Radar Earth Observation – ESA EO Data Access and resources, applications, Copernicus OA Hub

Activities

esa space solutions

- ESA is one of the few space agencies in the world to combine responsibility in nearly all areas of space activity.


space science


human spaceflight


exploration


earth observation


launchers


navigation

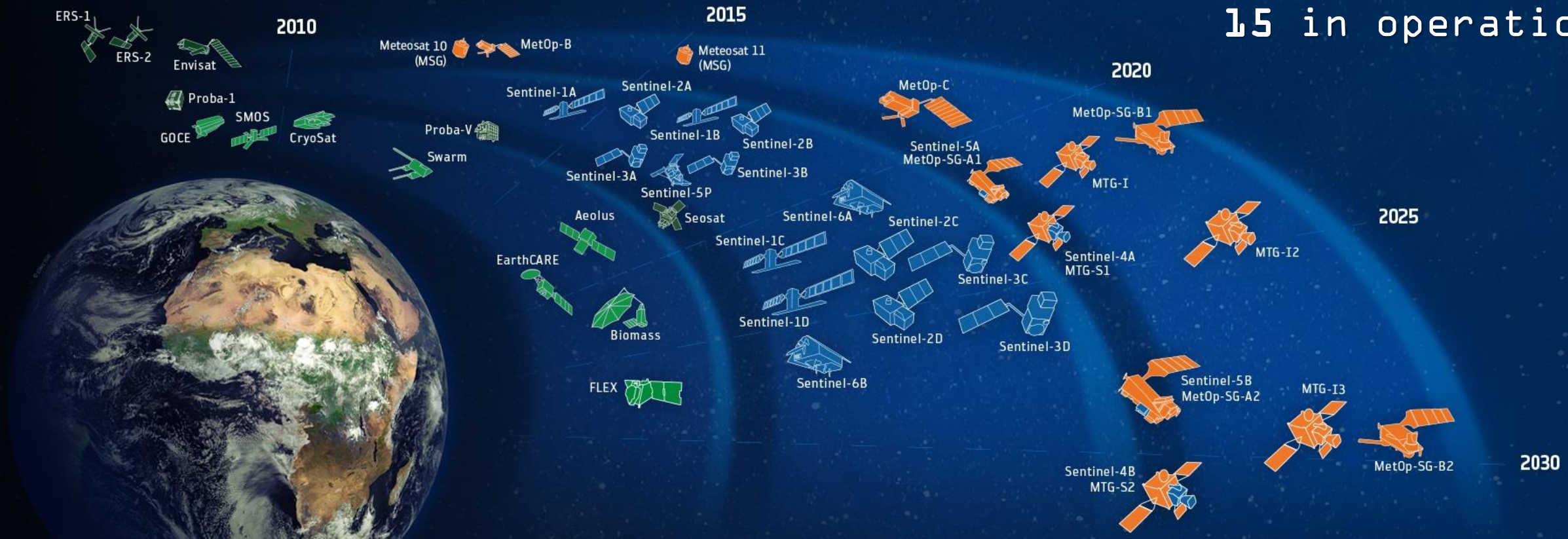

operations


technology


telecommunications

ESA-Developed Earth Observation Missions

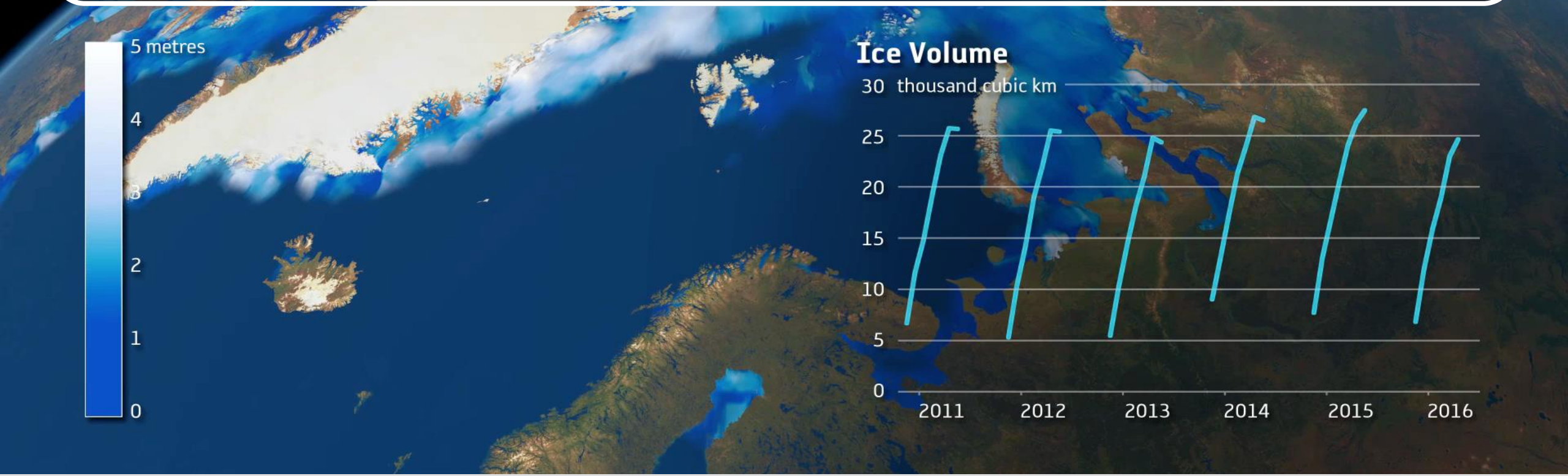
Satellites
25 under development
15 in operation



cryosat
Arctic Sea Ice Thickness

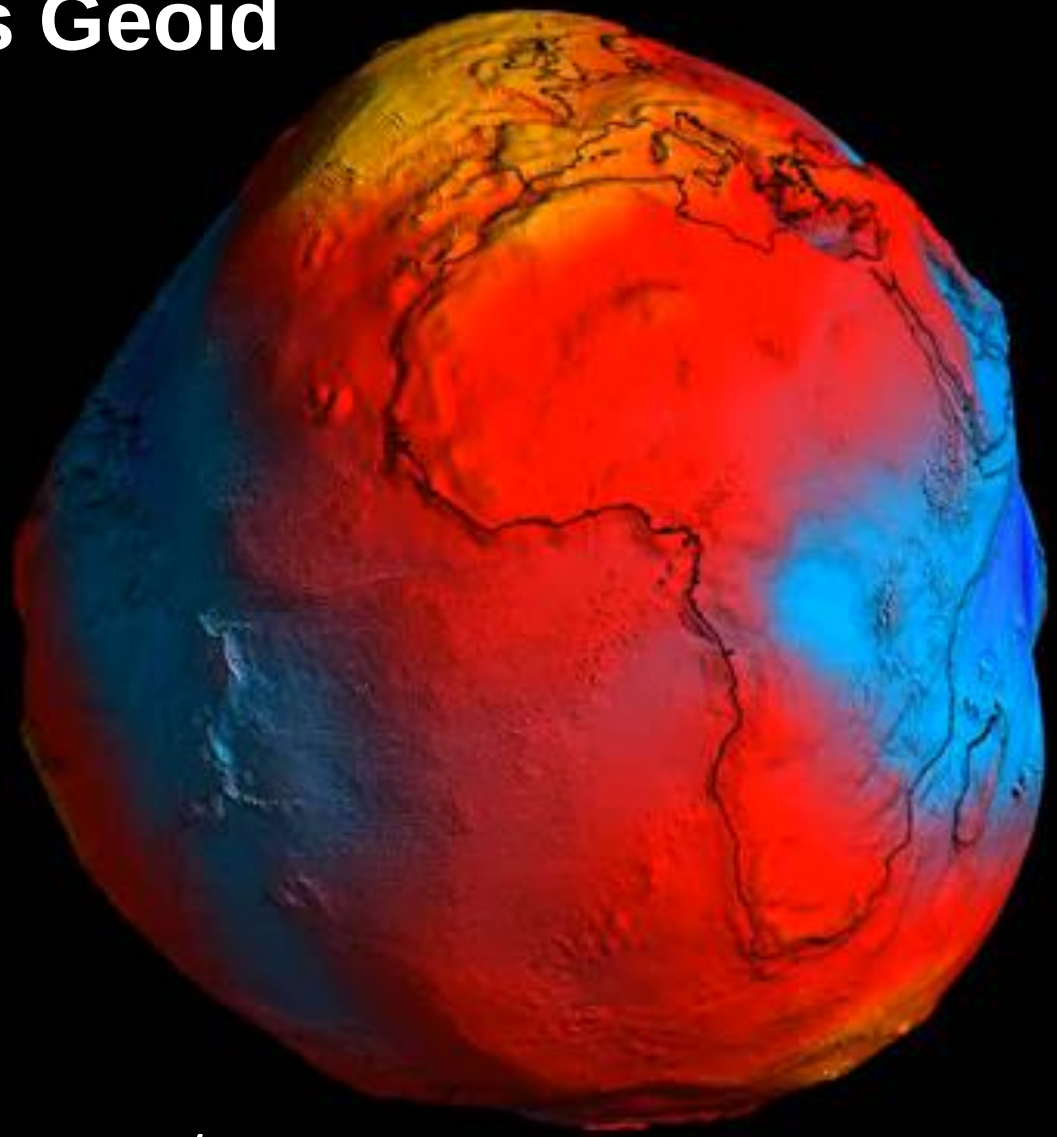
esa

Science: Earth Explorers



Science: Earth Explorers

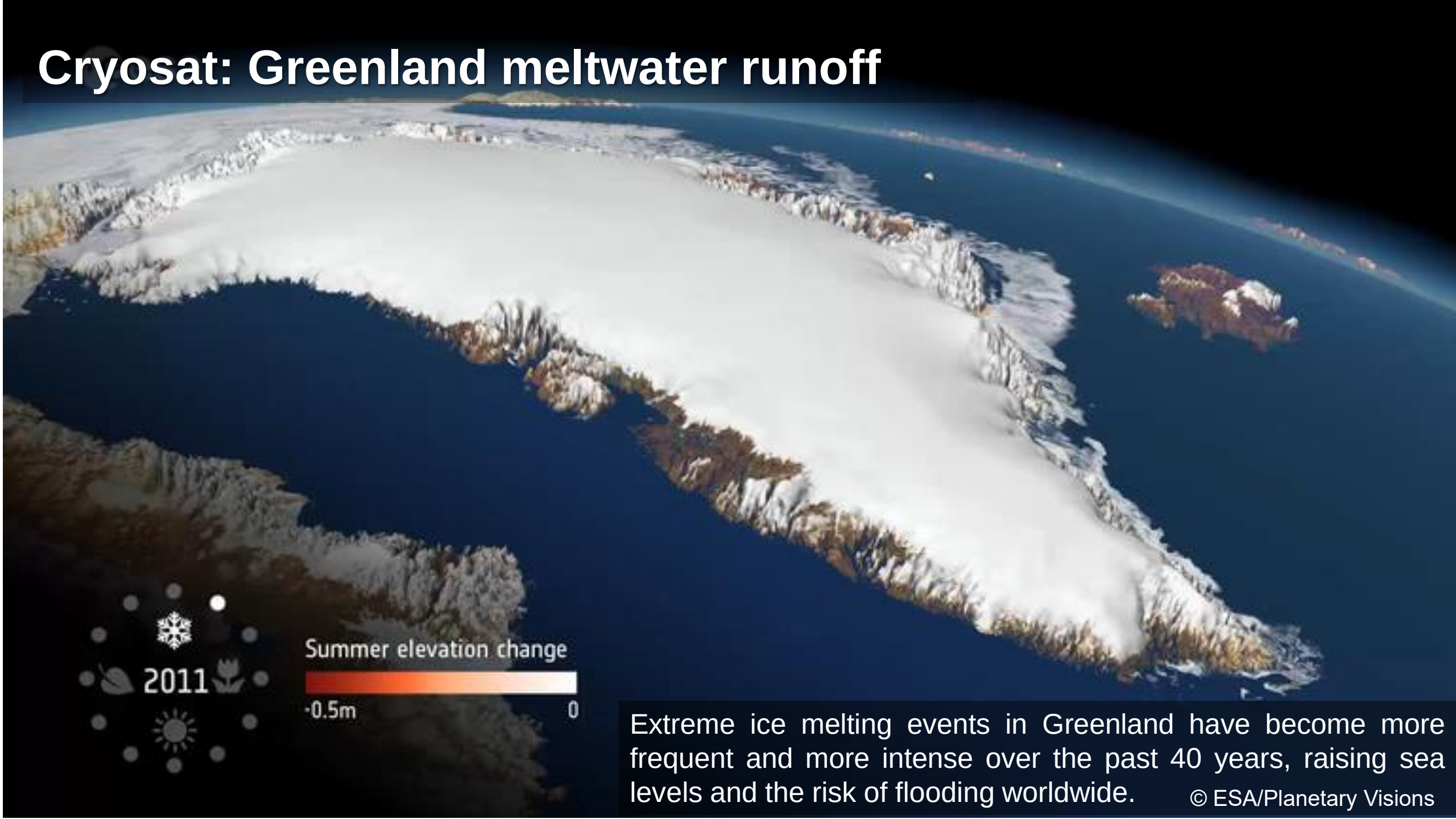
GOCE: Earth's Geoid



- model of the 'geoid' with unprecedented accuracy and spatial resolution
- crucial reference for measuring ocean circulation and sea-level change

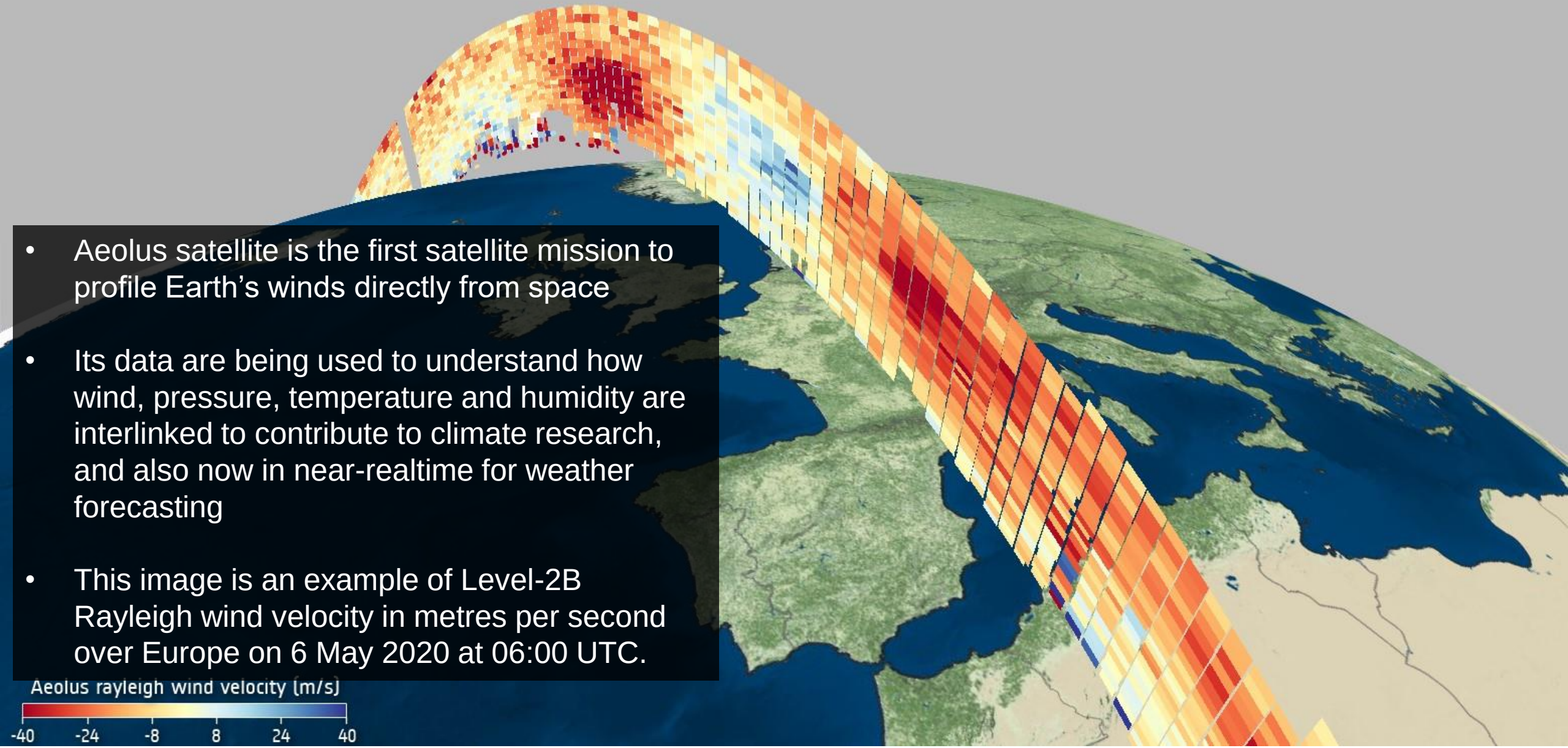
https://visioterra.net/VtGsep/

Cryosat: Greenland meltwater runoff



Extreme ice melting events in Greenland have become more frequent and more intense over the past 40 years, raising sea levels and the risk of flooding worldwide.

Aeolus: Wind profile from Aeolus 6 May 2020



- Aeolus satellite is the first satellite mission to profile Earth's winds directly from space
- Its data are being used to understand how wind, pressure, temperature and humidity are interlinked to contribute to climate research, and also now in near-realtime for weather forecasting
- This image is an example of Level-2B Rayleigh wind velocity in metres per second over Europe on 6 May 2020 at 06:00 UTC.

Future Earth Explorers

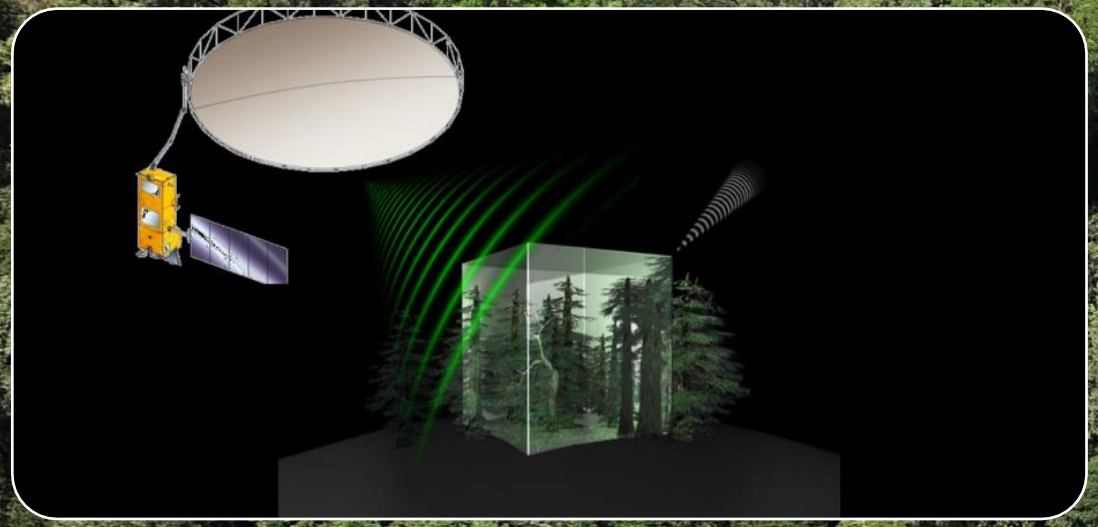
Upcoming Earth Explorers

6

EarthCARE

- Clouds, aerosols & radiation
- High preformance lidar tech.
- Partnership JAXA
- Launch planned 2021

Further Earth Explorers



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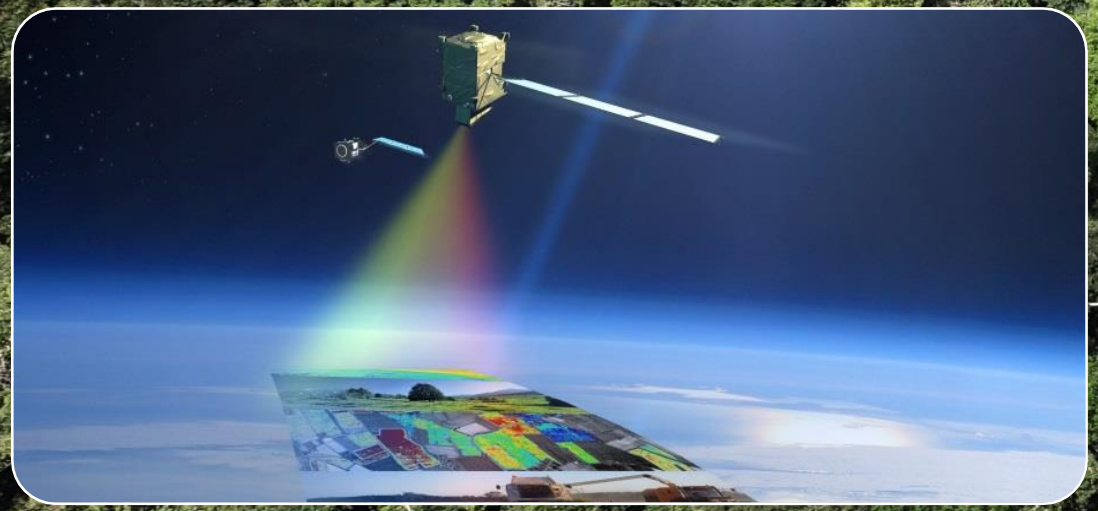
Biomass

- Biomass estimates
- First P-band SAR in space
- Launch planned 2022



8

FLEX

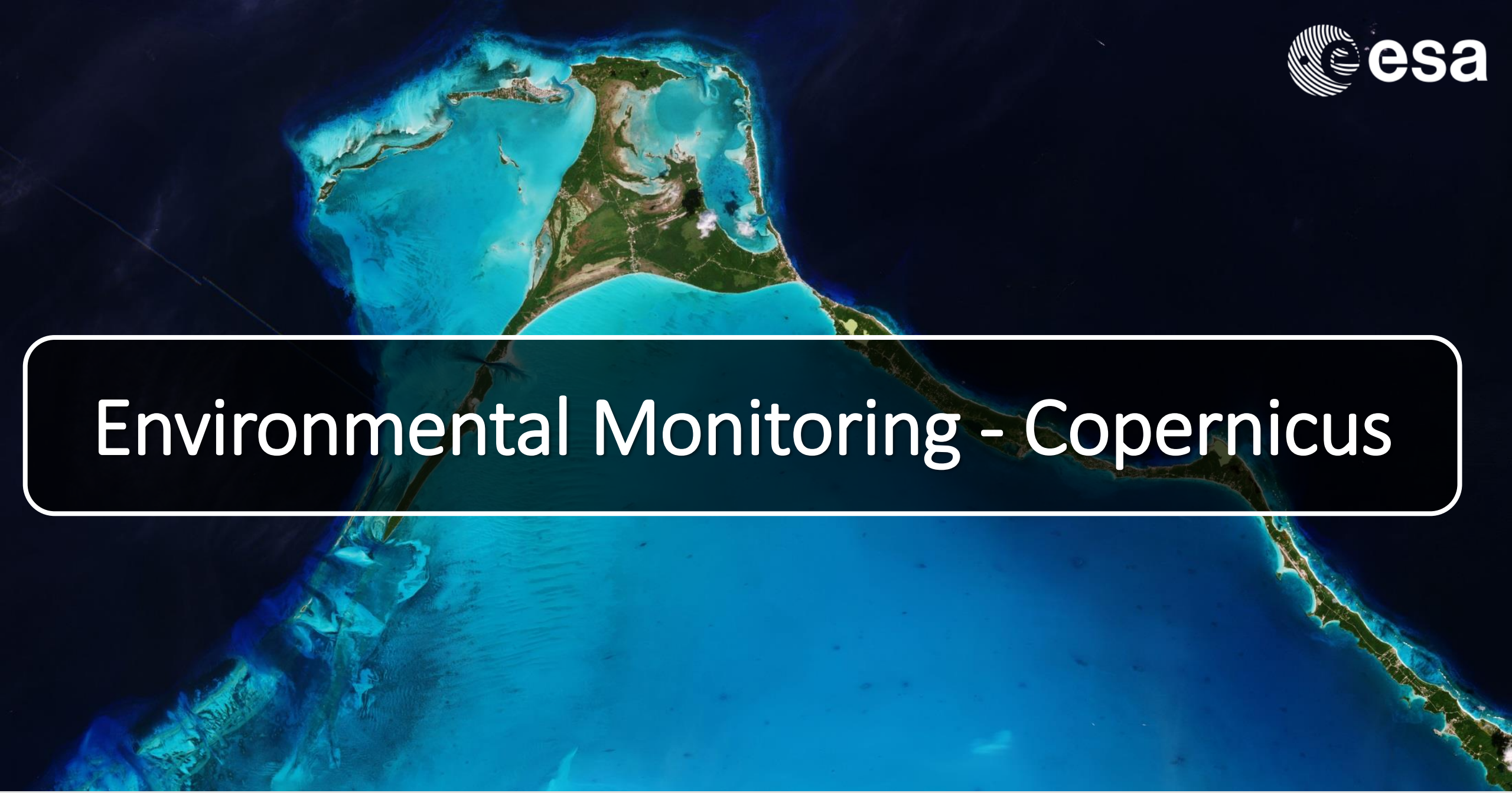
- Vegetation fluorescence, indicator of photosynthesis
- Launch planned 2022

Future missions

12

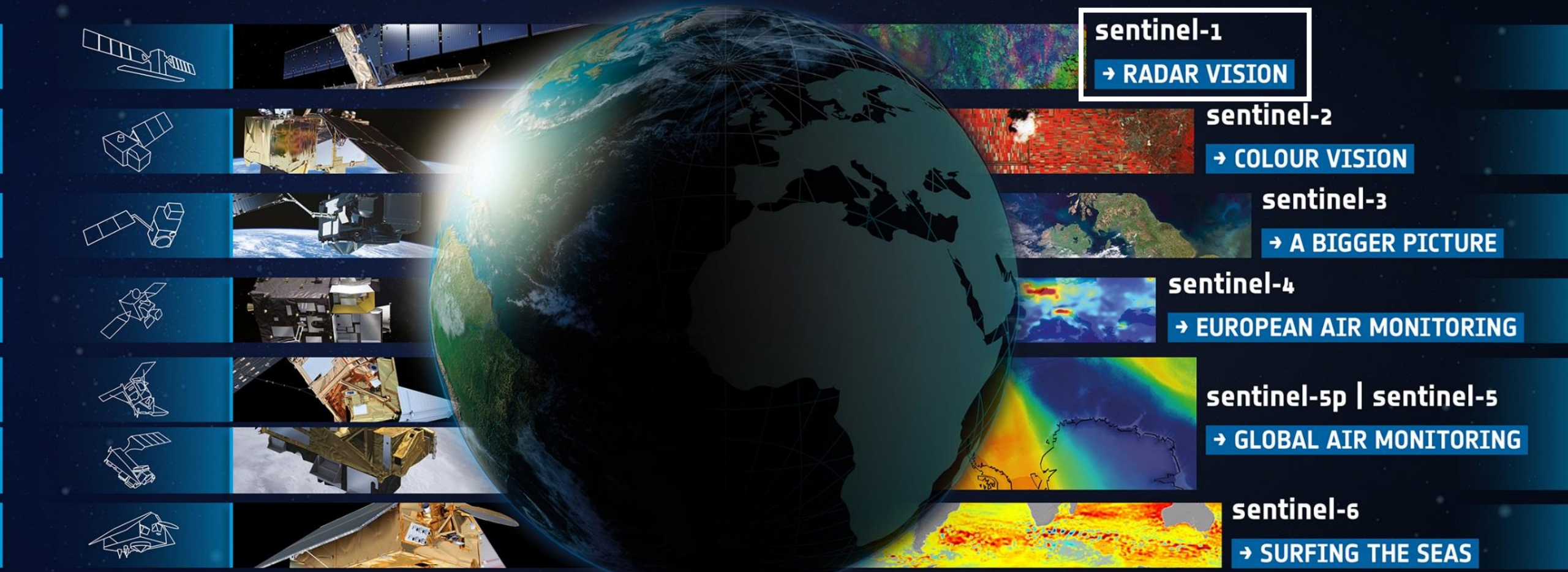
Earth Explorer 12

- A Call for Ideas was issued on 20 February 2023. The deadline to submit a full proposal is 29 September 2023



Environmental Monitoring - Copernicus

Environmental Monitoring: Copernicus Sentinels

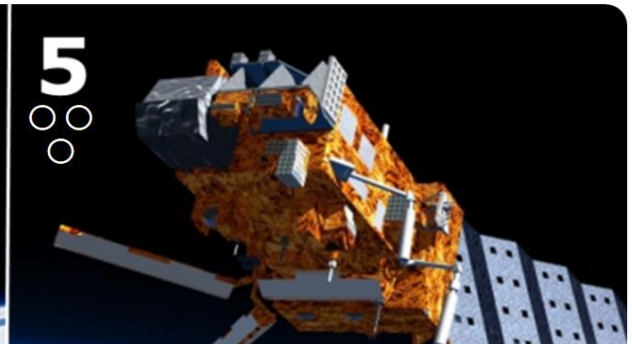


The Big Data Revolution

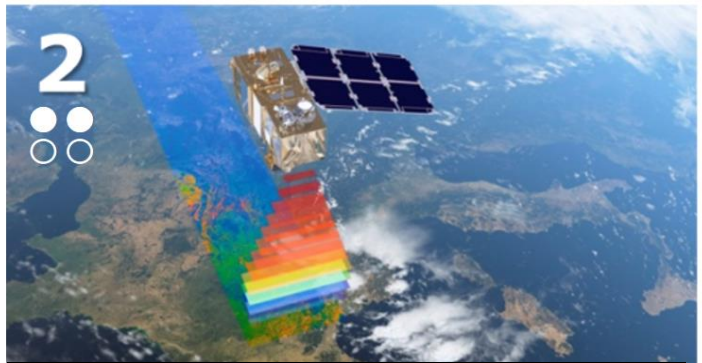
Copernicus is the largest producer of EO data in the world

Sentinel-1 (A/B) – SAR imaging
All weather, day/night applications, interferometry

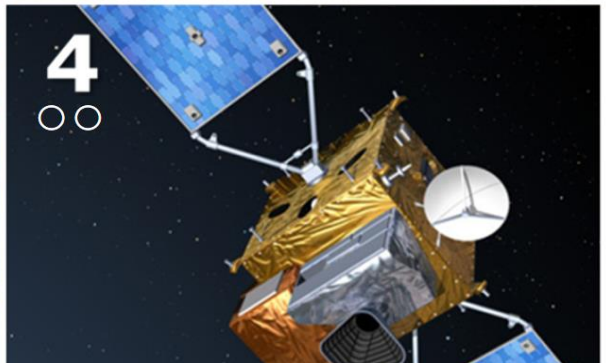
Sentinel-3 (A/B) – Ocean and global land monitoring



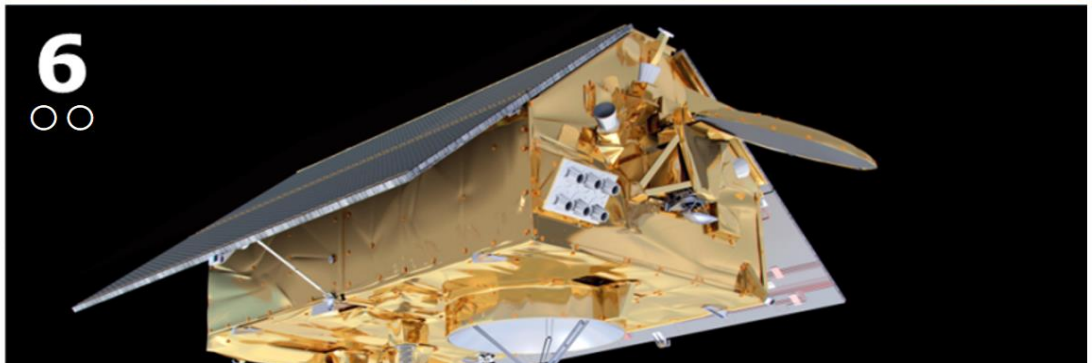
Sentinel-5 precursor/ Sentinel-5 (A/B) – Low Earth-orbit
Atmospheric composition monitoring



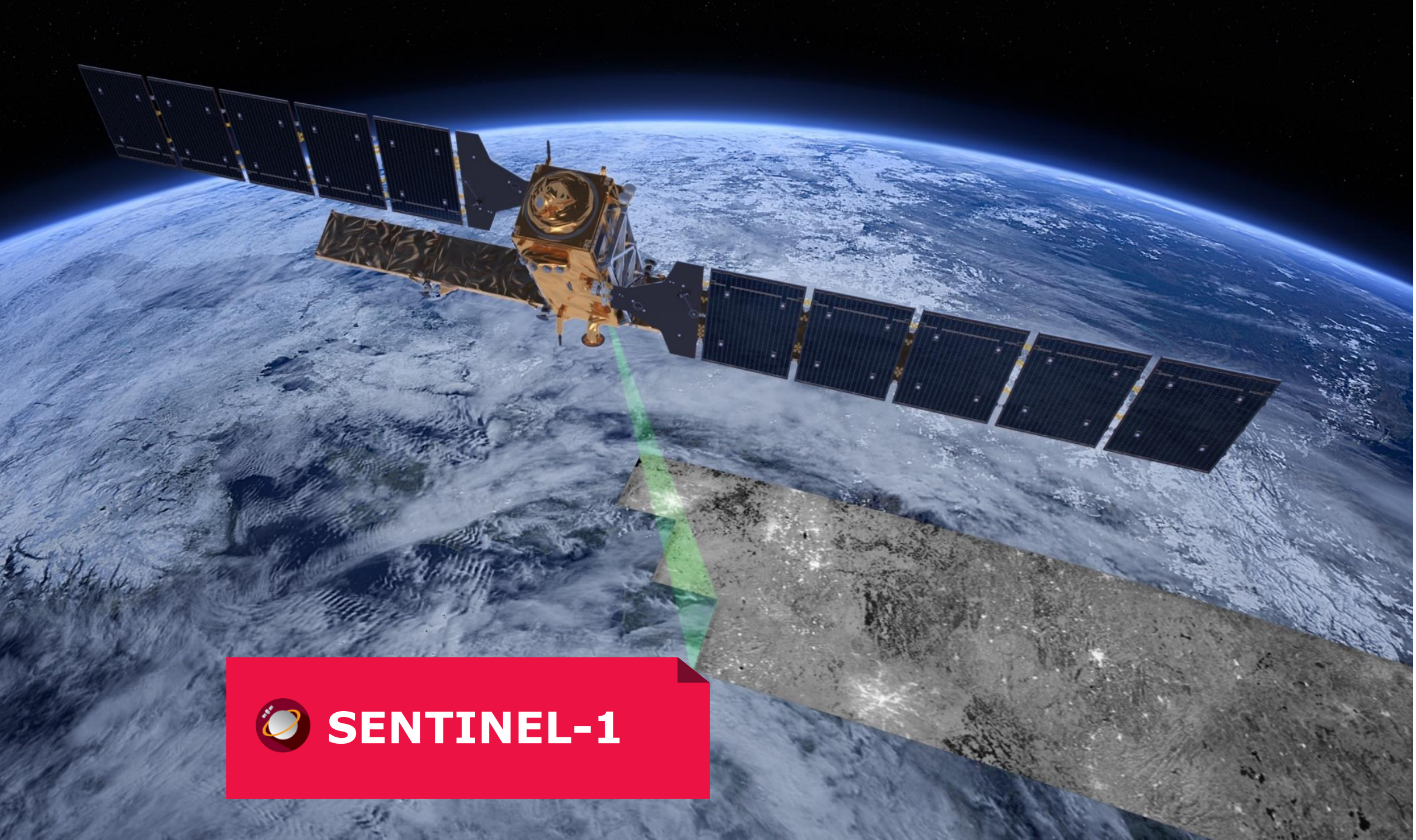
Sentinel-2 (A/B) – Multi-spectral imaging, Land applications: urban, forest, agriculture,…



Sentinel-4 (A/B) – Geostationary atmospheric

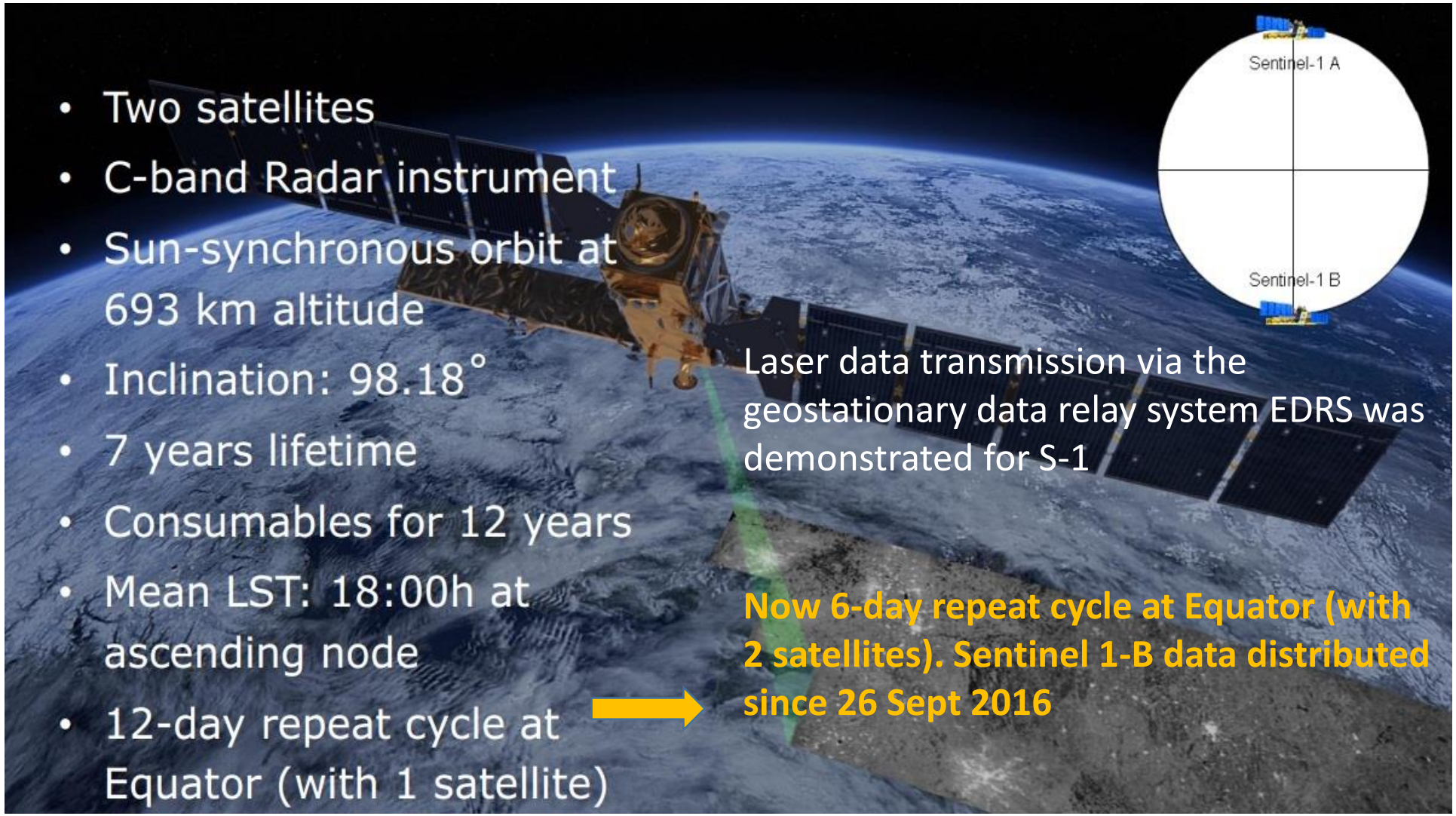


Sentinel 6 - Jason-CS (A/B) – Low inclination Altimetry
Sea-level, wave height and marine wind speed


SENTINEL-1

Sentinel-1

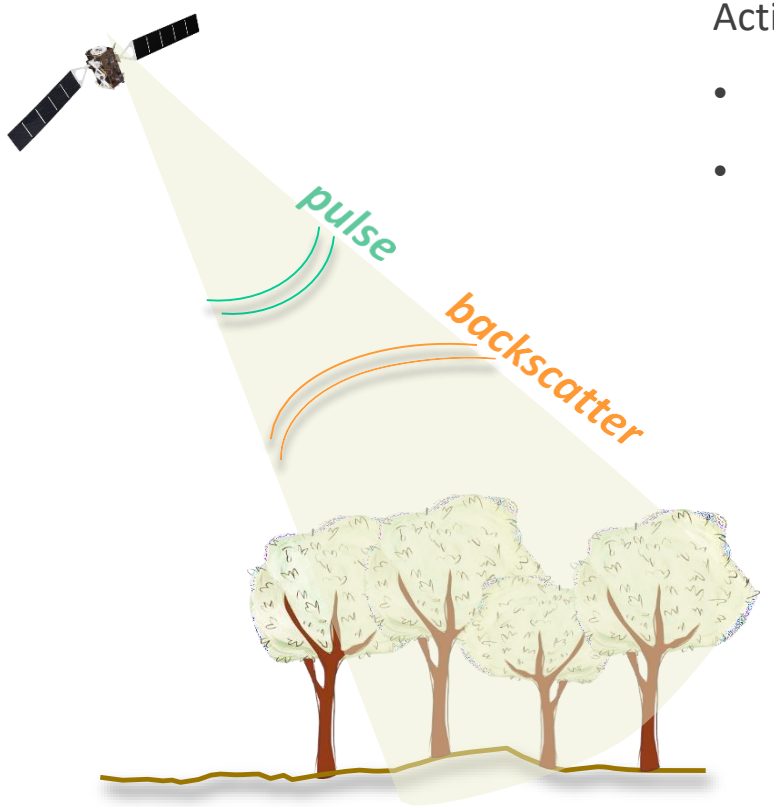
Mission Overview



Active Radar Remote Sensing

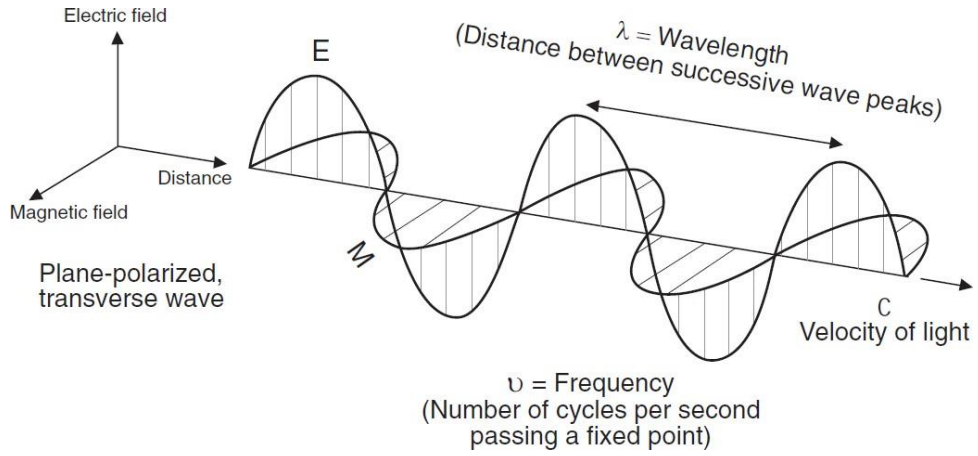
Basic characteristics of radar systems/SAR sensors

- **active** $\Rightarrow$ **independent of sun illumination**



Active remote sensing sensors generate EM-waves

- no sunlight required night time acquisitions possible
- no problems due to bad illumination

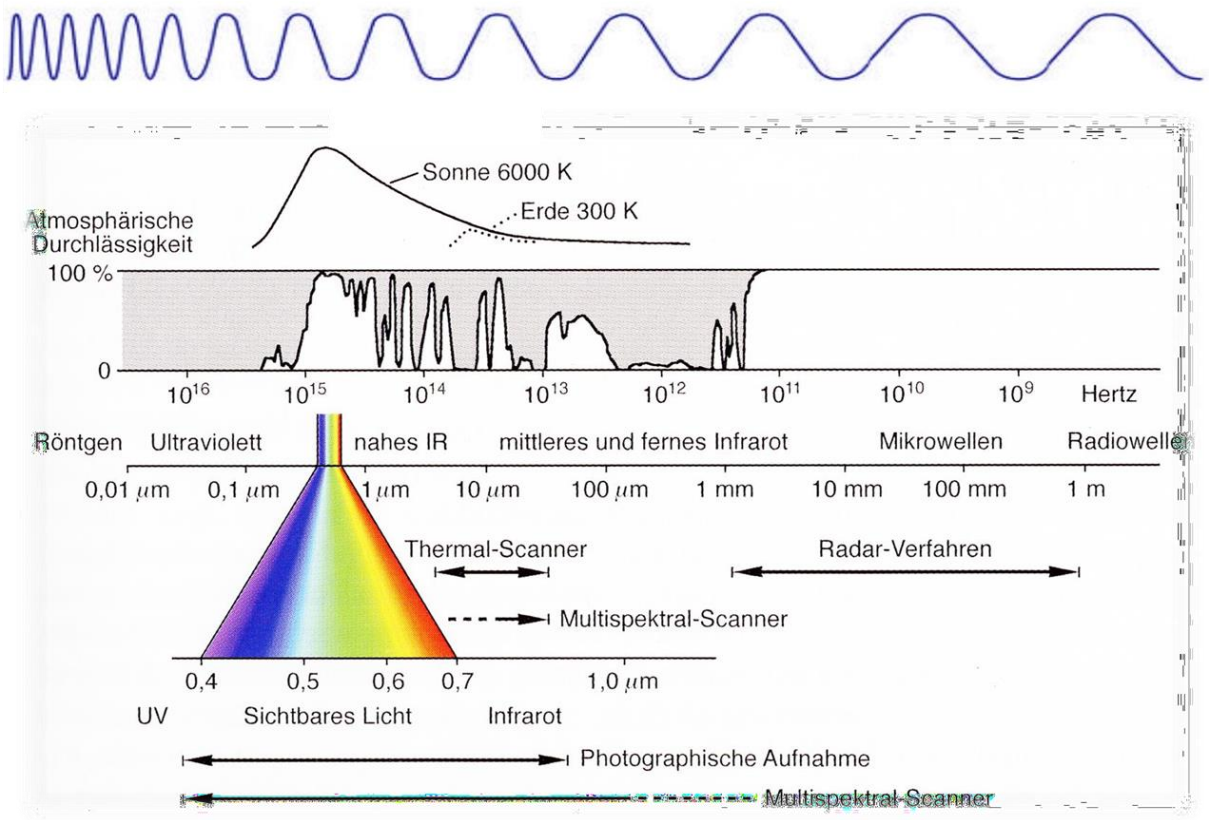


Active Radar Remote Sensing

Basic characteristics of radar systems/SAR sensors

- **active** $\Rightarrow$ **independent of sun illumination**

electromagnetic spectrum



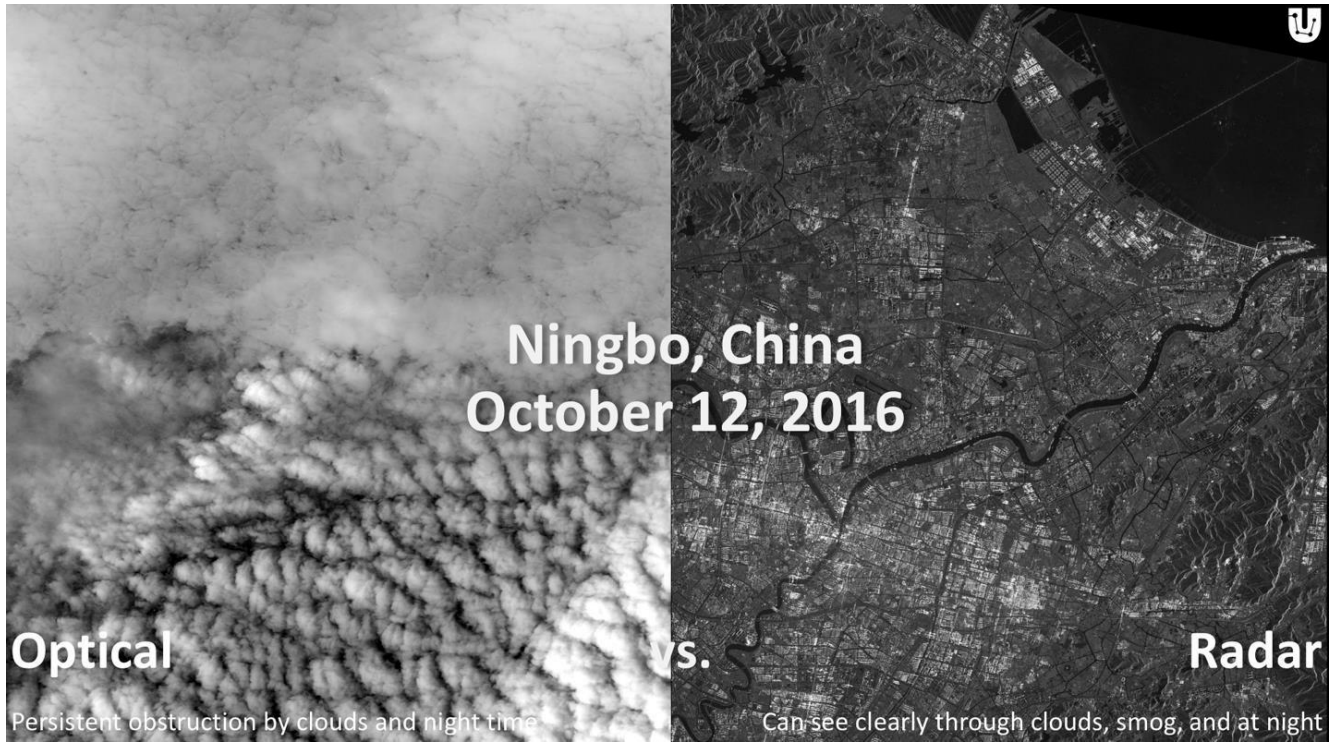
Active Radar Remote Sensing

Basic characteristics of radar systems/SAR sensors

- active ⇒ independent of sun illumination
- **microwave** ⇒ **penetrates into/through objects**

  clouds and (partially) canopy, soil, snow

  (almost) no problems with clouds, dust, fog. Sensing of „hidden“ objects

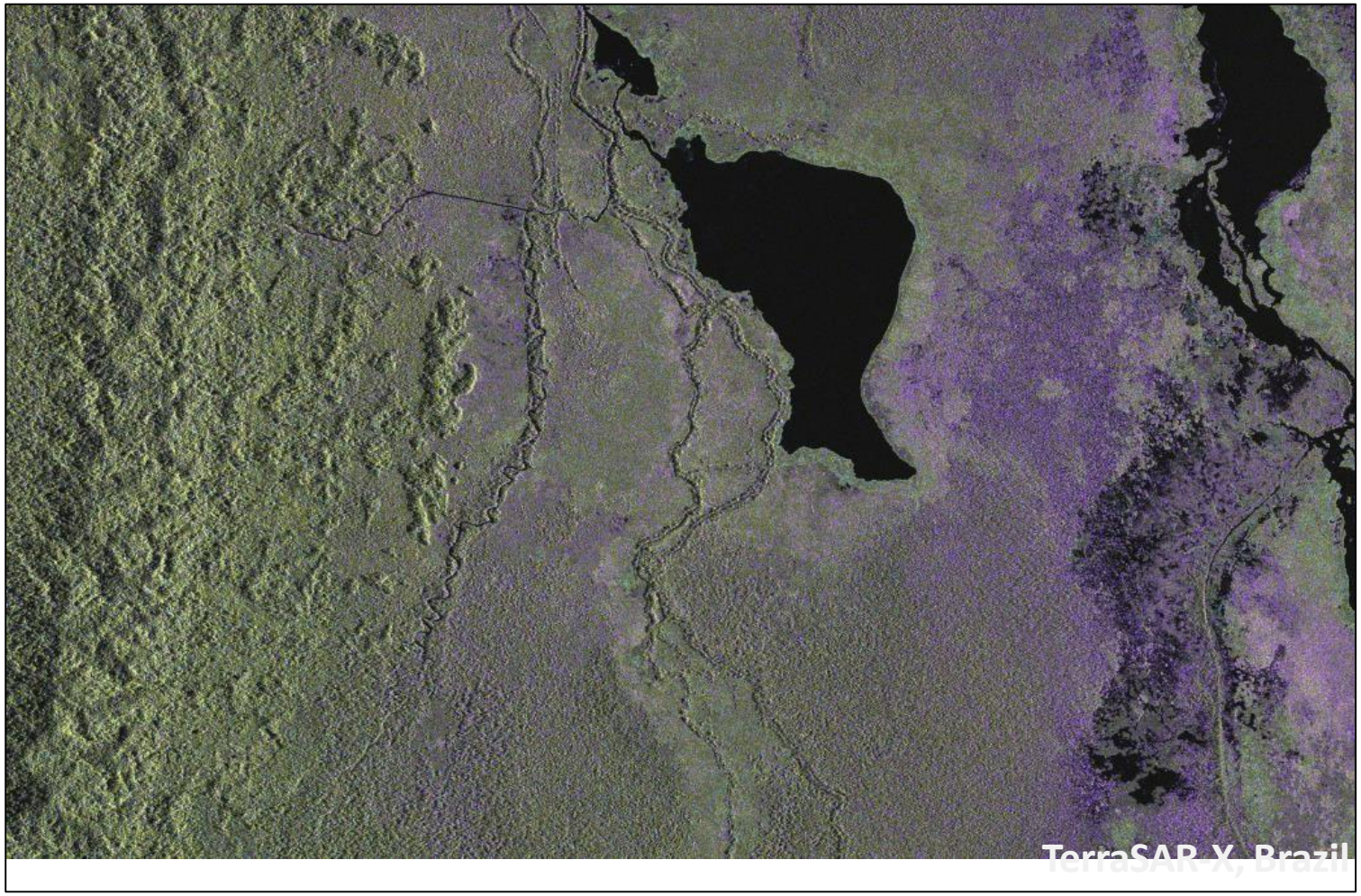


https://ubique.americangeo.org/company-and-not-for-profit-spotlights/ursa-space-systems/

Active Radar Remote Sensing

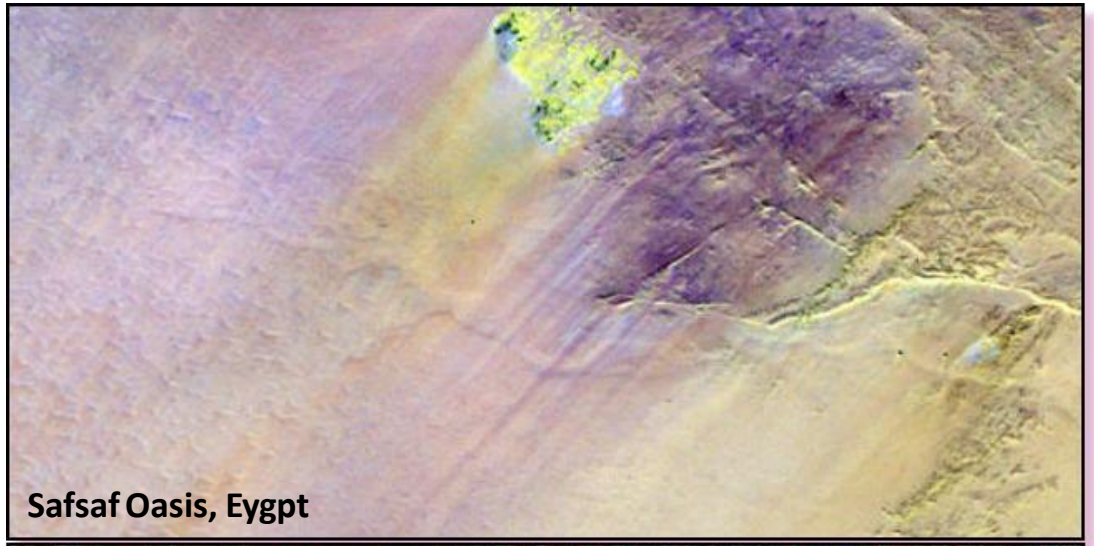
Characteristics / Example all weather

Cloud cover is a big problem in remote sensing of moist tropics

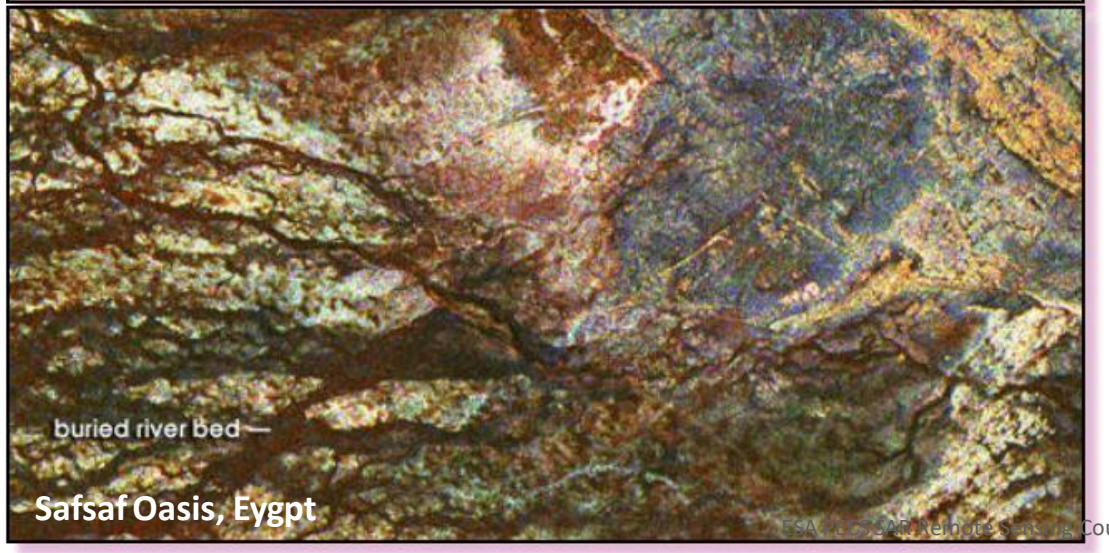


Active Radar Remote Sensing

Characteristics / penetration through sand



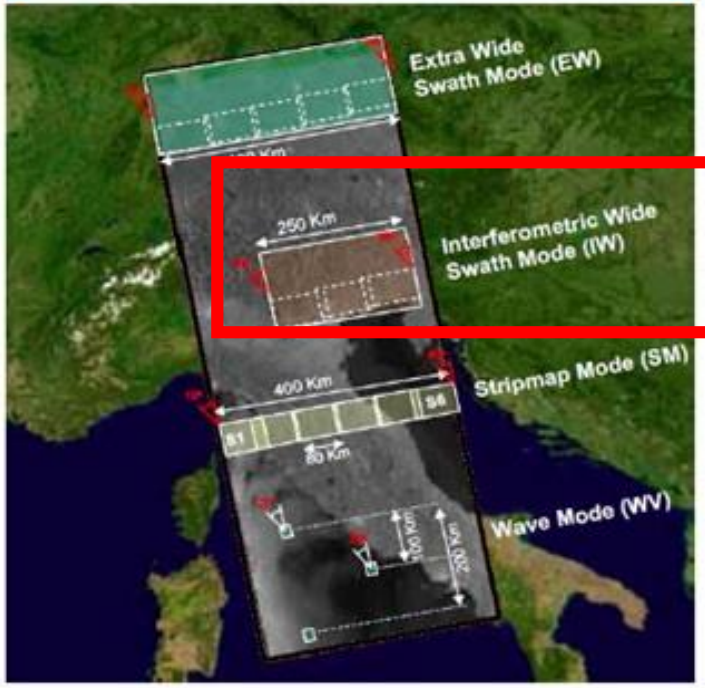
Landsat Thematic Mapper
shows the desert's surface



SIR-C/X-SAR
shows what the landscape might look like if stripped bare of sand

Sentinel-1

SAR Operational Modes



Resolution	Swath Width	Polarisation
20 x 40 m²	> 400 km	HH+HV or VV+VH
5 x 20 m²	> 250 km	HH+HV or VV+VH
5 x 5 m²	> 80 km	HH+HV or VV+VH
5 x 5 m²	20 x 20 km² at 100 km spacing	HH or VV

- **Daily coverage of high priority areas, e.g. Europe, Canada, shipping routes**

Main modes of operations:

- **IW over land and coastal waters (normally VV or VV-VH polarization)**
- **EW over extended sea (VV or VV-VH) and sea-ice (HH or HH-HV) areas**
- **WV over open oceans**

Copernicus

Active Radar Remote Sensing

Advantages / Example all weather

- active ⇒ independent of sun illumination
- **microwave** ⇒ **penetrates into/through objects**

The penetration depth is depending on **wavelength** and **dielectric characteristics** of objects

wavelengths:

X-band: 3 cm
C-band: 6 cm
L-band: 23 cm

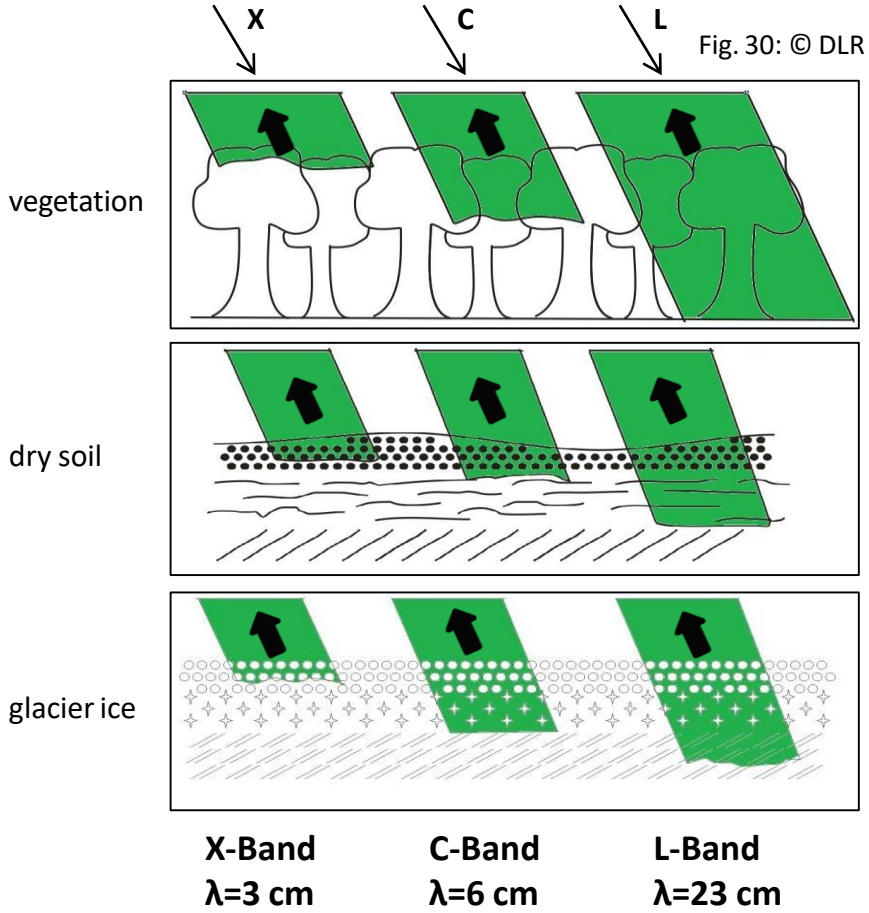


Fig. 30: © DLR

Geometric Effects in SAR images

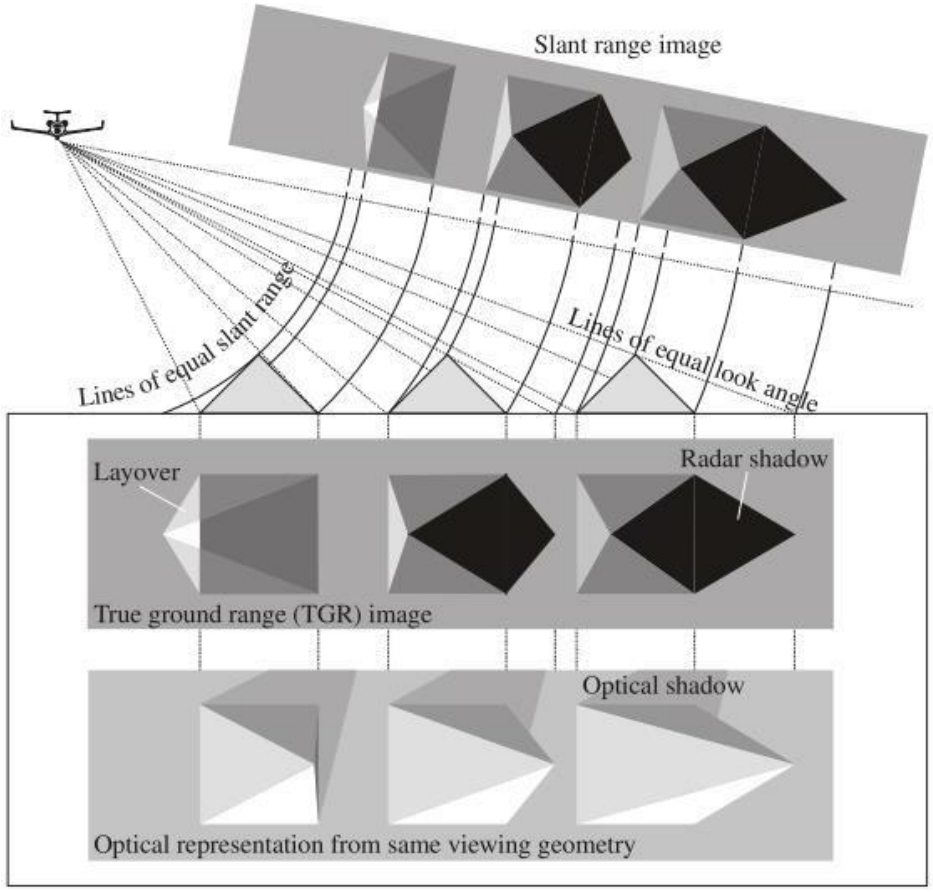
Effects of side-looking geometry

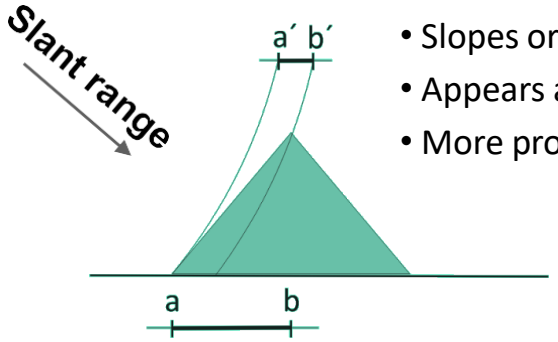
→ The mapping of a radar image is contrary to the intuitive mapping of an optical image

→ Side looking geometry of SAR systems cause some typical geometric effects

- Controlled by:
  - ❖ Incidence angle
  - ❖ Topography

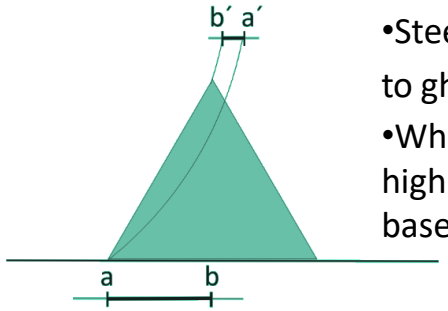
- The effects are:
  - ❖ Foreshortening
  - ❖ Layover
  - ❖ Radar shadow





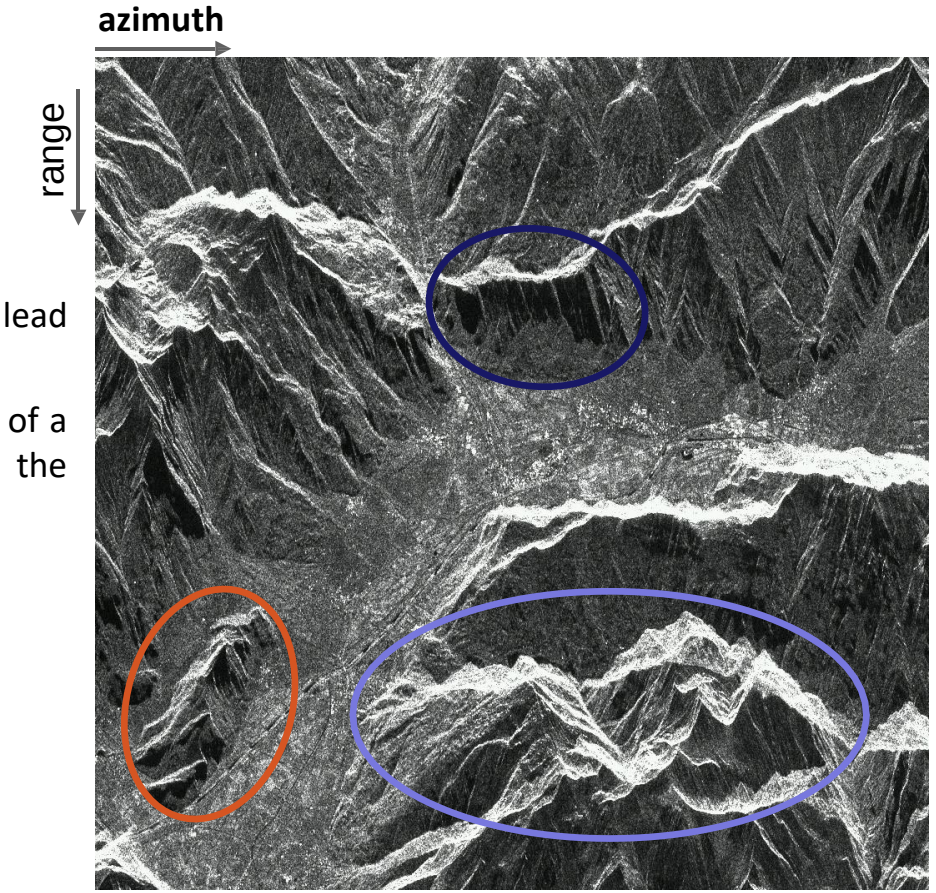
Foreshortening

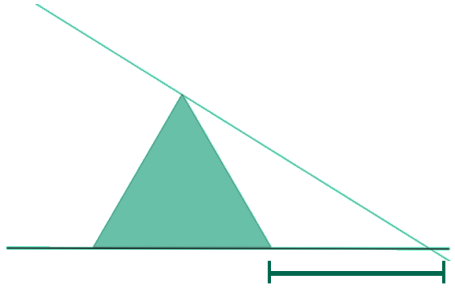
- Slopes oriented to the SAR appear compressed (Distance between a and b is shortened)
- Appears as very bright area
- More pronounced in near range (small incidence angle) than in far range (high incidence angles)



Layover

- Steep slopes oriented to the SAR lead to ghost images
- When radar beam reaches the top of a high feature (b) before it reaches the base (a)



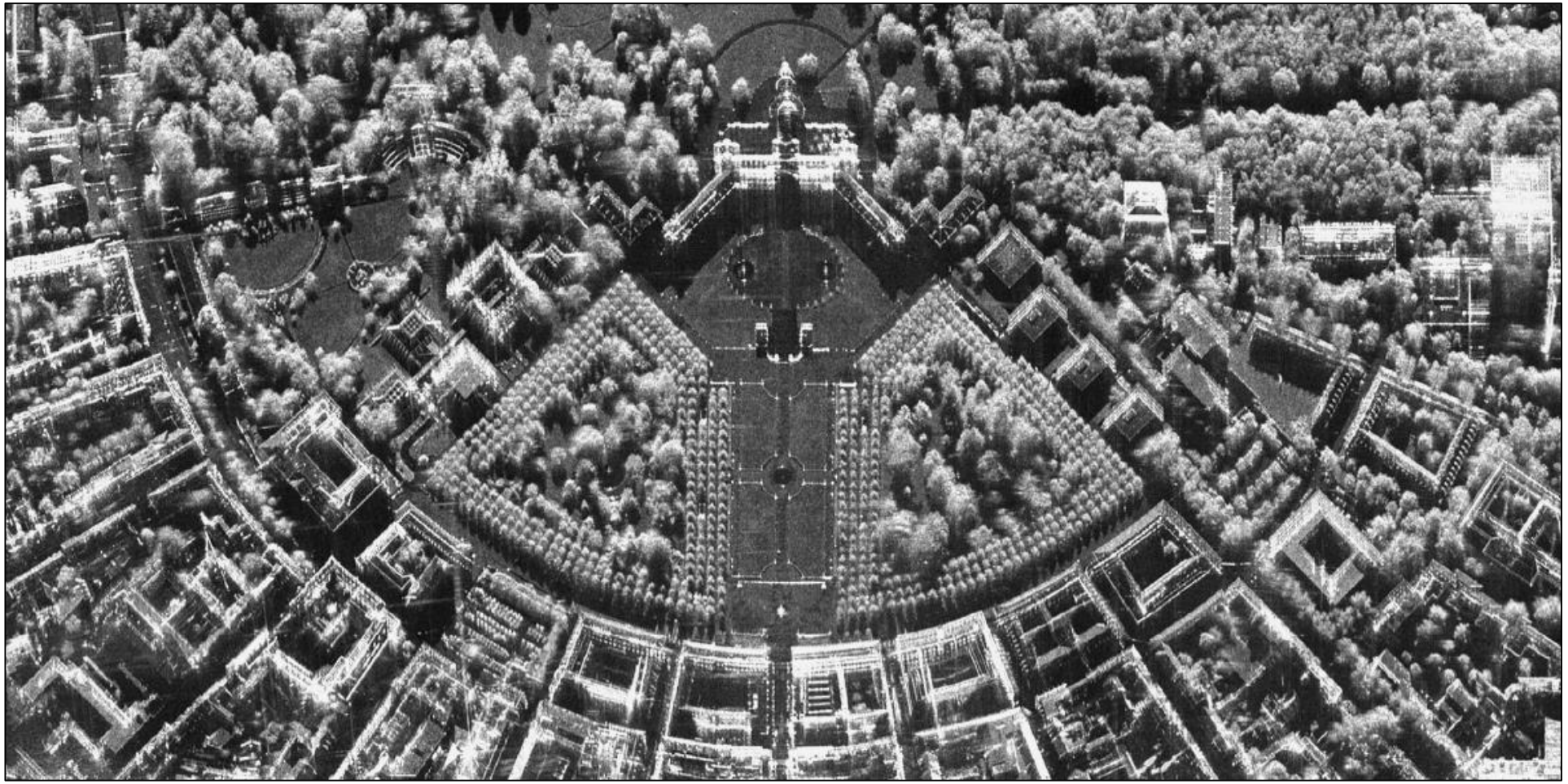


Radar shadow

- Steep slopes oriented away from the SAR return no signal
- No signals can be transmitted to this area (as it is blocked by the slope)
- Thus no signals can be scattered back from these areas
- Appears as black area in the image

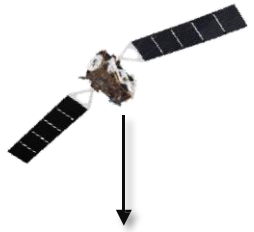
SAR Data Example

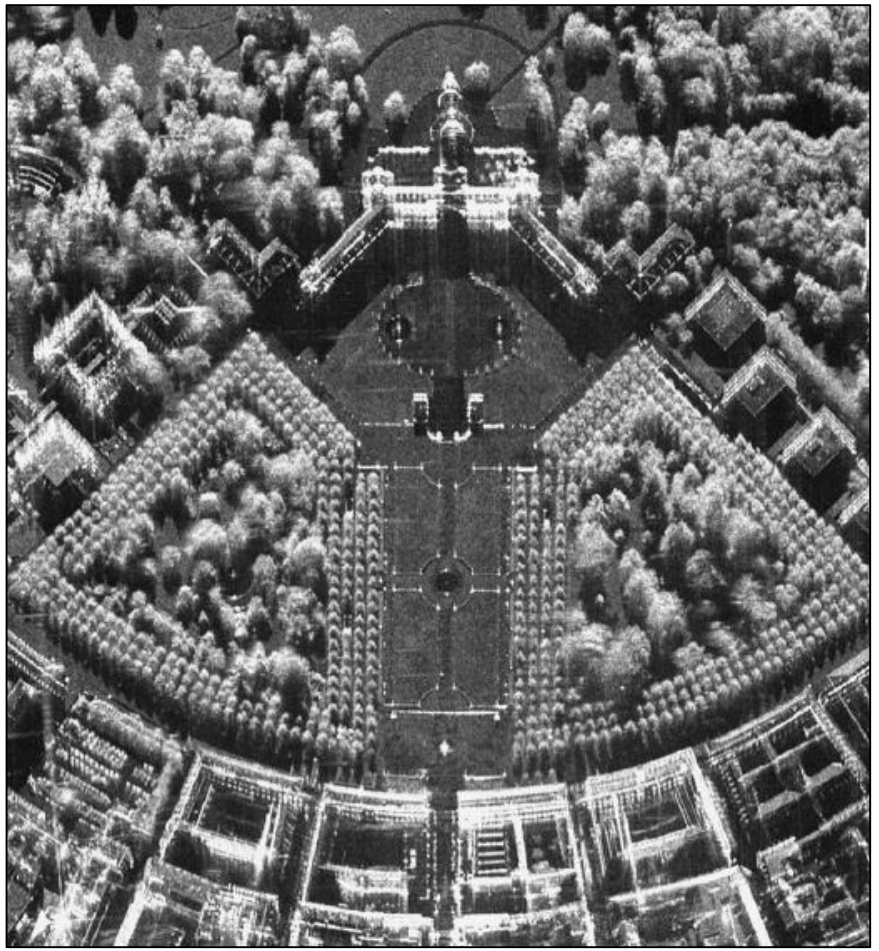
Effects of side-looking geometry



Andreas R. Brenner and Ludwig Roessing, Radar Imaging of Urban Areas by Means of Very High-Resolution SAR and Interferometric SAR, IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 46, NO. 10, OCTOBER 2008 (X-band)

SAR Data Examples

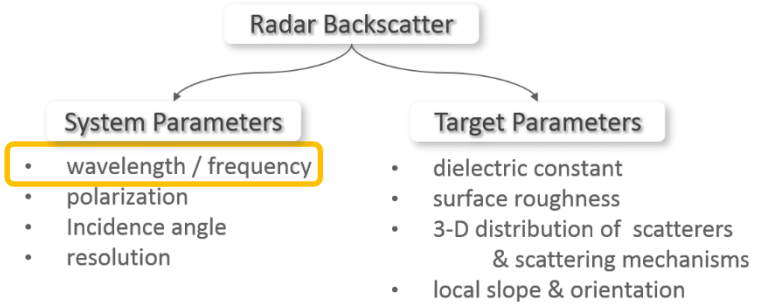


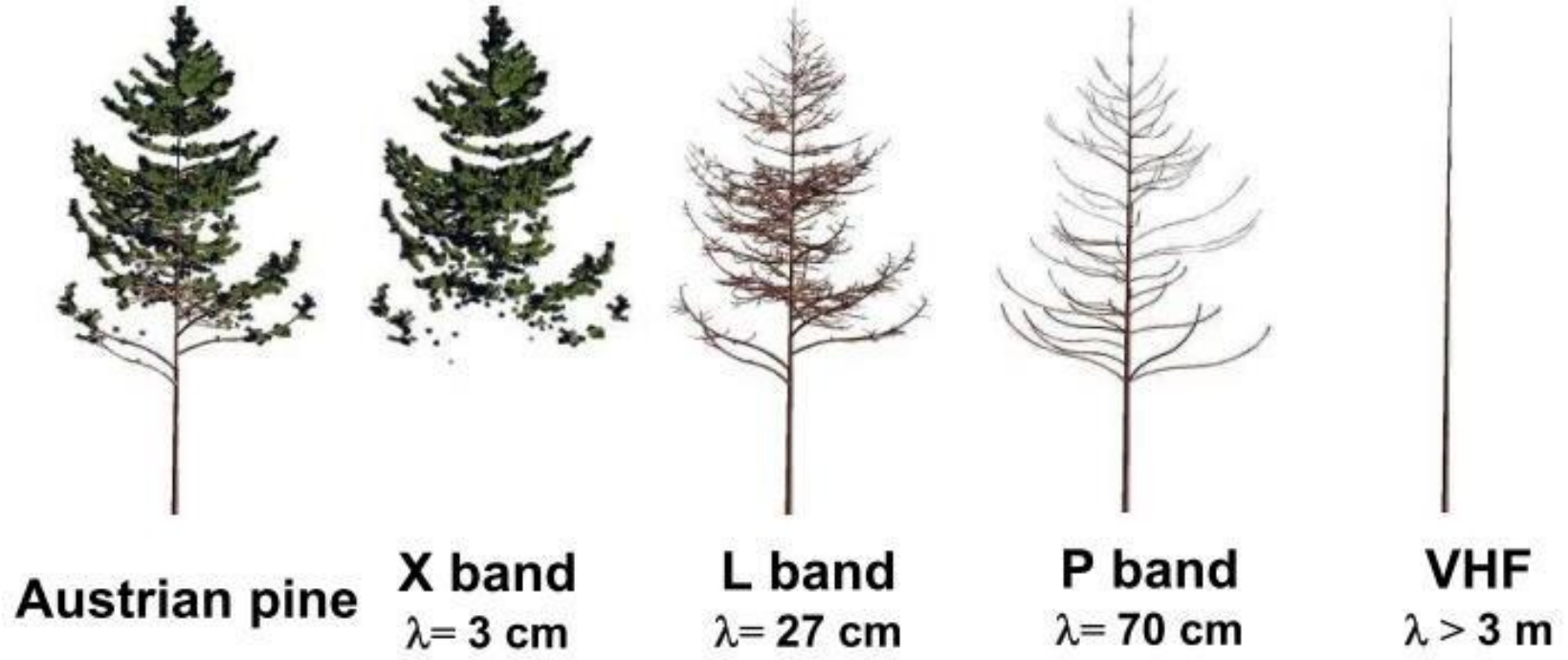


GoogleMaps

Influences on radar backscatter

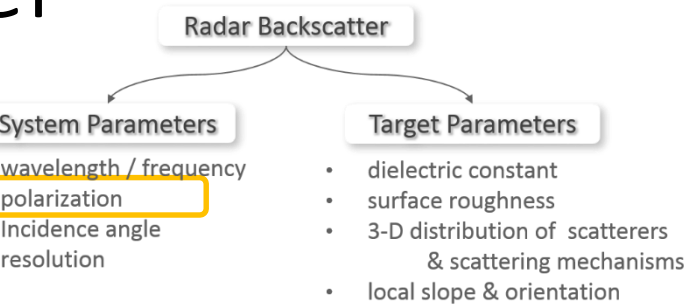
System parameters : Wavelength/Frequency

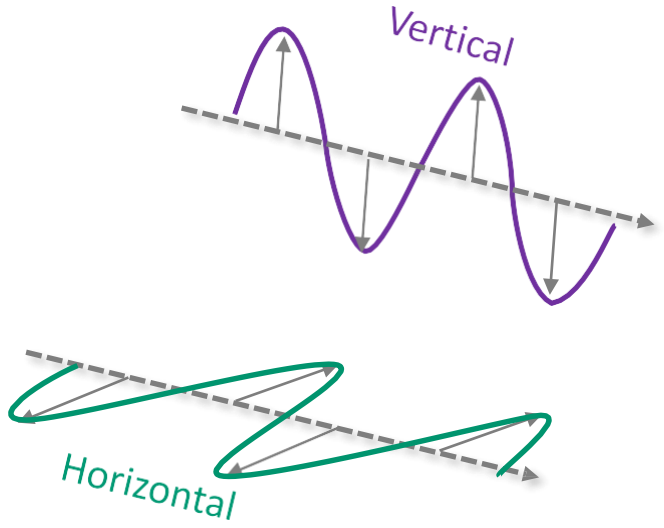




Influences on radar backscatter

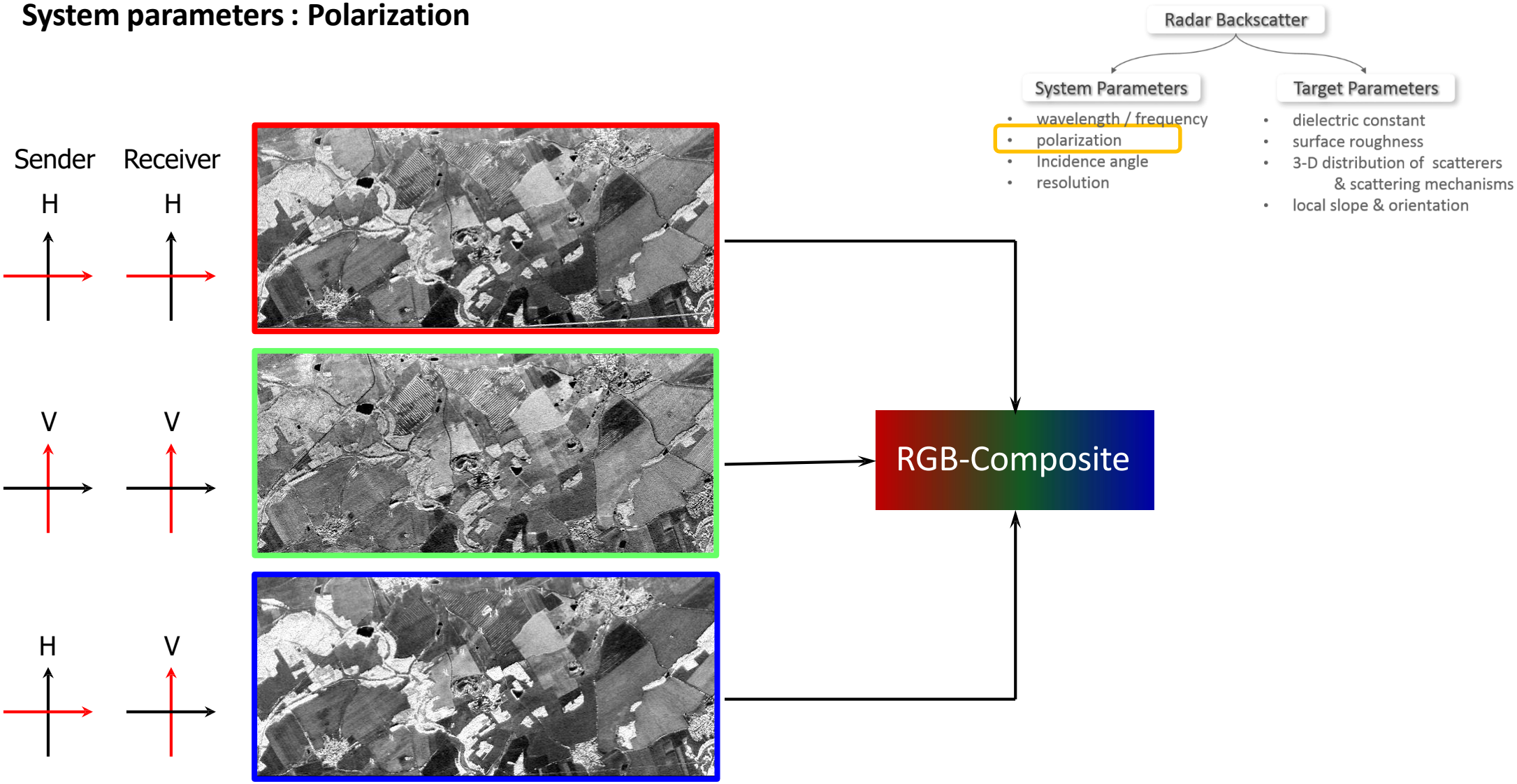
System parameters : Polarization

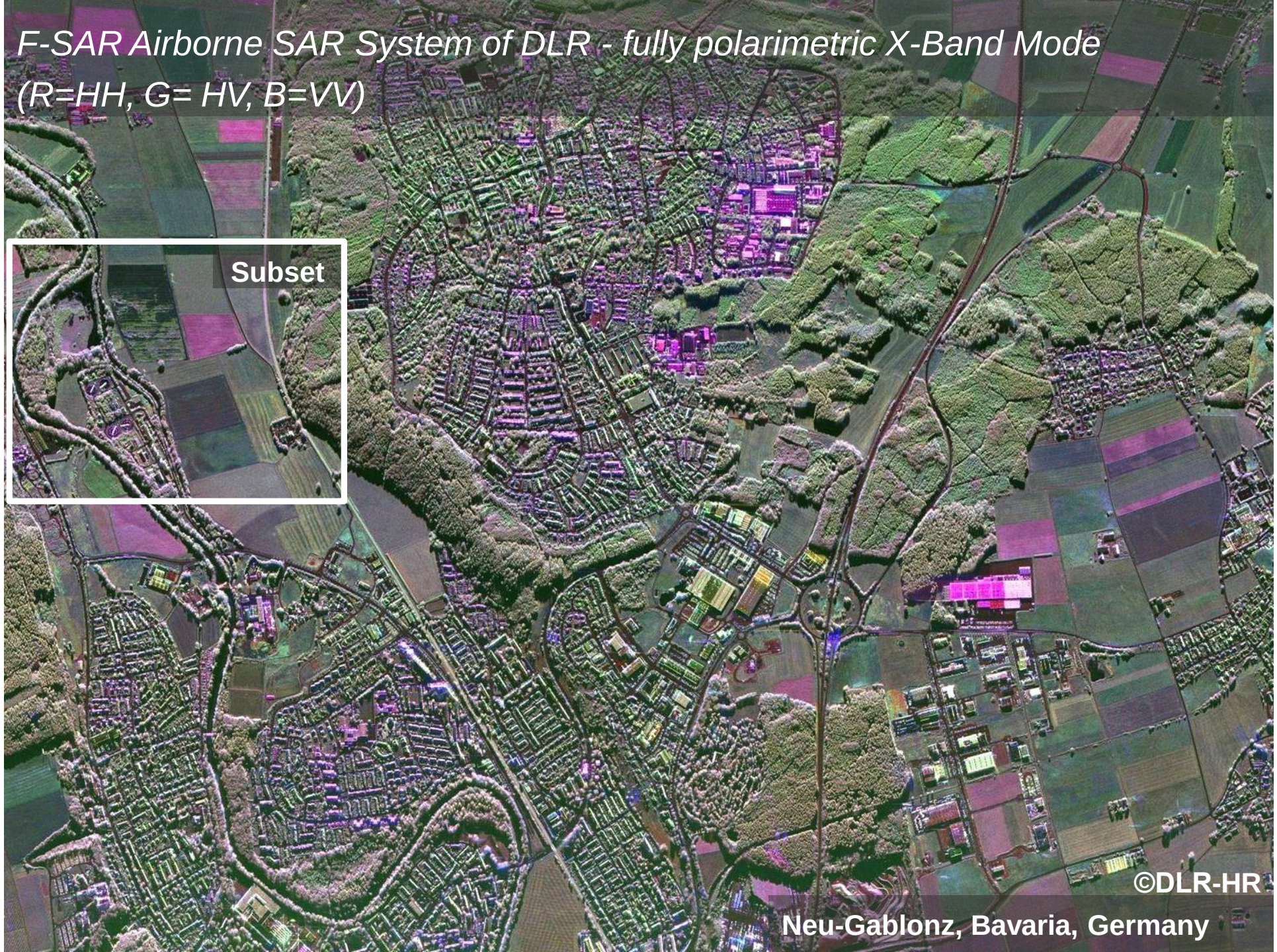


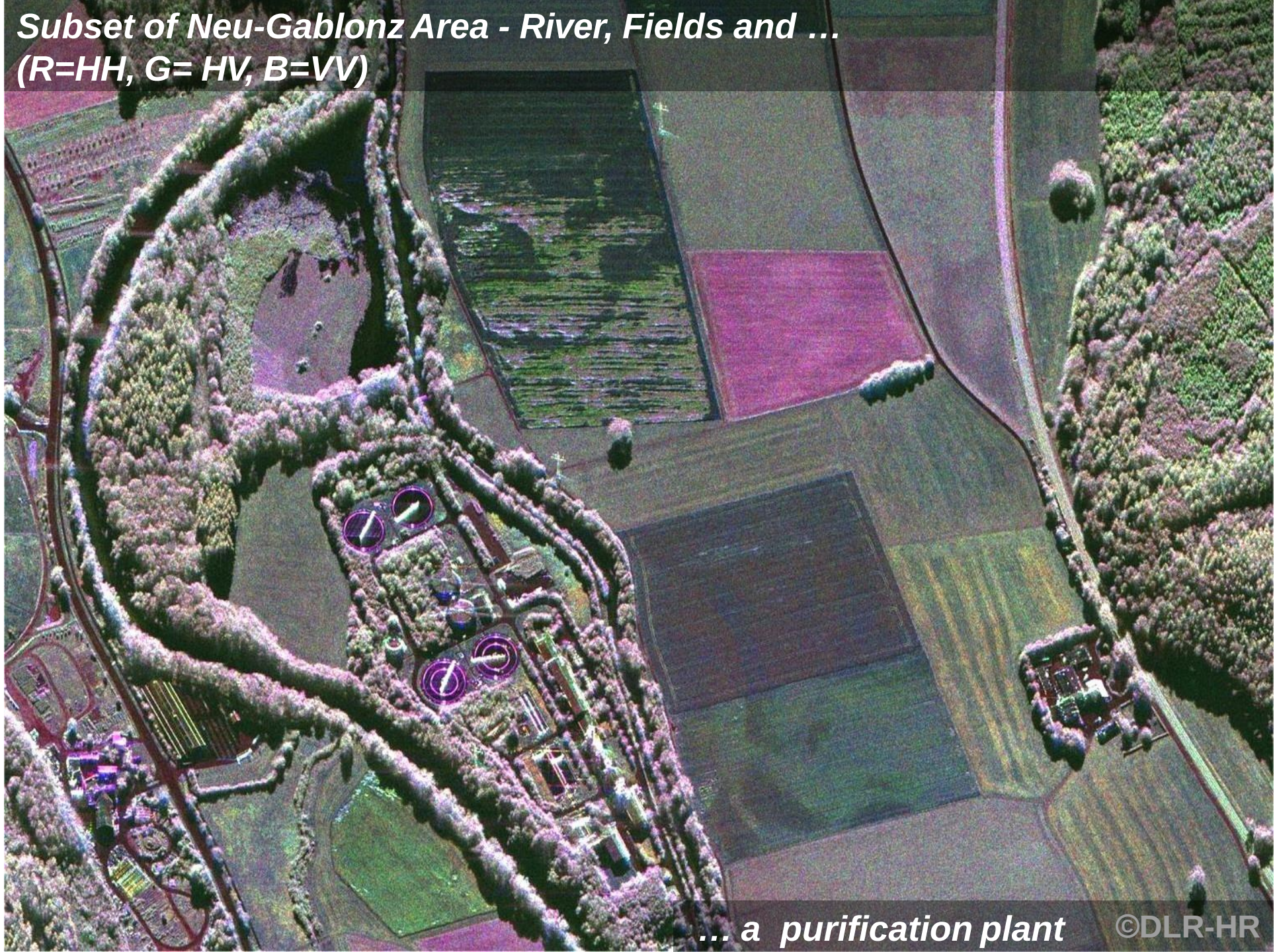


Influences on radar backscatter

System parameters : Polarization

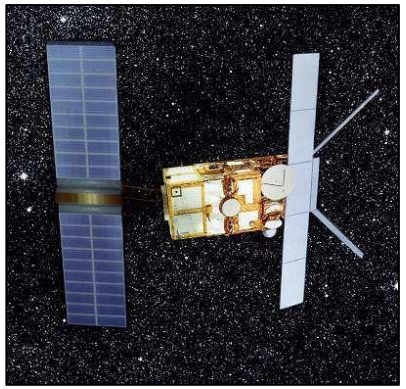



F-SAR Airborne SAR System of DLR - fully polarimetric X-Band Mode
(R=HH, G= HV, B=VV)
Subset
©DLR-HR
Neu-Gablonz, Bavaria, Germany


Subset of Neu-Gablonz Area - River, Fields and …
(R=HH, G= HV, B=VV)
… a purification plant
©DLR-HR

Active Radar Remote Sensing

Examples of satellite based radar sensors

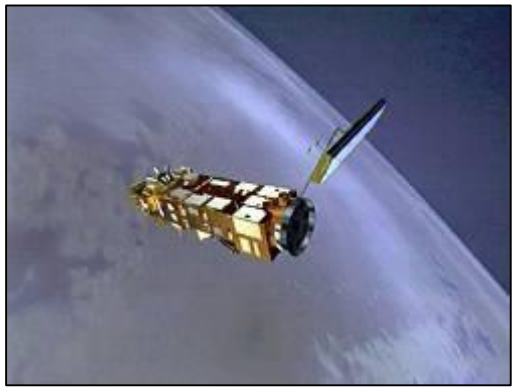


ERS-1, 2

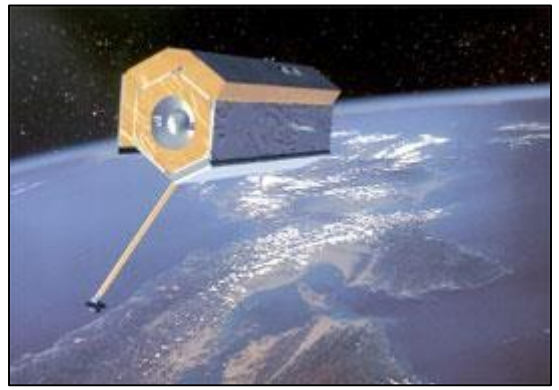
JERS-1

Radarsat 1, 2

ALOS (PALSAR)

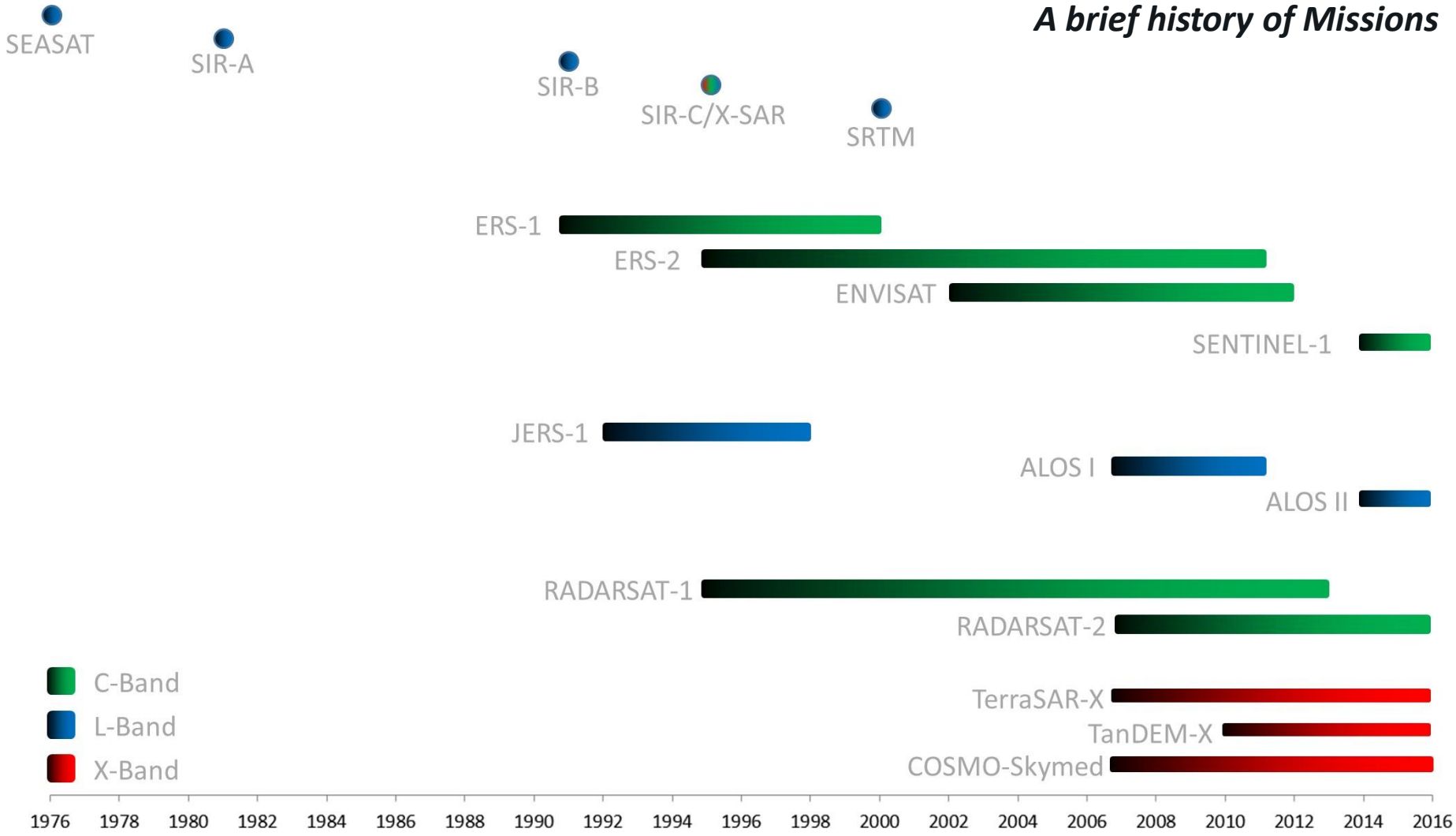


Envisat (ASAR)



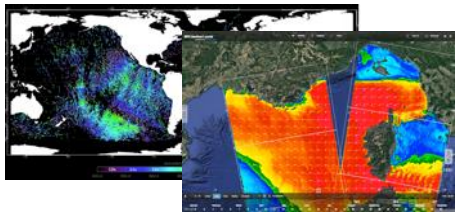
TerraSAR-X

Active Radar Remote Sensing



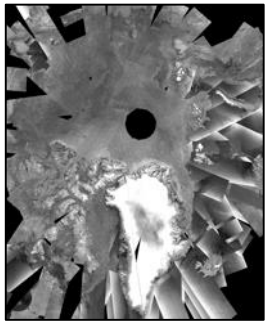
Sentinel-1 applications → ever increasing

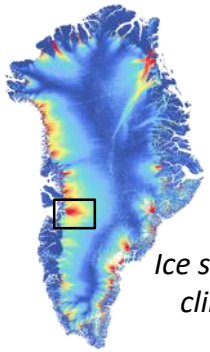
Maritime surveillance: oil spill monitoring, ship detection, illegal fisheries, etc.



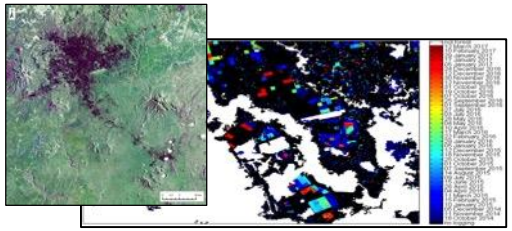
Sea state: wind, wave

Sea ice and iceberg monitoring

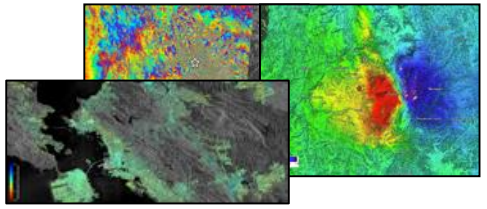




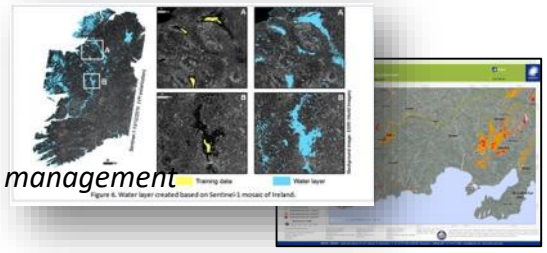
Ice sheets, glaciers, climate change



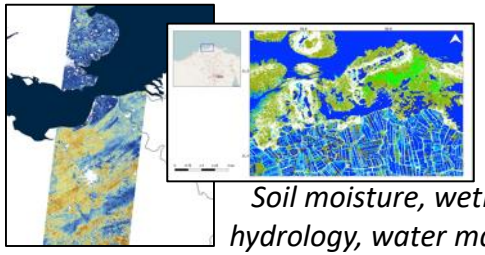
Land use, agriculture, forestry, logging, land classification, urban planning



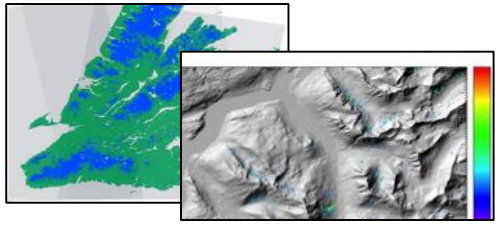
Ground deformation: subsidence, landslides, earthquakes, volcanoes, infrastructure monitoring



Emergency management



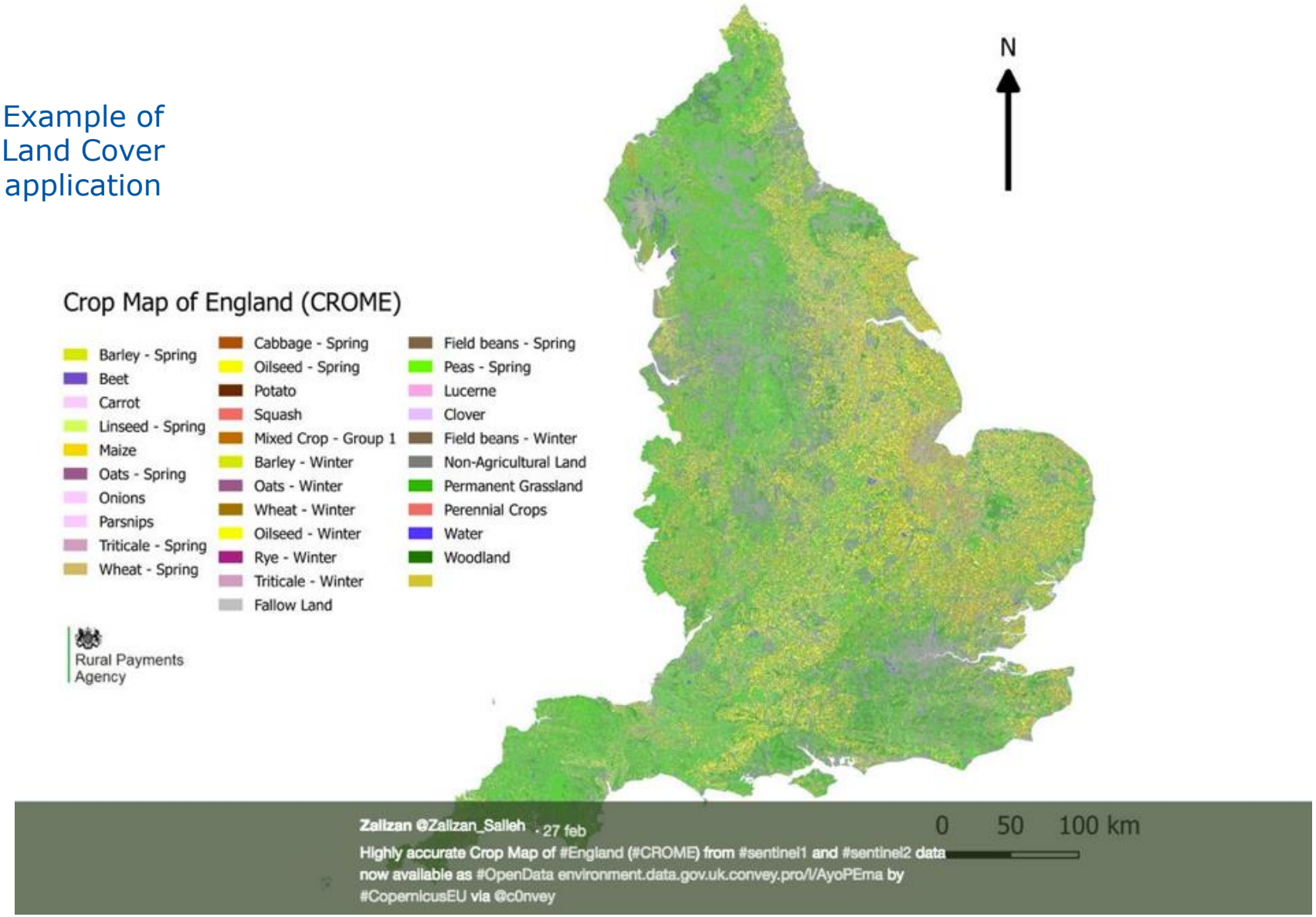
Soil moisture, wetland, hydrology, water mapping



Snow, permafrost, avalanches,…

Example of UK map of crop classification

Example of Land Cover application



ESA Data Policy

→ ESA Earth Observation Data Policy

- To stimulate a balanced development of Science, Public Utility and Commercial Applications, consistent with the mission's objectives
- To maximize the beneficial use of data from ESA EO satellites

ERS and Envisat

Earth Explorers

ESA Third Party Missions

ESA Data Policy

- *Free datasets*

  (Free of charge; User registration and acceptance of ESA Terms & Conditions are required → Open access)

- *Restrained datasets*

  (Free of charge; User registration, submission of a "Project (Full) Proposal" and acceptance of the ESA Terms & Conditions are required, after its evaluation a quota will be assigned)

Data Policy of individual data providers

In some case, a reproduction cost (e.g. ALOS) or Specific Restrictions (limitations of quota, geographical restrictions, etc.) to the use of data may be applied for TPM

→ Where to access EO data

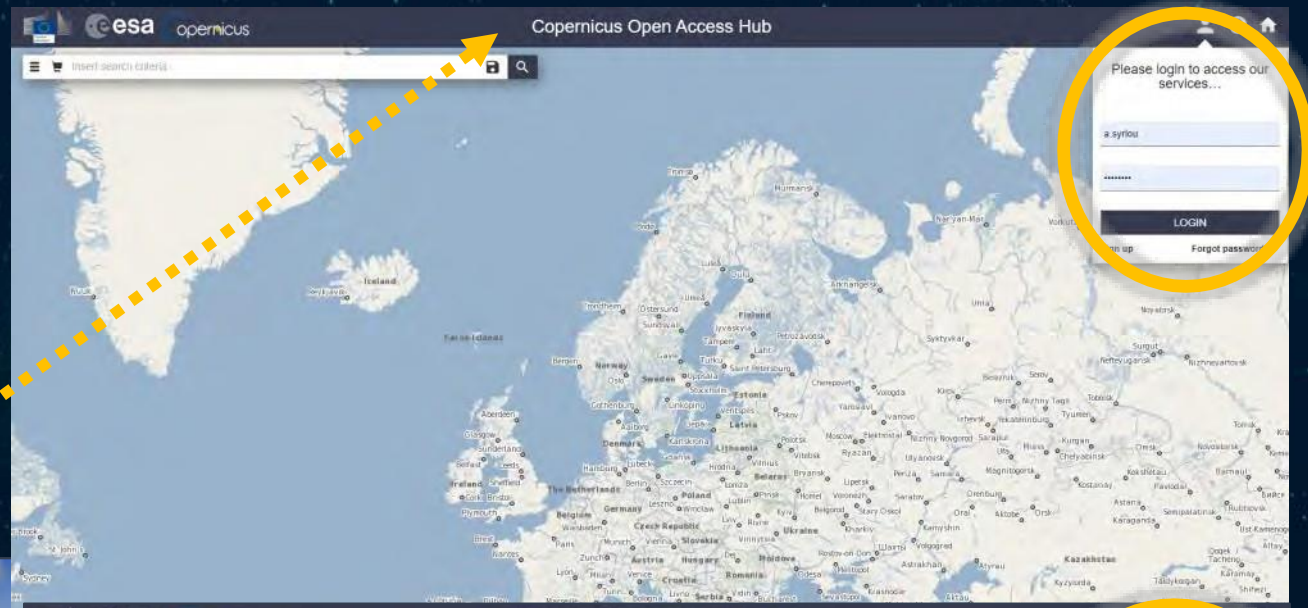
Free open source platforms

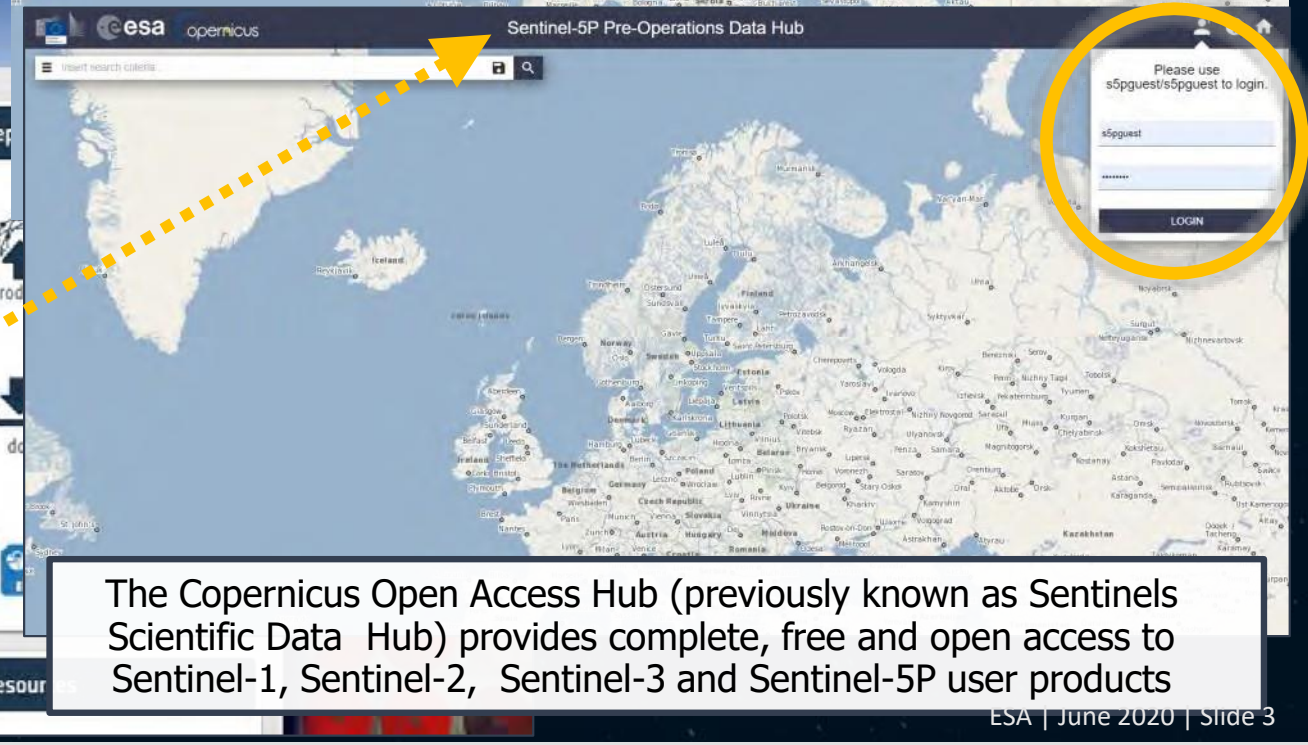
- **Copernicus Open Access Hub**
- Earth System Lab
- ESA Thematic Exploitation Platforms
- Alaska Satellite Facility
- Copernicus Global Land Service
- **Copernicus Data Space Ecosystem**
- **Sentinel Data Access Service**
- USGS Earth Explorer
- Sentinel Application Platform software
- Open Data Cube

Namib Desert (Sentinel-2, 27 October 2017)

→ Copernicus Open Access Hub

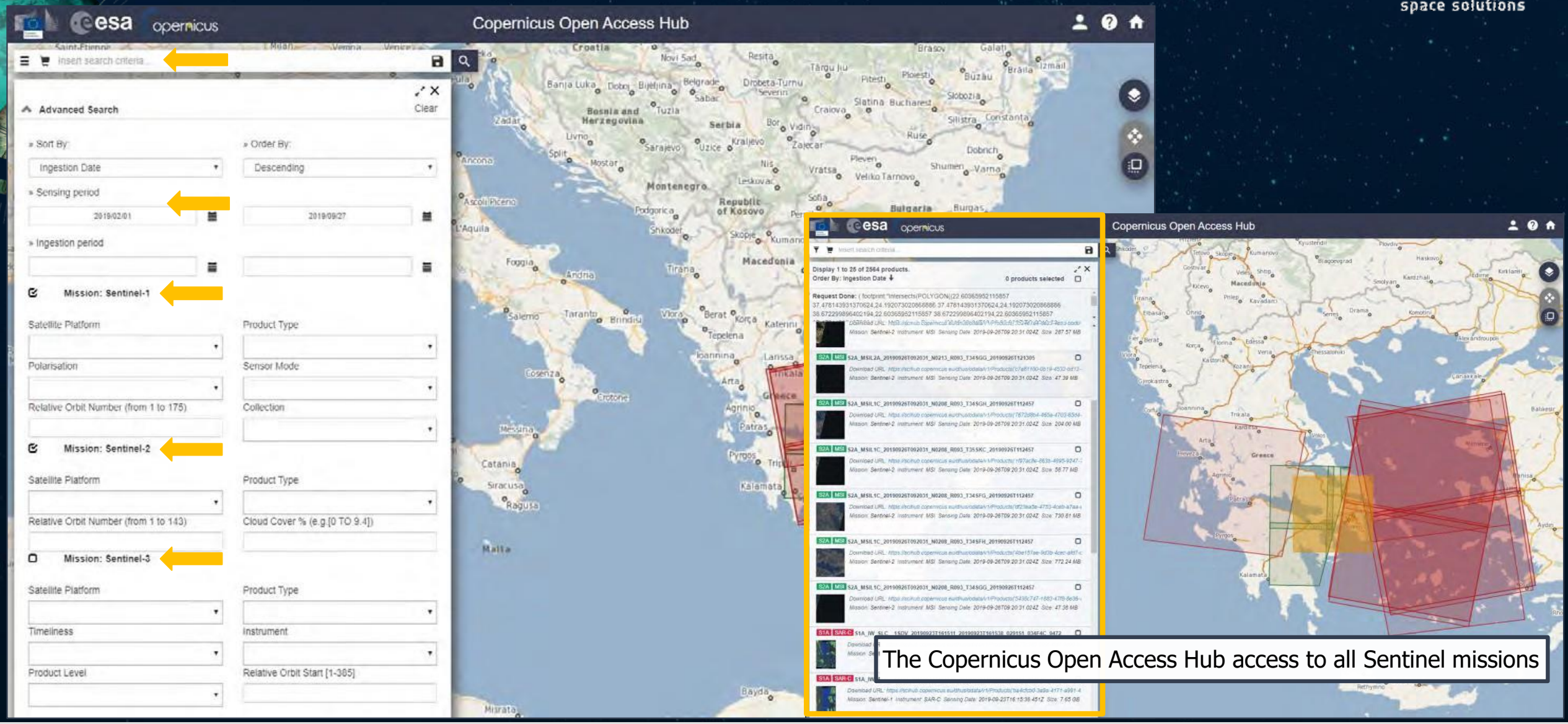
https://scihub.copernicus.eu/





The Copernicus Open Access Hub (previously known as Sentinels Scientific Data Hub) provides complete, free and open access to Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P user products

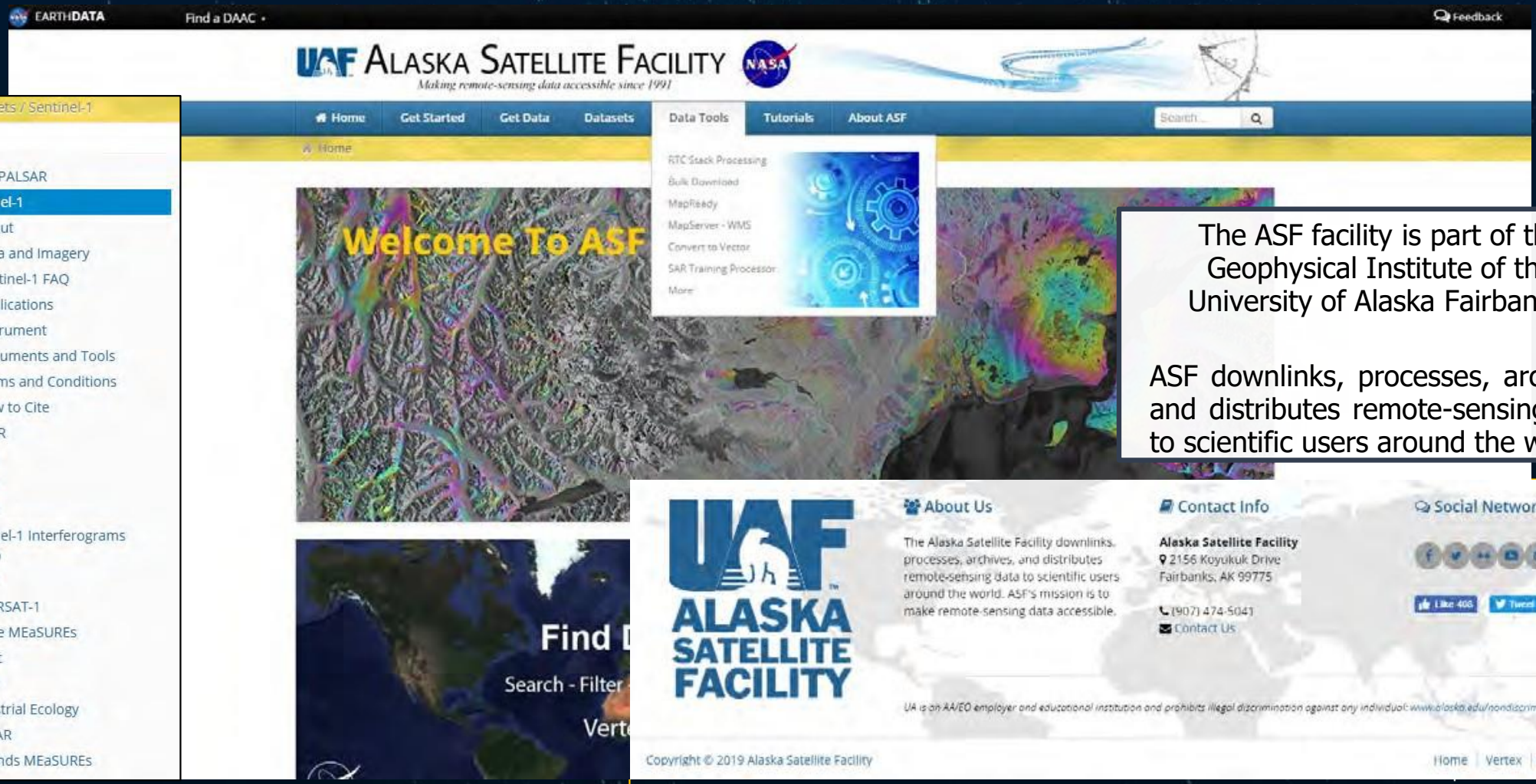
→ Copernicus Open Access Hub



The Copernicus Open Access Hub access to all Sentinel missions

→ Alaska Satellite Facility (ASF)

https://www.asf.alaska.edu/
https://www.asf.alaska.edu/asf-tutorials/data-recipes/

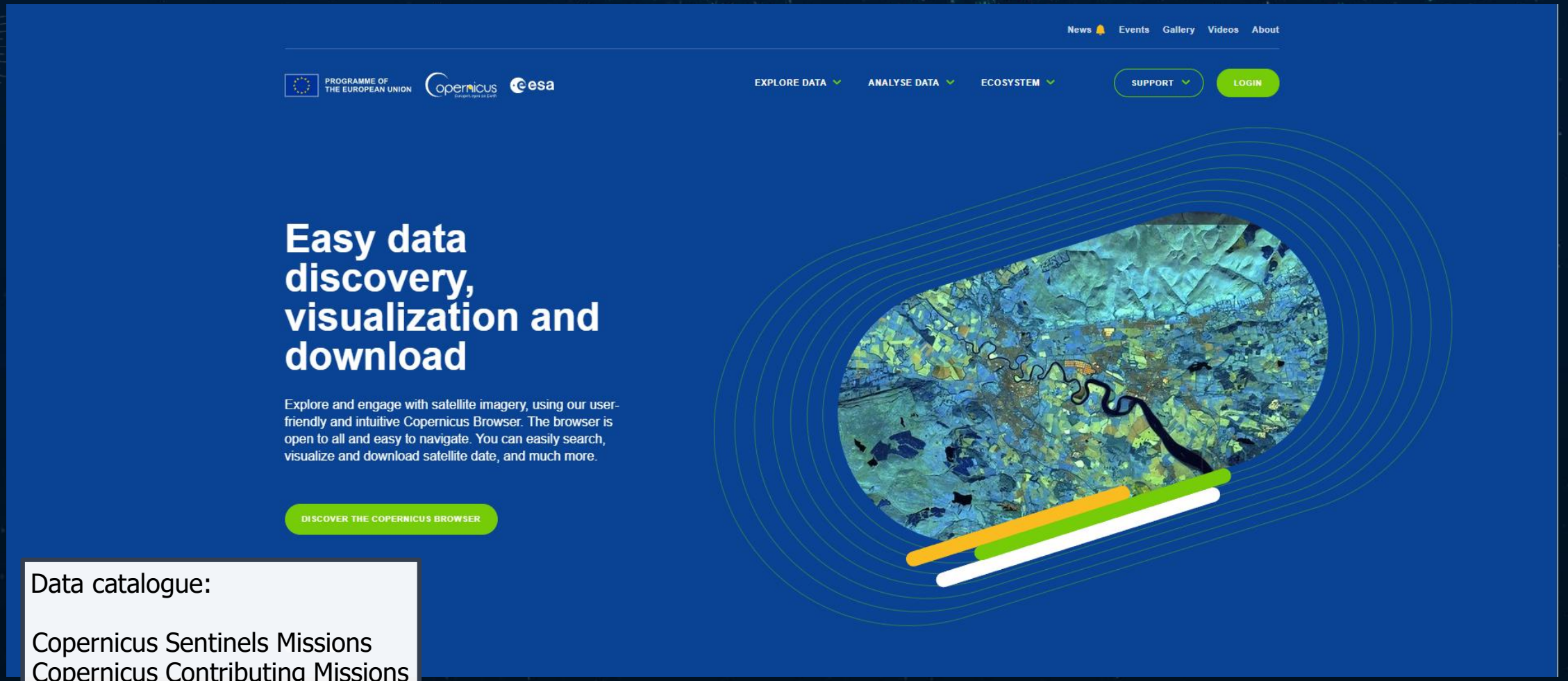


The ASF facility is part of the Geophysical Institute of the University of Alaska Fairbanks.

ASF downlinks, processes, archives, and distributes remote-sensing data to scientific users around the world

→ Copernicus Data Space Ecosystem

https://dataspace.copernicus.eu/

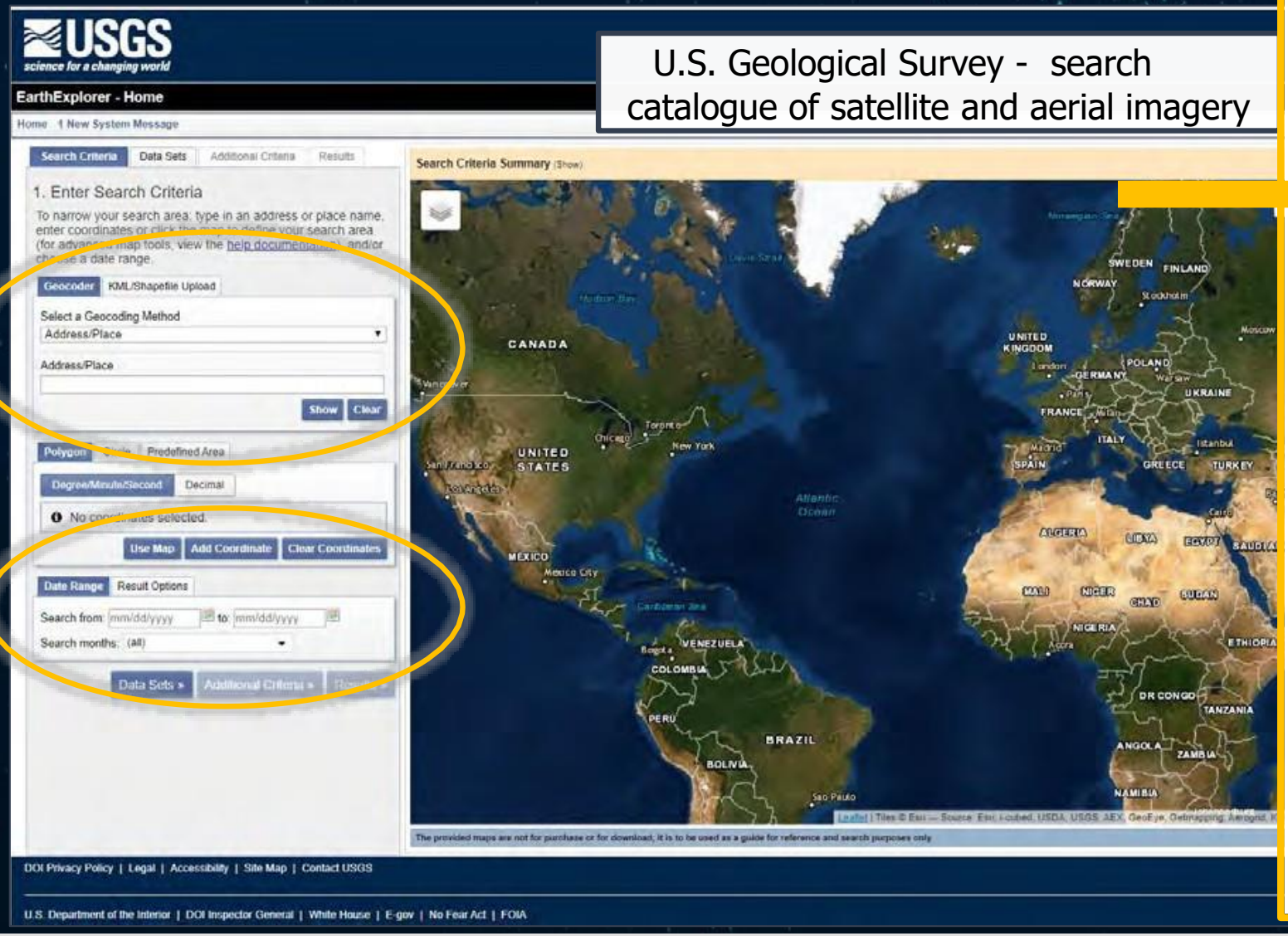


Data catalogue:

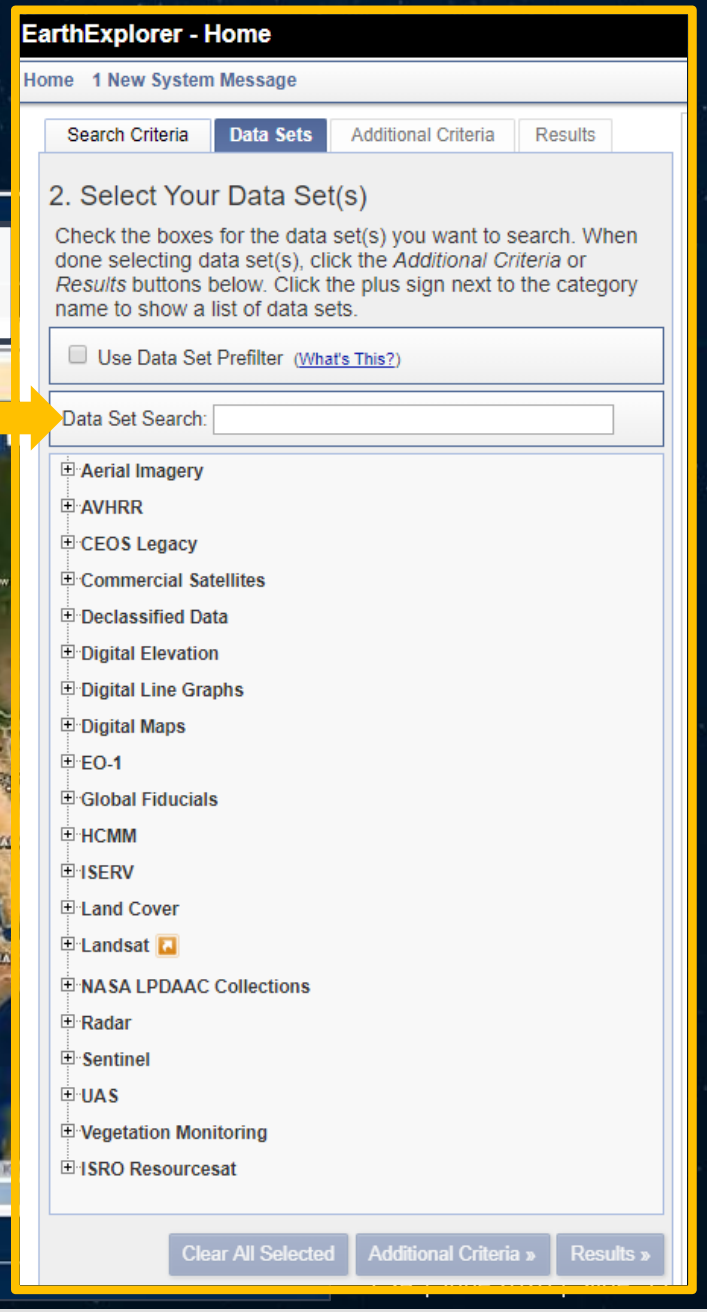
Copernicus Sentinels Missions
Copernicus Contributing Missions
Federated data sets

→ USGS Earth Explorer

https://earthexplorer.usgs.gov/

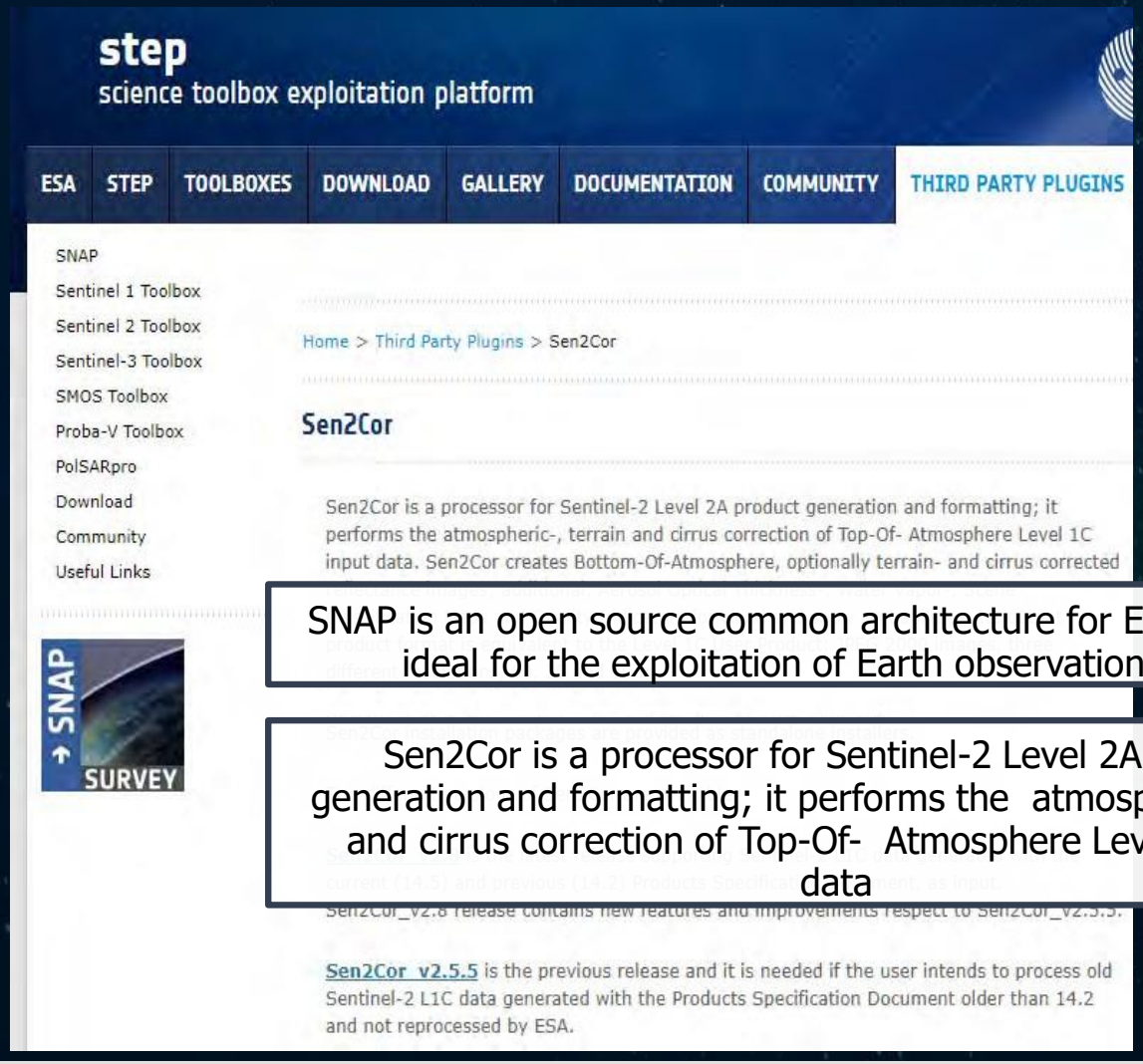


U.S. Geological Survey - search catalogue of satellite and aerial imagery



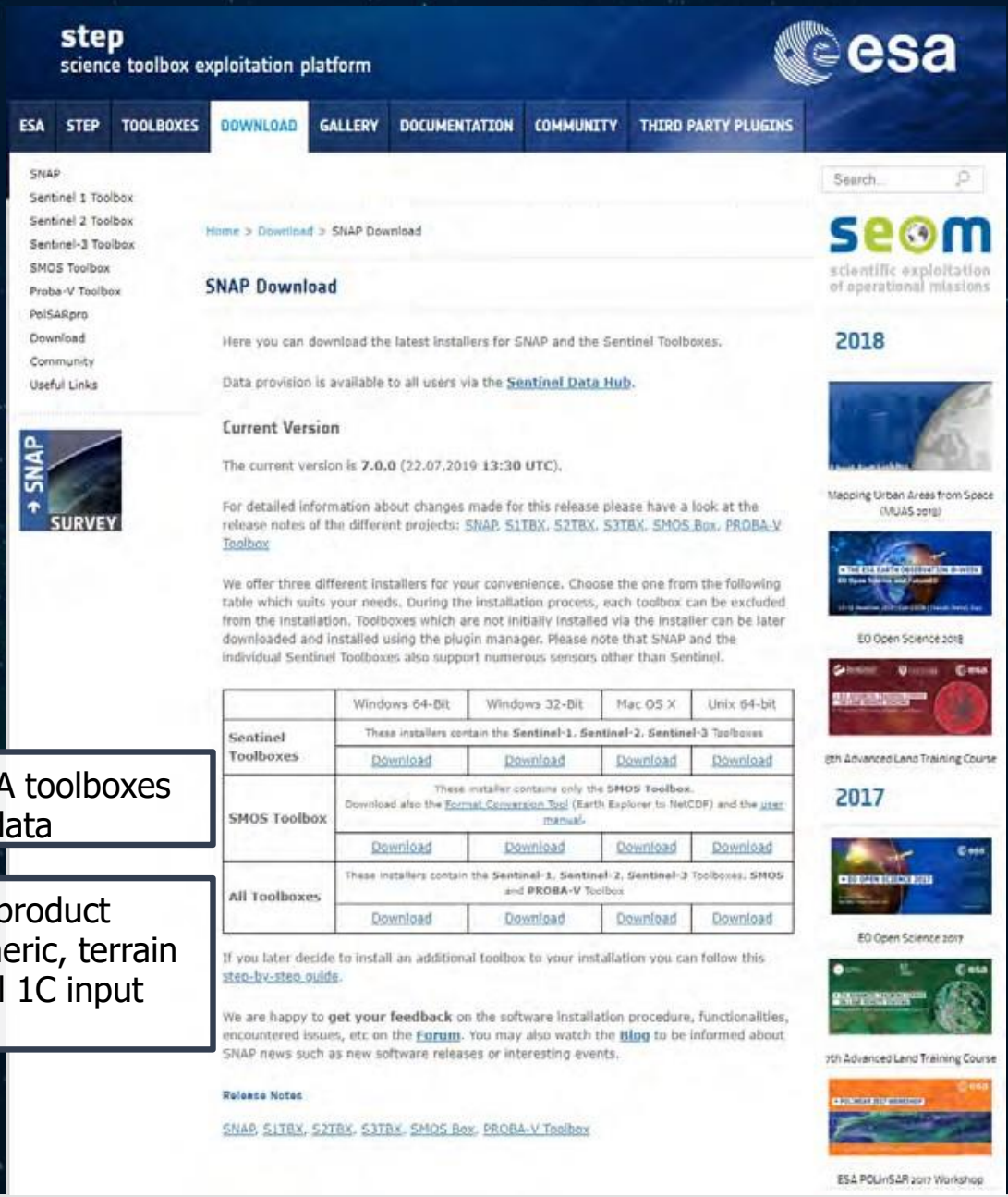
→ SNAP (Sentinel Application Platform) software

http://step.esa.int/main/download/snap-download/



SNAP is an open source common architecture for ESA toolboxes ideal for the exploitation of Earth observation data

Sen2Cor is a processor for Sentinel-2 Level 2A product generation and formatting; it performs the atmospheric, terrain and cirrus correction of Top-Of- Atmosphere Level 1C input data



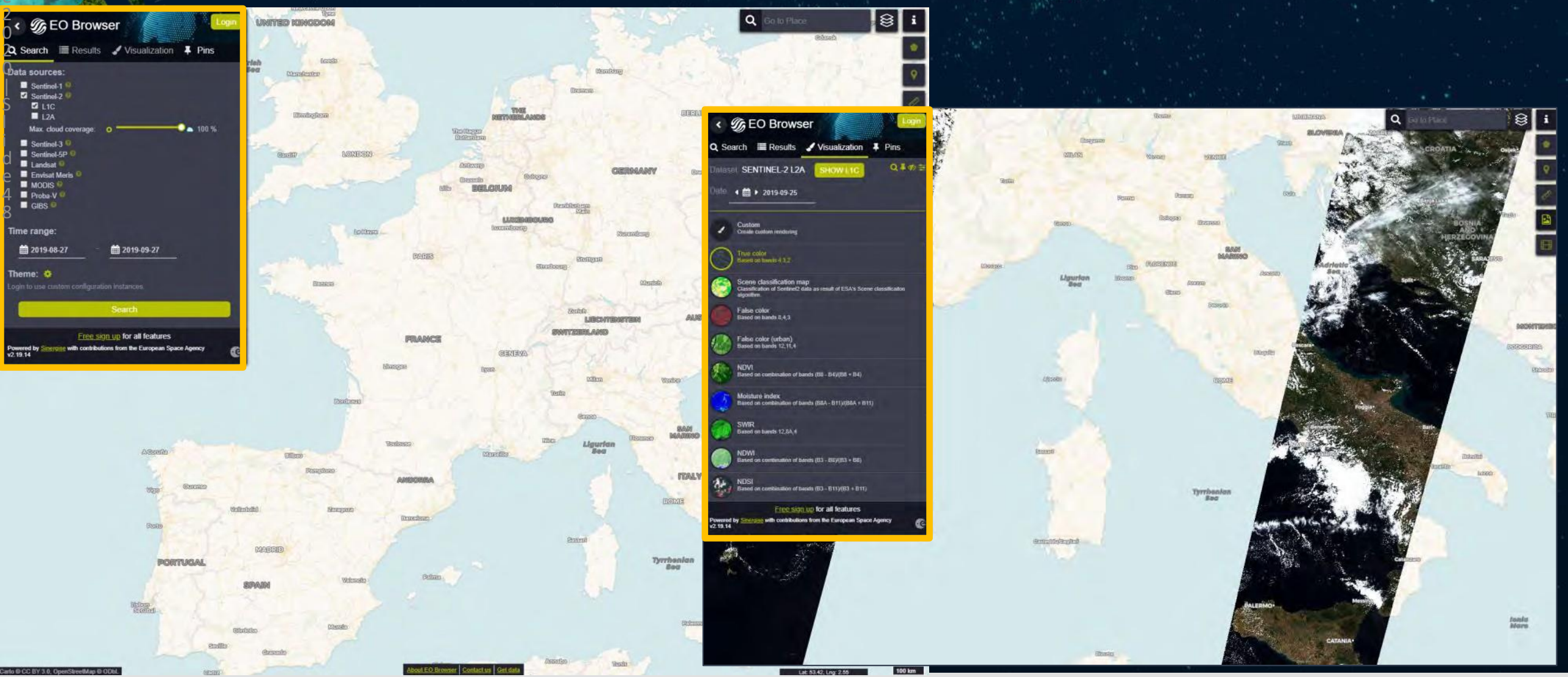
→ Where to access EO data

Partially open-source EO platforms

- **EO Browser Sentinel Hub**
- DIAS - Copernicus Data & Information Access Services
- Google Earth Engine
- Earth on AWS

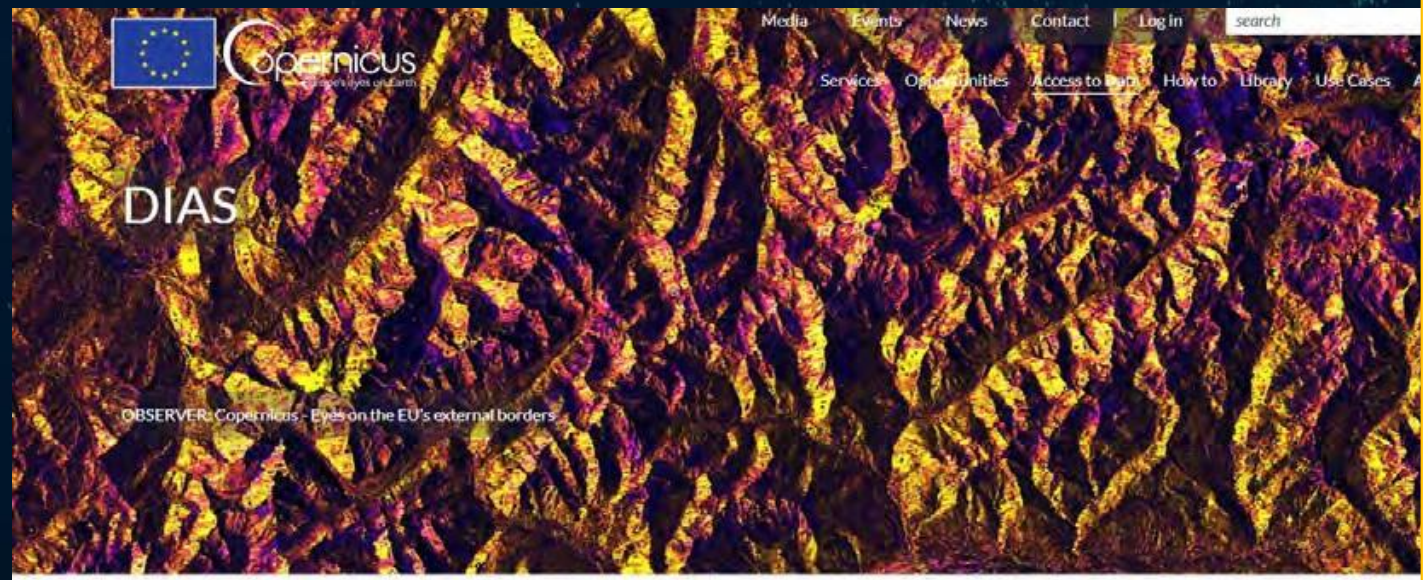
→ EO Browser - SENTINEL Hub

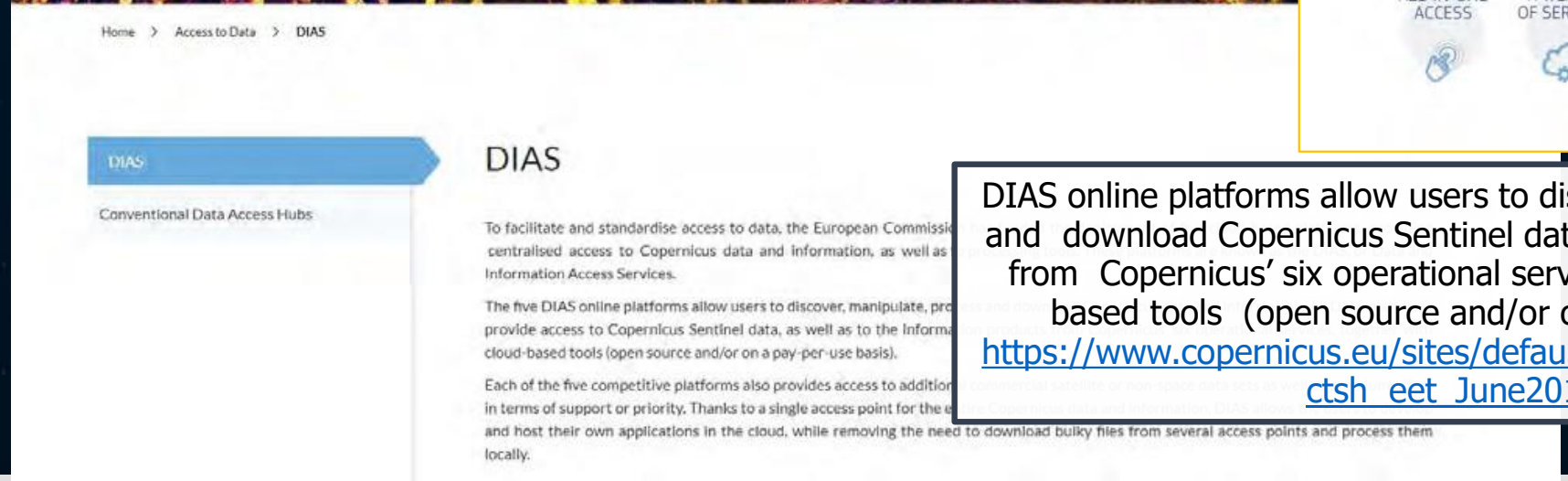
https://apps.sentinel-hub.com/eo-browser/



→ DIAS - Copernicus Data & Information Access Services

https://www.copernicus.eu/en/access-data/dias

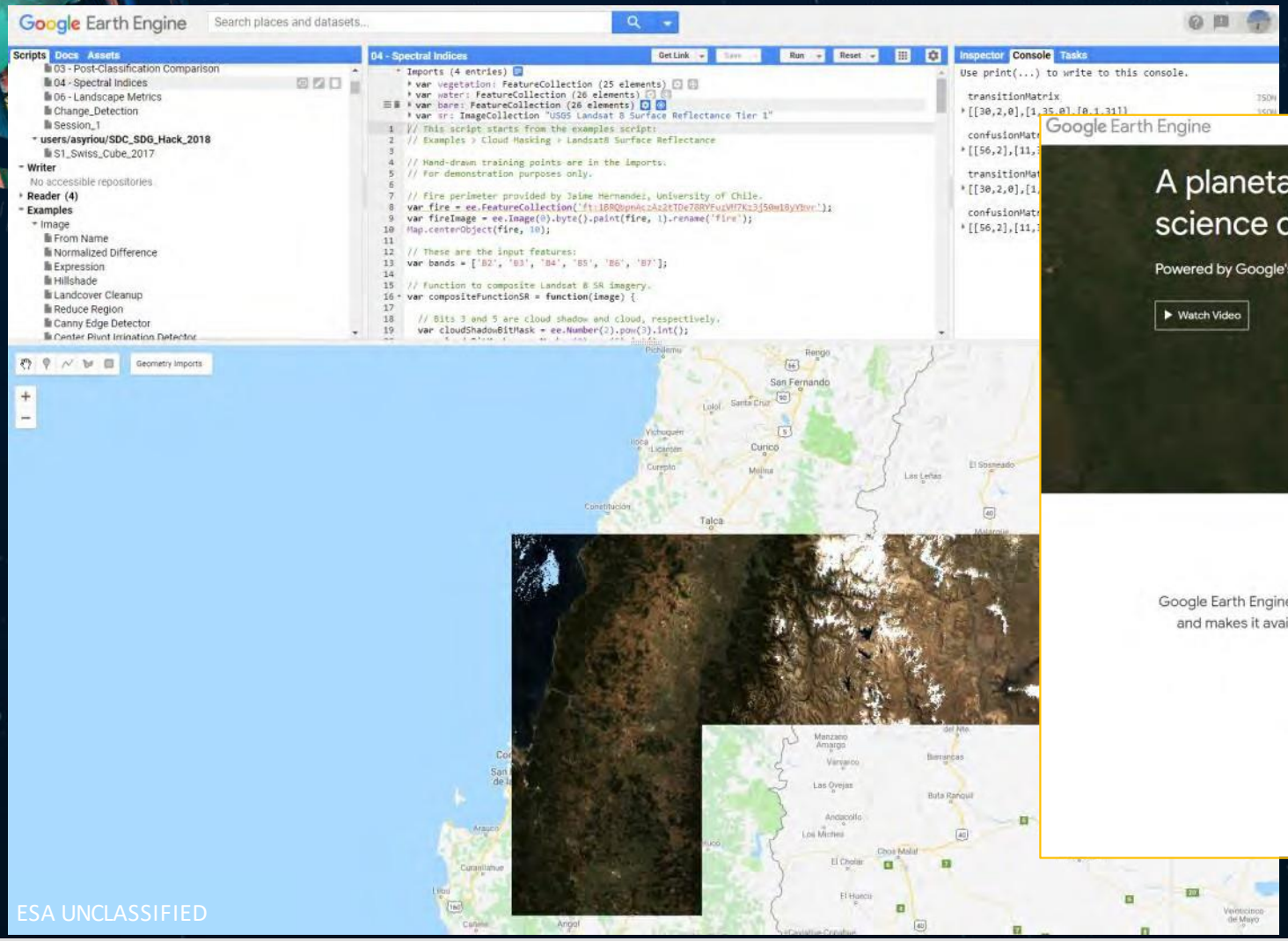


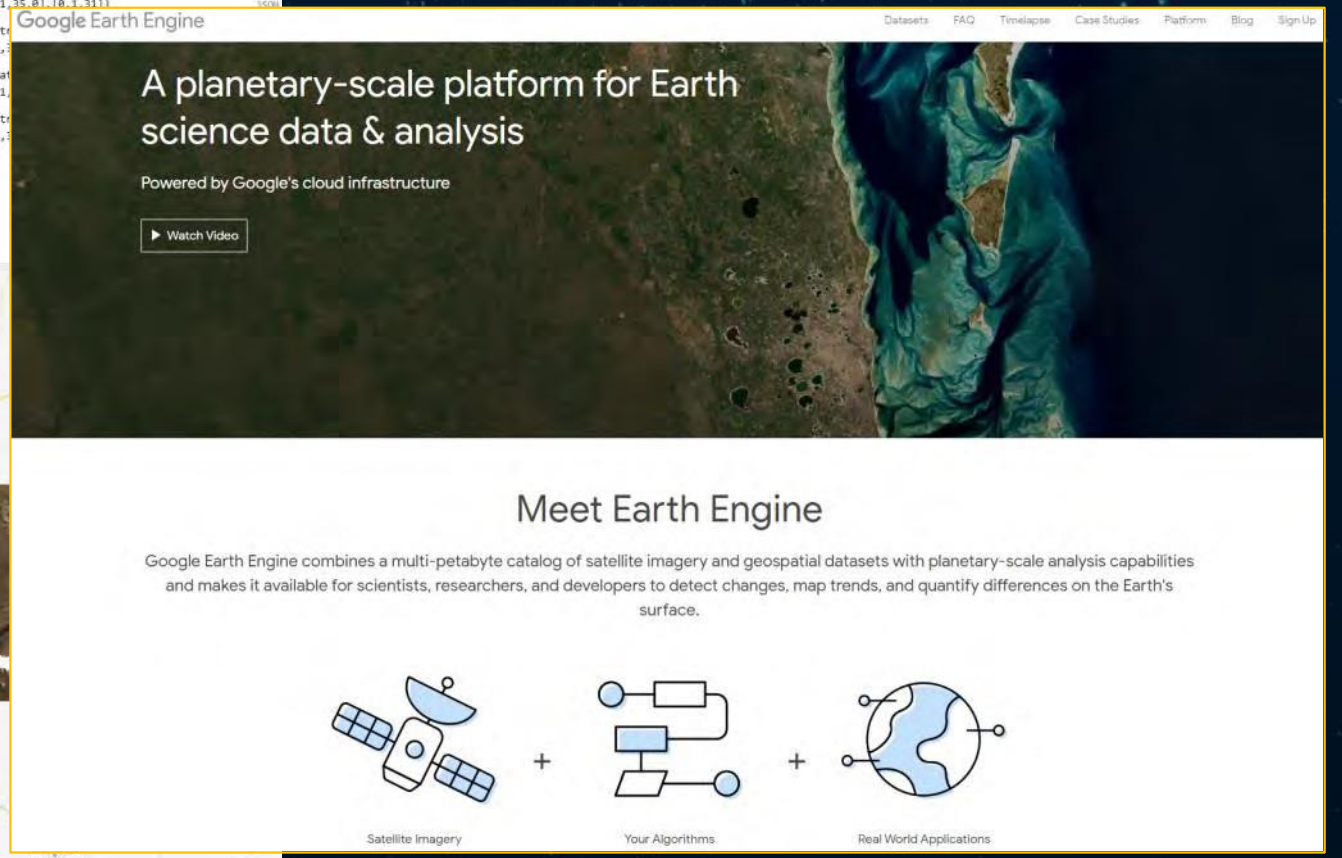


DIAS online platforms allow users to discover, manipulate, process and download Copernicus Sentinel data and information products from Copernicus' six operational services, together with cloud-based tools (open source and/or on a pay-per-use basis)
https://www.copernicus.eu/sites/default/files/Copernicus_DIAS_Factsh_eet_June2018.pdf

→ Google Earth Engine

https://earthengine.google.com/platform/





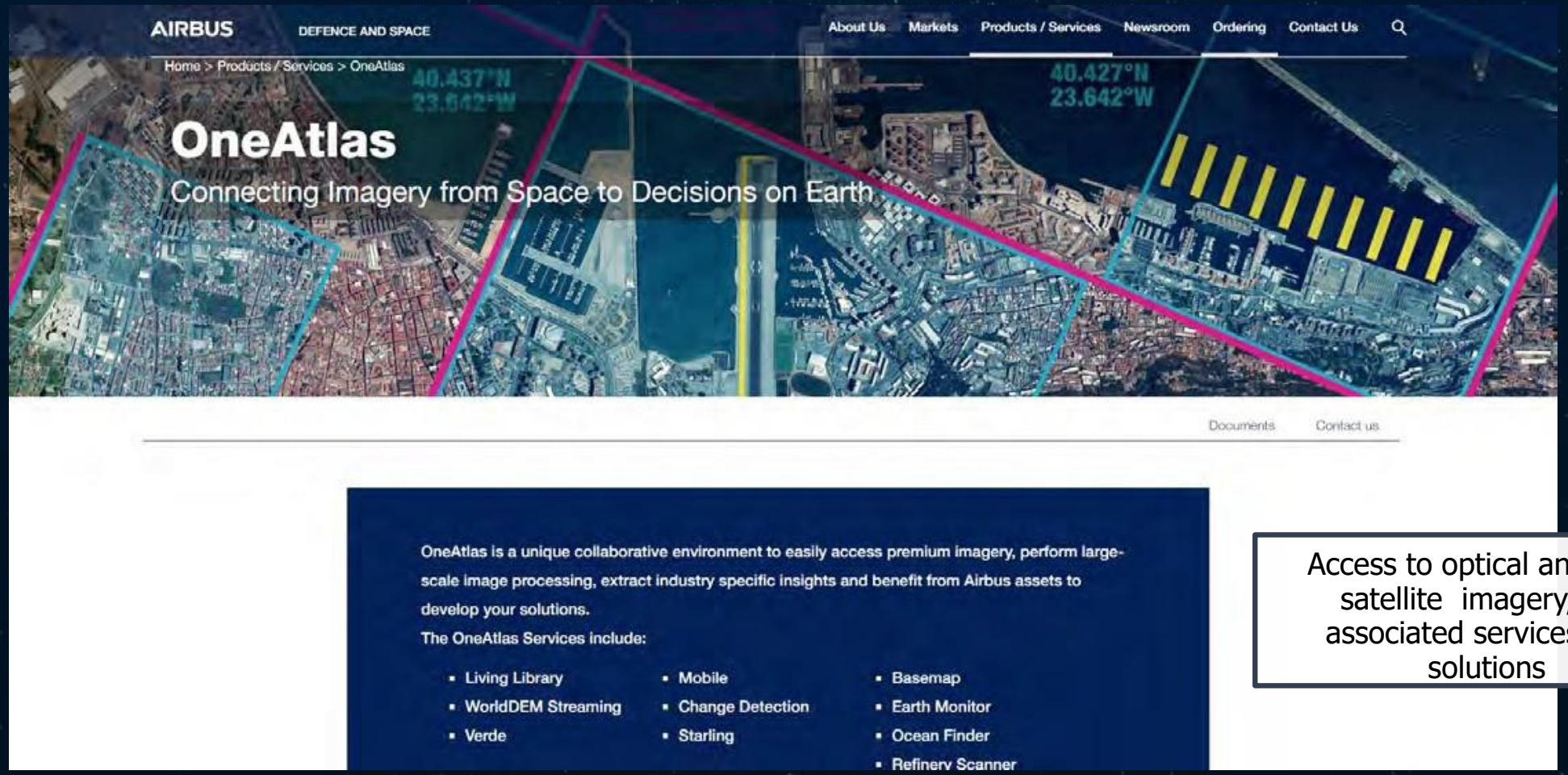
→ Where to access EO data

Commercial EO platforms

- DigitalGlobe / Maxar
- OneAtlas
- Planet platform
- e-Geos
- Decartes Labs

→ OneAtlas

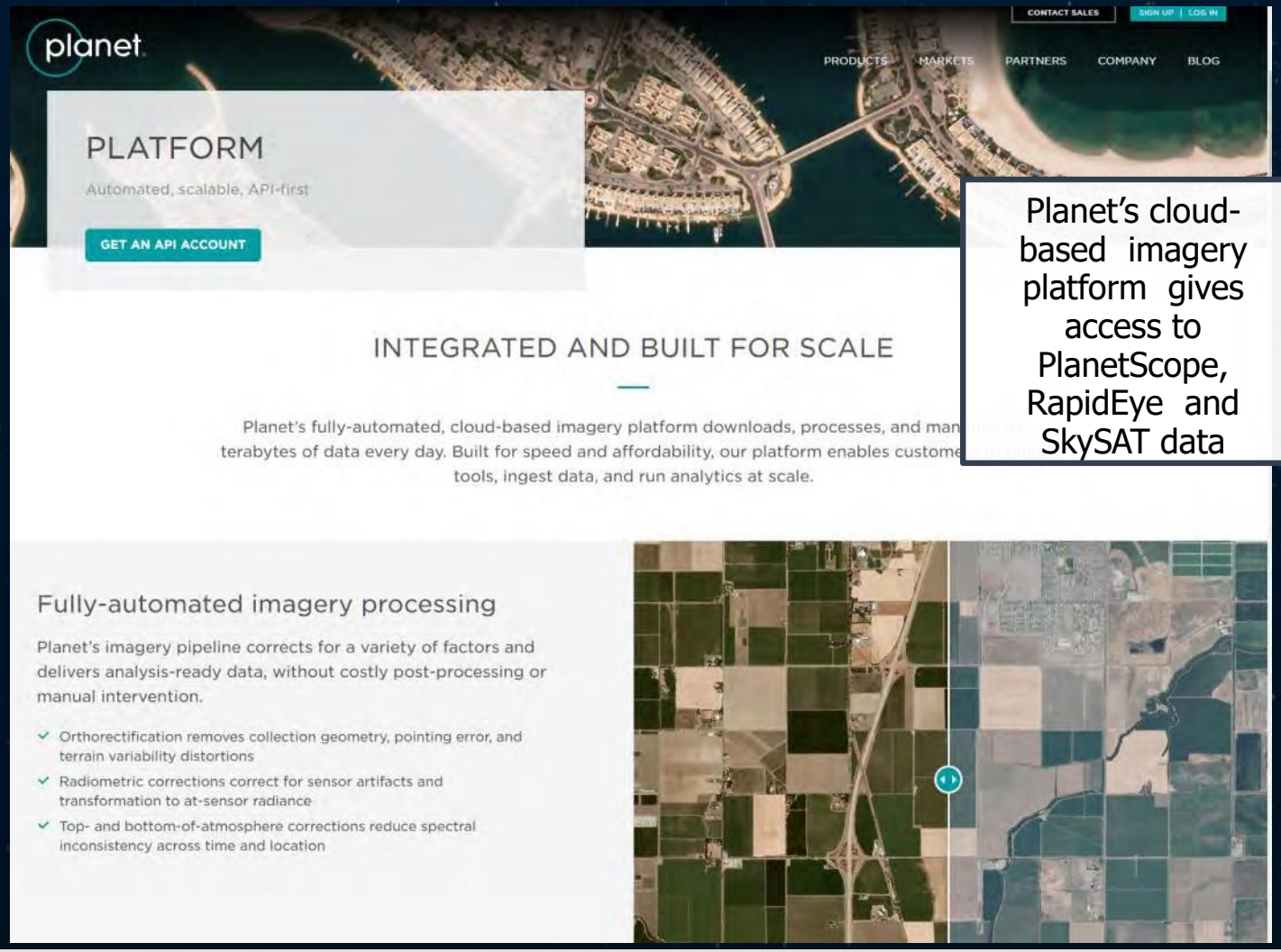
https://www.intelligence-airbusds.com/oneatlas/



Access to optical and radar satellite imagery, and associated services and solutions

→ Planet Platform

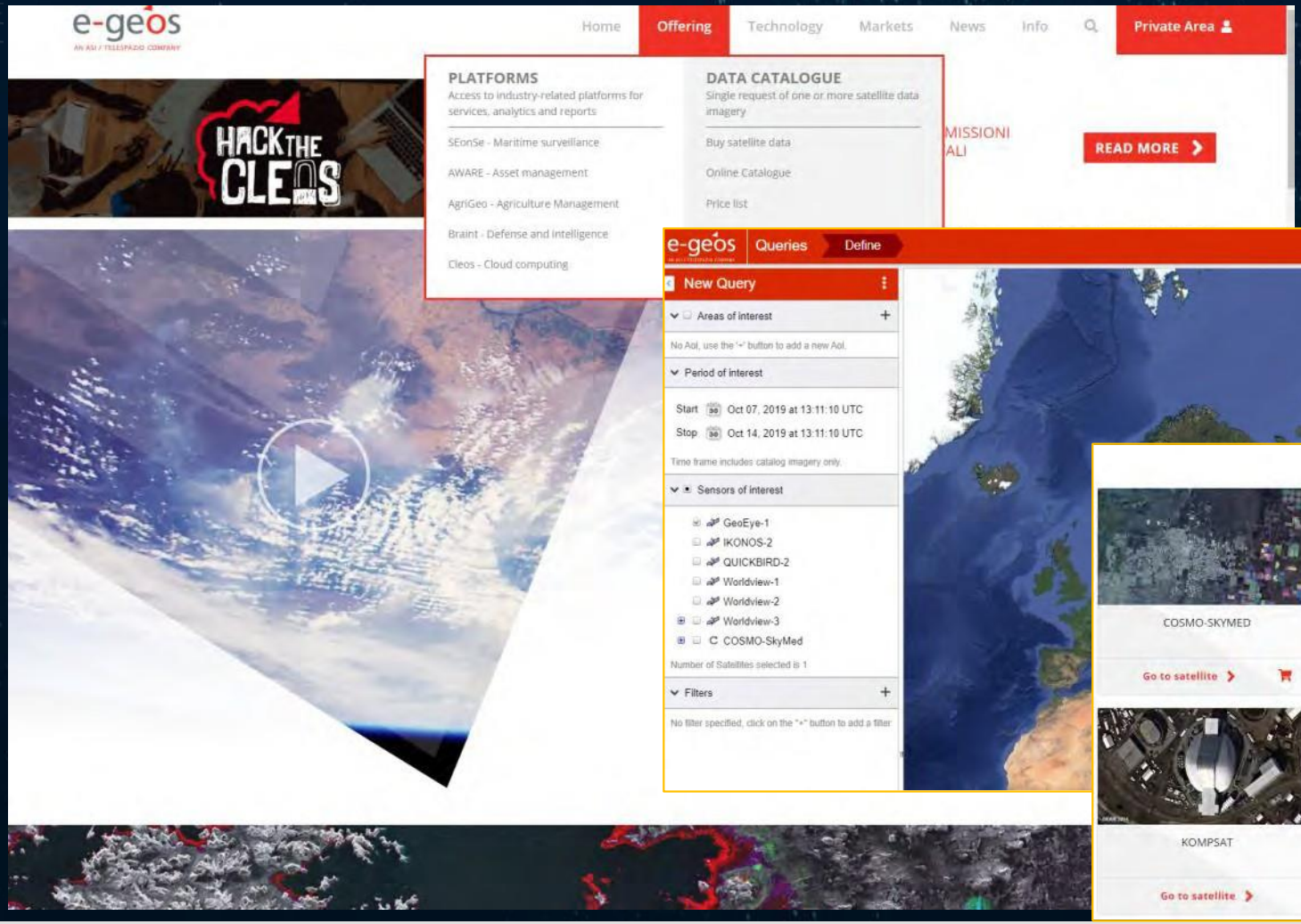
https://www.planet.com/products/platform/

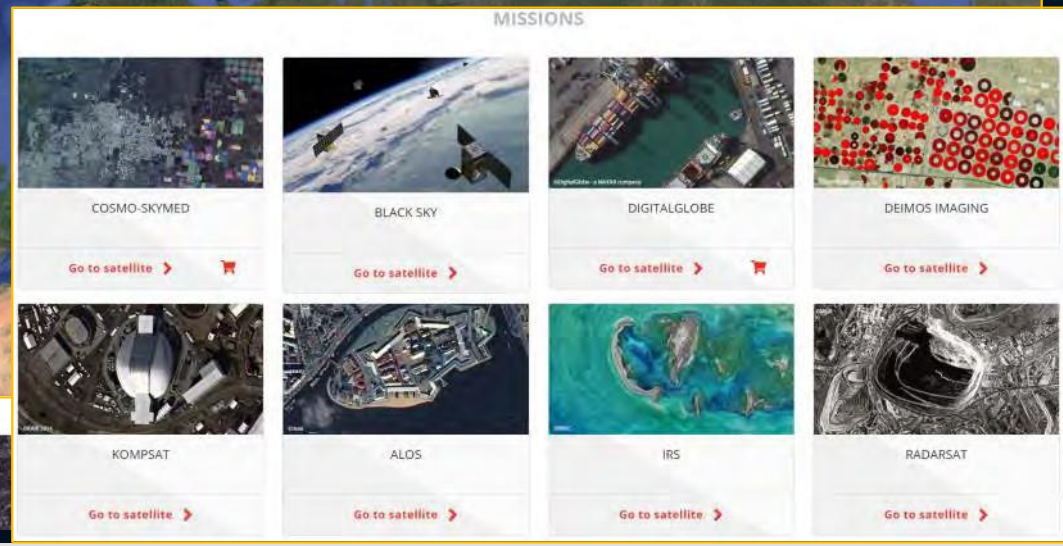


Planet's cloud-based imagery platform gives access to PlanetScope, RapidEye and SkySAT data

→ e-geos

https://www.e-geos.it/

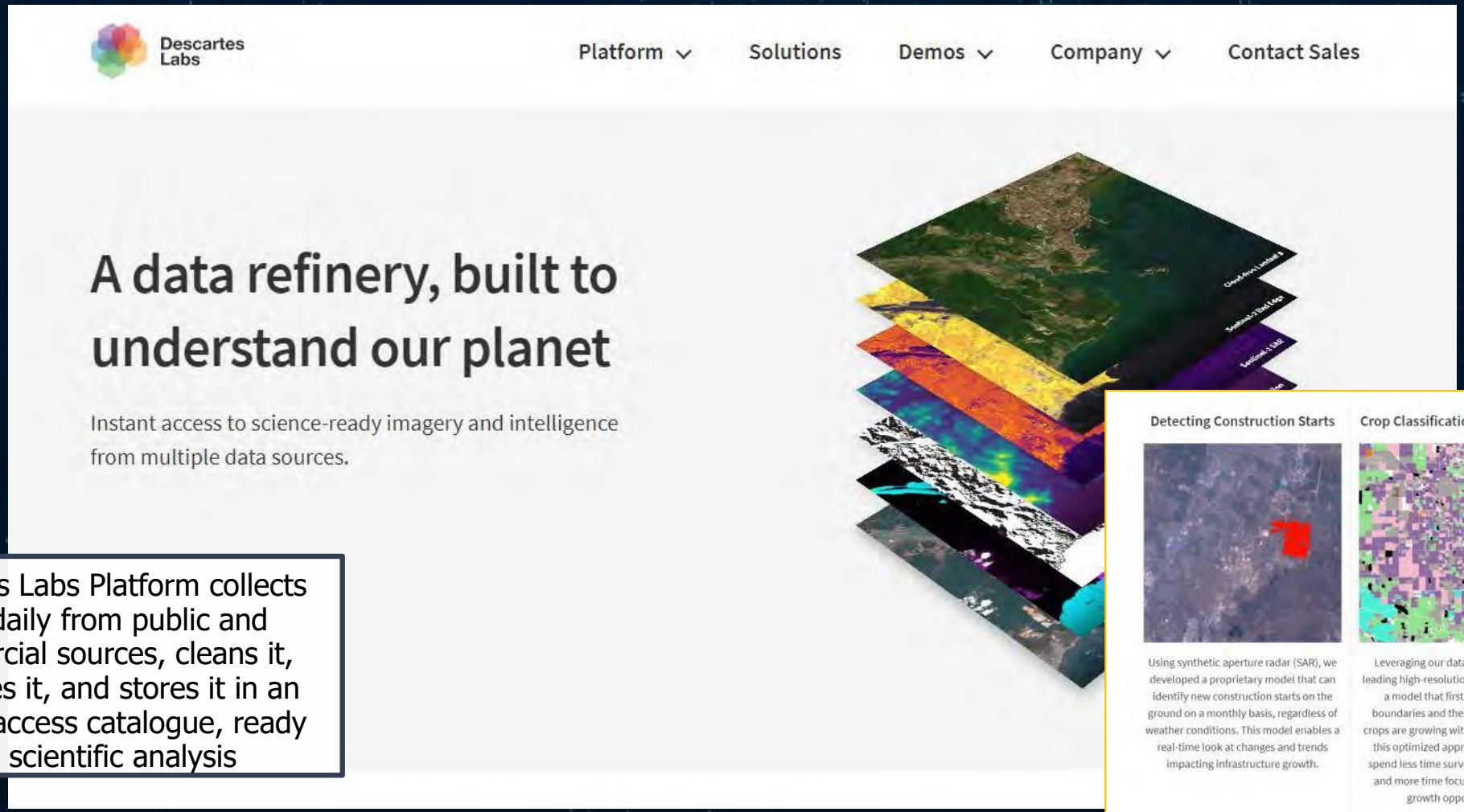




e-geos offer a wide selection of platforms for services, analytics and reports, together with an online EO data catalogue

→ Descartes Labs

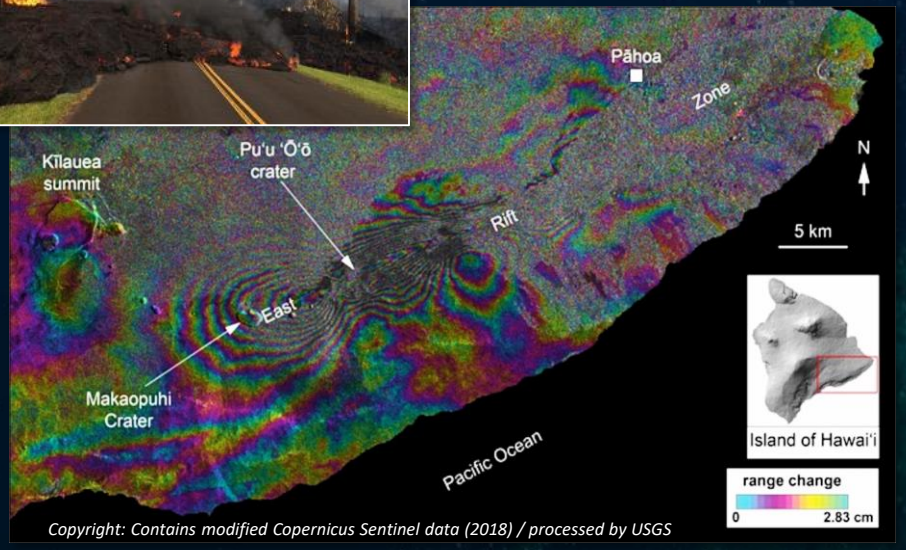
https://www.descarteslabs.com/



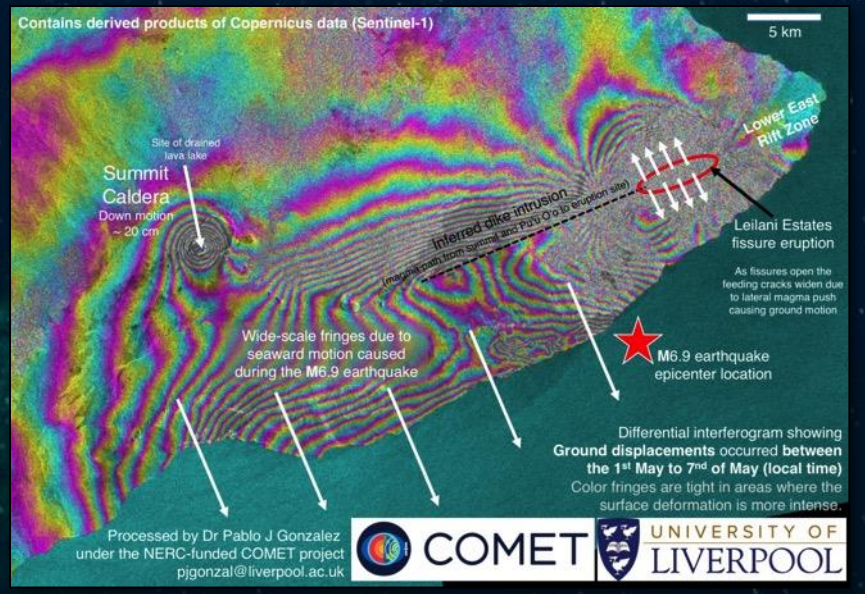
Descartes Labs Platform collects data daily from public and commercial sources, cleans it, calibrates it, and stores it in an easy-to-access catalogue, ready for scientific analysis

Sentinel-1: a major tool for geophysicists

Eruption and earthquake near Kilauea volcano, Hawaii (3 May 2018)



*Sentinel-1 interferogram (19 April – **1 May 2018**)*



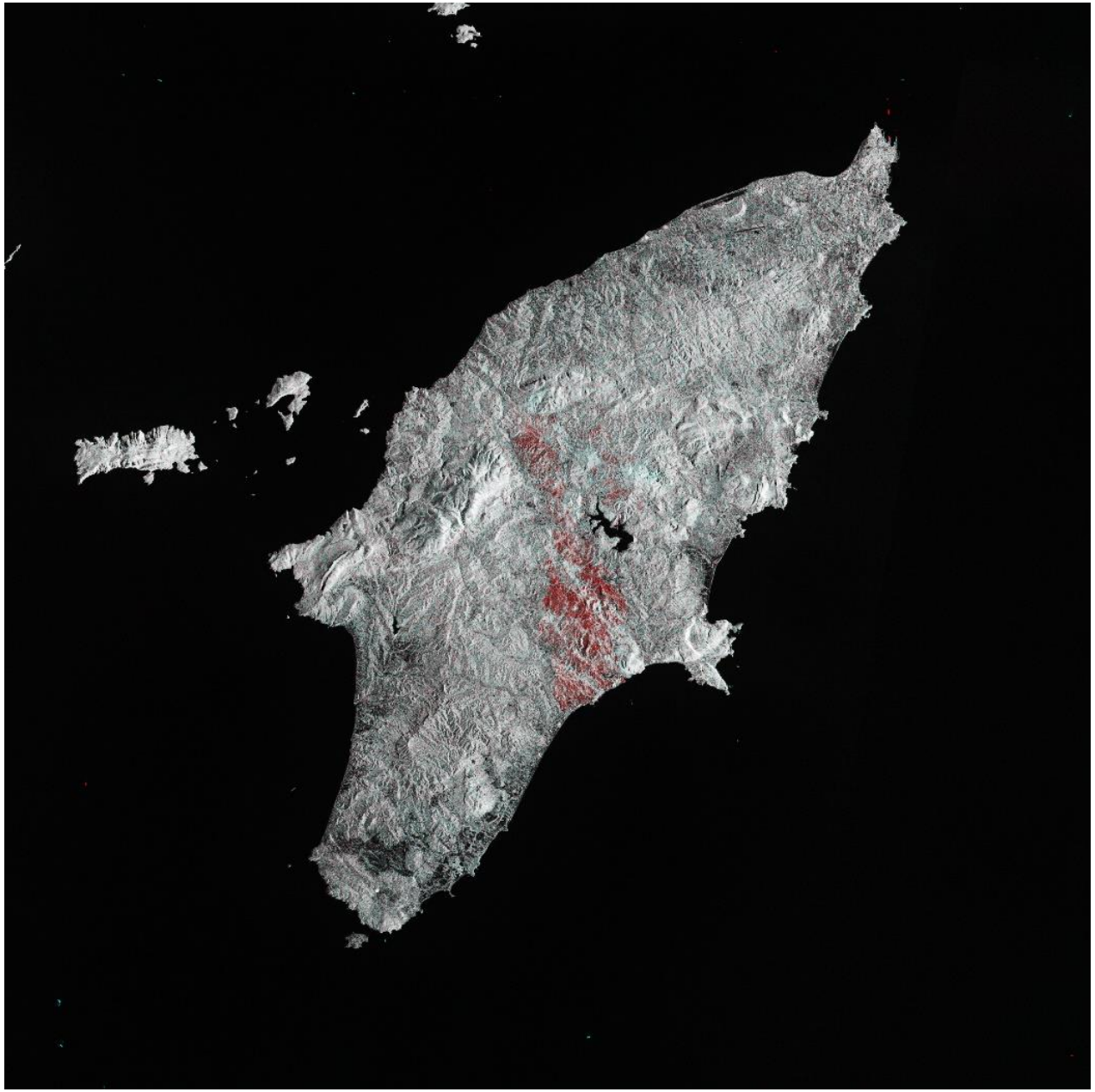
*Sentinel-1 interferogram (**1 May – 7 May 2018**)*

Deformation due to magmatic intrusion → magma withdrawn from middle East Rift Zone and intruded beneath lower East Rift Zone.

EO Browser

PRACTICAL 1
SENTINEL-1 FOR MAPPING WILDFIRES

RHODES, GREECE (12 - 24 July)



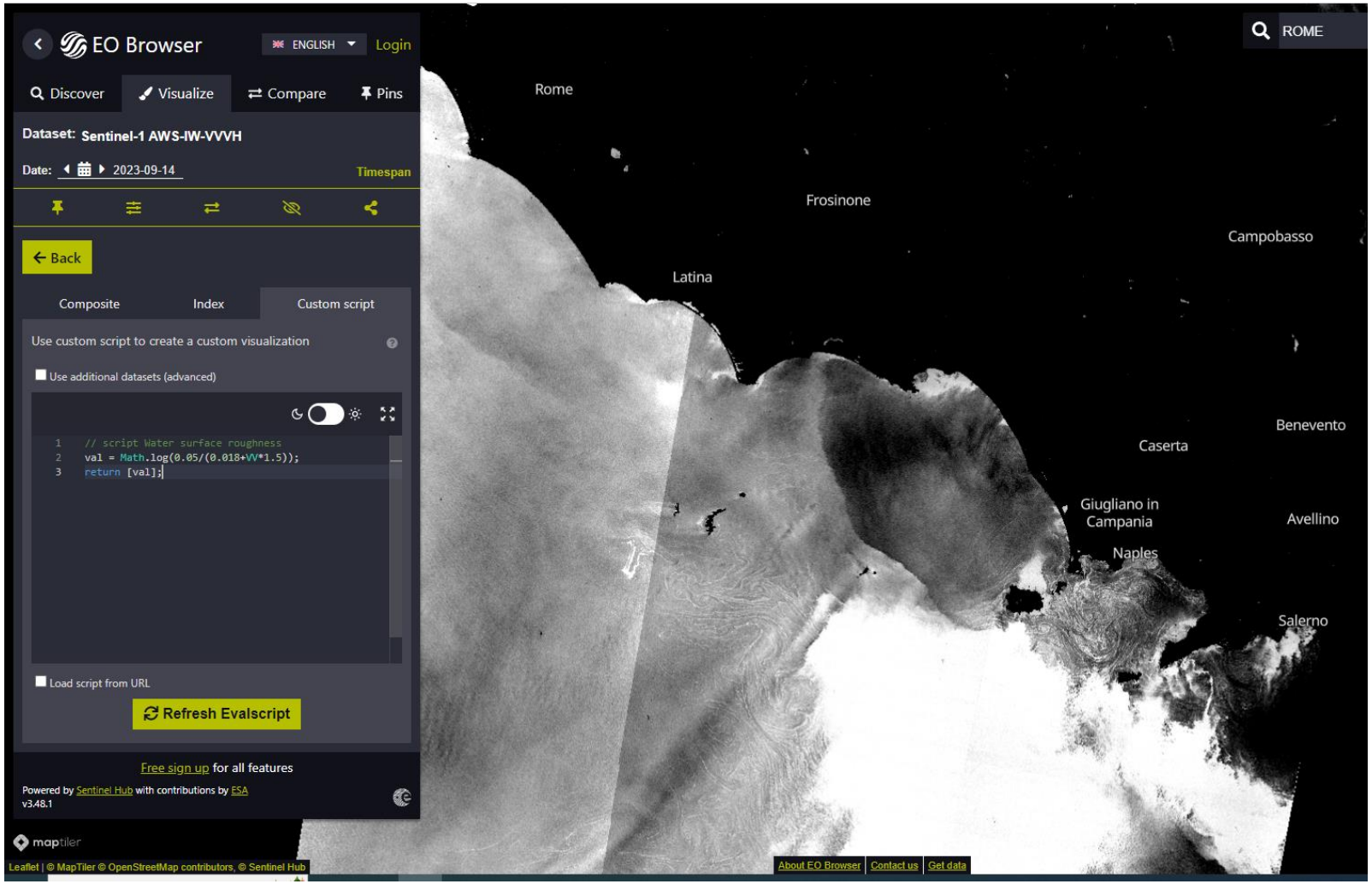
Between 18 and 28 July 2023, wildfires broke out on Rhodes. Fierce blazes ravaged almost 18,000 hectares of land, destroyed buildings, trapped animals and led to a mass evacuation of thousands of tourists.

sentinelhub

EO Browser

PRACTICAL 2
SENTINEL-1 FOR MAPPING WATER SURFACE ROUGHNESS

ROME, ITALY (14 September 2023)




```
// script Water surface roughness
val = Math.log(0.05/(0.018+VV*1.5));
return [val];
```

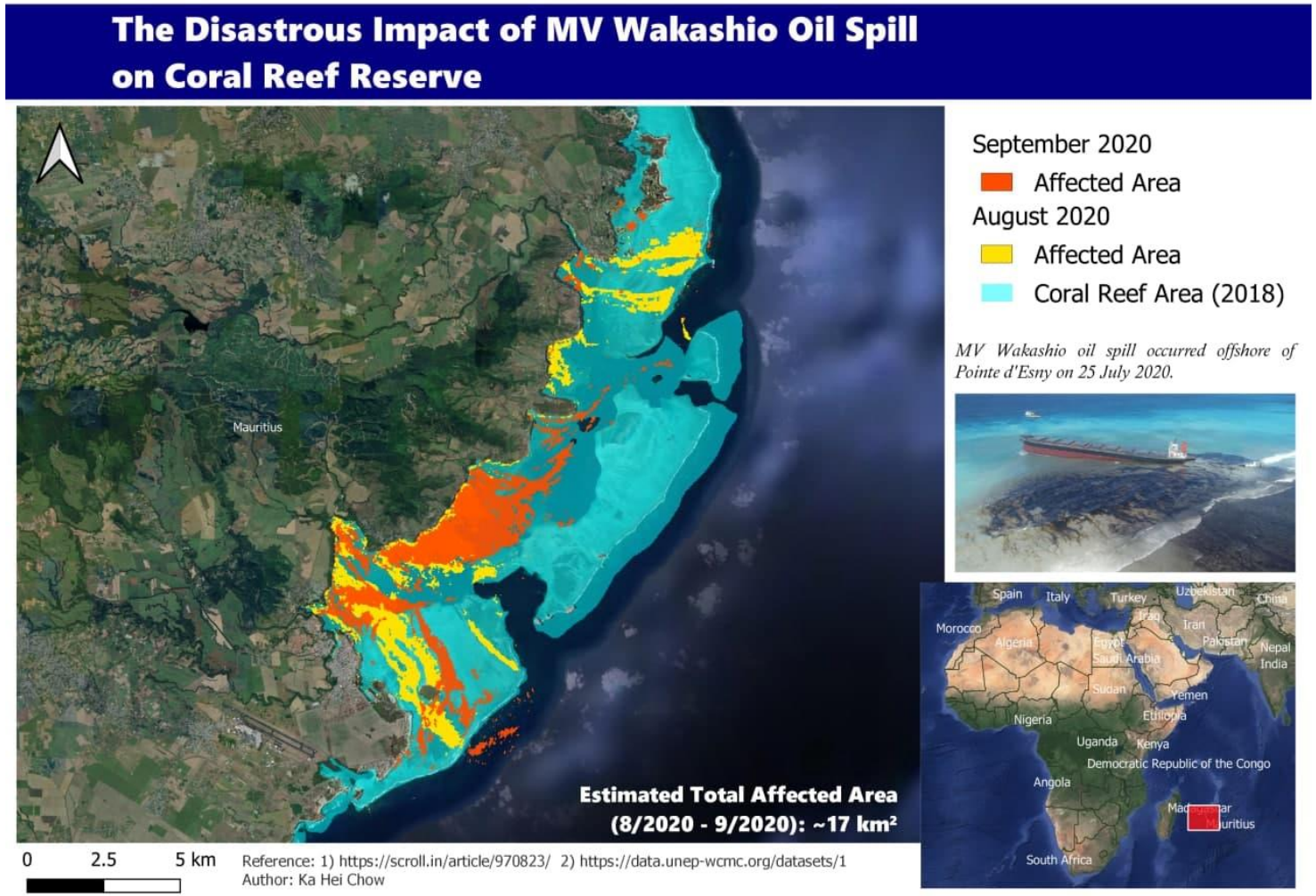
sentinelhub

EO Browser

PRACTICAL 3
SENTINEL-1 FOR MAPPING OIL SPILL

Pointe d'Esny (29.7.2020 - 10.8.2020)

```
//Oil slicks and Red tide monitoring
//By TIZNEGAR Startup Co, www.tiznegar.com
//Dataset:Sentinel-1 AWS-IW-VVVH

var ORM = Math.log(0.01/(0.01+VV*2));

if (ORM < [ 0] &&  VV< [ 0.01]&&  VH< [ 0.1]) {

   return colorBlend
    (ORM,
        [-1.6, -1.2, -.8, -.4, -.2, 0],
       [

     [0,0,.1 ],
     [0,0,.8],
     [1,0,0],
     [1,.5,.2],
     [1,.8,.2],
     [1,1,.4],
     [.5,.8,.3],


      ]);
}
else {
 return [2.5*VV,2.5*VV,2.5*VV]
}
```



Thank you for the attention