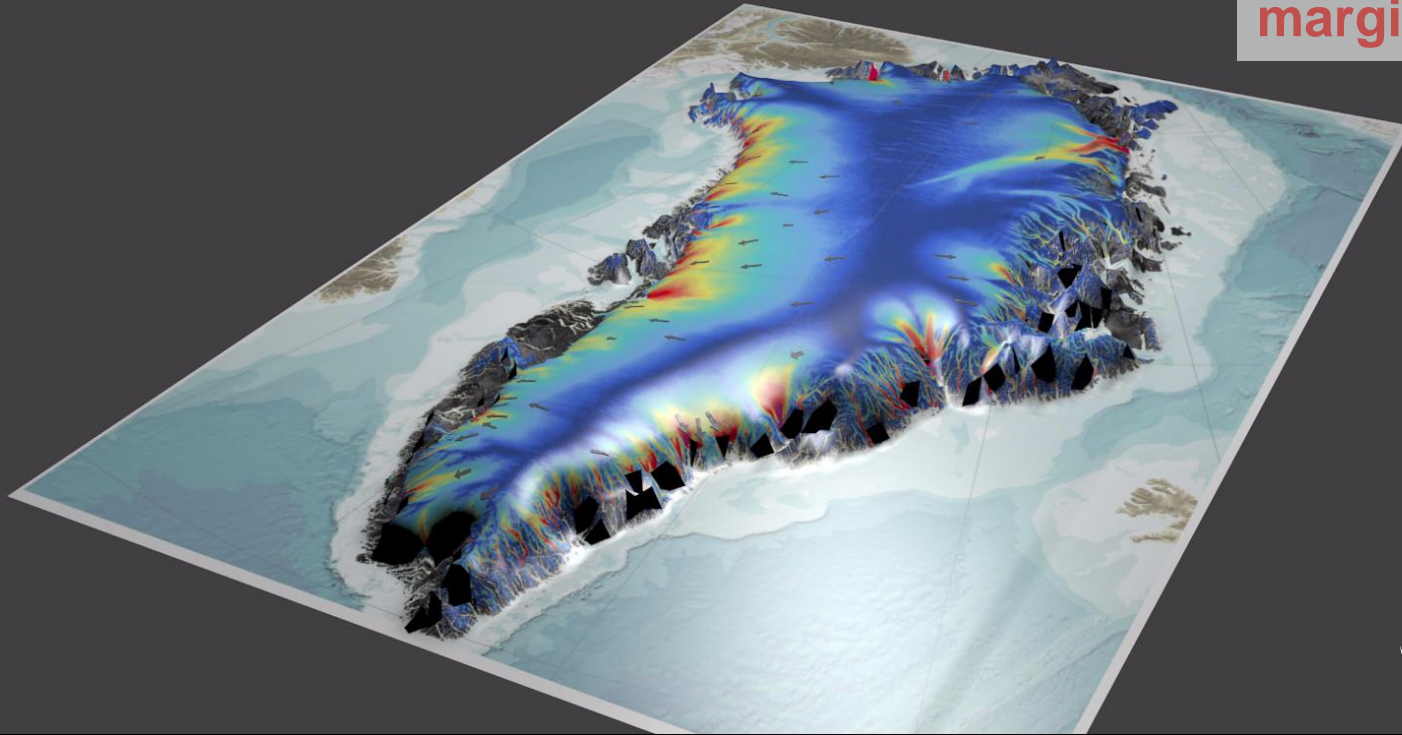# Regular Iceberg detection maps based on Sentinel-1 imagery routinely generated by CMEMS

Daily maps of position of icebergs

Monitoring ice sheets with Sentinel-1

**A routine observatory of ice sheet margins**

Fisheries Surveillance for WARFP

World Bank project developed within the West Africa Regional Fisheries Project (WARFP) for IUU (Illegal, Unlicensed and Unreported) fisheries detection

Detection correlated with cooperative transponder data (green) and non-cooperative data (red) usually associated with IUU activities (vessels engaged in fishing in restricted areas/EEZs without authorisation).
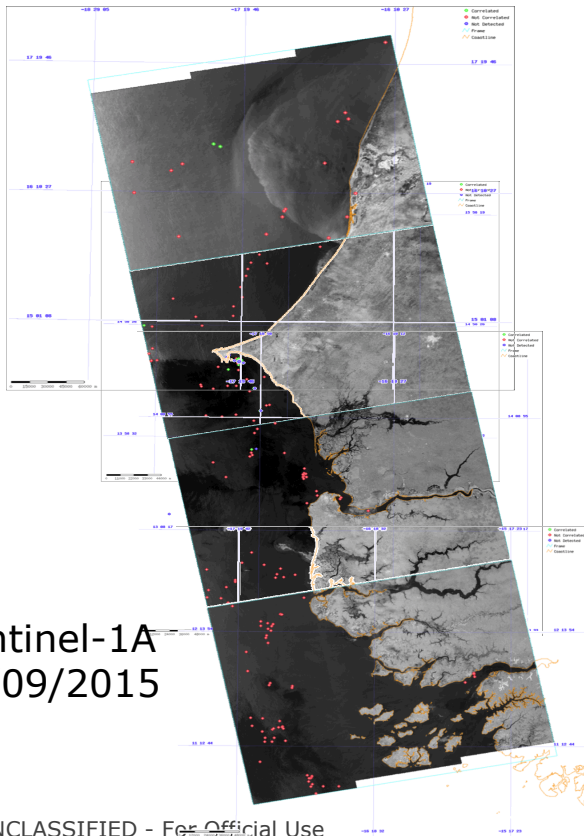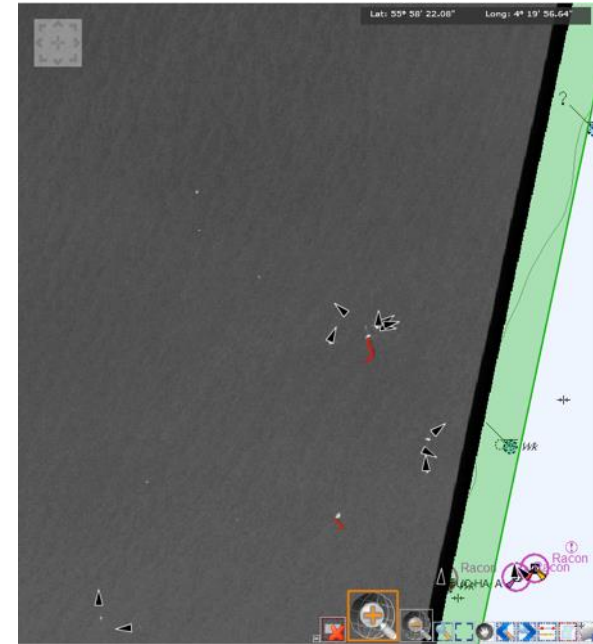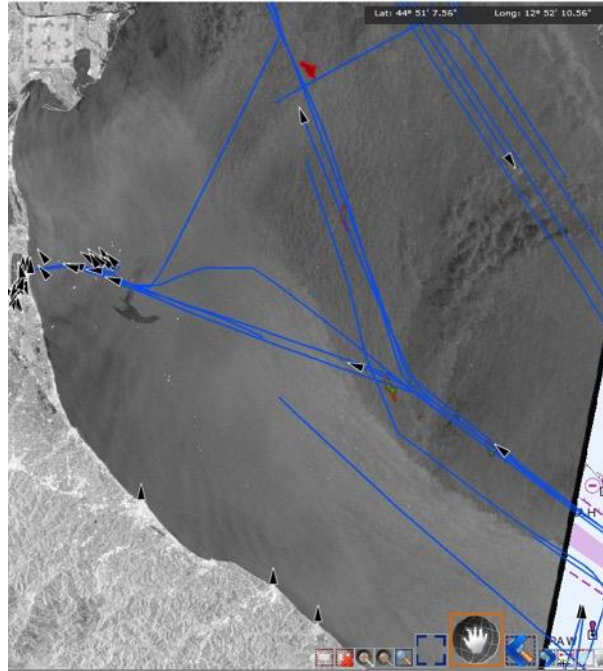

Sentinel-1A
30/09/2015
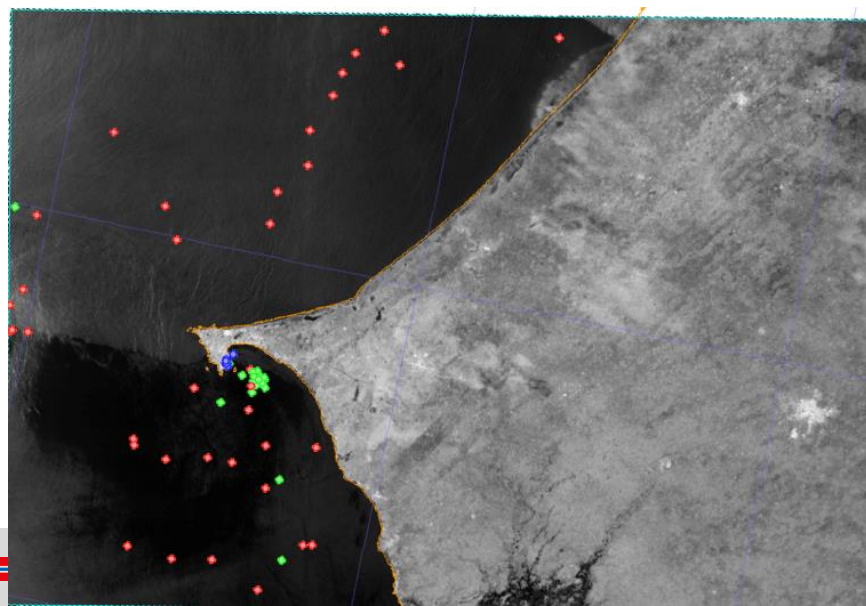
Sentinel-1 is operationally used by EMSA since June 2016 for the CleanSeaNet service

CleanSeaNet: the European satellite-based **oil pollution and vessel detection monitoring system**

→ Operated by the European Maritime and Safety Agency (EMSA)

Sentinel-1 currently represents 85 % of satellite imagery used for CleanSeaNet

acquired on 25 April 2014

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Multiple flowlines spills Identified East of the USAN FPSO (Floating Production Storage and Offloading) vessels, Nigeria, Gulf of Guinea

Sentinel-1A imagery, 18.01.2016

SED-018-SentinelVision

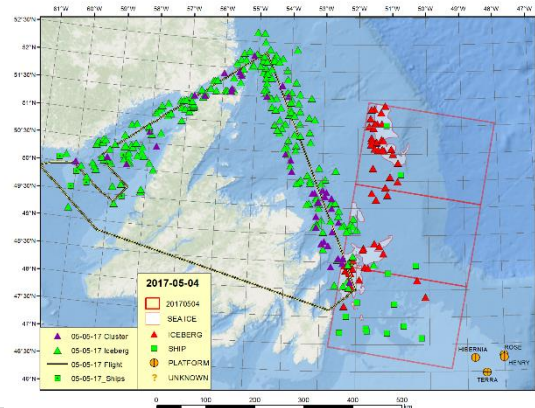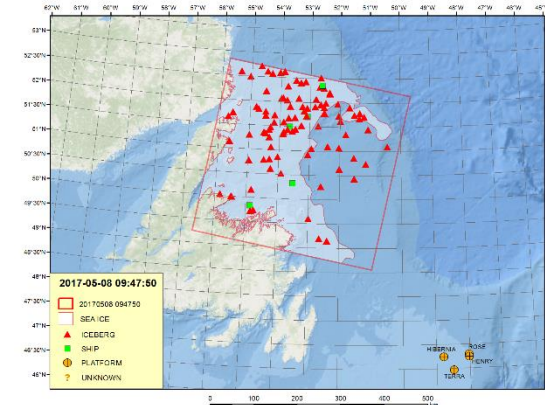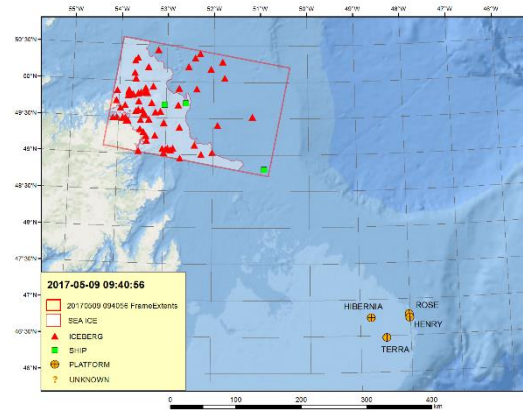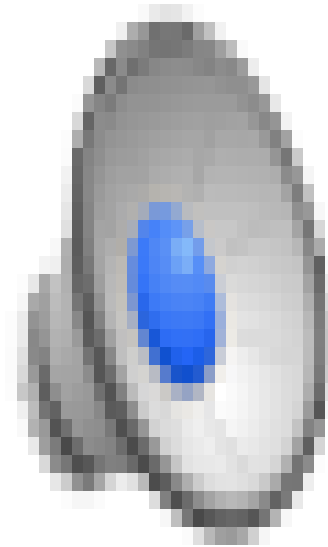powered by

European Space Agency

Offshore Oil and Gas Monitoring

Up to 50 Sentinel-1 images are being used each month to track upstream icebergs from several offshore platforms

Iceberg and ship detections are correlated with satellite AIS

Ice edge information also integrated into the product

Combined sigma_0 and coherence (both VV) for a part of Flevoland, using both S1A and S1B
Sep 2016 -> Feb 2017
(courtesy: Guido Lemoine, JRC)

- Coherence varies spectacularly due to soil cultivation in the autumn period
- Towards end of Nov, the change in coherence slows down, and most fields show high coherence because they are essentially stable bare soil (bright video frames).
- Over Jan and Feb, coherence blurs due to snow and frost/thaw affects, but the coherence patterns remain stable until late Feb

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Flood delineation map based on Sentinel-1 data
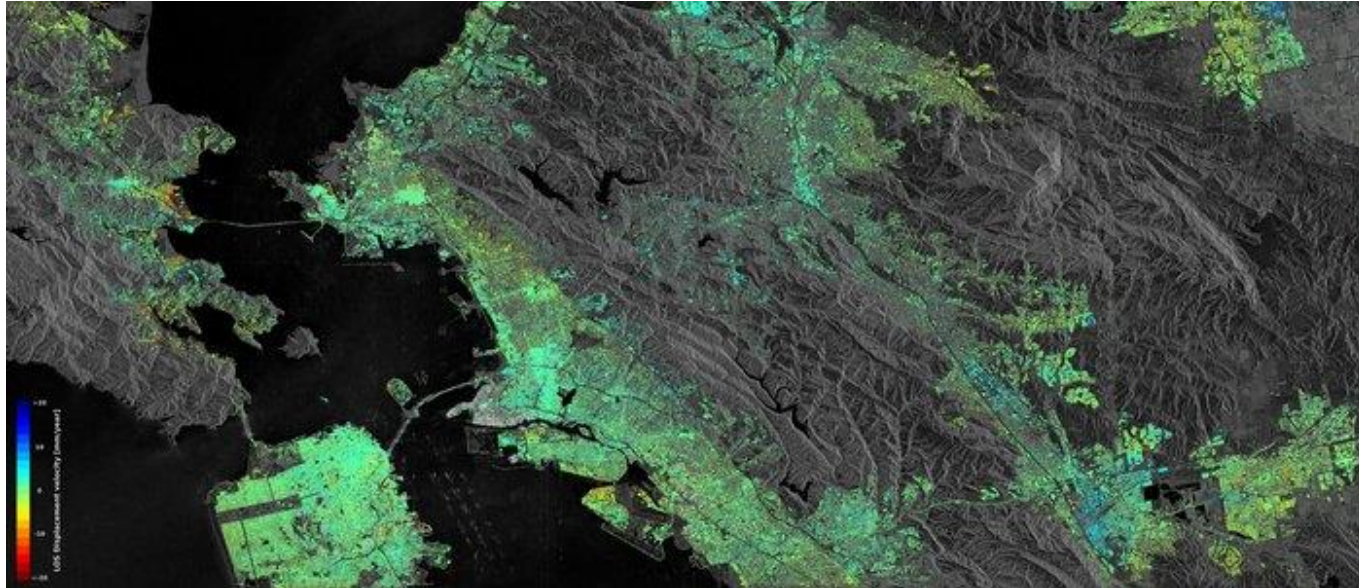# Copernicus Emergency Management Service Flood in Cumbria, UK, Dec 2015
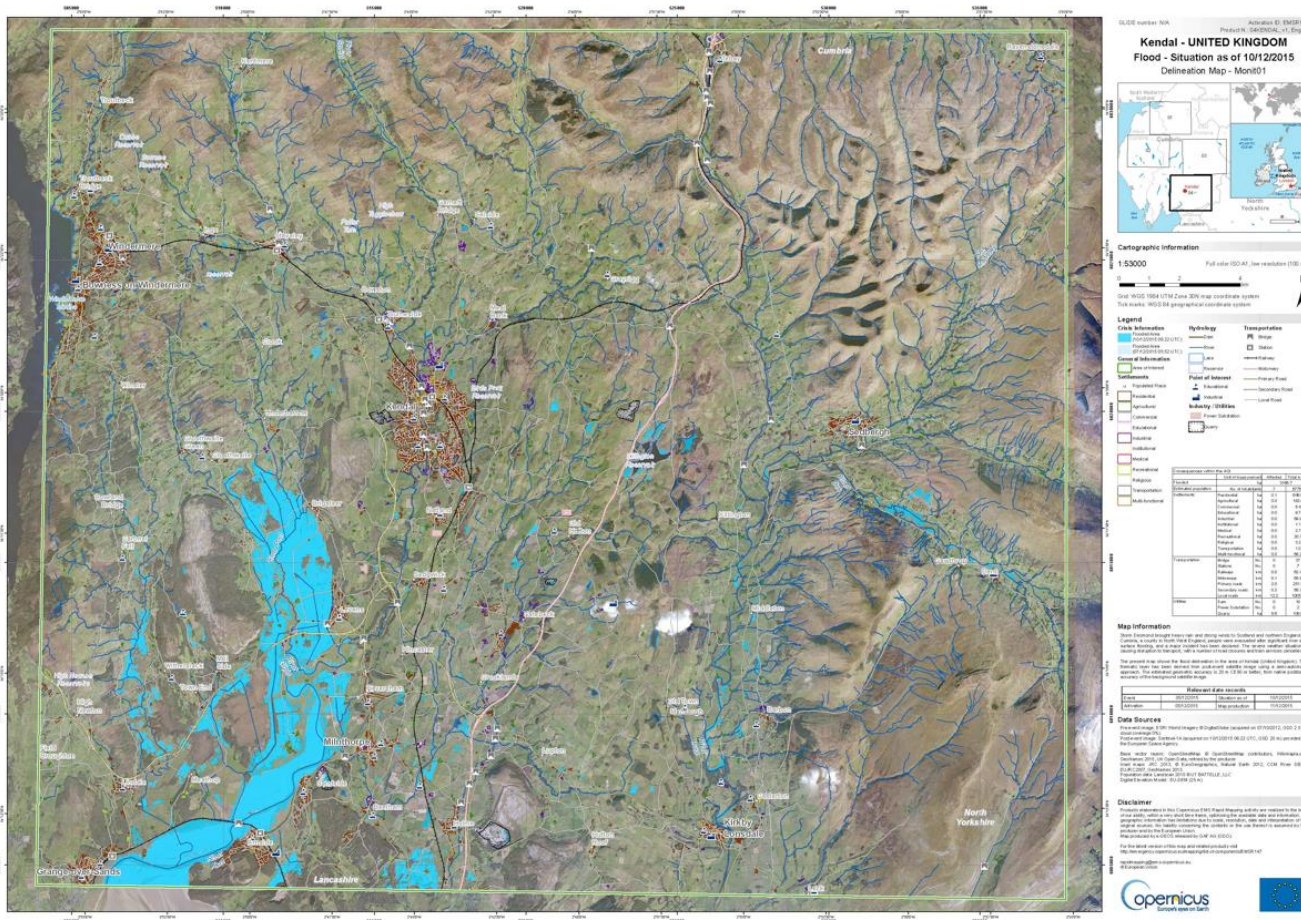
© Copernicus Service information (2015)/CEMS

Example of Land Deformation monitoring

Ground displacement of the San Francisco Bay Area measured by Sentinel-1

Hot spots are clearly observed, including the Hayward fault running north–south of the central-right side of the image. Subsidence of the newly reclaimed land in the San Rafael Bay on the left is also visible, while an uplift of land is visible in the lower right, possibly a result of a recovering groundwater level after a four-year long drought that ended in autumn 2015.

Contains modified Copernicus Sentinel data (2015–16) / ESA SEOM INSARAP study / PPO.labs / Norut / NGU

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San Francisco Millennium Tower sinking

Data from the Sentinel-1 satellites acquired between 22 Feb 2015 and 20 Sep 2016 show that Millennium Tower in San Francisco is sinking by about 40 mm a year in the 'line of sight' – the direction that the satellite is 'looking' at the building.

This translates into a vertical subsidence of almost 50 mm a year, assuming no tilting.

The coloured dots represent targets observed by the radar. The colour scale ranges from 40 mm a year away from radar (red) to 40 mm a year towards radar (blue). Green represents stable targets.

Contains modified Copernicus Sentinel data (2015–16) / ESA SEOM INSARAP study / PPO.labs / Norut / NGU
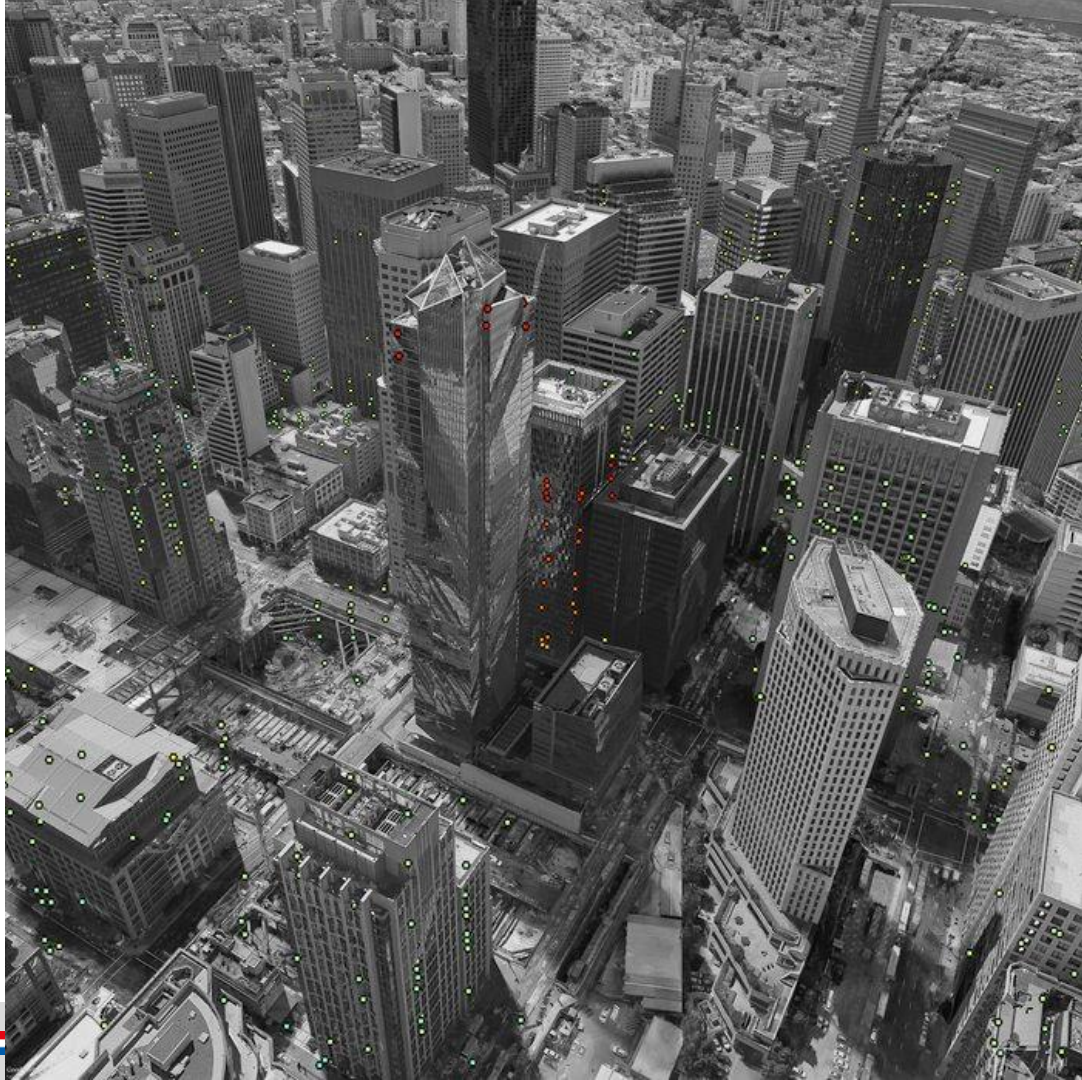
# Sentinel-2 Superspectral imaging mission

Mission profile

- Multispectral instrument with **13** spectral bands (VIS, NIR & SWIR)

- Sun synchronous orbit at **786 km** mean altitude

- **290 km** swath width

- **5 days** repeat cycle at Equator (cloud free) with 2 satellites

- **7 years** design life time, consumables for 12 years

- **10**, **20** and **60 m** spatial resolution

Mission objectives:

➢ Generic land cover maps

➢ Risk mapping and disaster relief

Sentinel-2: 13 Spectral Bands
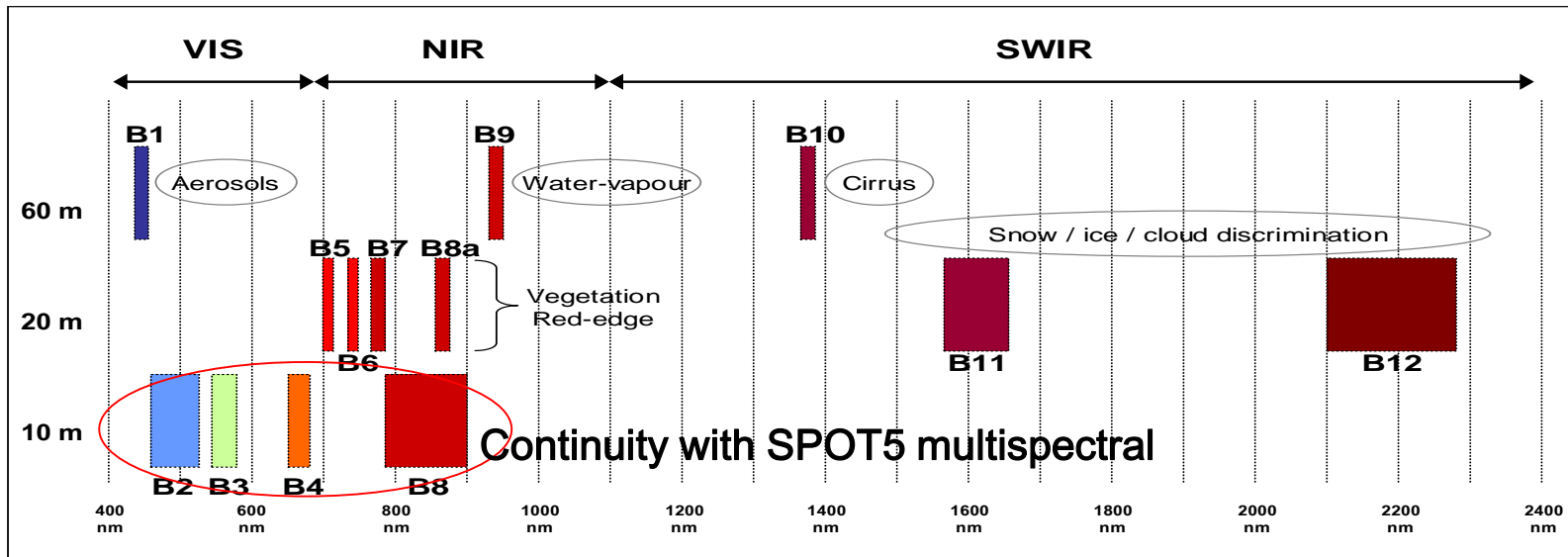
Spectral bands versus spatial resolution
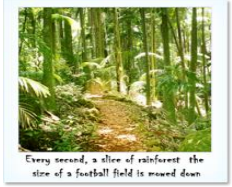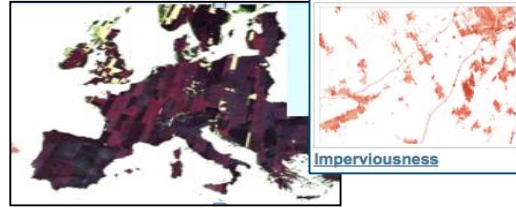
Continuity with SPOT5 multispectral

Ever increasing range of Applications
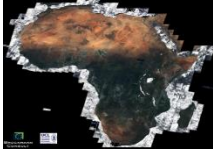
Forests & Carbon, Vegetation monitoring
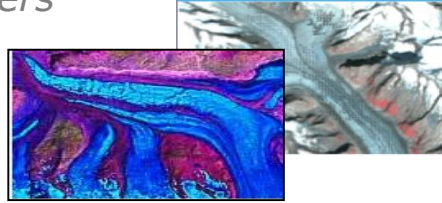
European Land cover, human impact, high resolution layers
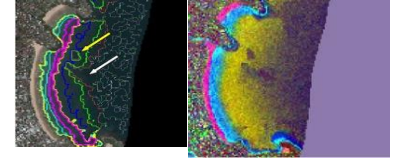
Imperviousness

URBAN ATLAS - IT001L-Roma

Regional to Urban Applications
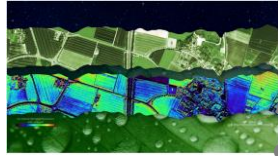
Agriculture, Fluorescence & biophysical parameters
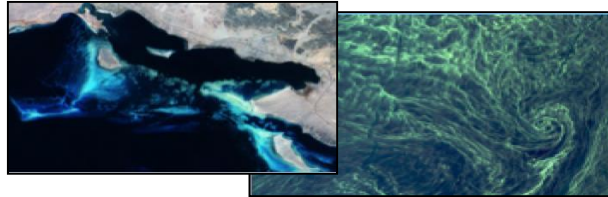
Global Land use & land cover

Glaciers & Ice

Coastal zones/bathymetry

Water quality, Wetlands

CHILE - San Antonio - Chaimavida

Emergency management
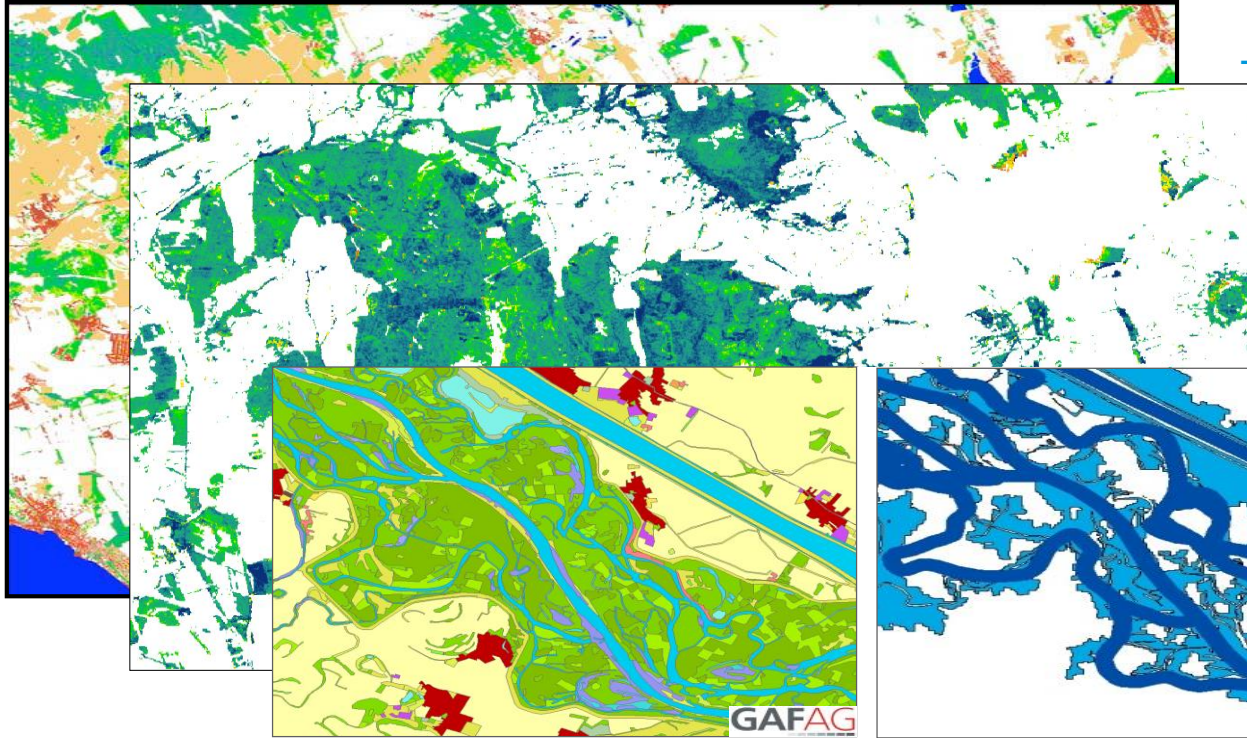
Geology & Geomorphology

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Copernicus Land Core Services

- Land cover/ use characteristics

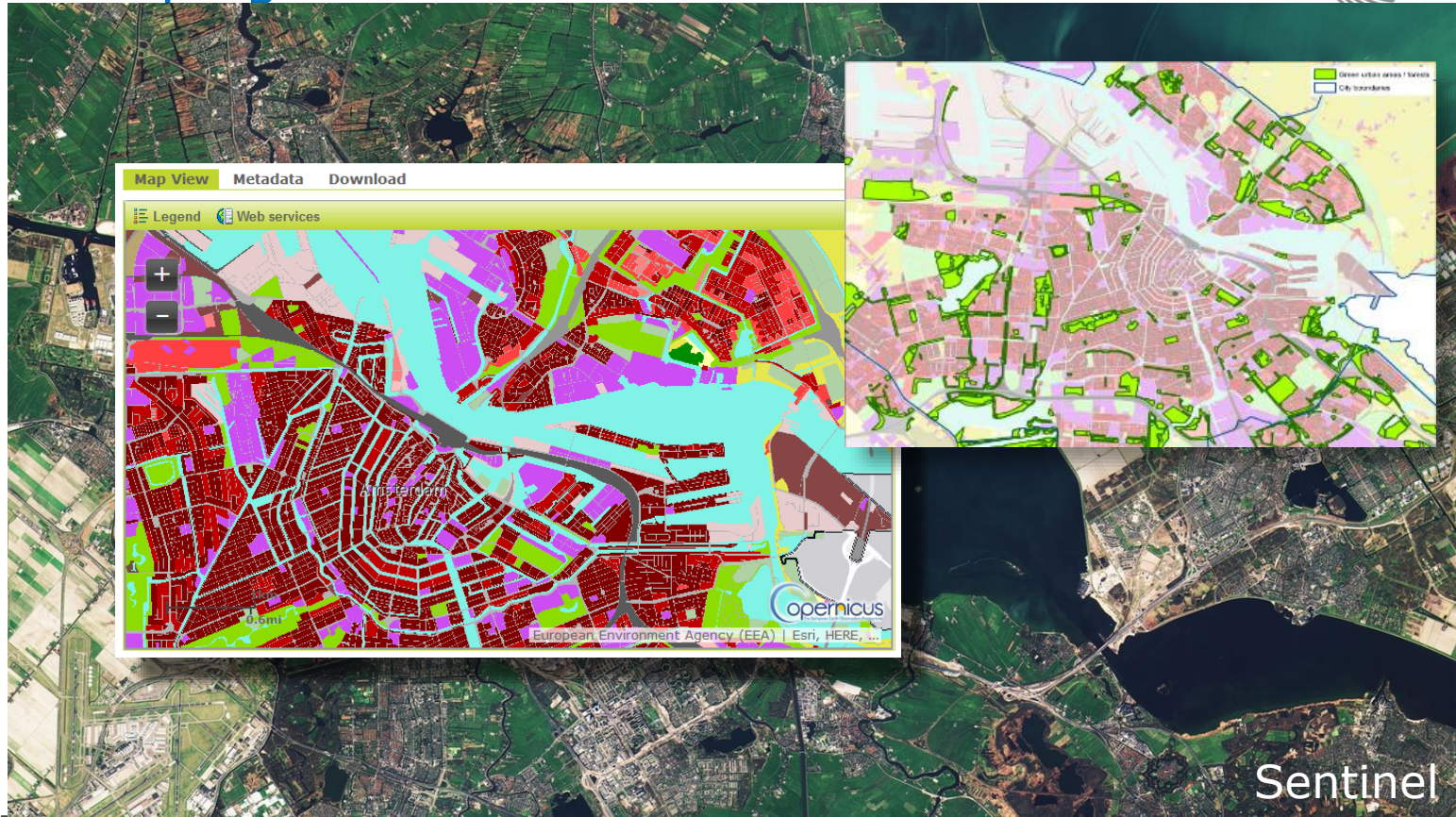 - Forest: Tree Cover Density [%]

  - European Riparian Zones

Sources: EEA; GAF AG

Developing a sustainable urban environment

European Space Agency