Earth Observation Principles and Applications

ESA Earth Observation Programme and related educational programme. Data access

8th ESA Training Course on Radar and Optical Remote Sensing, 5 - 9 September, 2016, Cesis, Latvia

Francesco Sarti, ESA

22 MEMBER STATES AND GROWING

ESA has 22 Member States: 20 states of the EU (Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Poland, Portugal, Romania, Spain, Sweden, UK) **plus Norway and Switzerland.**

Other EU states have Cooperation Agreements with ESA, such as Bulgaria, Cyprus, Lithuania and Malta. Latvia, Slovenia and Slovakia are participating in the Plan for European Cooperating States (PECS).

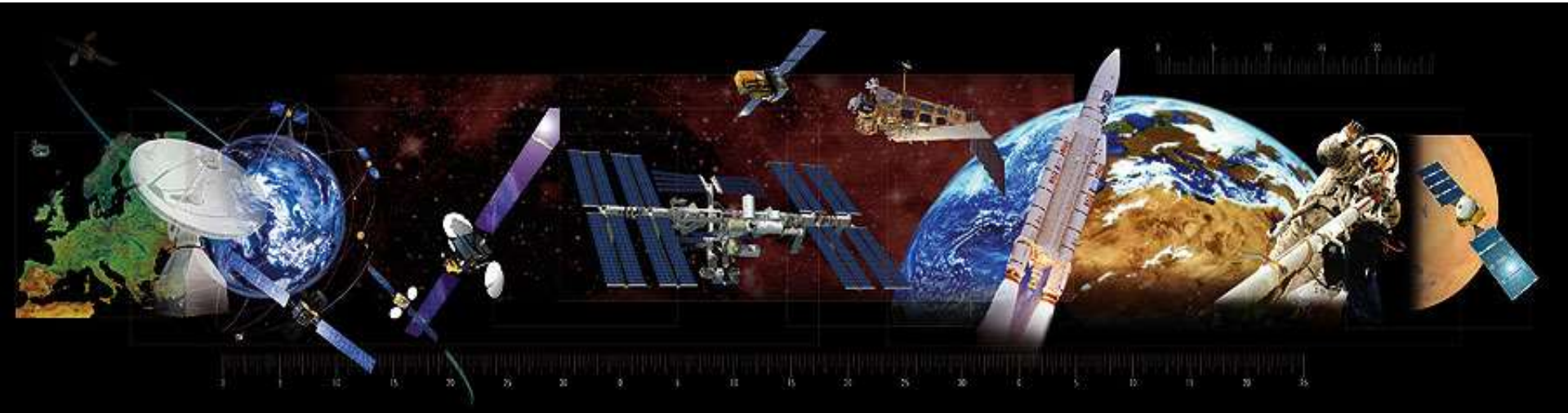
Canada takes part in some programmes under a Cooperation Agreement.

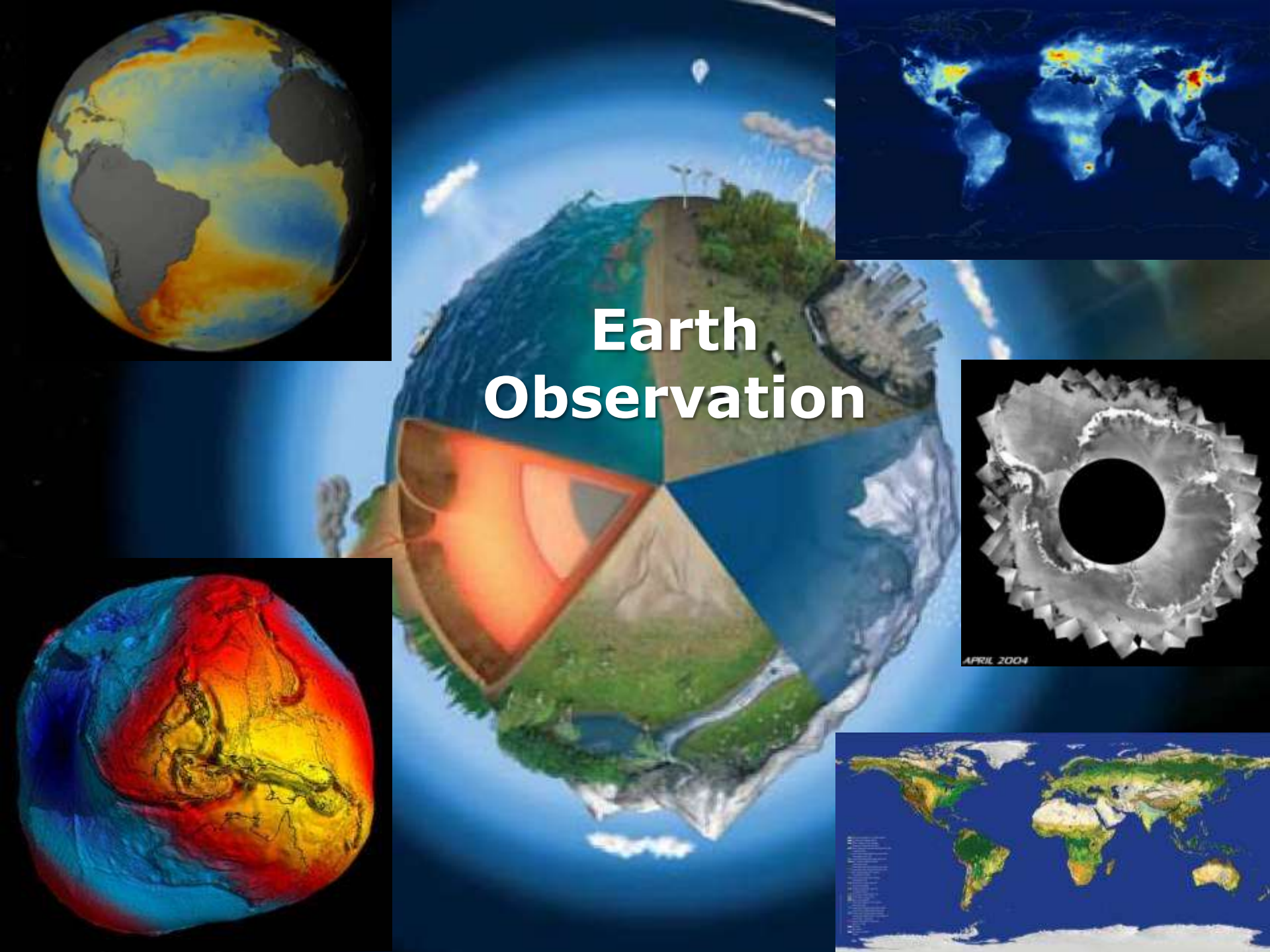
ACTIVITIES

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

1. **Space science**
2. **Human spaceflight**
3. **Exploration**
4. **Earth observation**
5. **Launchers**

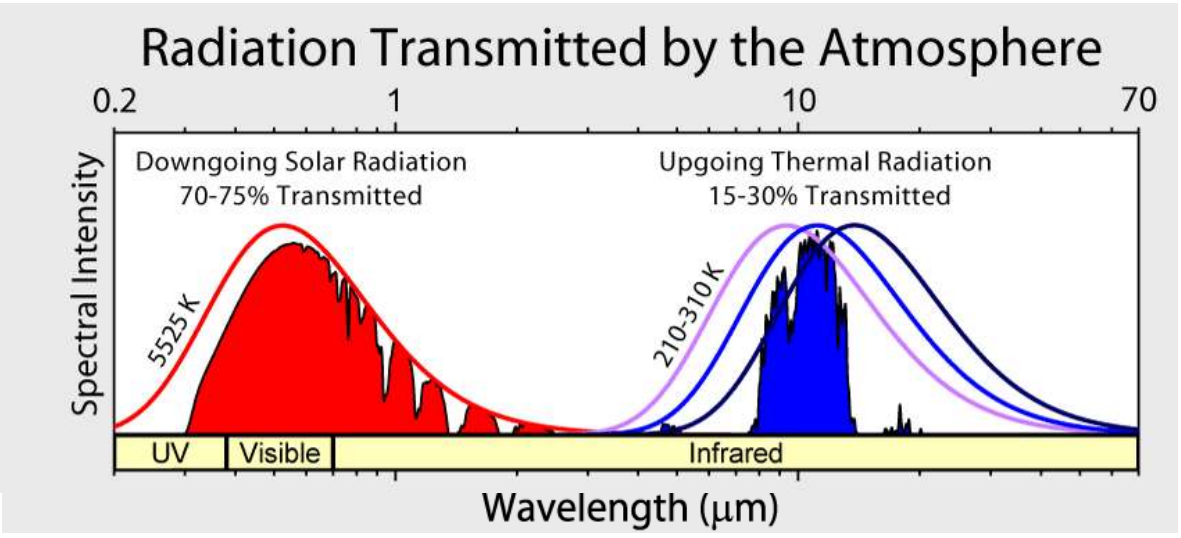
- **Navigation**
- **Telecommunications**
- **Technology**
- **Operations**

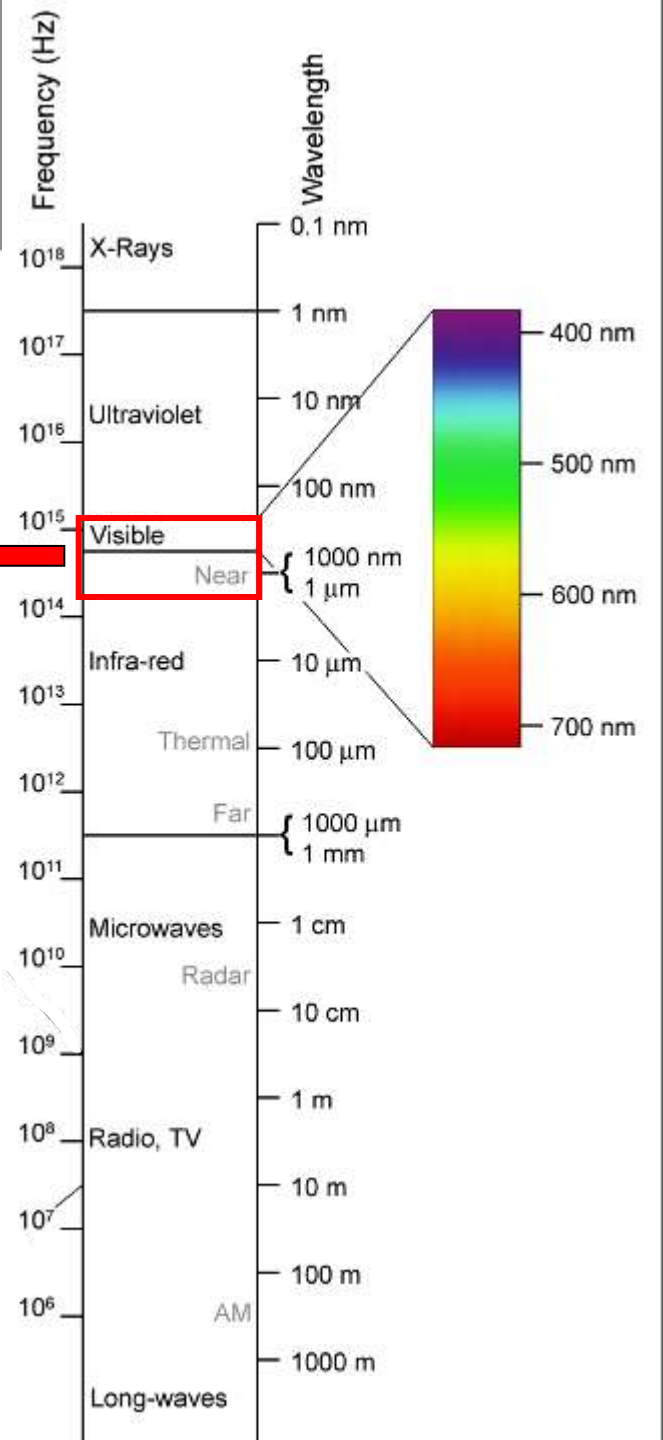



Earth
Observation
APRIL 2004

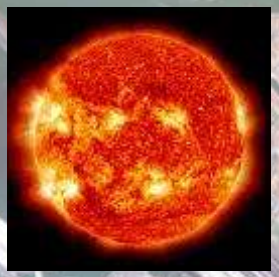
The electromagnetic spectrum

Visible (VIS) + Near Infrared (NIR)= Optical

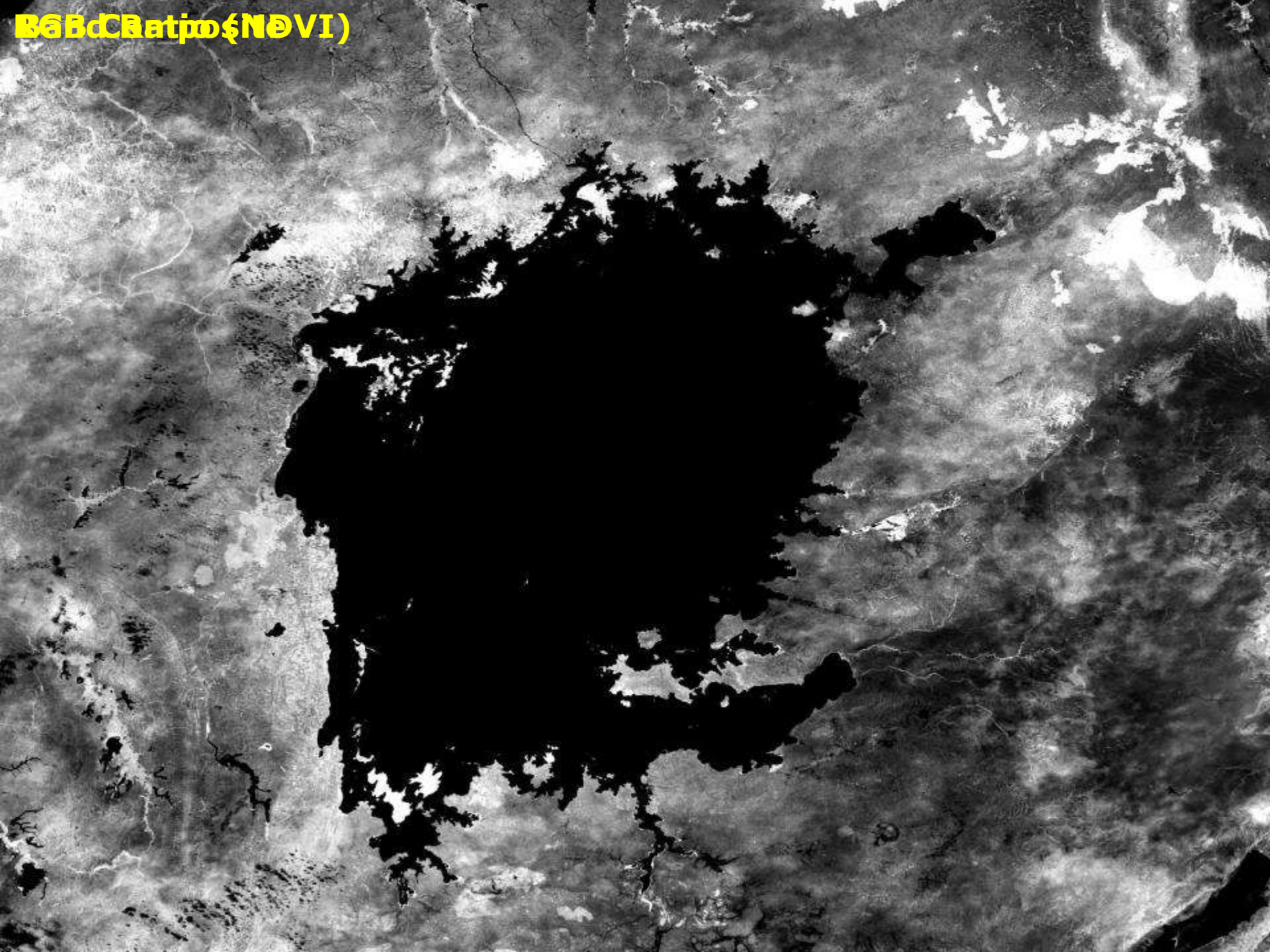




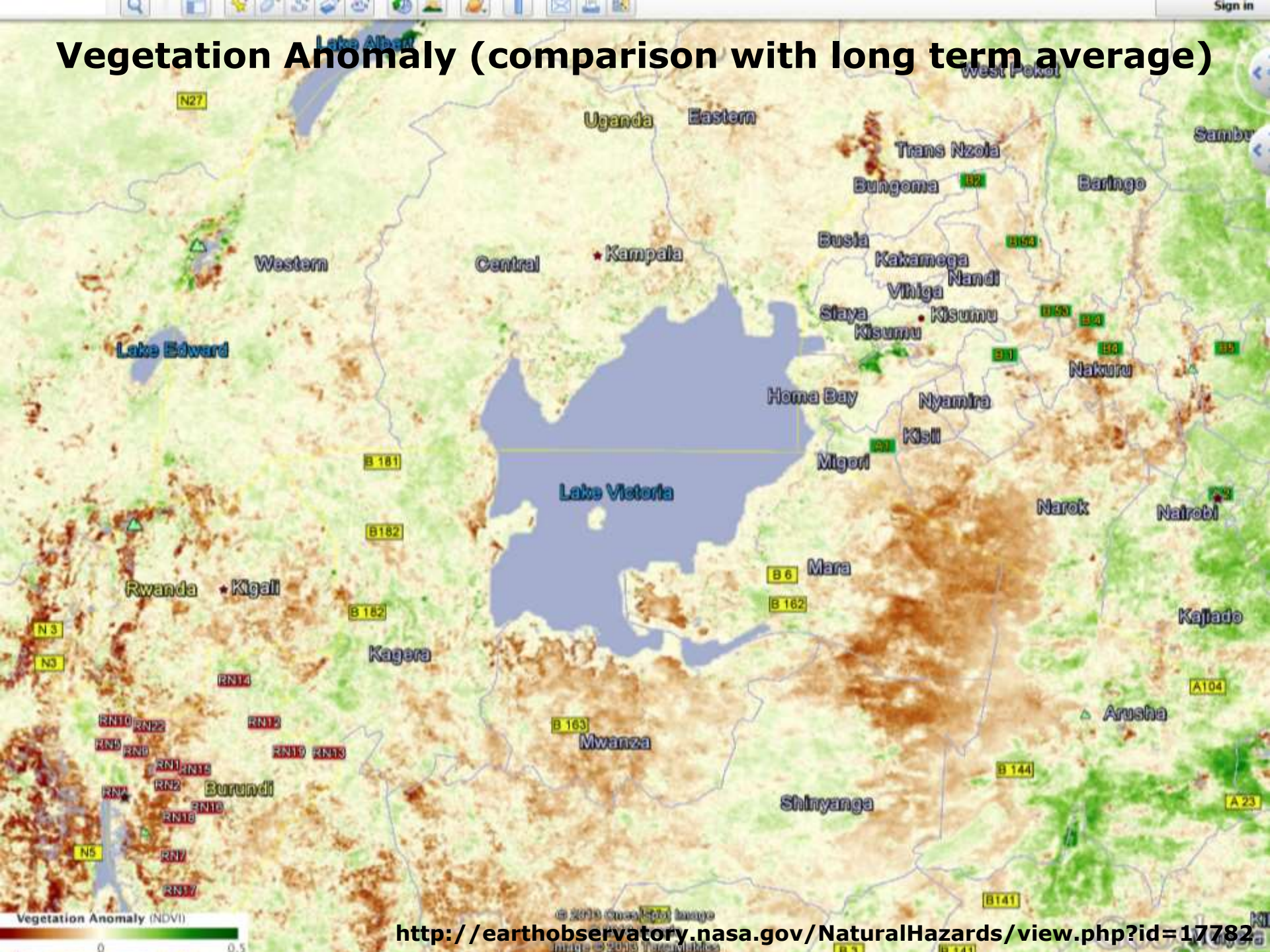
Passive Sensors



Primary source of energy: *Sun*

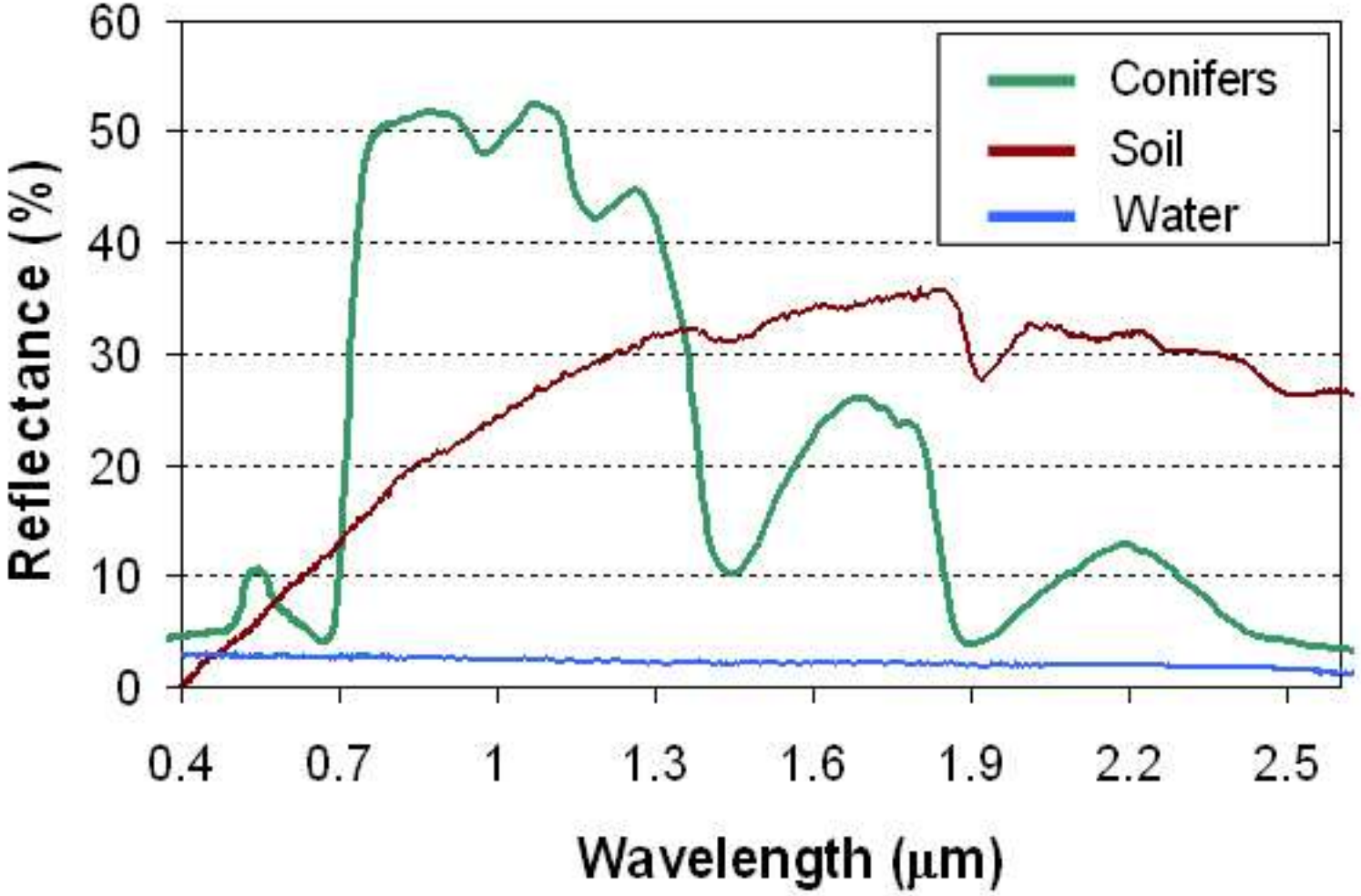

Band Ratio (NDVI)

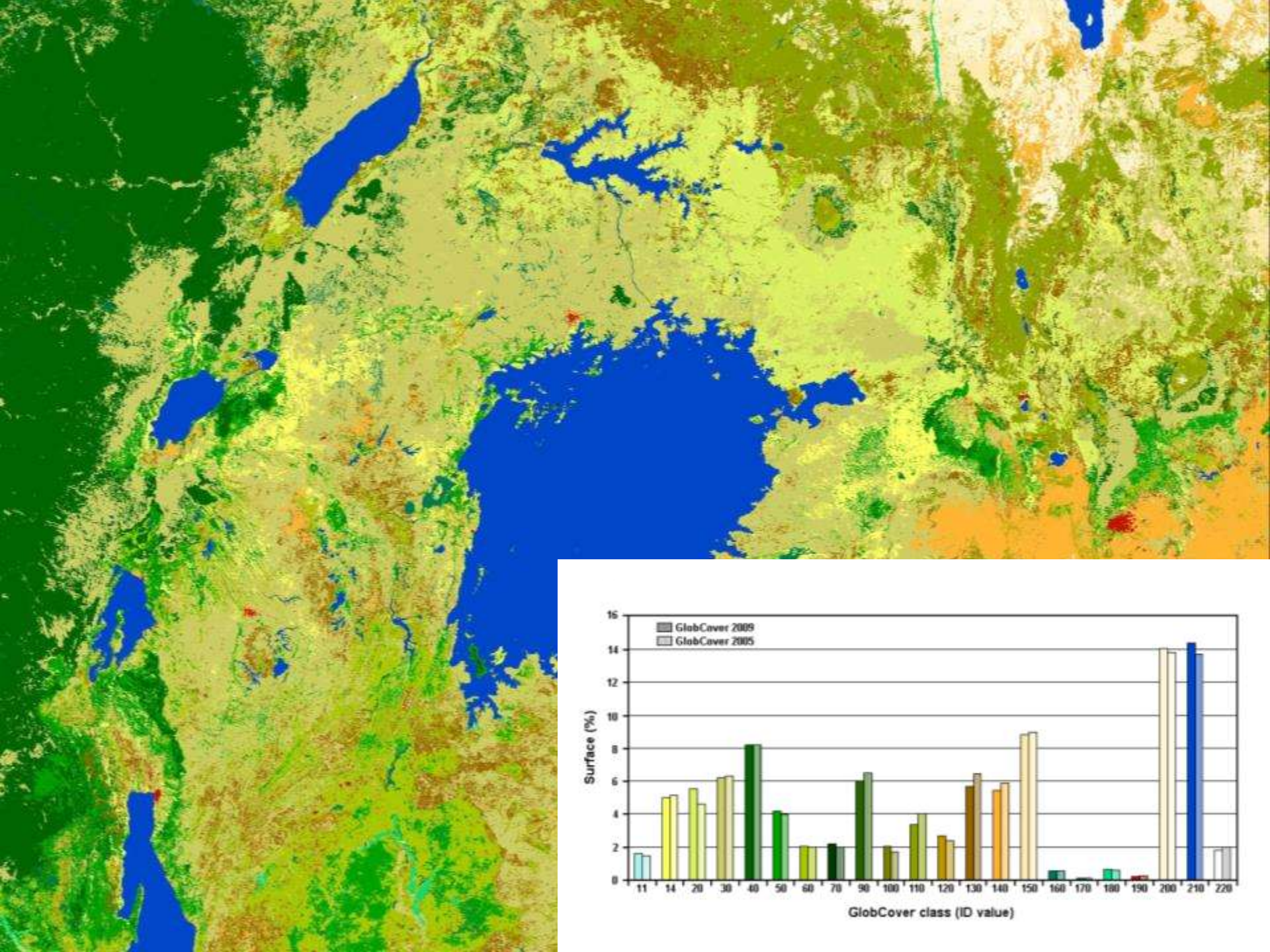
Vegetation Anomaly (comparison with long term average)

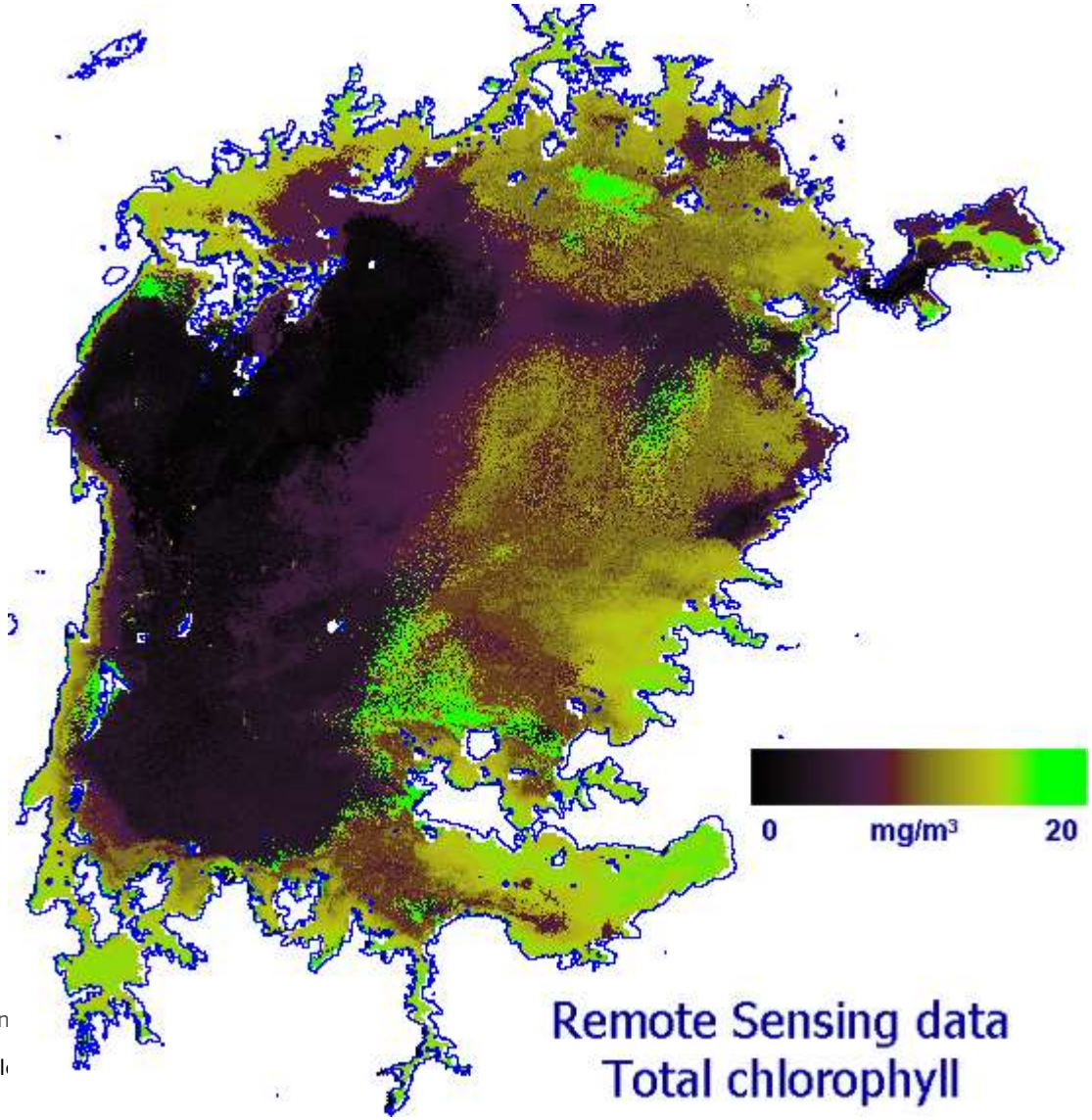


http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=17782

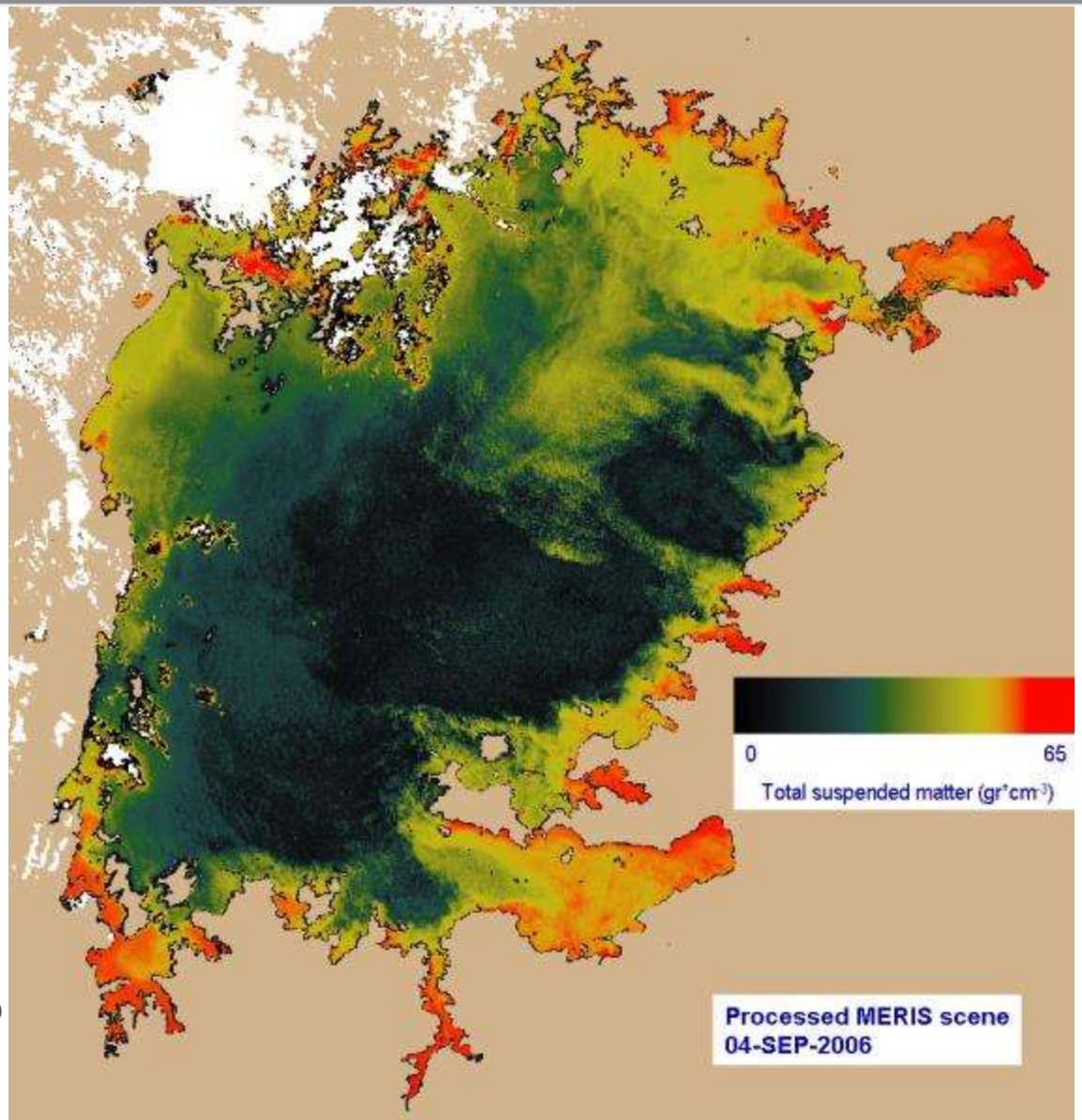
Spectral signatures



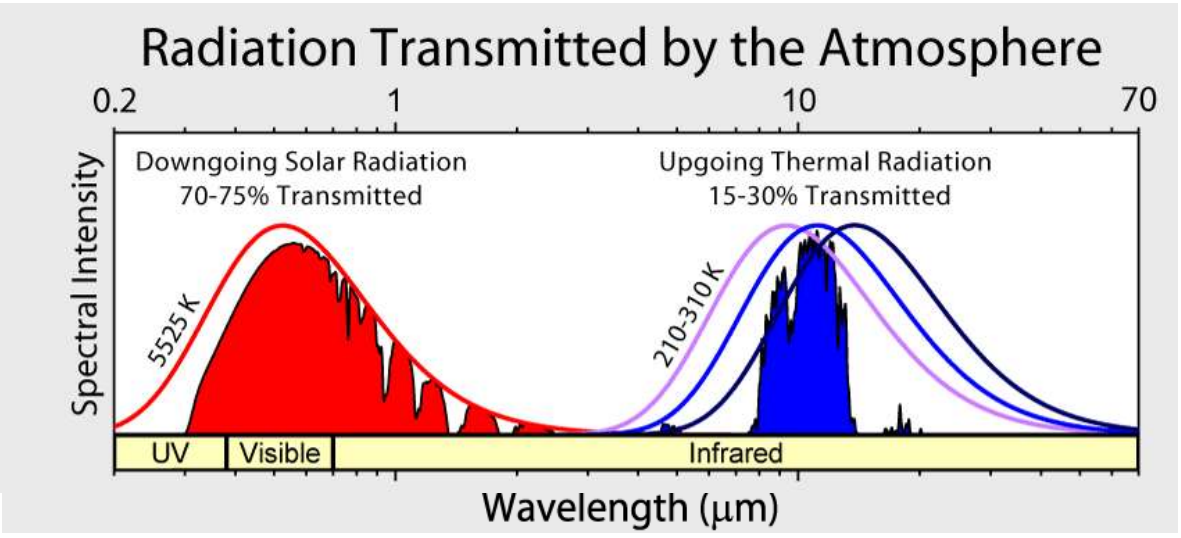

GlobCover 2009
GlobCover 2005
Surface (%)
0
2
4
6
8
10
12
14
16
11
14
20
30
40
50
60
70
90
100
110
120
130
140
150
160
170
180
190
200
210
220
GlobCover class (ID value)



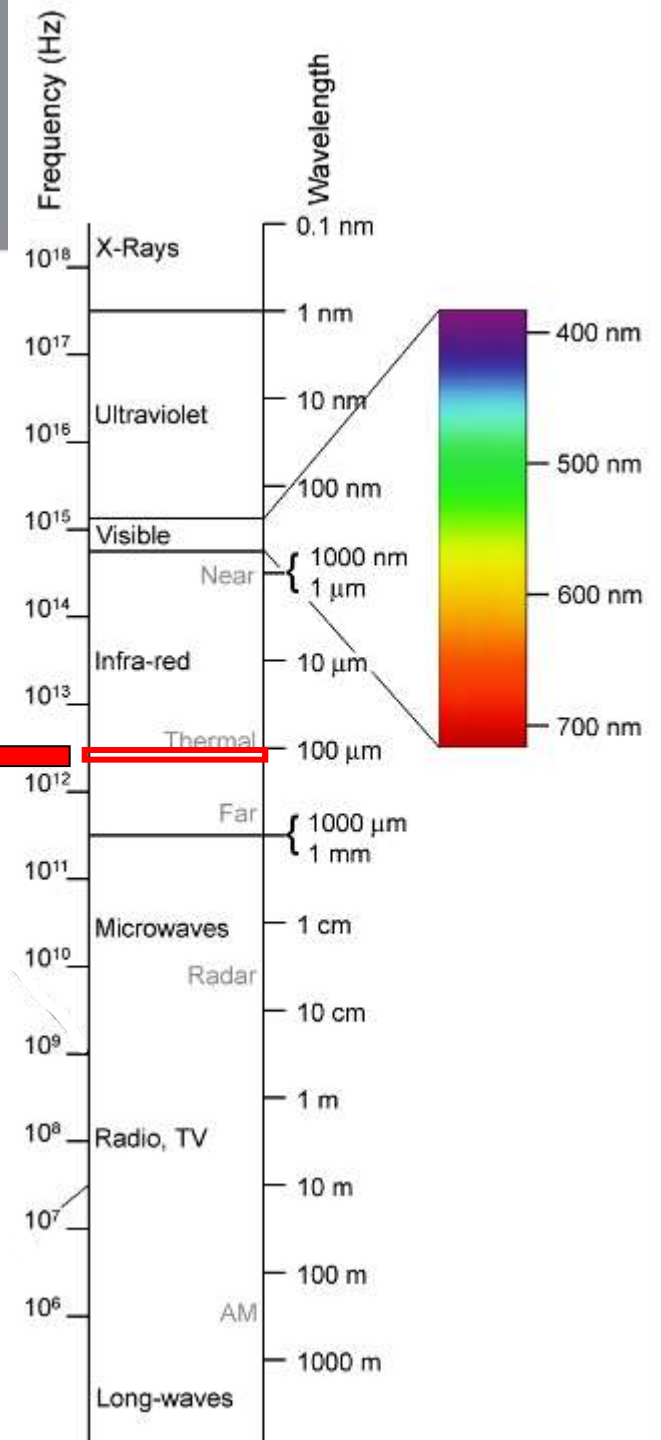
Remote Sensing data
Total chlorophyll



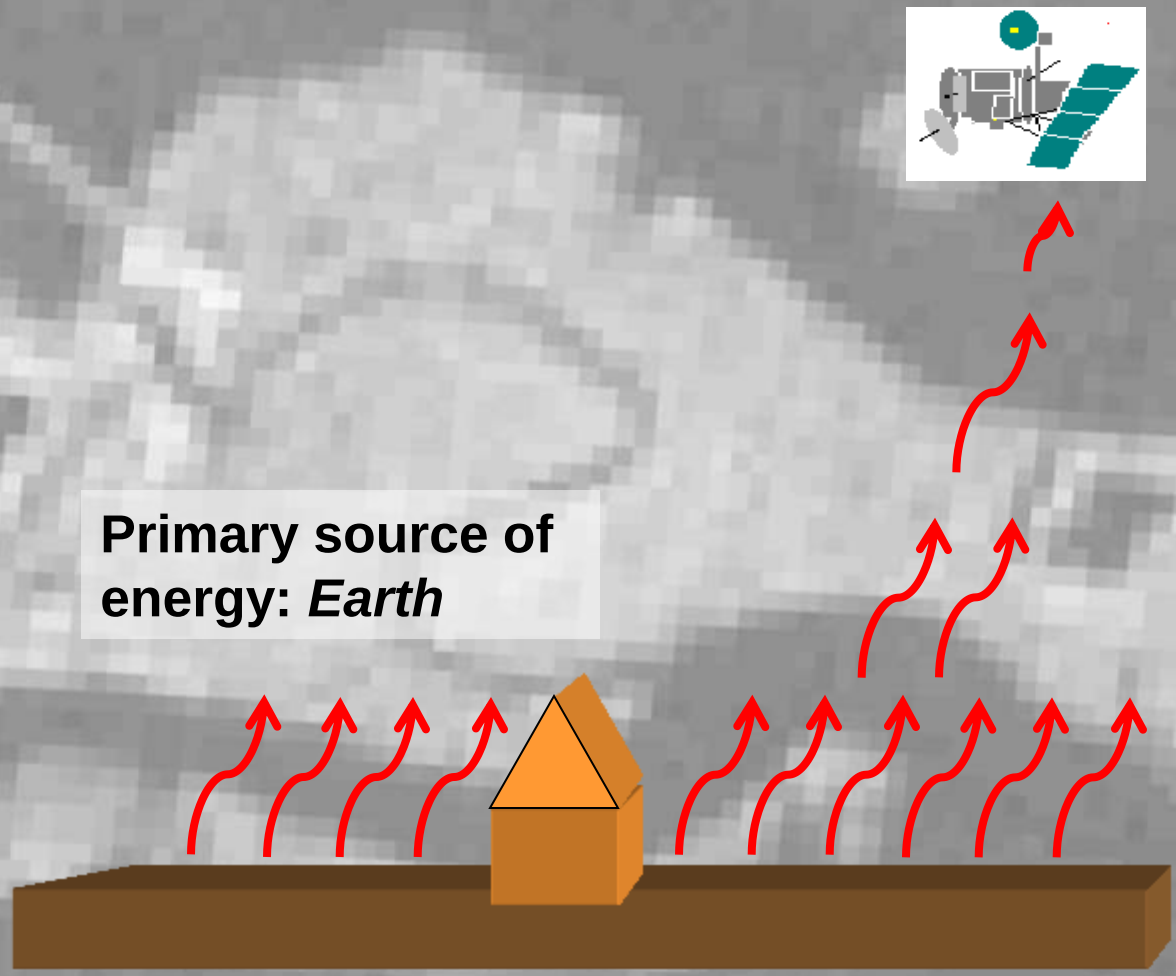
The electromagnetic spectrum



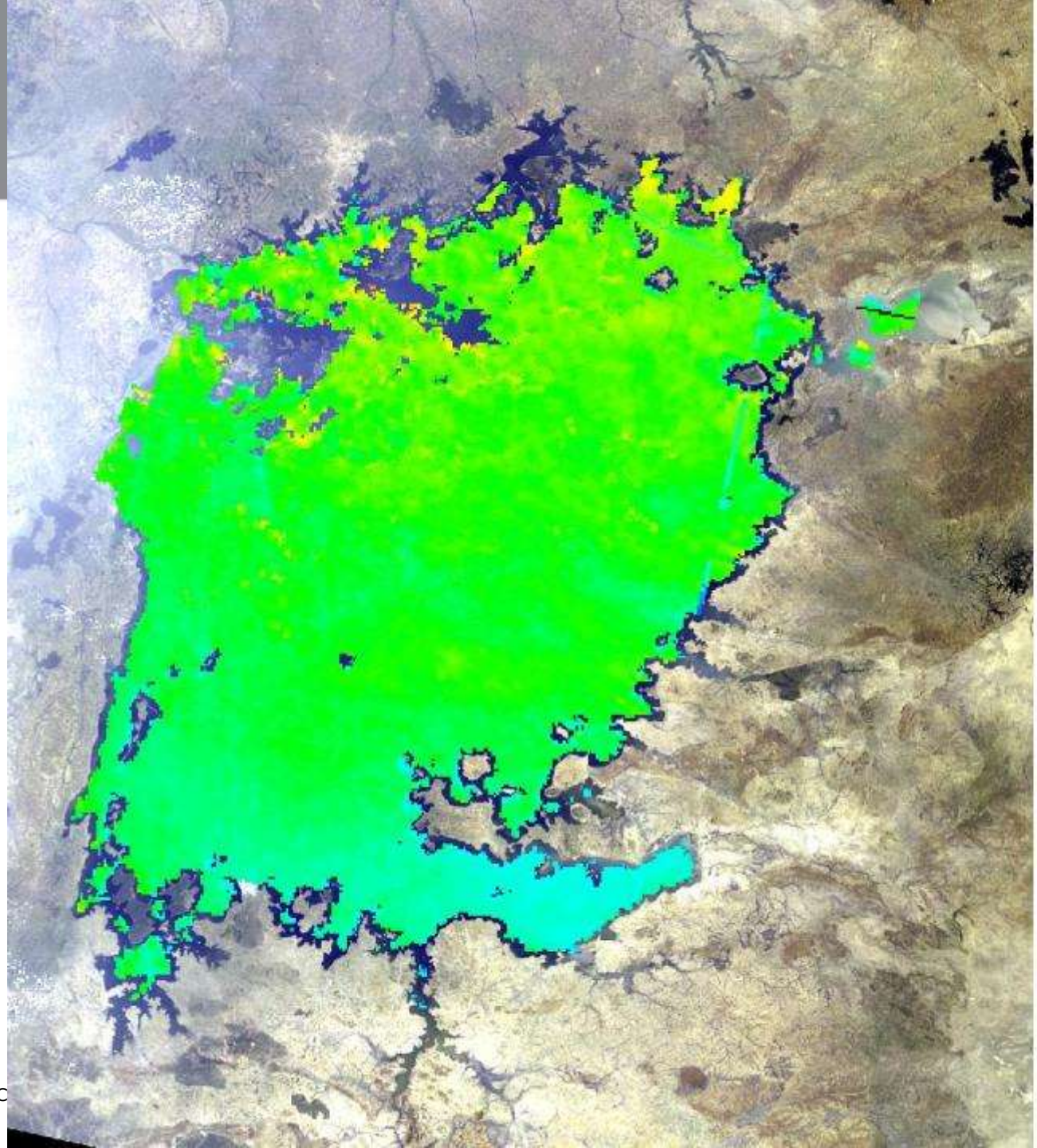
Thermal Infrared (TIR)



Passive Sensors



Primary source of energy: *Earth*



Derived from 3
AATSR scenes:

16-AUG-2006
19-AUG-2006
24-AUG-2006

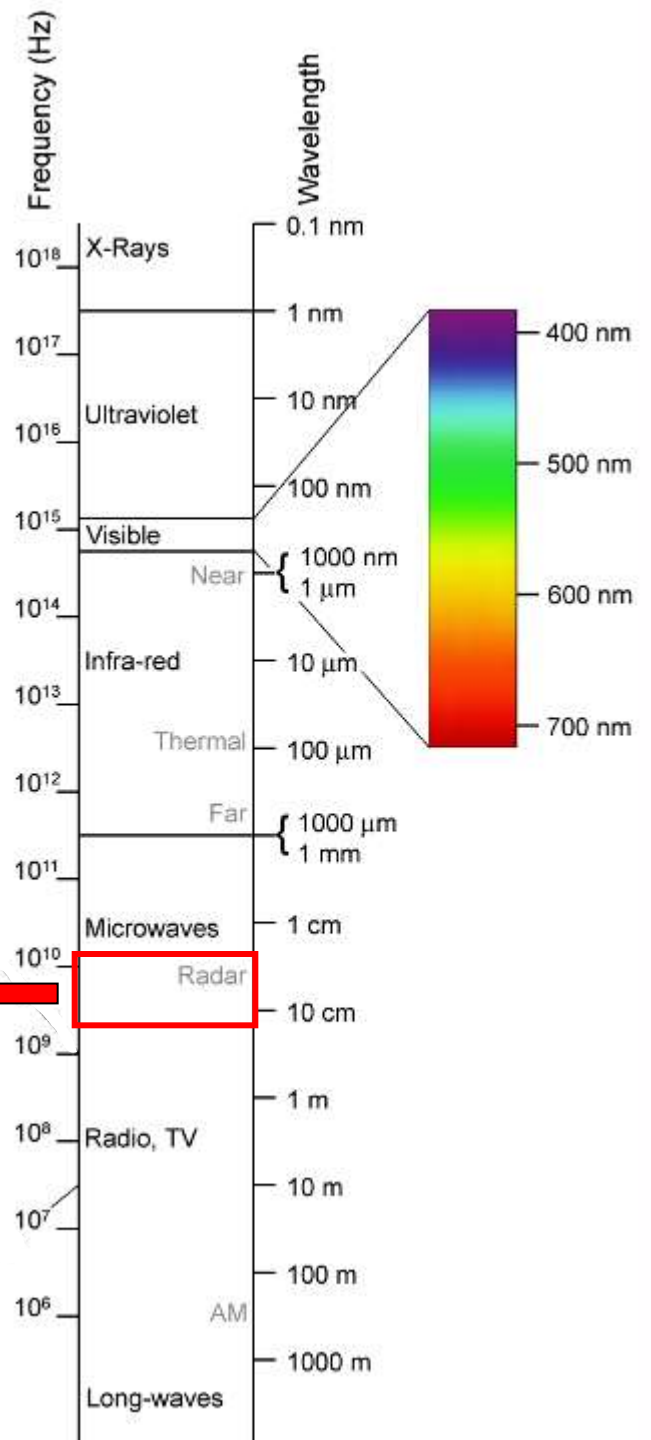
Legend

Temperature (°C)

- 18.5 <= T < 19.0
- 19.0 <= T < 19.5
- 19.5 <= T < 20.0
- 20.0 <= T < 20.5
- 20.5 <= T < 21.0
- 21.0 <= T < 21.5
- 21.5 <= T < 22.0
- 22.0 <= T < 22.5
- 22.5 <= T < 23.0
- 23.0 <= T < 23.5
- 23.5 <= T < 24.0
- 24.0 <= T < 24.5
- 24.5 <= T < 25.0
- 25.0 <= T < 25.5
- 25.5 <= T < 26.0
- 26.0 <= T < 26.5
- 26.5 <= T < 27.0
- 27.0 <= T < 27.5
- 27.5 <= T < 28.0
- 28.0 <= T < 28.5

The electromagnetic spectrum

Synthetic Aperture Radar (SAR)

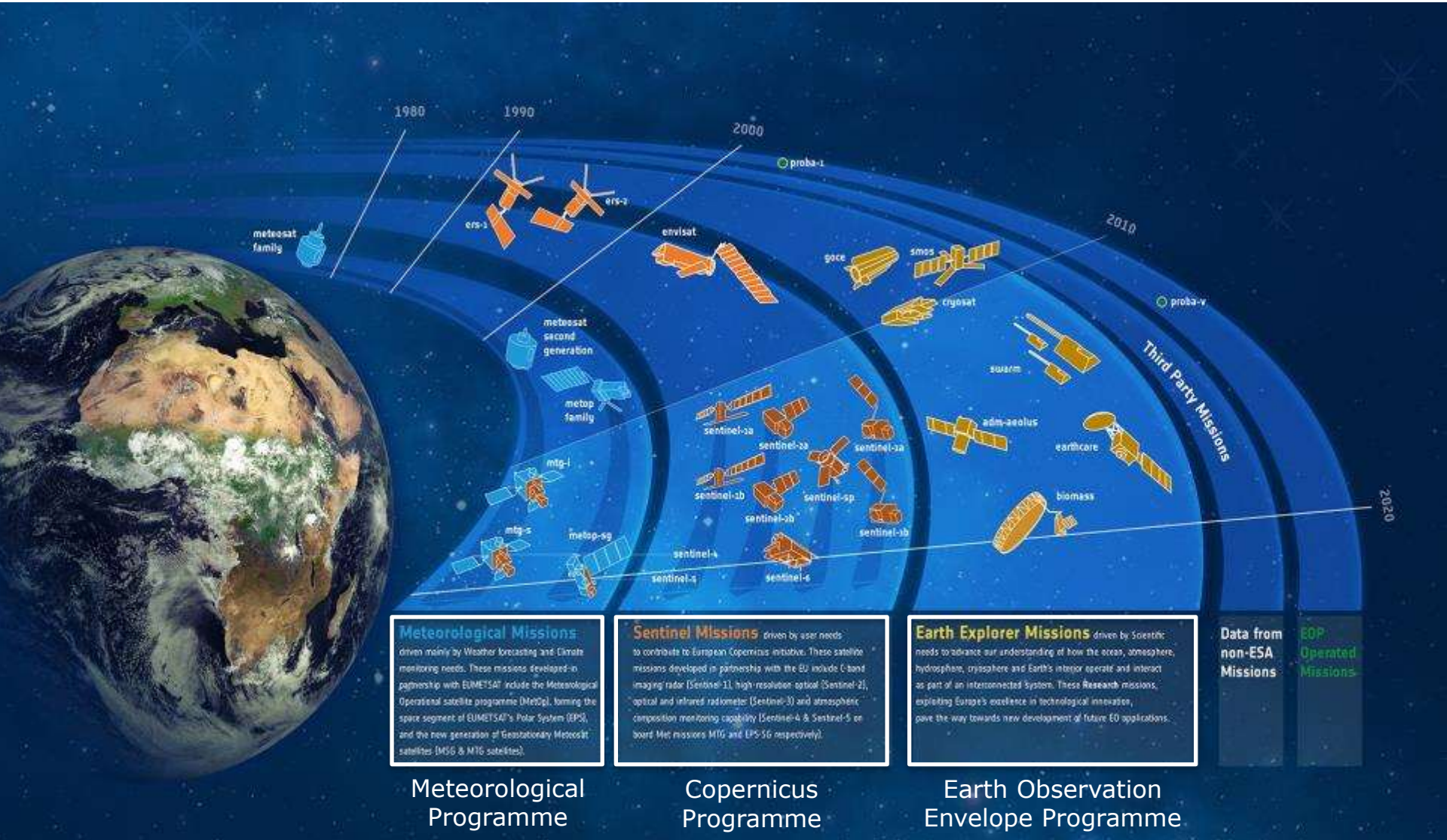


Active Sensors

Source of energy:
Satellite

ESA Earth Observation Programmes

ESA Earth Observation Programmes

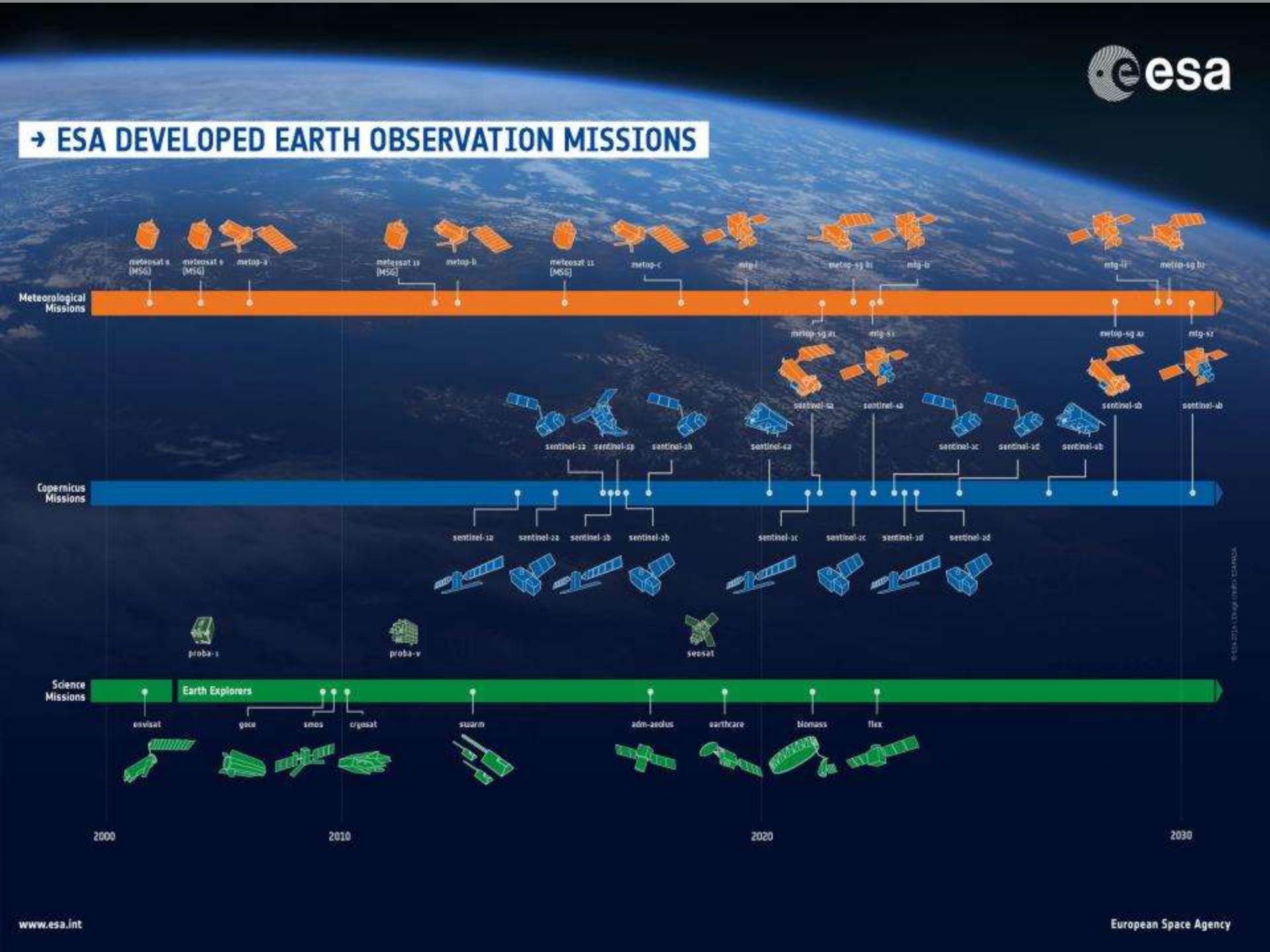


Meteorological Programme

Copernicus Programme

Earth Observation Envelope Programme

→ ESA DEVELOPED EARTH OBSERVATION MISSIONS

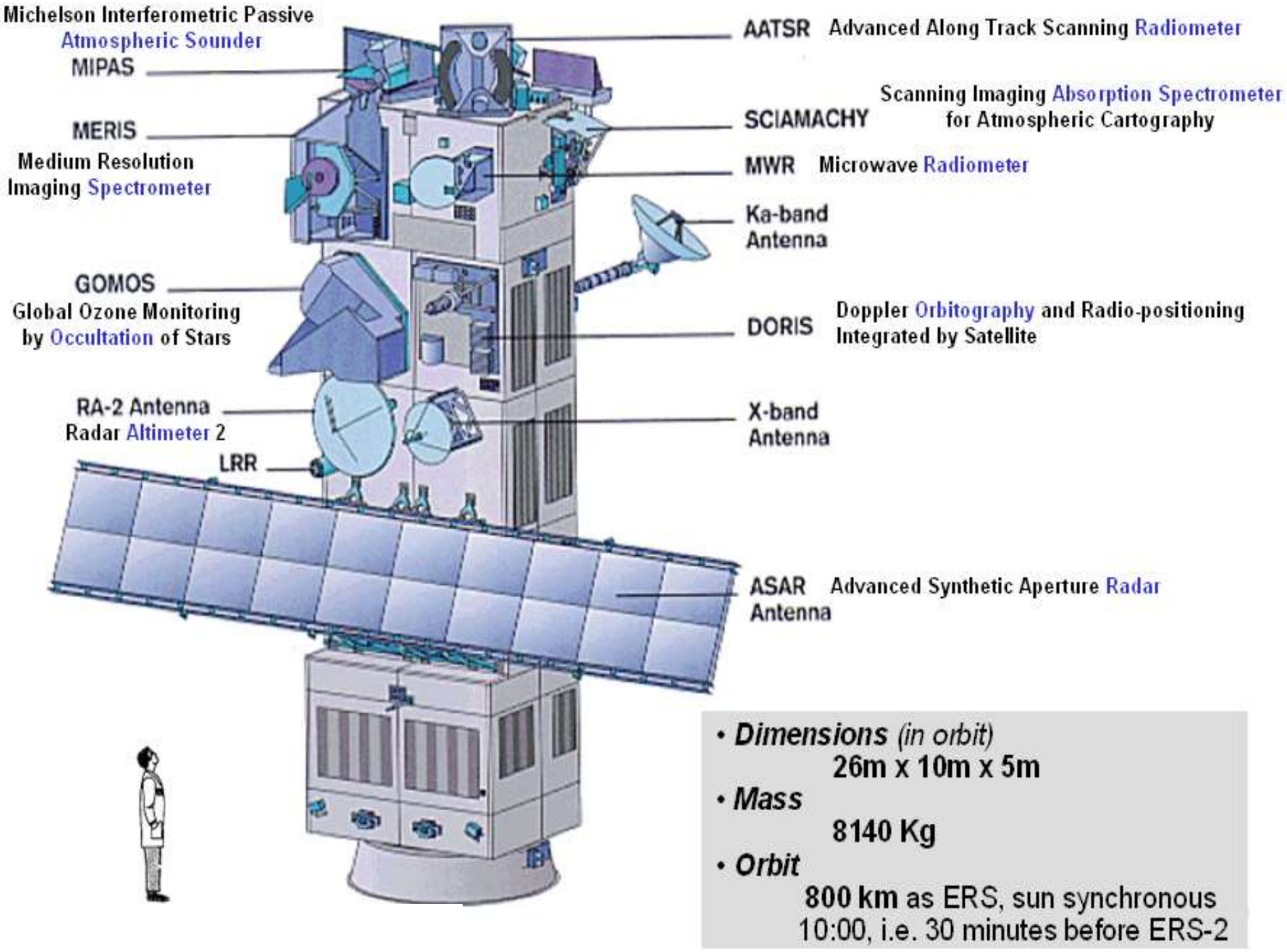


www.esa.int

European Space Agency

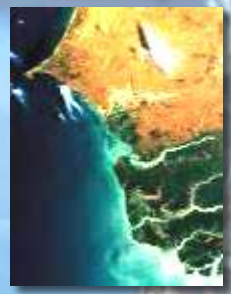
The Heritage: ERS and Envisat data

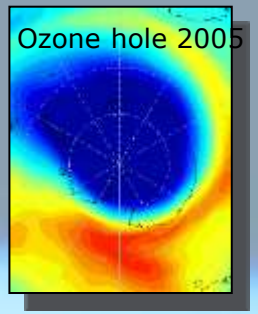
- ERS and Envisat missions 1991-2012
- More than 2 Petabytes of data
- Two decades of global change records
- Need for preservation, availability and exploitation

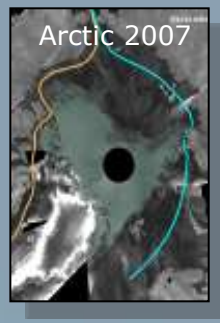


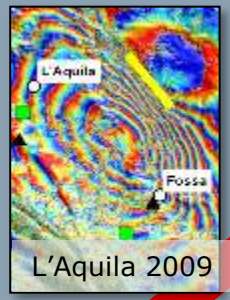
- ***Dimensions*** *(in orbit)*
  26m x 10m x 5m
- ***Mass***
  8140 Kg
- ***Orbit***
  800 km as ERS, sun synchronous
  10:00, i.e. 30 minutes before ERS-2

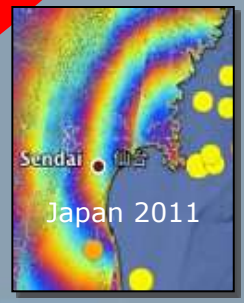
ENVISAT mission: 10 years

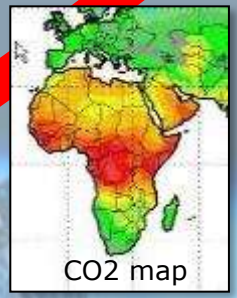


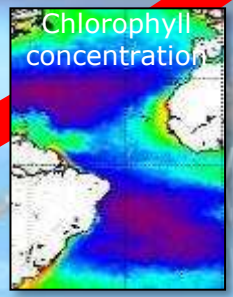


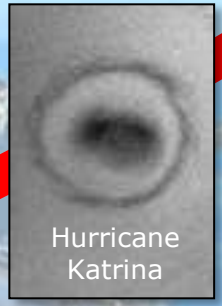


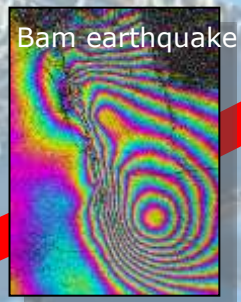












Serving 4000 scientific projects and many operational users. Many applications for disaster monitoring

Envisat Symposium Salzburg (A)

Envisat Symposium Montreux (CH)

Living Planet Symposium Bergen (N)

Mar 02 | **Sep 04** | **Apr 07** | **Jun 10** | **Mar 12**

and many workshops dedicated to specific Envisat user communities

ENVISAT
An example of multisensor application: Risk Management

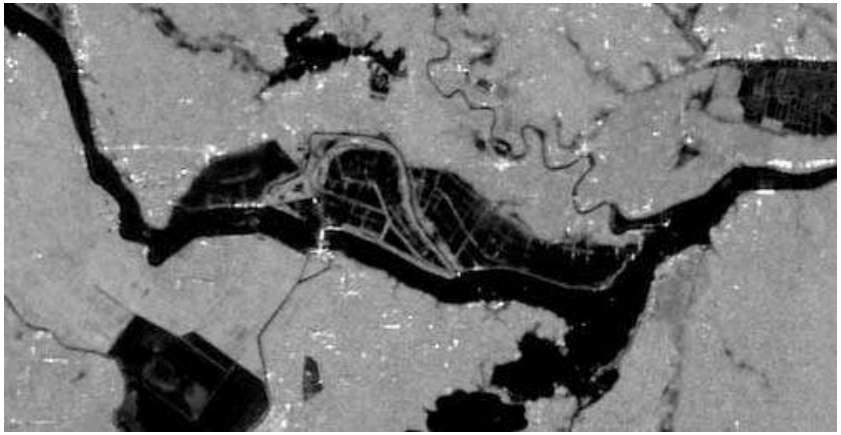
1) Use of optical data for Risk Management


Moscow Fires (Meris FR 2011)

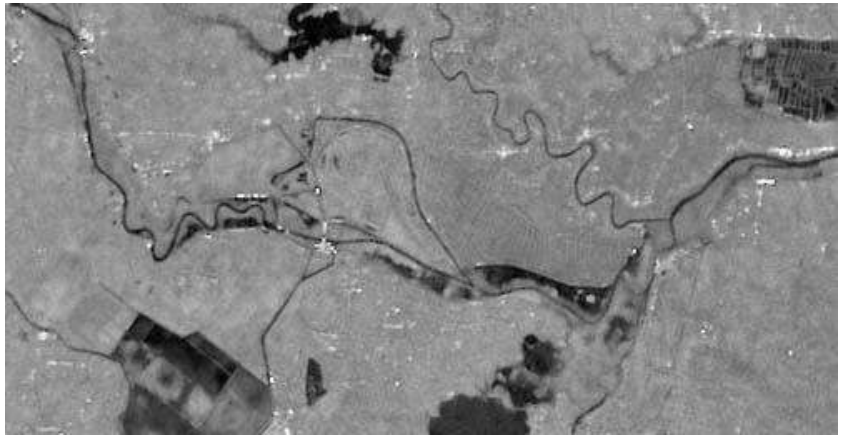

Baltic Sea Algal Blooms
(MERIS_FR_2005.07.13)

2) Use of radar backscatter for Risk Management

Flood mapping using satellite radar



ASAR WSM 150m spatial resolution acquired 15th July 2007, descending pass, polarisation HH.

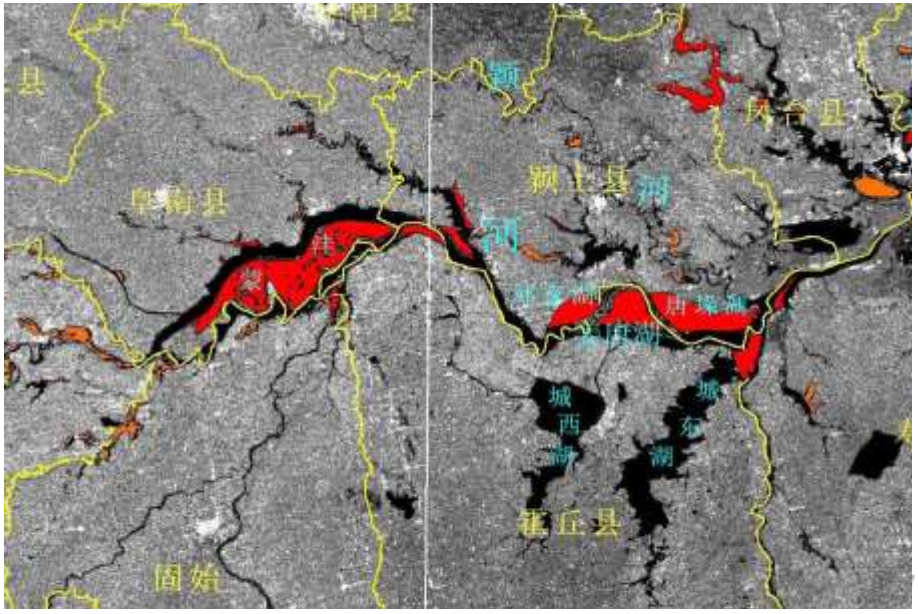


ASAR WSM 150m spatial resolution acquired 12th August 2006, descending pass, polarisation HH.

Inundated areas are clearly visible in this Envisat ASAR image acquired during floods in China in July 2007.

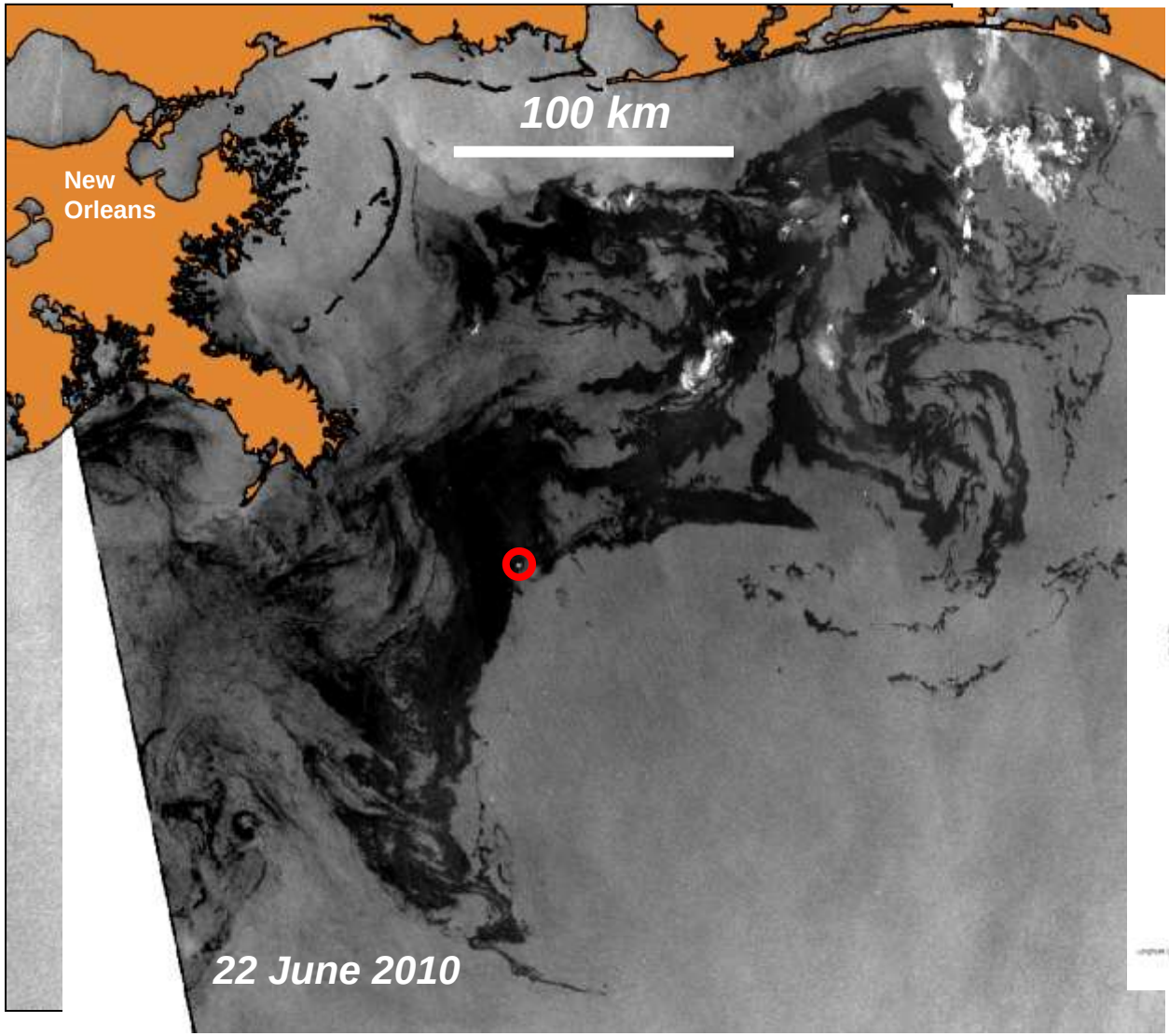
FLOODING IN CHINA (JULY 2007)

The two images were acquired during the same season but different years, one during the flooding, the other the year before. By comparing the two images, both with the same geometry (Wide Swath Mode, descending pass) and same polarisation (HH) it is possible to assess the extent of the flooding.

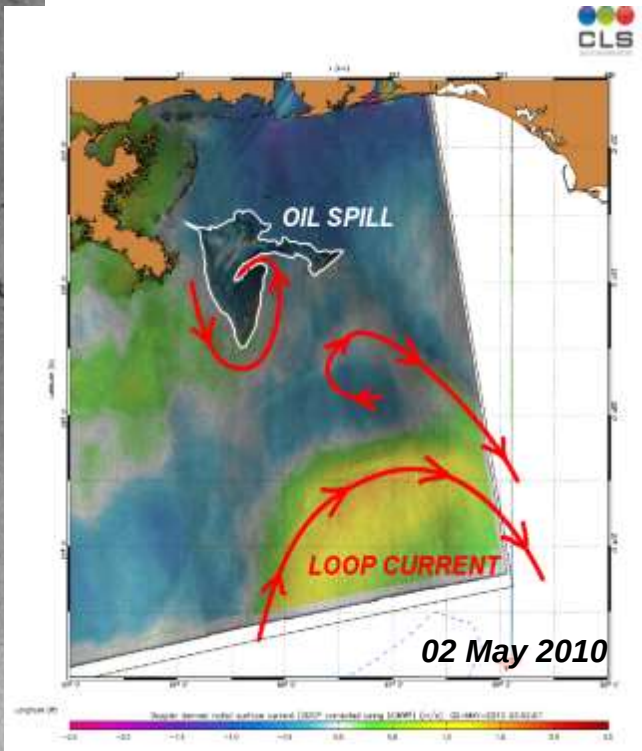


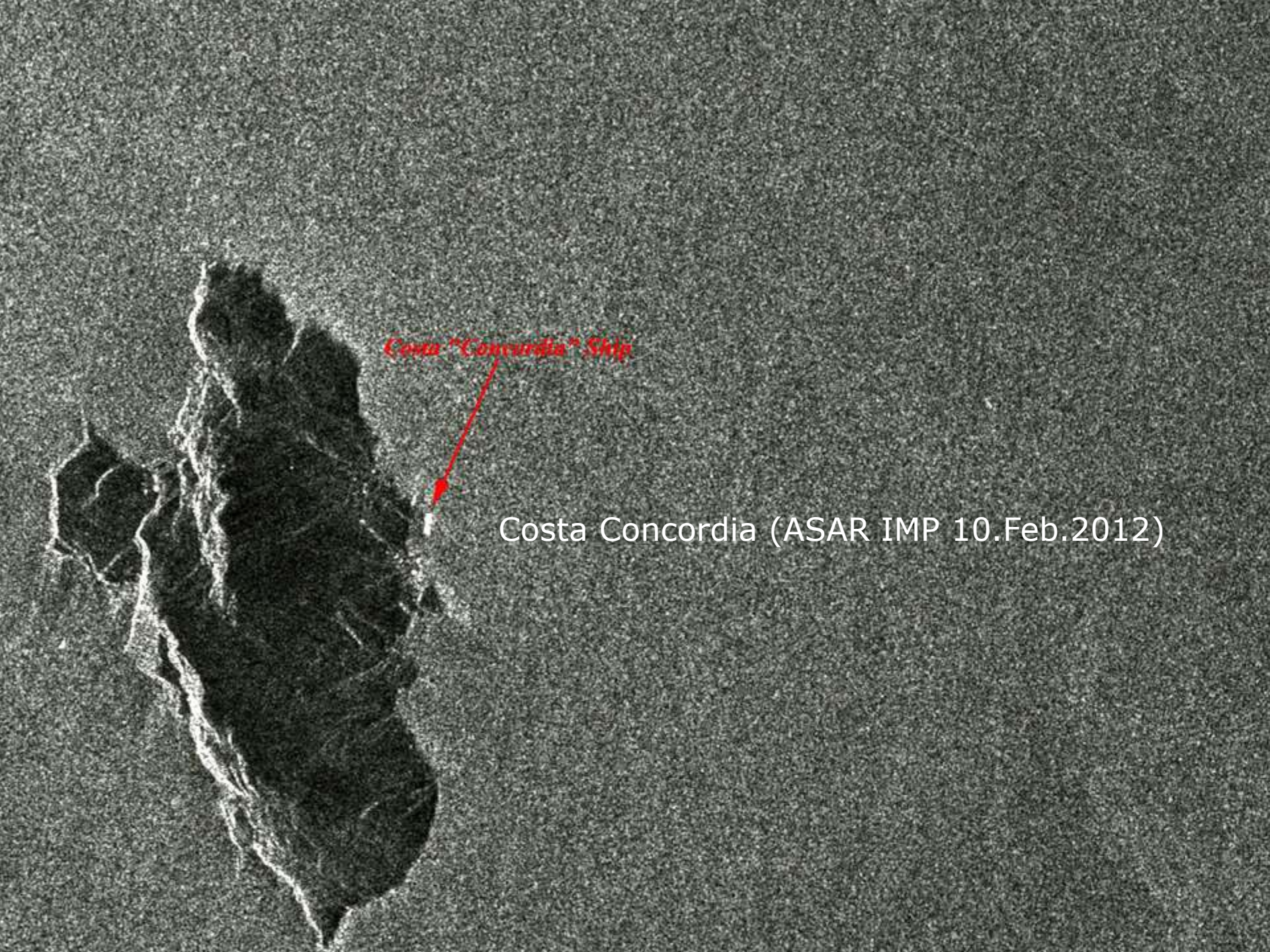
Courtesy of IWHR, Beijing

Oil spill monitoring using radar satellite



The Louisiana Oil Spill disaster from space
(Envisat ASAR)





Costa Concordia (ASAR IMP 10.Feb.2012)

Iceberg B-15A
(ASAR_WSM_15Apr05)

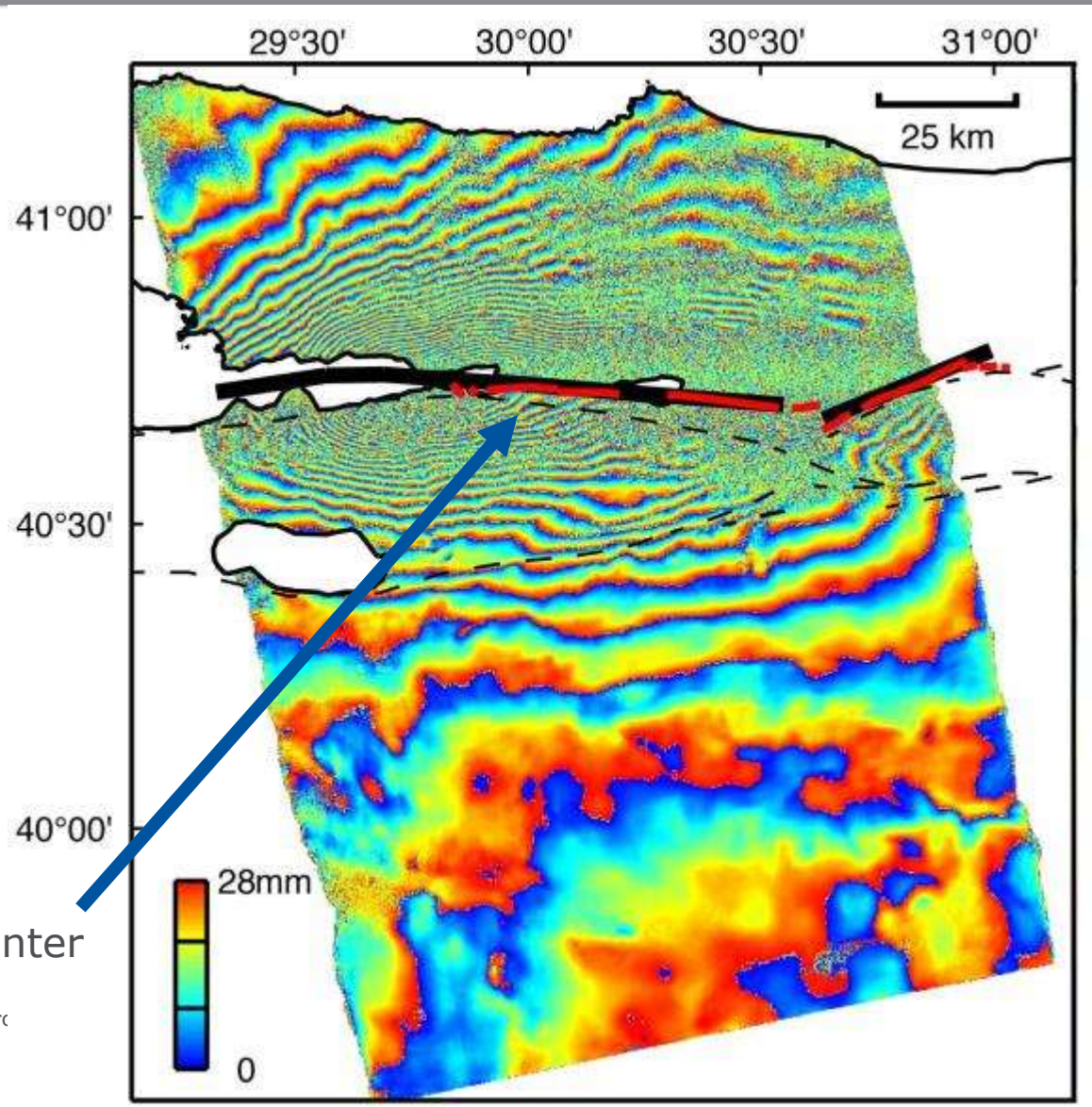
Iceberg B-15A Antarctic (ASAR_WSM from 4th to 20th Apr 05)

Use of radar phase (InSAR, PS) for Risk Management

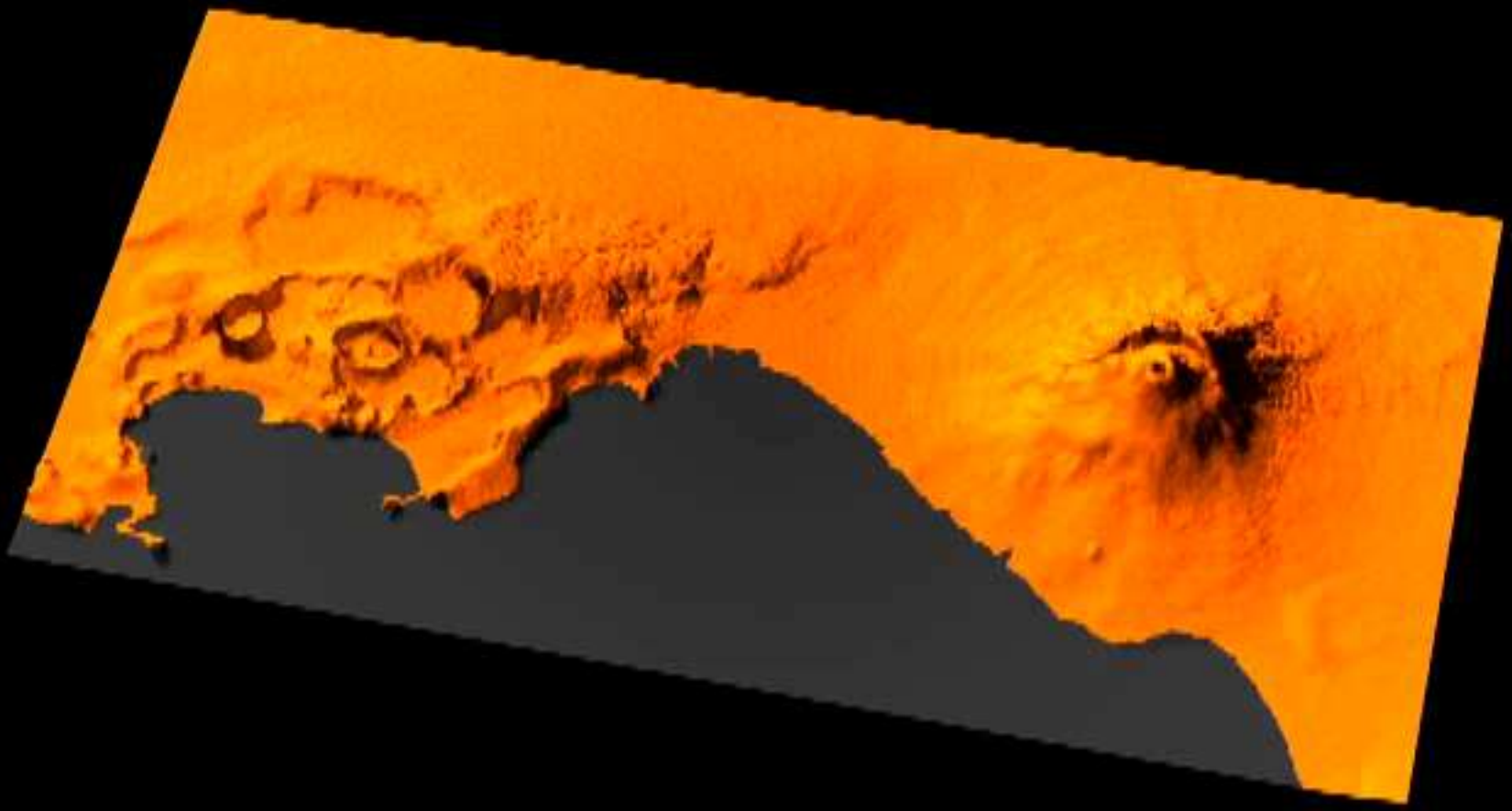
Earthquake in Izmit, Turkey (1999)

Post-seismic deformation measured by Interferometric SAR

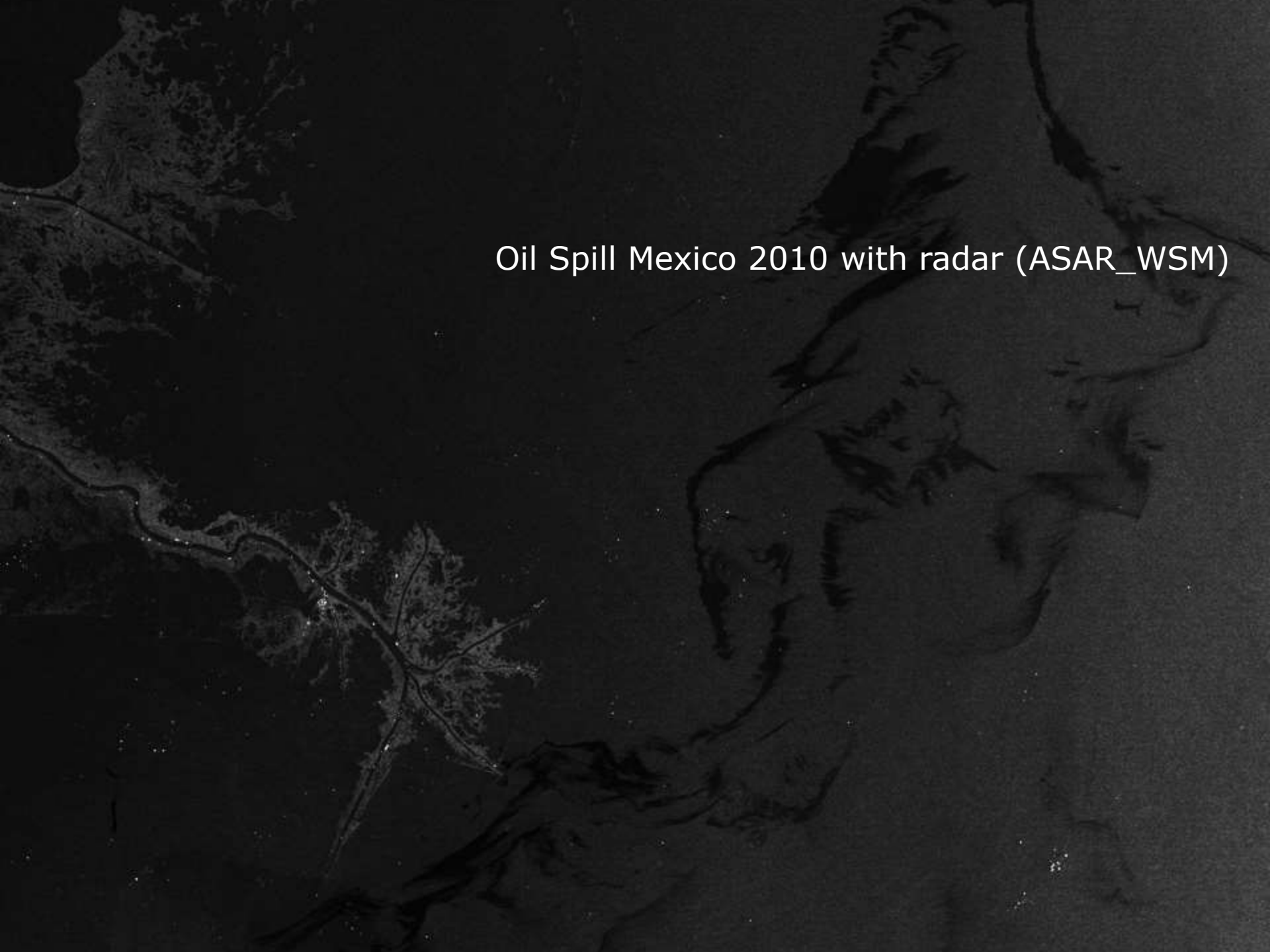
- Synthetic Aperture Radar (ERS-1, ERS-2)
- Generation of Interferogram (phase difference between two SAR images)
- One colour pattern (fringe) corresponds to 28 mm deformation along the line of sight
- This works through clouds or darkness (Radar Data)

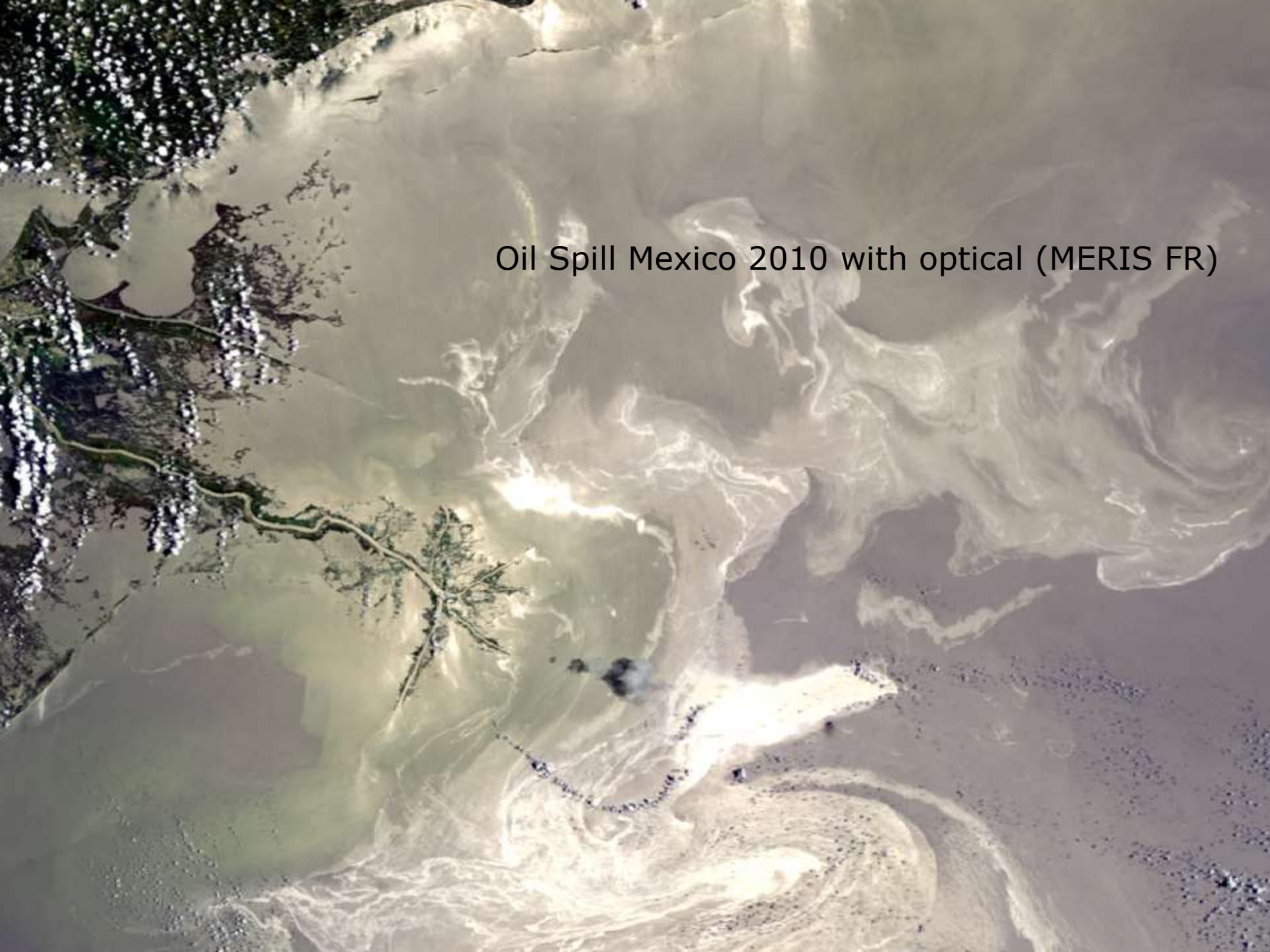


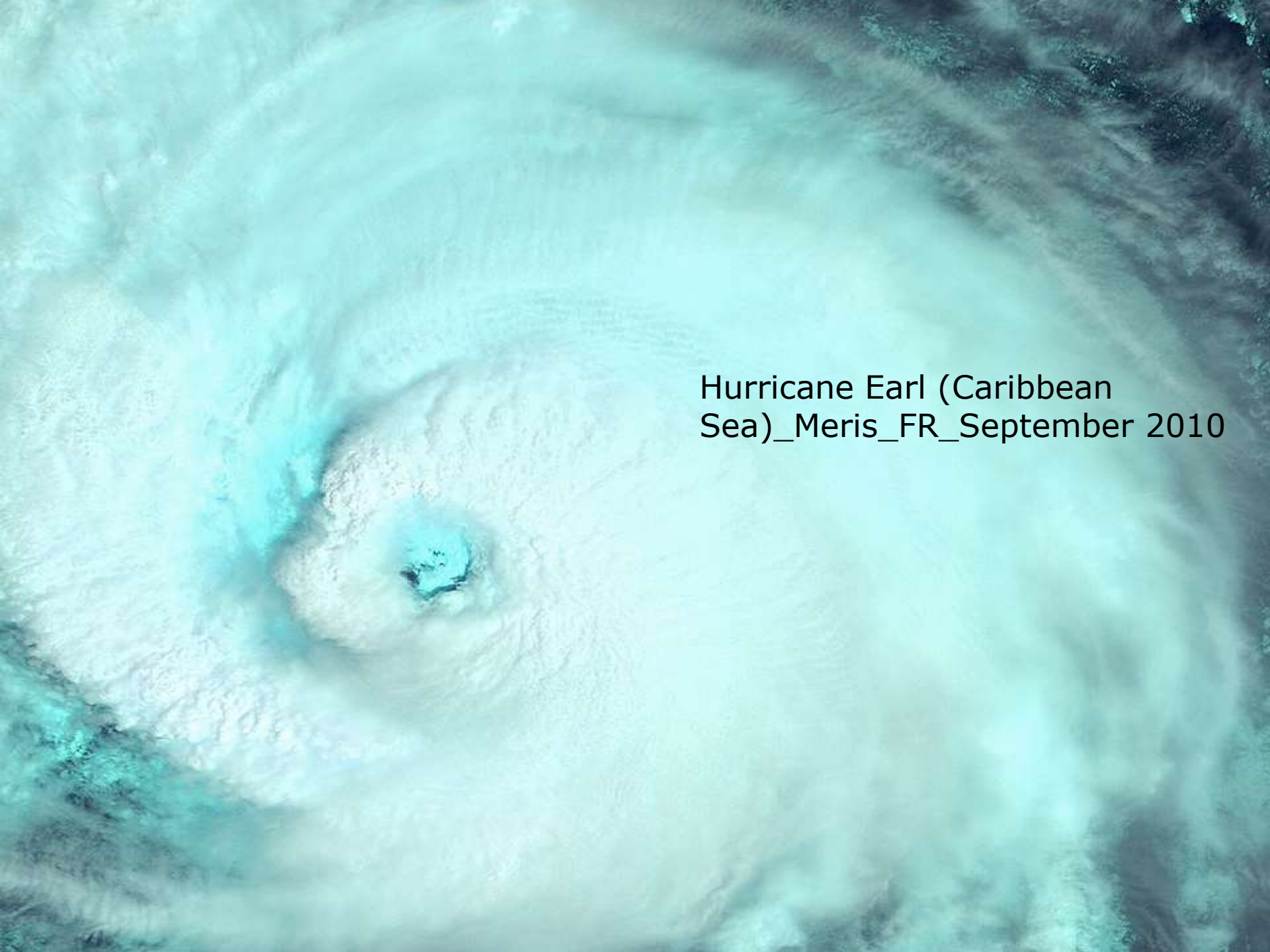
Campi Flegrei: observation by InSAR



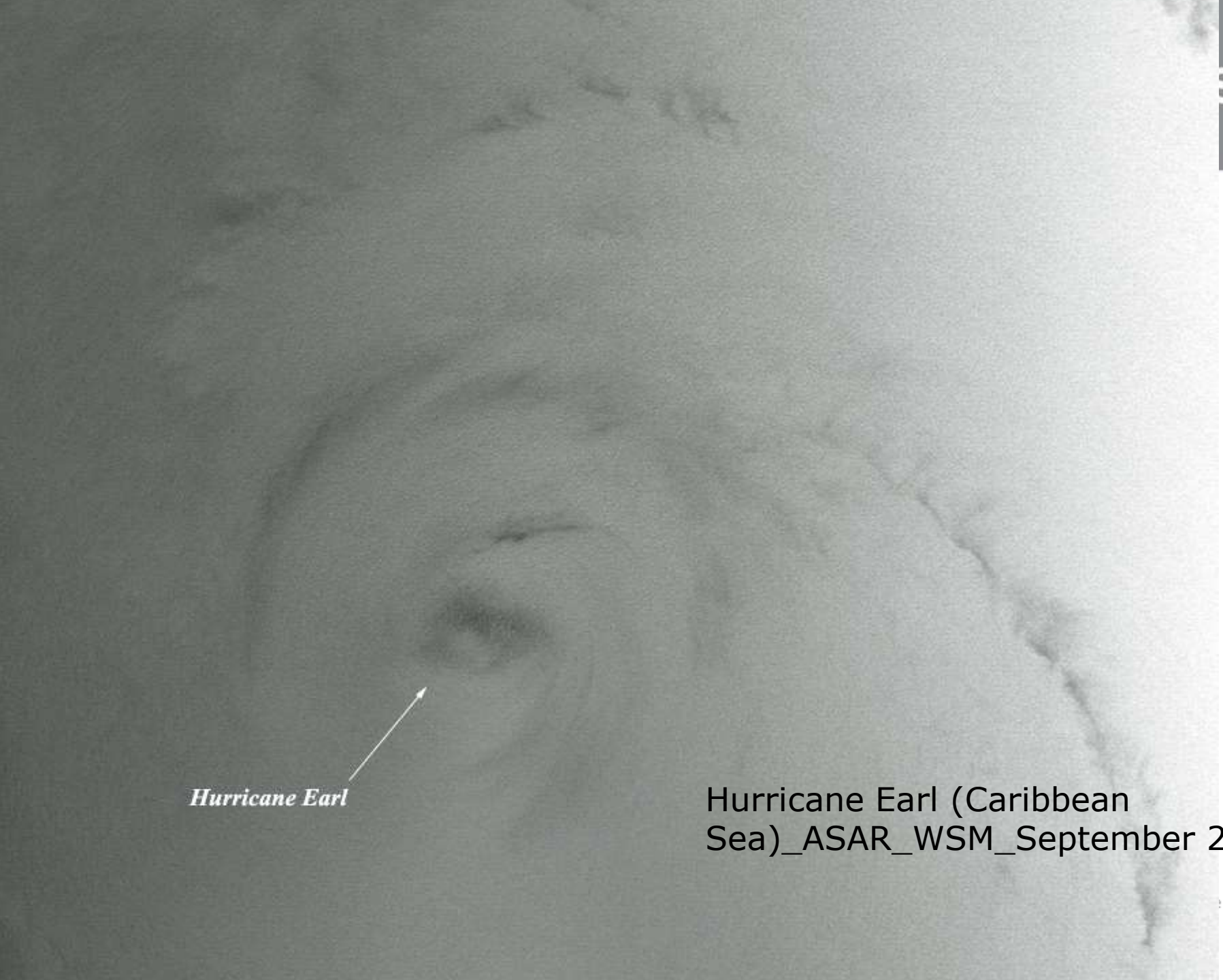
3) Use of radar backscatter, combined with optical data, for Risk Management


Oil Spill Mexico 2010 with radar (ASAR_WSM)


Oil Spill Mexico 2010 with optical (MERIS FR)

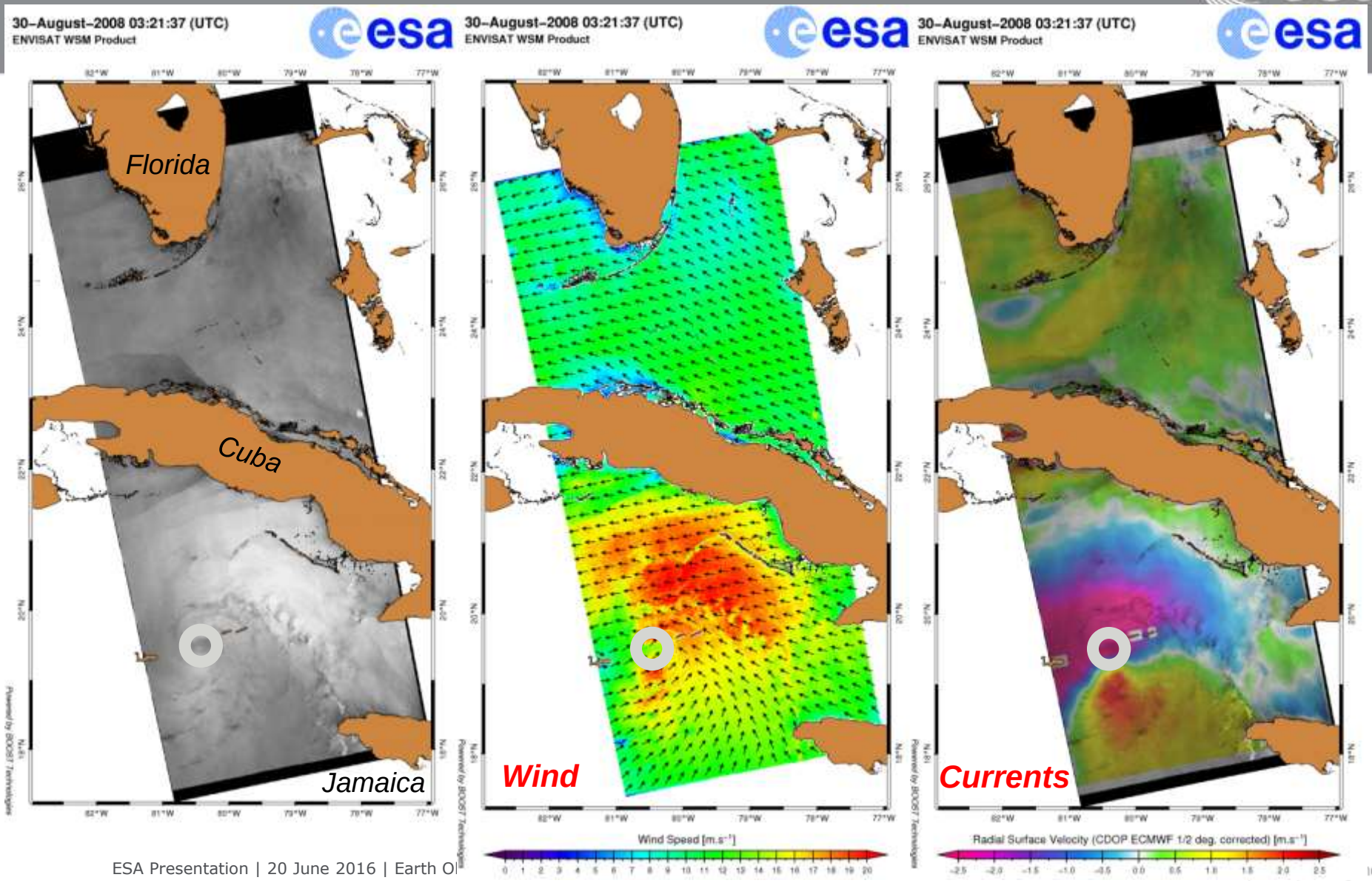


Hurricane Earl (Caribbean Sea)_Meris_FR_September 2010



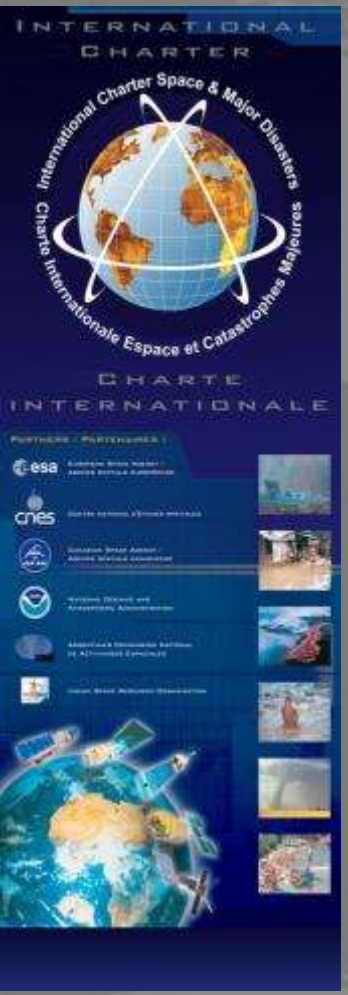
Hurricane Earl (Caribbean Sea)_ASAR_WSM_September 2010

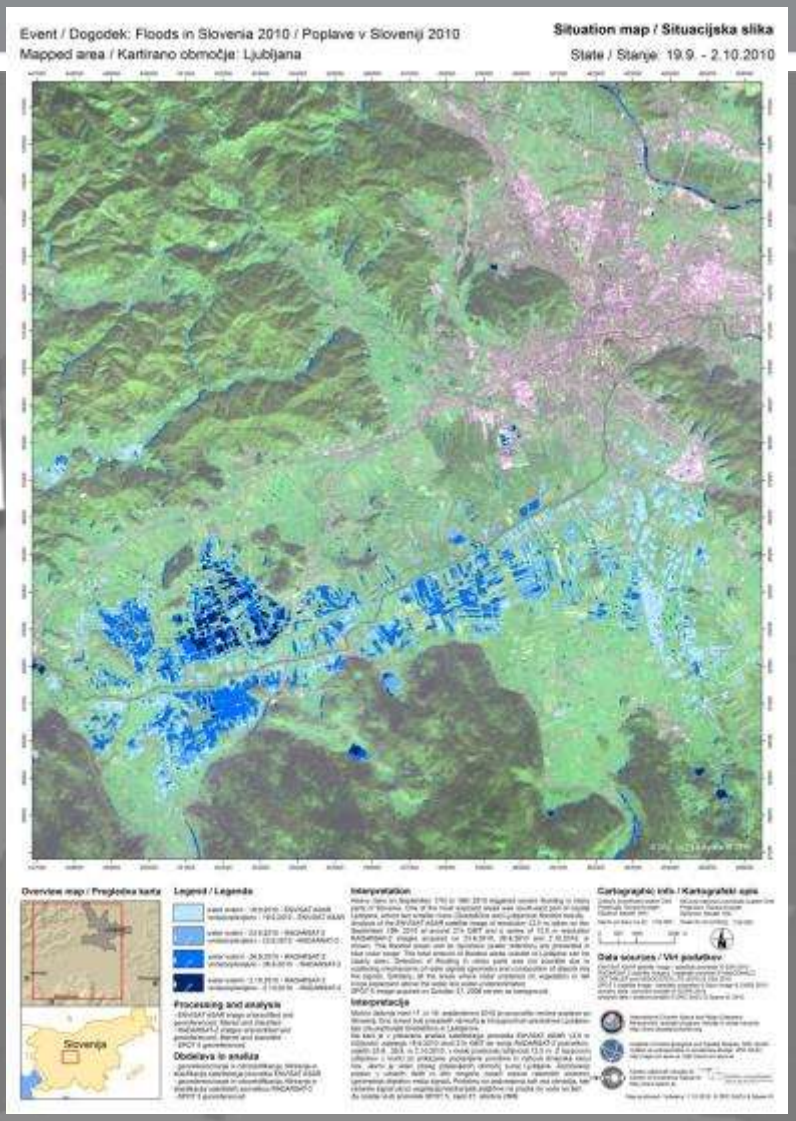
Hurricane Gustav: wind and currents



http://soprano.boost-technologies.com

International Charter Space & Major Disasters





More than 400 activations in 110+ countries since 2000 !

The example of the 2010 Slovenia Floods (from Envisat ASAR, Radarsat-2)

Universal Access since Sept. 2012

Disasters types supported

The International Charter makes priority tasking of different EO missions in a rapid fashion; it is designed to address sudden requests concerning major disasters caused by:

Natural events

- Earthquakes
- Fires
- Floods
- Ice jams
- Landslides
- Tsunamis
- Ocean storms
- Volcanic eruptions

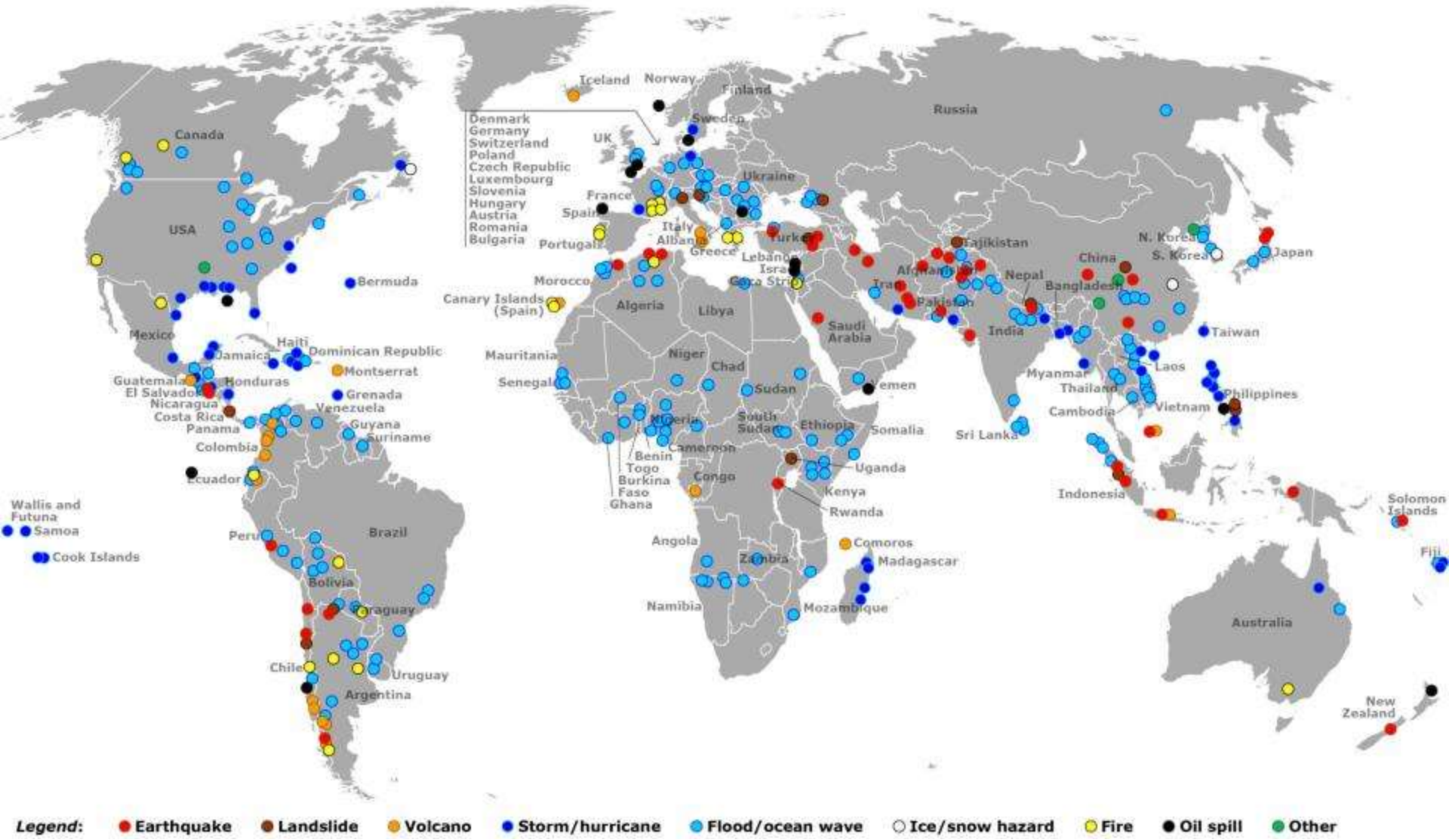
Man-made events

- Oil spills
- Industrial accidents





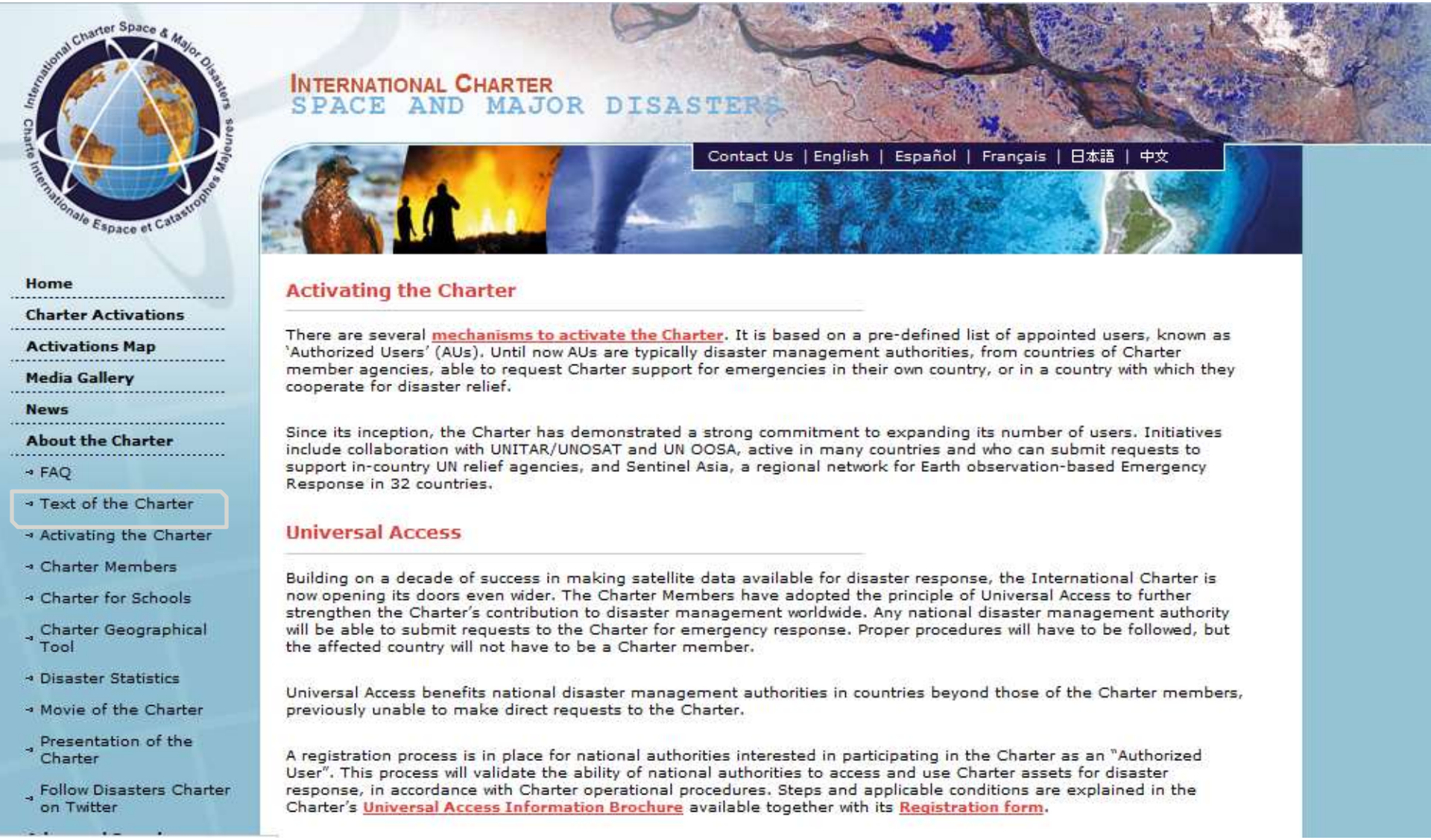
Activation Distribution



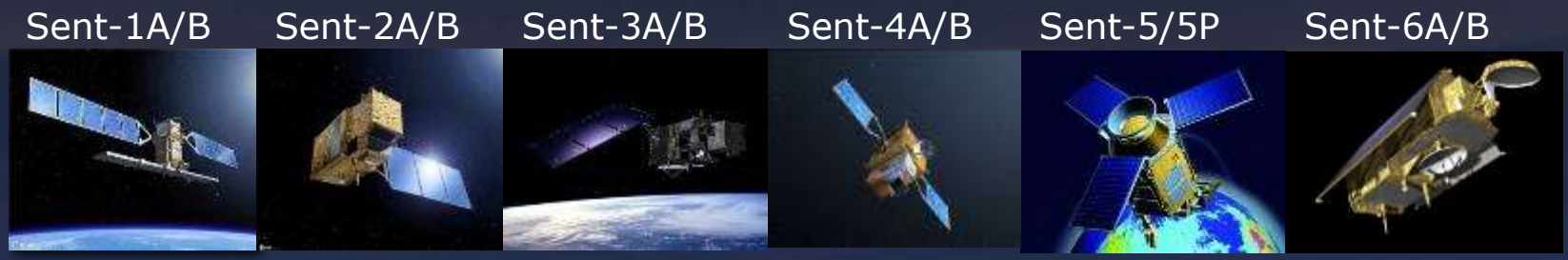
As of October 15, 2012

www.disasterscharter.org

Charter website



Copernicus: A New Generation of Data Sources



- Copernicus is a European space flagship programme led by the European Union
- Copernicus provides the necessary data for operational monitoring of the environment and for civil security
- ESA coordinates the space component

Components & Competences

Overall Programme Coordination

- Space Component
- Services Component
- In-Situ Component

Coordinators:

- esa
- European Commission
- EEA

Partners:

- Industries
- Private companies
- National Space Agencies
- Eumetsat
- Service operators
- National environmental agencies

Copernicus Sentinel Data Policy

Sentinel Data Policy = FREE and OPEN access

- Main principles of Sentinel data policy:
  - **Open** access to Sentinel data by anybody and for any use
  - **Free** of charge data licenses
  - Restrictions possible due to technical limitations or security constraints

Copernicus dedicated missions: the ESA Sentinels…

S1A/B: Radar Mission  2014/2016

S2A/B: High Resolution Optical Mission 2016/2017

S3A/B: Medium Resolution Imaging and Altimetry Mission 2016/2017

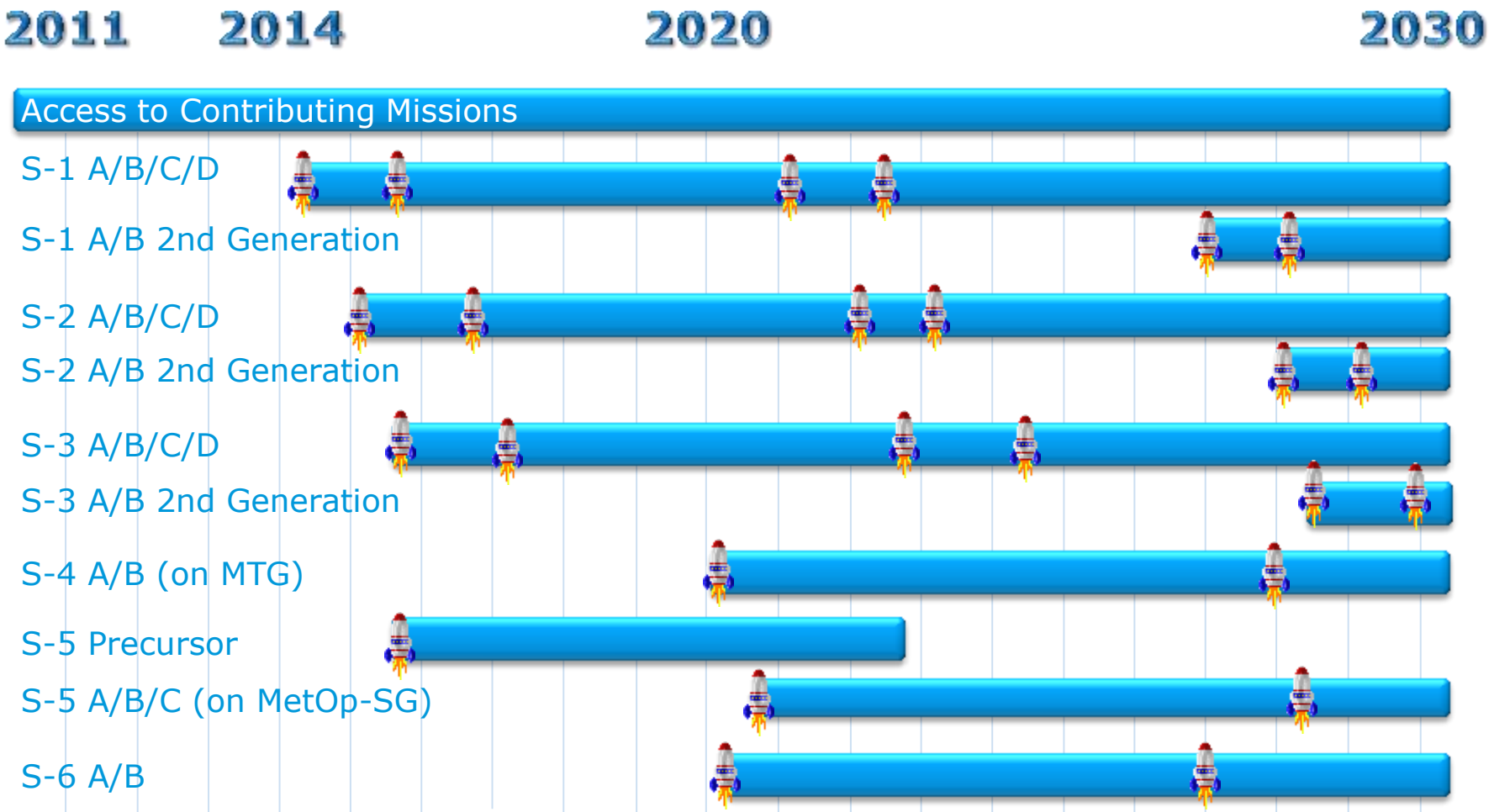
S4A/B: Geostationary Atmospheric Chemistry Mission 2019/2027

S5P: Low Earth Orbit Atmospheric Chemistry Mission 2016

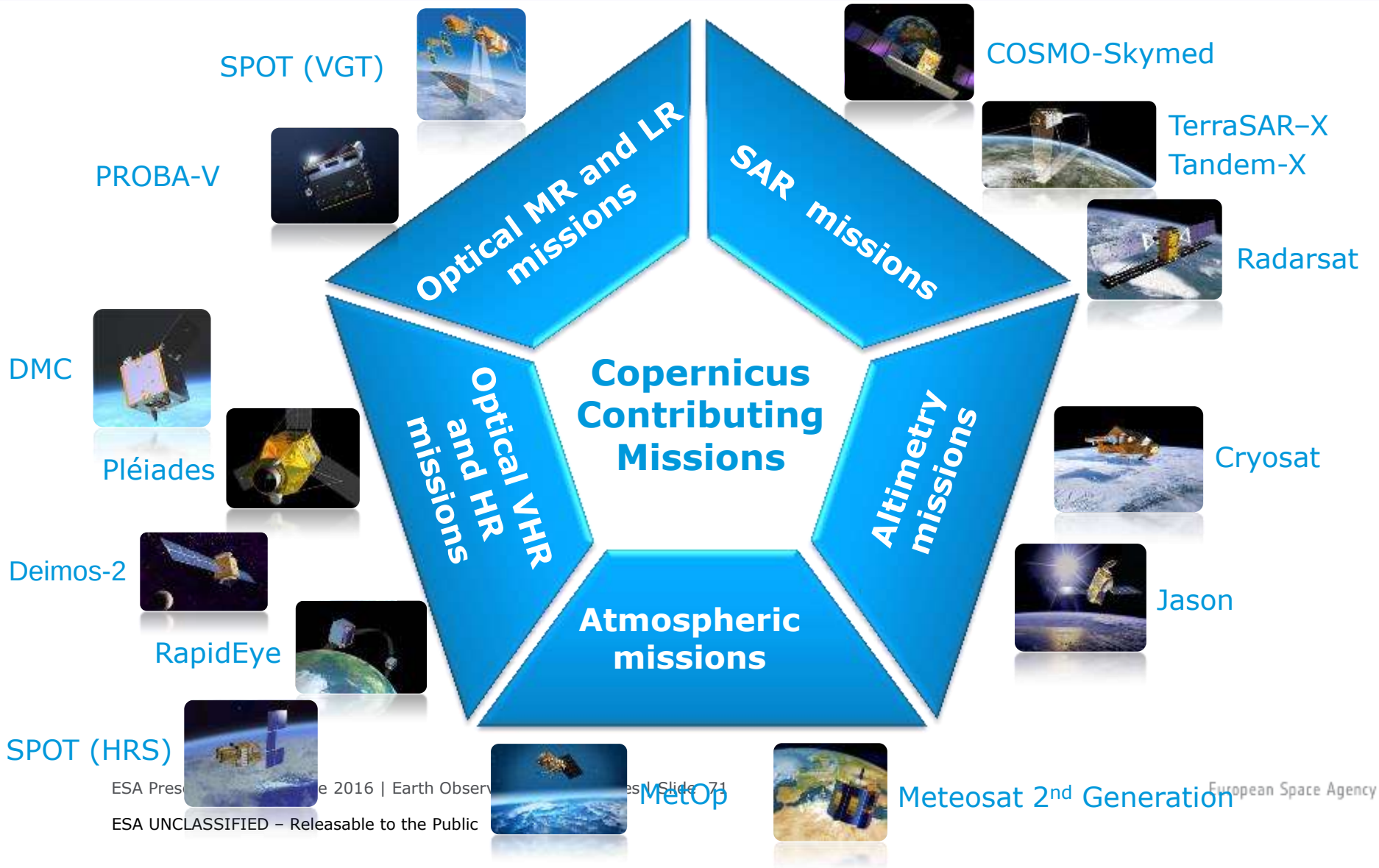
S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission 2020/2027

S6-(Jason-CS) **A/B:** Altimetry Mission 2019/2025

… with a long-term operational perspective



Copernicus Contributing Missions



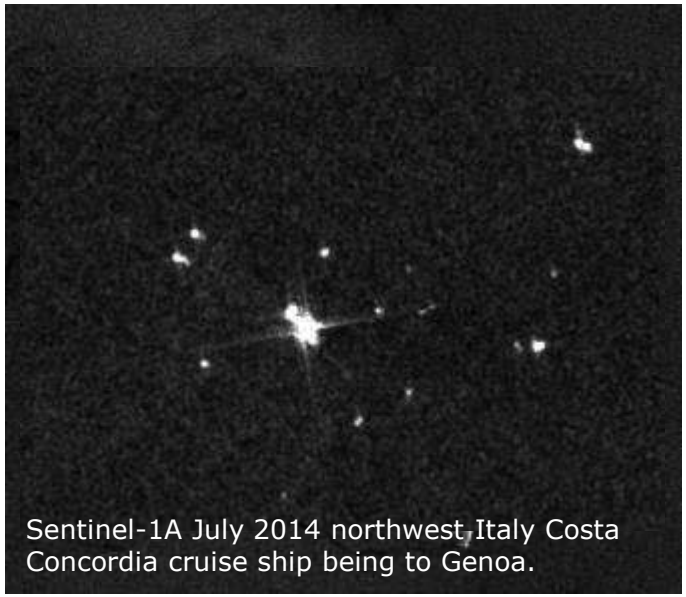
Sentinel-1 (A: launched April 2014, B: launched April 2016) is the first of a series of operational radar satellites that will provide data continuity until 2030

Sentinel-1 mission objectives

✓**Data continuity of ERS and ENVISAT missions**

✓ **Copernicus imaging radar mission for ocean, land, emergency applications:**

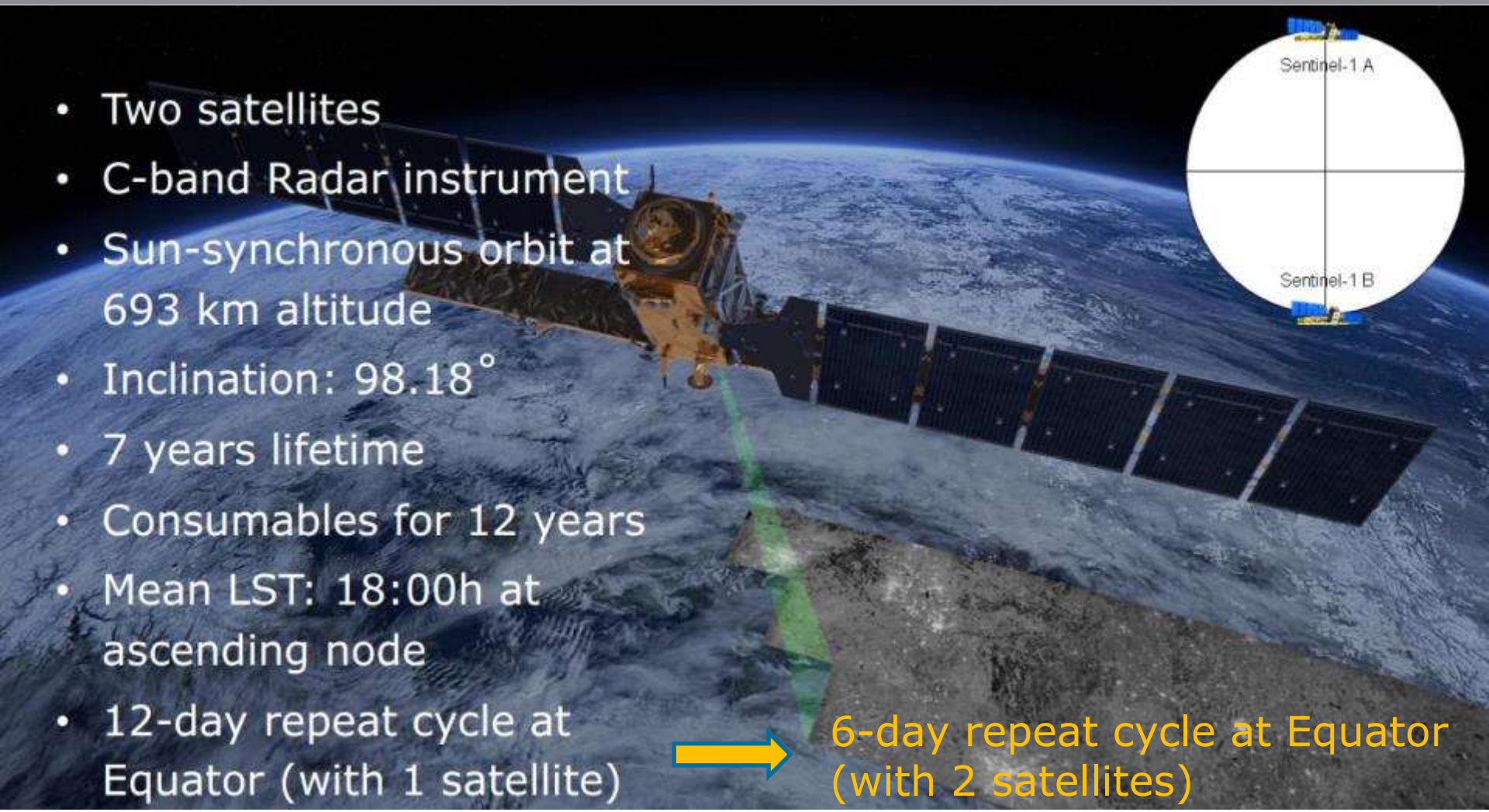
- monitoring sea ice zones and the arctic environment
- surveillance of marine environment (oil spill monitoring)
- maritime security (e.g. ship detection)
- wind, wave, current monitoring
- monitoring of land surface motion (subsidence, tectonics, volcanoes)
- support to emergency / risk management and humanitarian aid in crisis situations
- mapping of land surfaces: forest, water and soil, agriculture, etc.



Sentinel-1A July 2014 northwest Italy Costa Concordia cruise ship being to Genoa.

Flood delineation map over Balatun Bosnia and Herzegovina

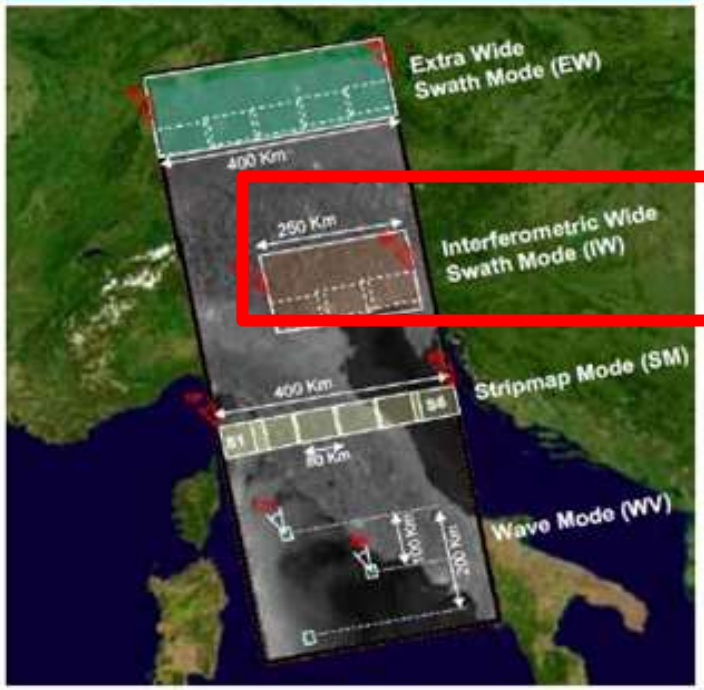
Sentinel-1
Mission Overview



- Two satellites
- C-band Radar instrument
- 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 (with 1 satellite)

→ 6-day repeat cycle at Equator (with 2 satellites)

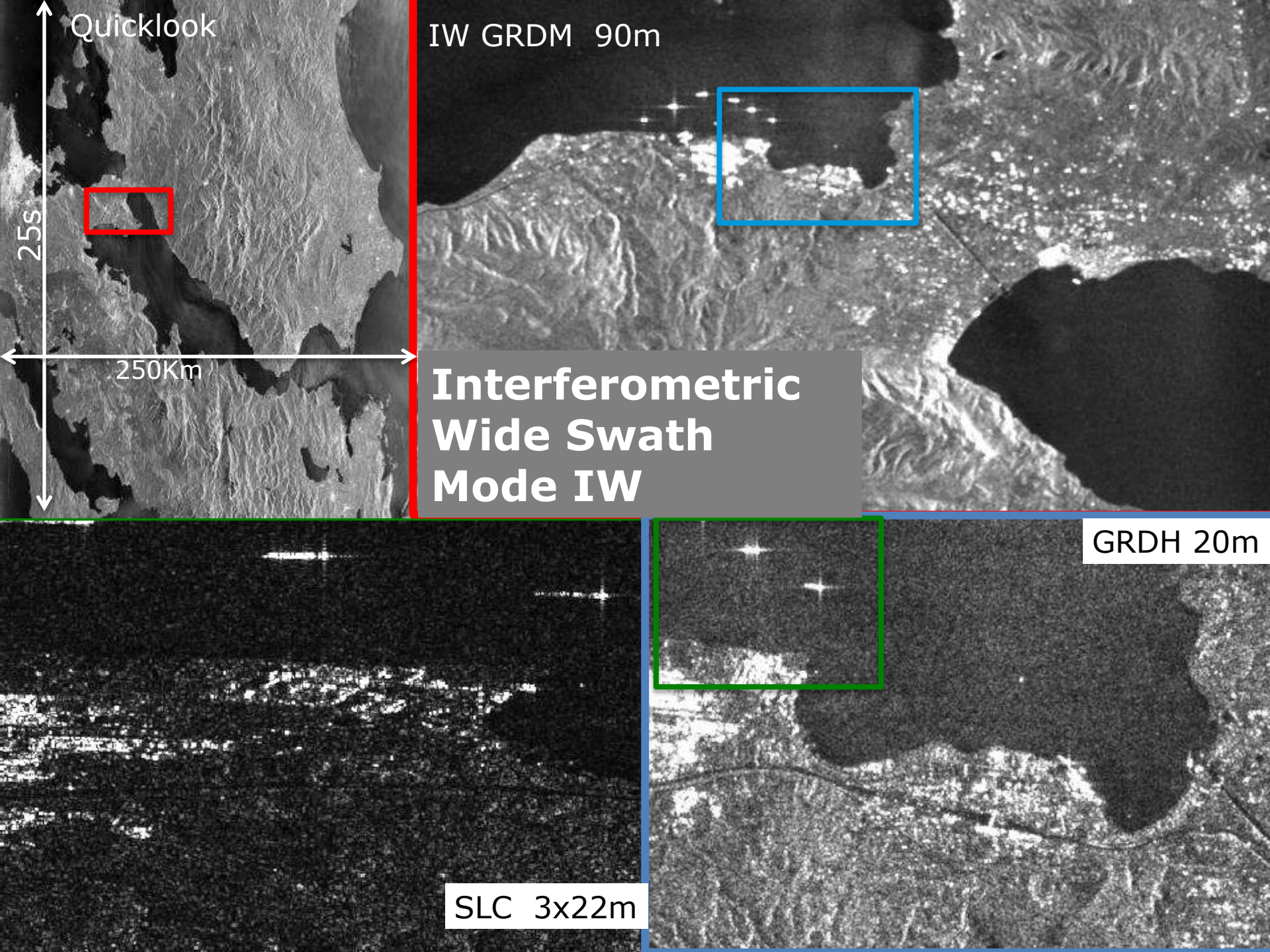
Sentinel-1
SAR Operational Modes

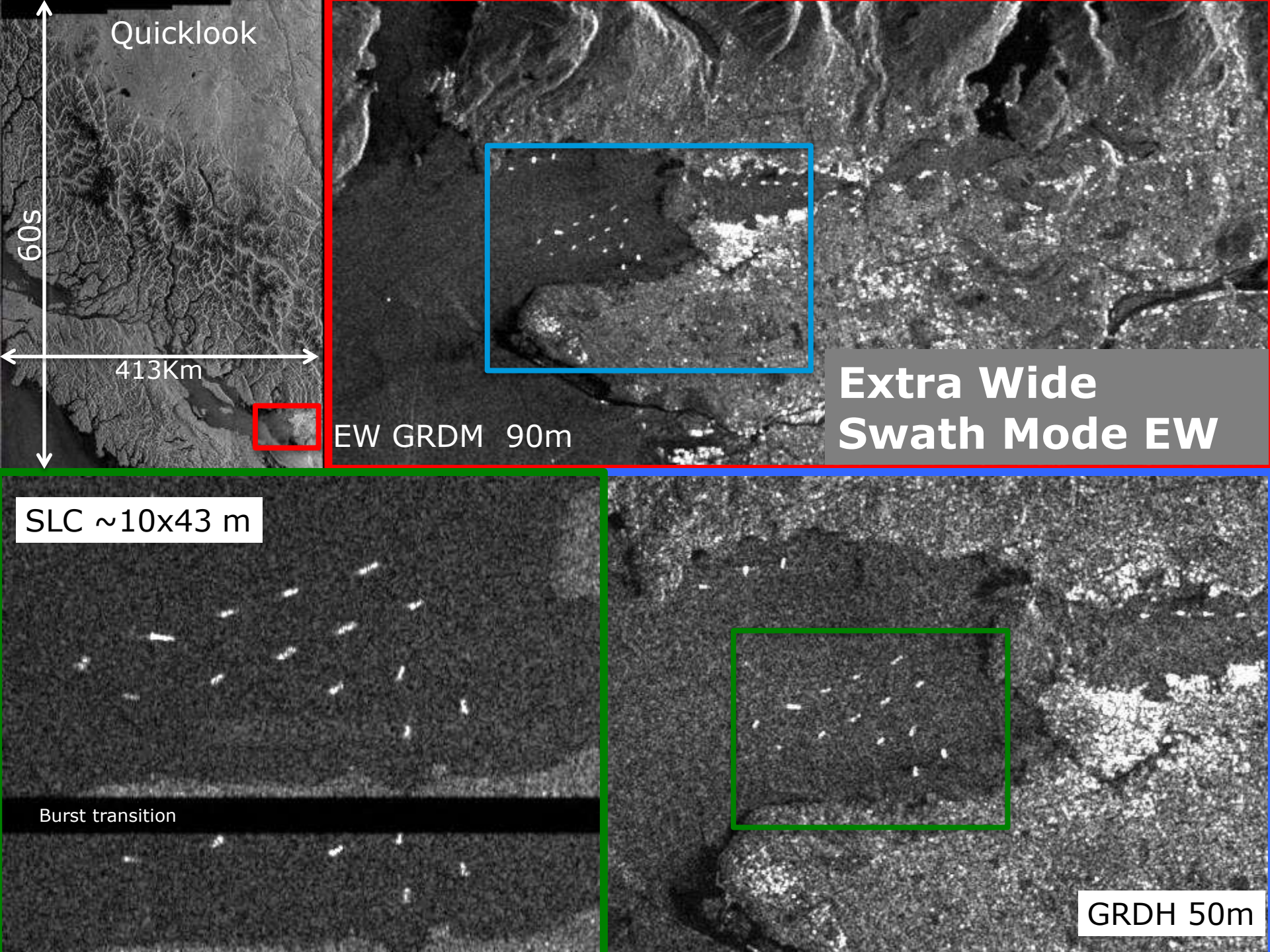
Operational Modes	Resolution	Swath Width	Polarisation
			
Extra Wide Swath Mode (EW)	20 x 40 m²	> 400 km	HH+HV or VV+VH
Interferometric Wide Swath Mode (IW)	5 x 20 m²	> 250 km	HH+HV or VV+VH
Stripmap Mode (SM)	5 x 5 m²	> 80 km	HH+HV or VV+VH
Wave Mode (WV)	5 x 5 m²	20 x 20 km² at 100 km spacing	HH or 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**


Quicklook
25s
250Km
IW GRDM 90m
Interferometric
Wide Swath
Mode IW
SLC 3x22m
GRDH 20m


Quicklook
60s
413Km
EW GRDM 90m
Extra Wide
Swath Mode EW
SLC ~10x43 m
Burst transition
GRDH 50m

Sentinel-1 (SAR) versus Envisat ASAR

Sentinel-1

- **10** m ground range resolution (stripmap mode)
- **250** km swath width (Interferometric wide swath mode – 20m ground range resolution)
- **6** days repeat cycle (with 2 satellites)
- **2 x 260 Mb/s** downlink data rate
- **7** years design lifetime (consumables for 12 years)

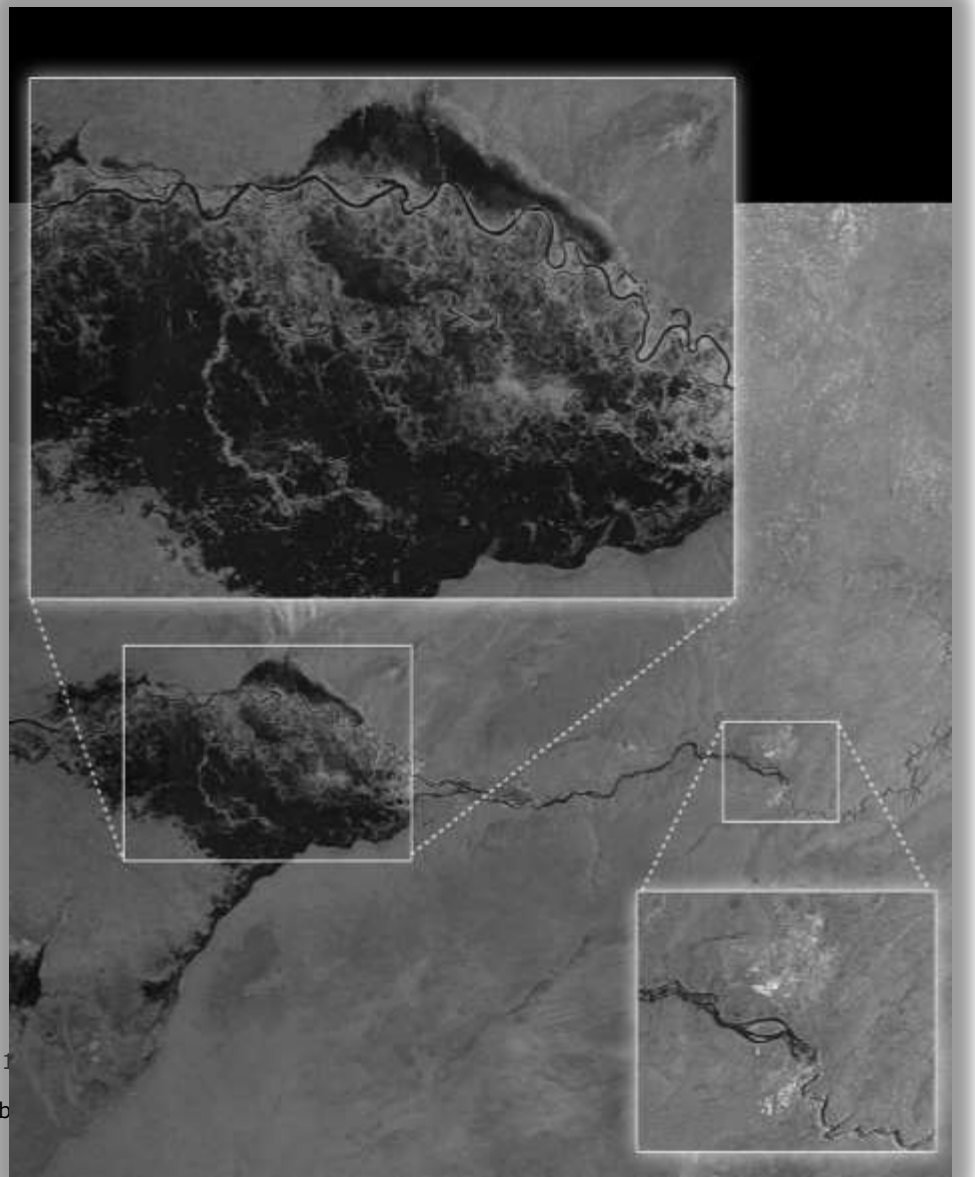
Envisat ASAR

- **20** m ground range resolution
- **100** km swath width (Imaging mode)
- **35** days repeat cycle
- Up to **100 Mb/s** space to ground data rate
- **5** years design lifetime

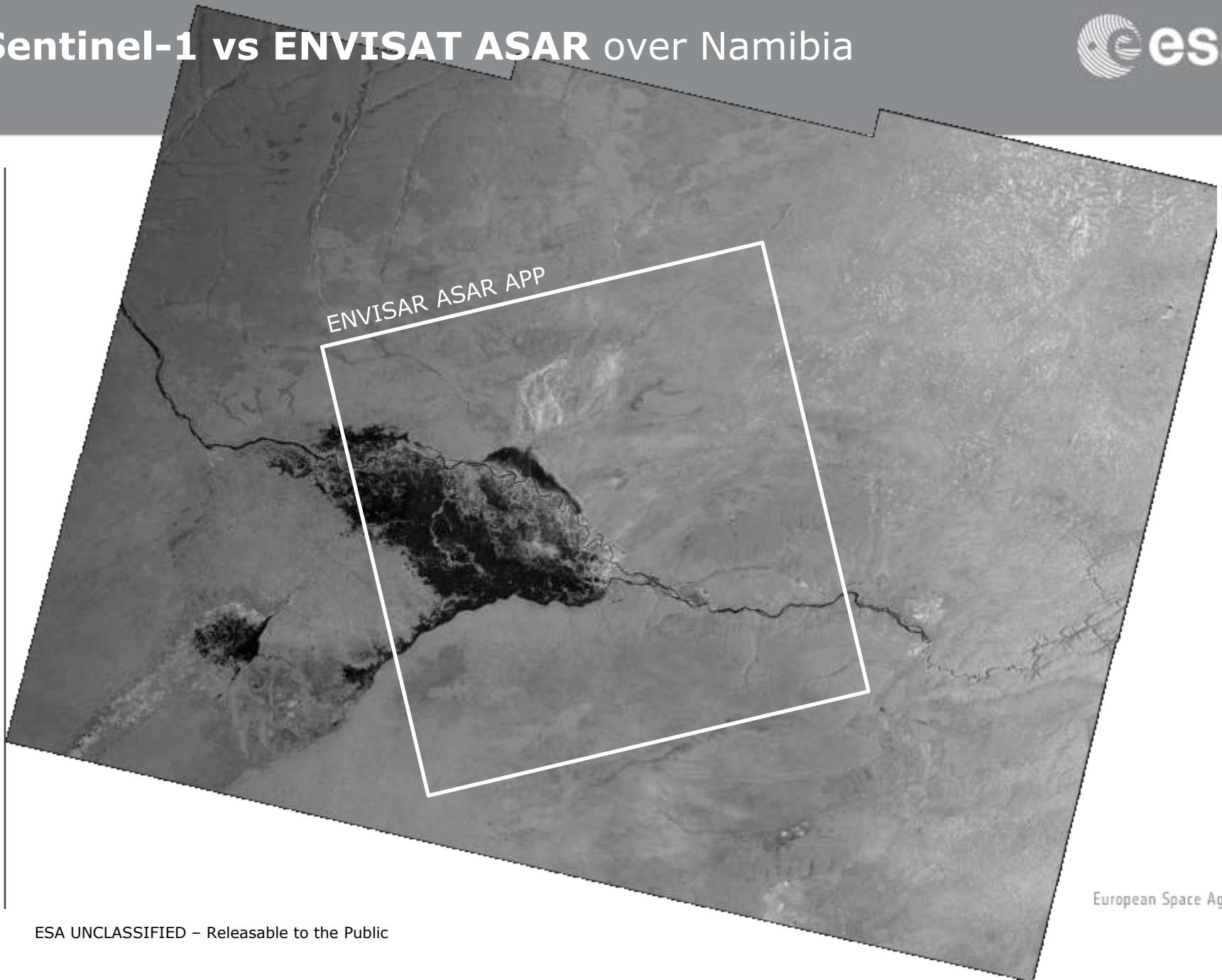
First Images of Sentinel-1A

Zambezi River Flooding and Victoria Falls, Namibia

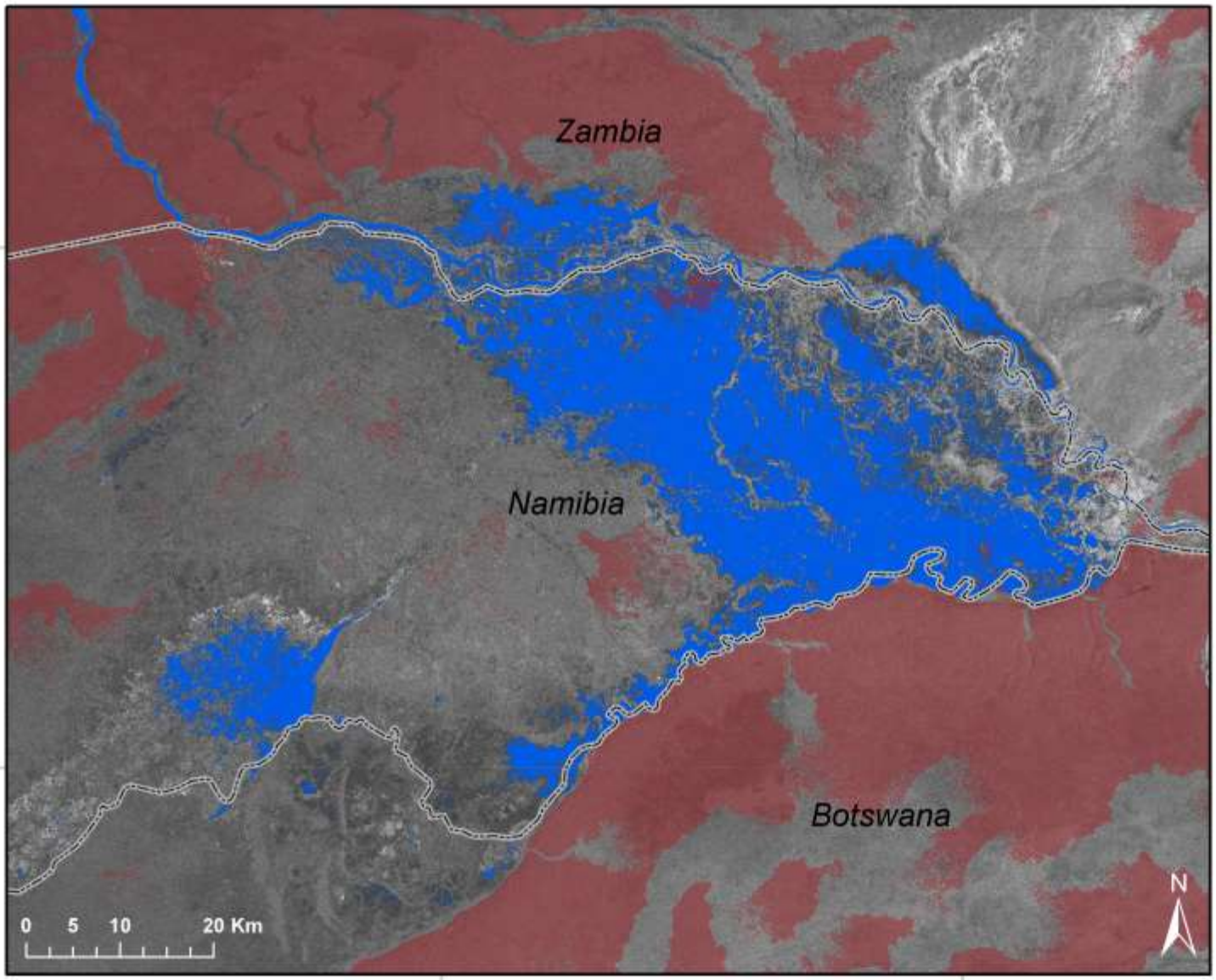
13 April 2014



Sentinel-1 vs ENVISAT ASAR over Namibia



Sentinel-1 Flood Monitoring of Caprivi Flood Plain, Namibia



Legend

- Country border
- Derived HAND Index > 10 m
- Flooded areas

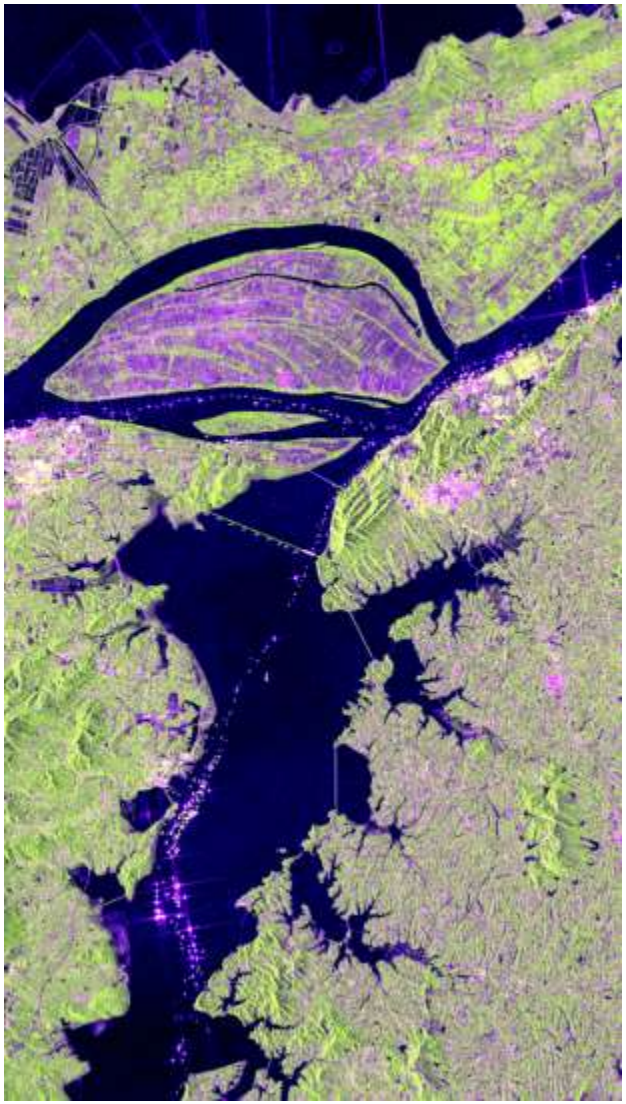
Description:
This map shows the flooding situation in the Caprivi flood plain of Zambezi River on 13th of April, 2014. The flood was delineated with the Water Observation and Information System (WOIS) based on SENTINEL-1A satellite data.

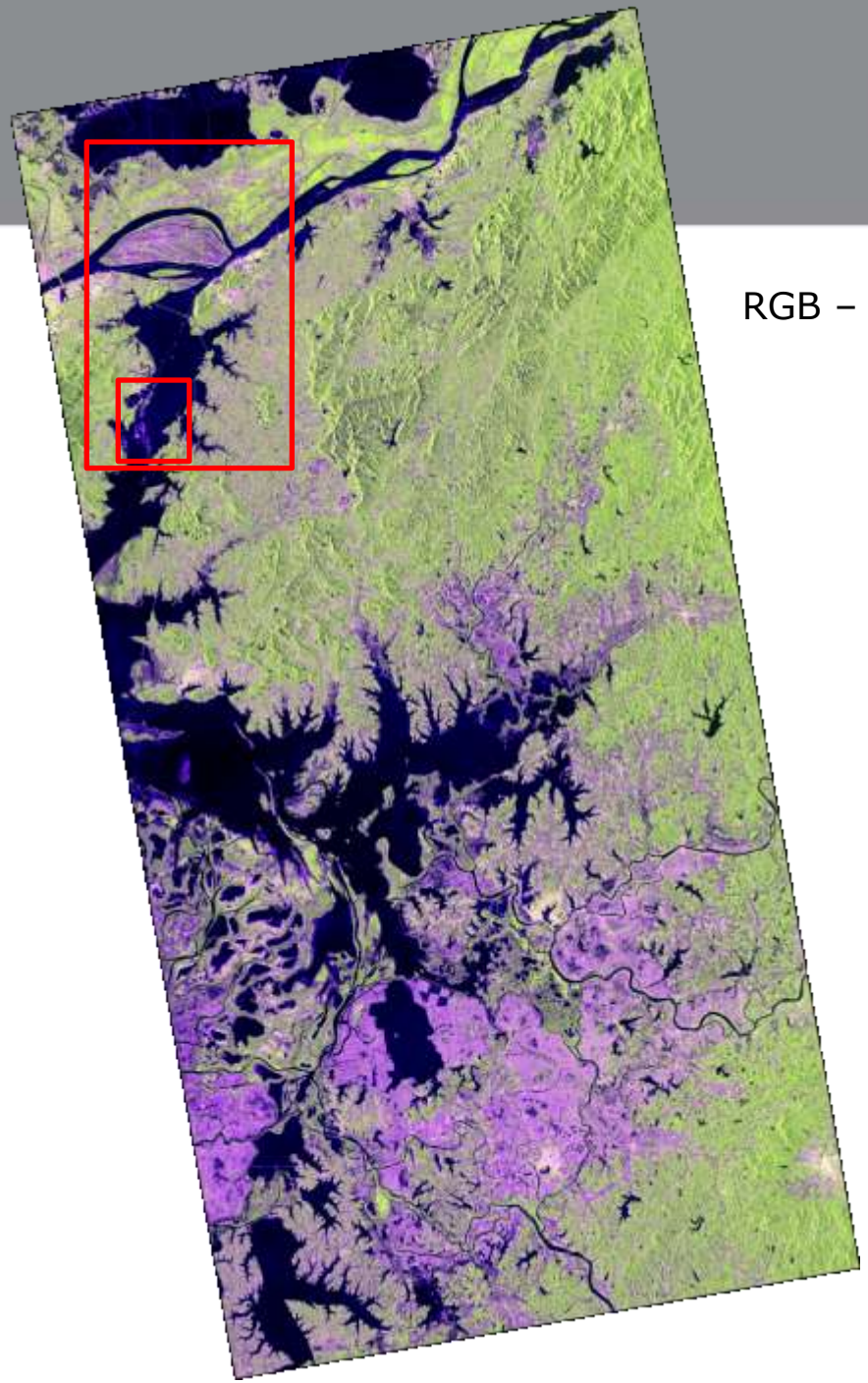
Source data:
SENTINEL-1A IW mode, 20 m resolution, acquired on 13th of April, 2014 at 03:50 GMT.
SENTINEL-1 image was provided by the European Space Agency.

Cartographic Reference
Projection: EPSG:4326
Datum: WGS 84


Balatun - BOSNIA AND HERZEGOVINA
Flood - 13/05/2014
Delineation Map - Detail
Croatia
Bosnia and Herzegovina
Serbia
Cartographic Information
1:20'000
Legend
Map Information
Data Sources
Dissemination/Publication
Framework
Map Production
Serbia
Macvanski
Sava
Republika Srpska
Area of Interest - Detail
Copernicus

S1A Polarimetric Composition
Poyang Lake



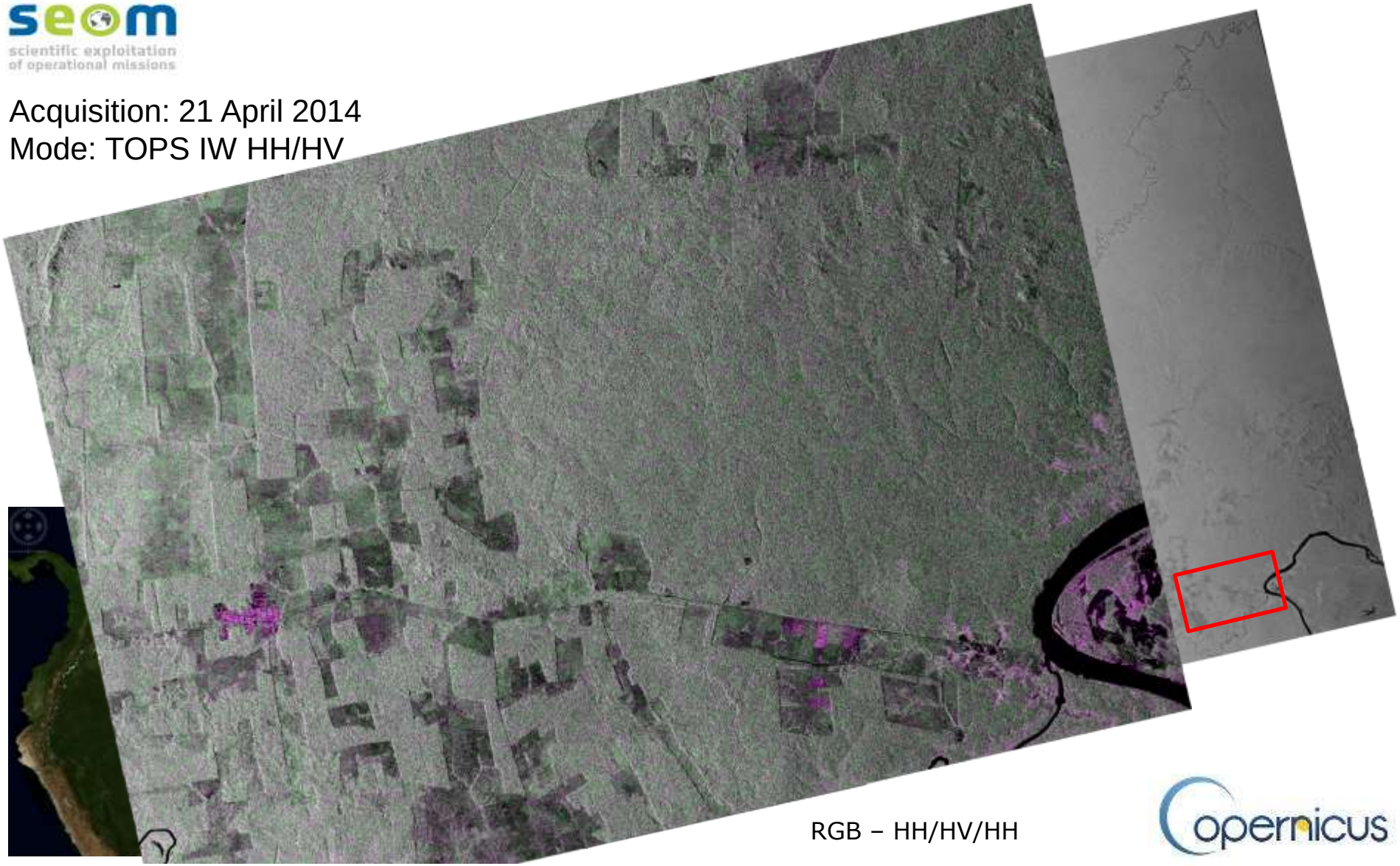


RGB – VV VH VV/VH

Sentinel-1
Deforestation over Brazil

seom
scientific exploitation of operational missions

Acquisition: 21 April 2014
Mode: TOPS IW HH/HV



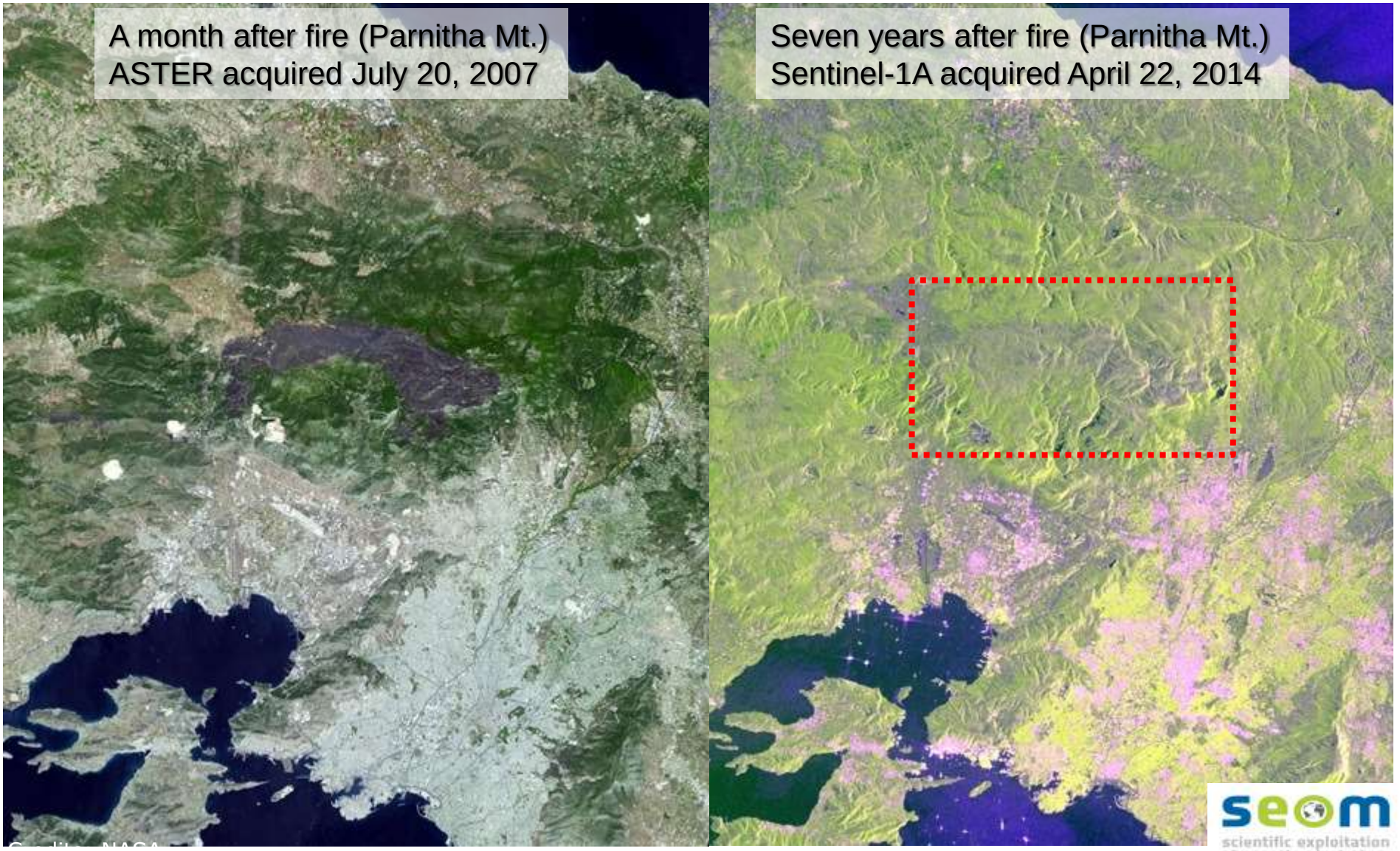
RGB – HH/HV/HH

esa

opernicus

Sentinel-1

Vegetation Regeneration – Burn Scar (Greece)



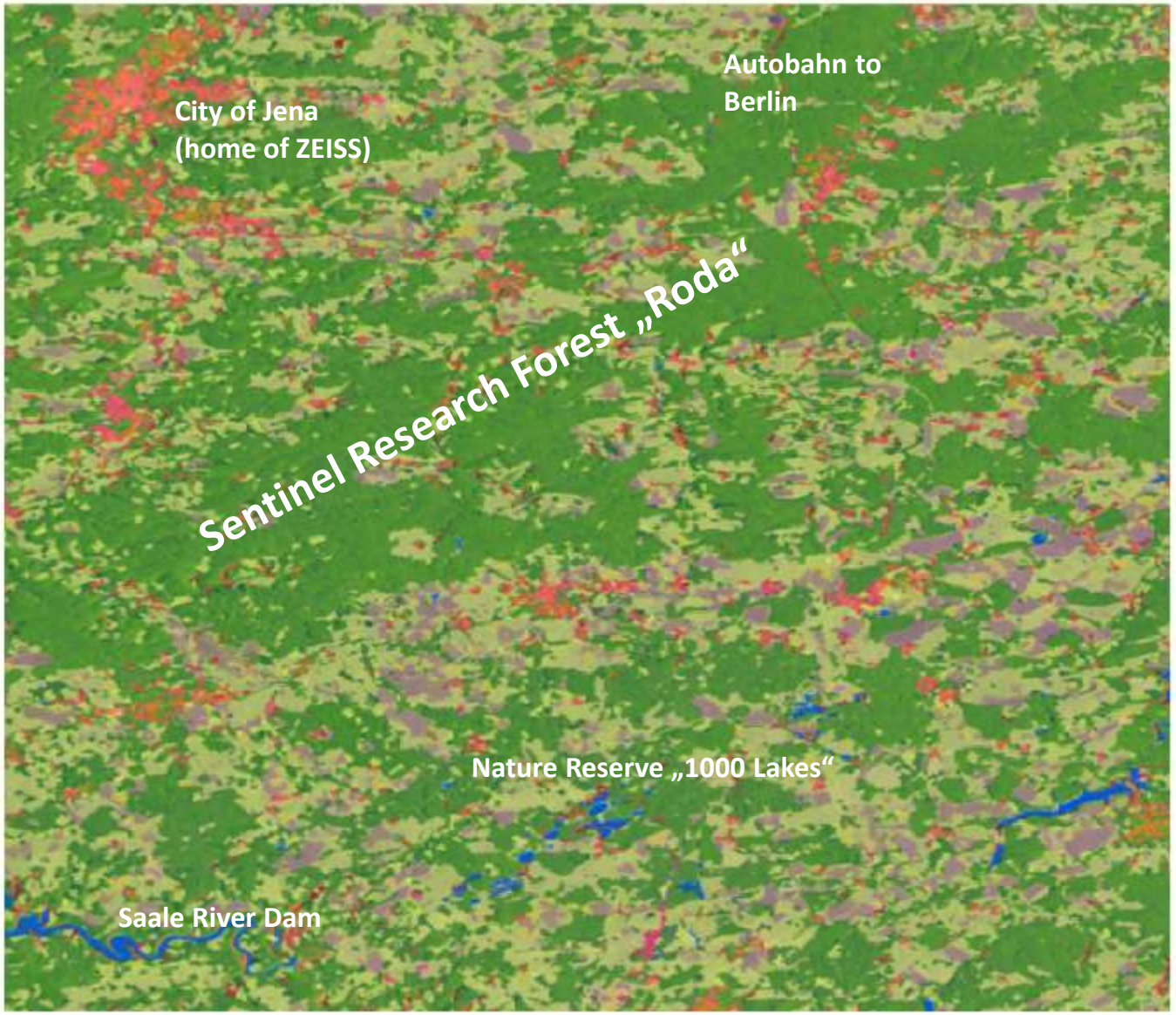
Icebergs Antarctica Peninsula Sentinel-1A (RGB HV-HH-HH)

Post processing with Sentinel 1 Toolbox

seom
scientific exploitation of operational missions

Sentinel-1

Land Classification Dual Pol HH-HV (Germany)



Class. Method:
Random Forest

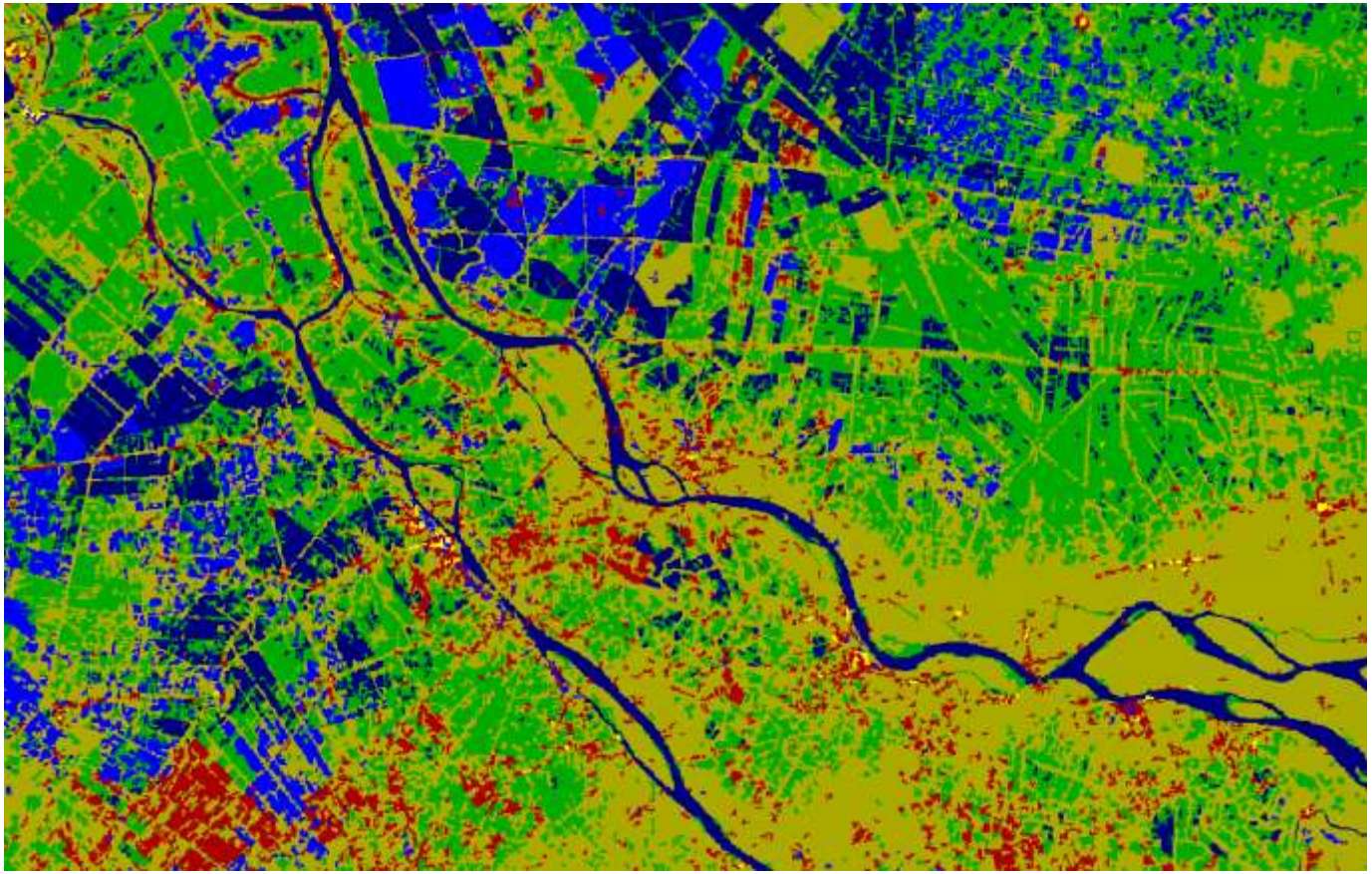
Classes:
Forest
Water
Urban
Winter crops
Bare fields

Location: Thuringia, Central Germany
Acquisition Date: 26-April-2014
Credit Univ. of Jena
Chris Schnmullius

European Space Agency

PRELIMINAY RESULTS RICE MONITORING

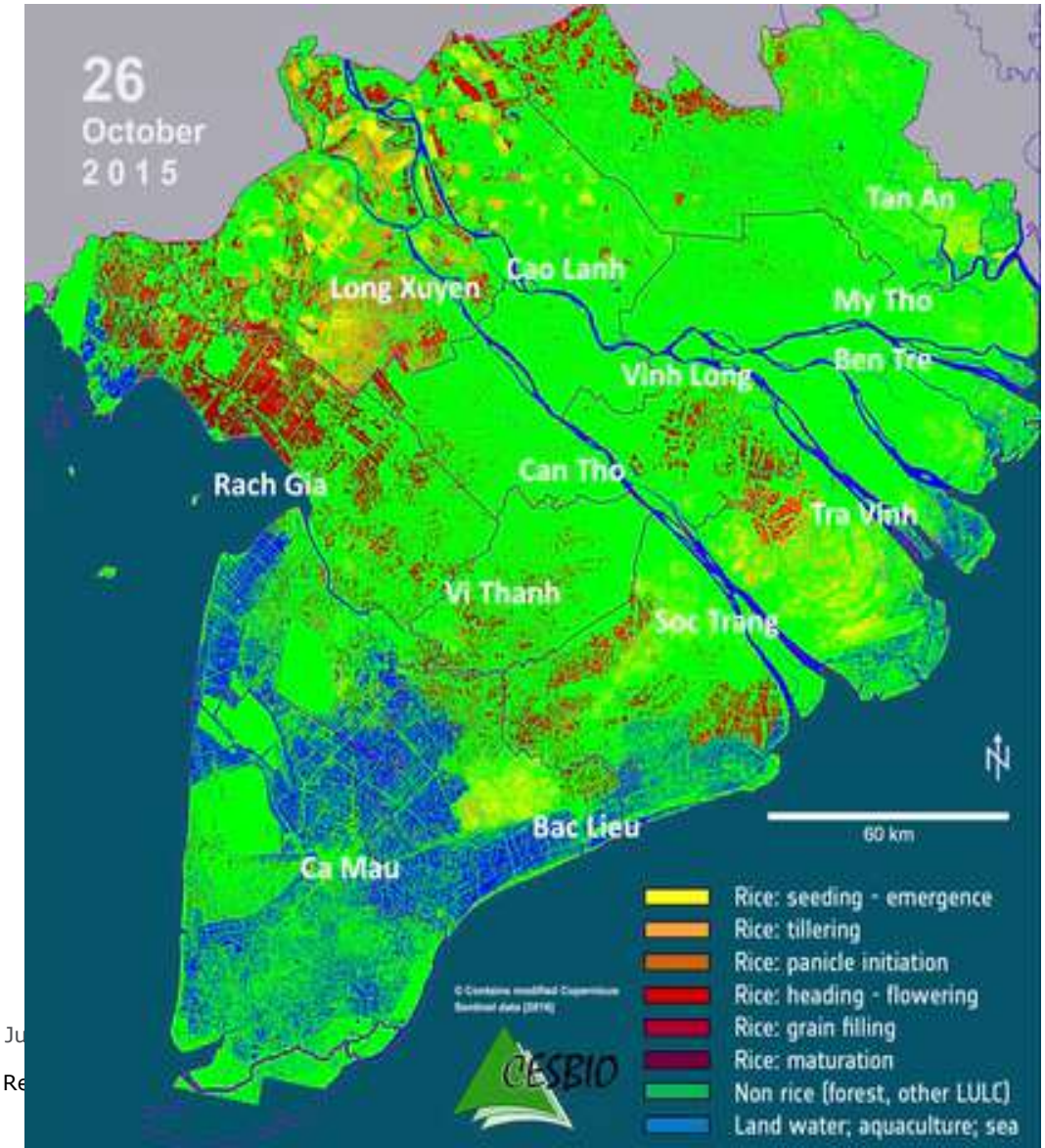
S-1A geocoded – 8 & 20 Aug, 80m (detail) – Vietnam



rice stage 1
rice stage 2
rice stage 3
non-rice

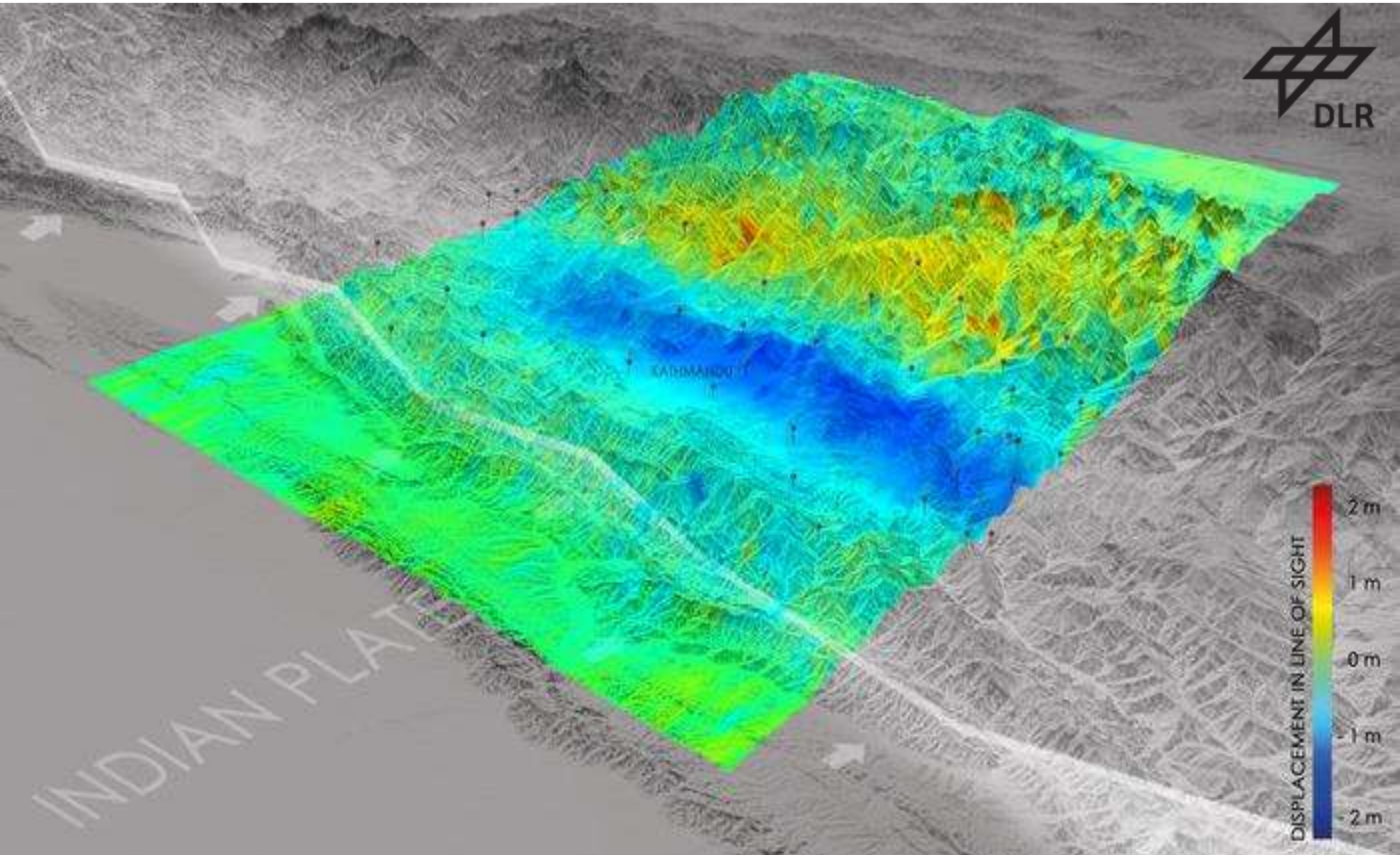
Courtesy SARMAP

Sentinel-1: Mekong Delta Rice Crops

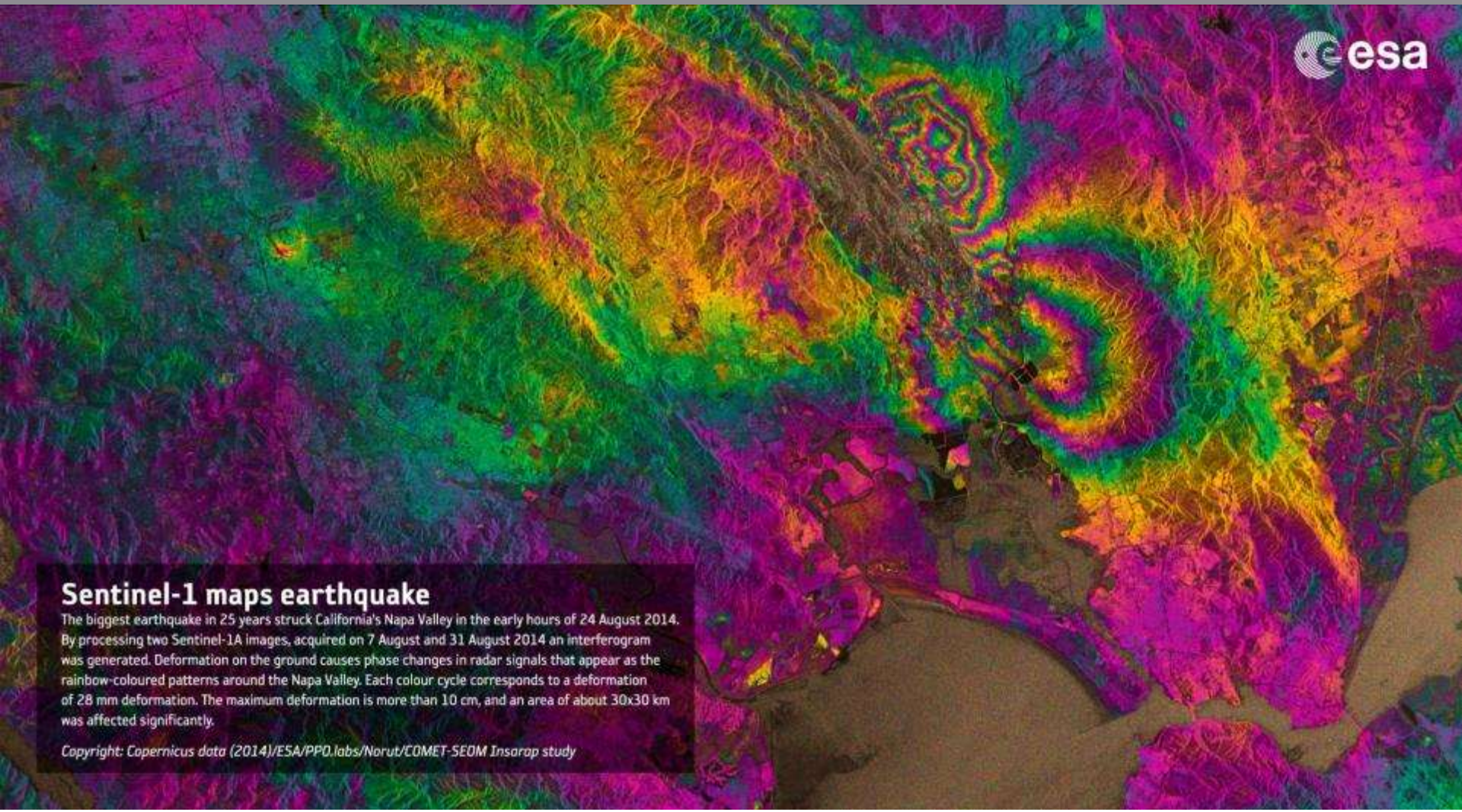


contains modified Copernicus Sentinel data (2015–16) /CESBIO/ESA DUE GEO-Rice Innovator project

Sentinel-1A: Nepal Earthquake

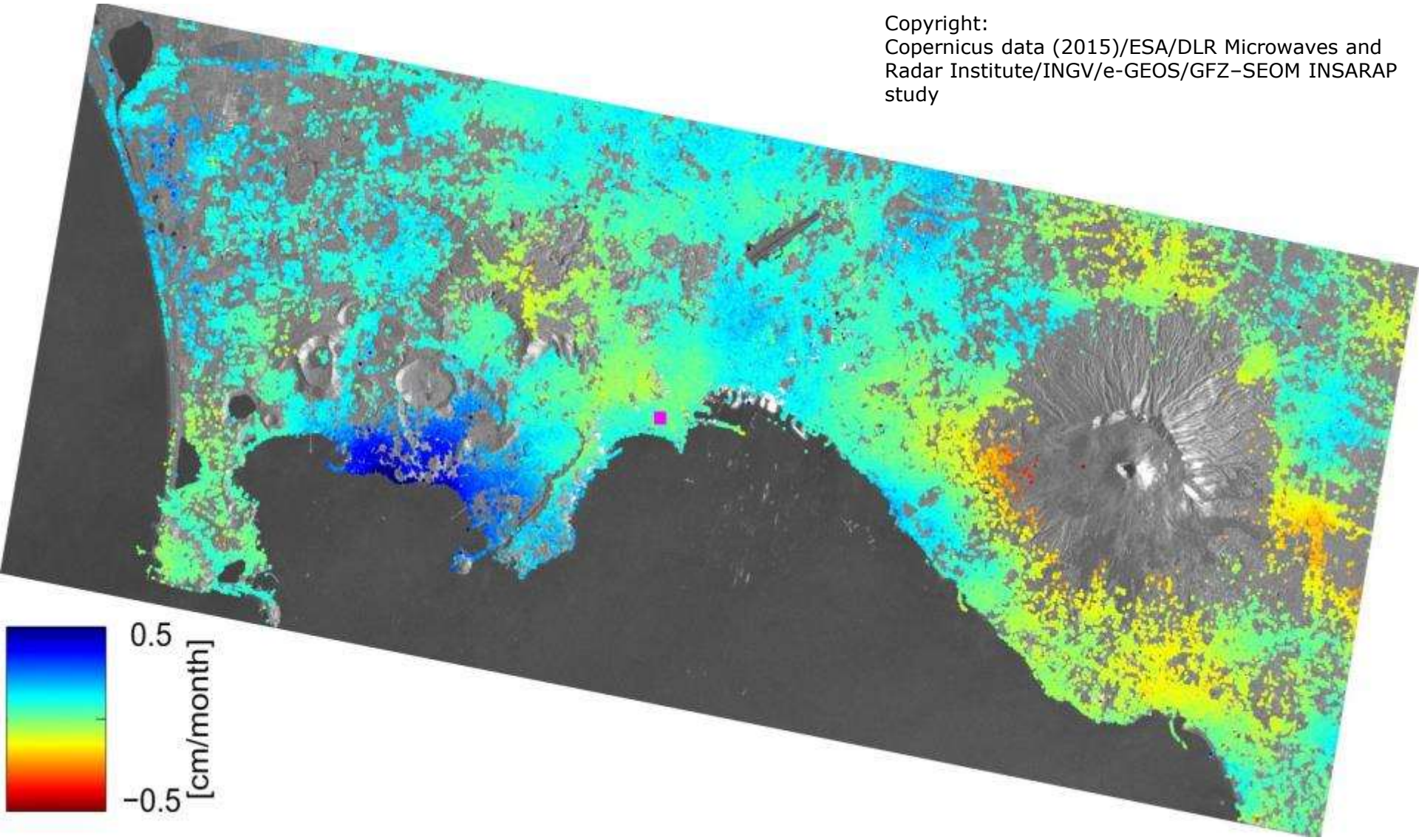


Sentinel-1 *Napa Valley Earthquake*
INSARAP (NORUT-PPO.labs-Univ. Leeds-COMET)

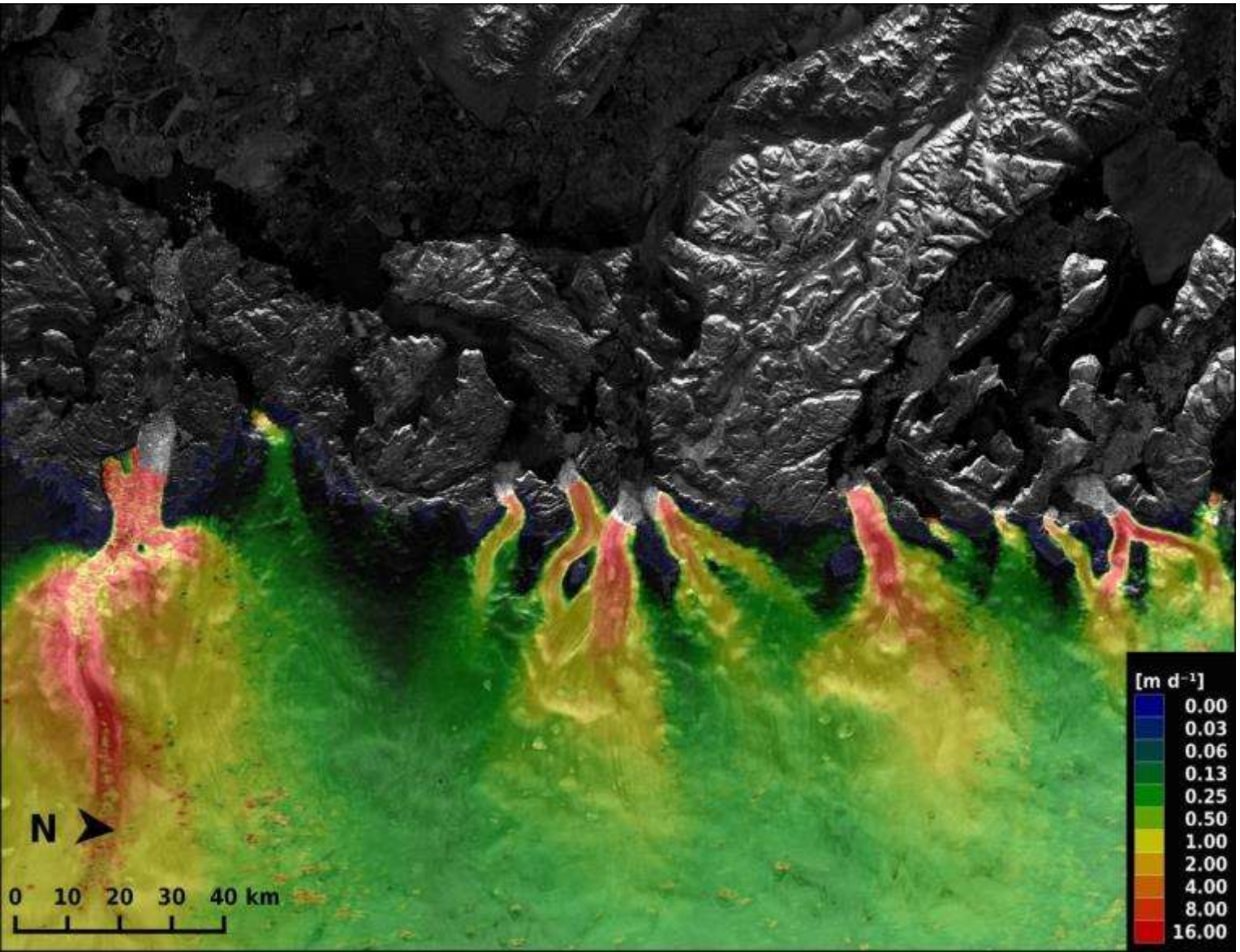


seom
scientific exploitation of operational missions

Campi Flegrei seen by Sentinel-1A



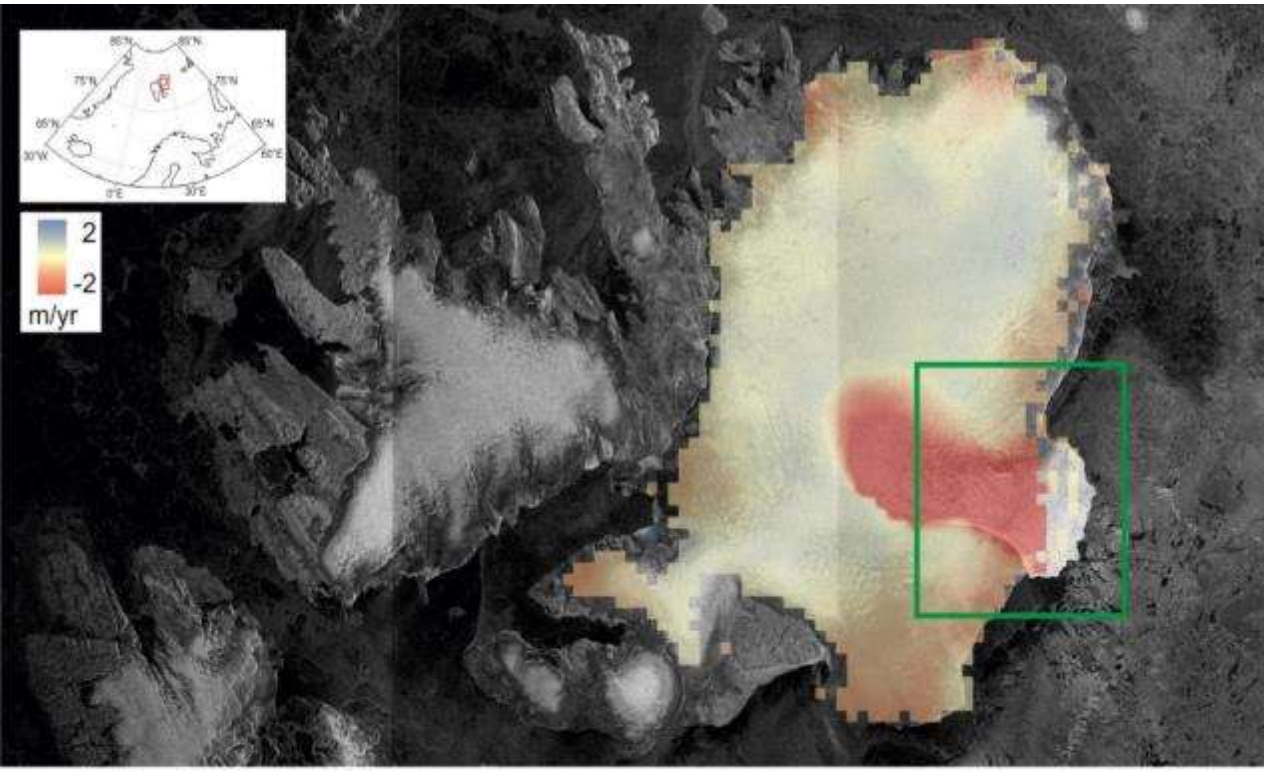
Ice Streams seen by Sentinel-1A

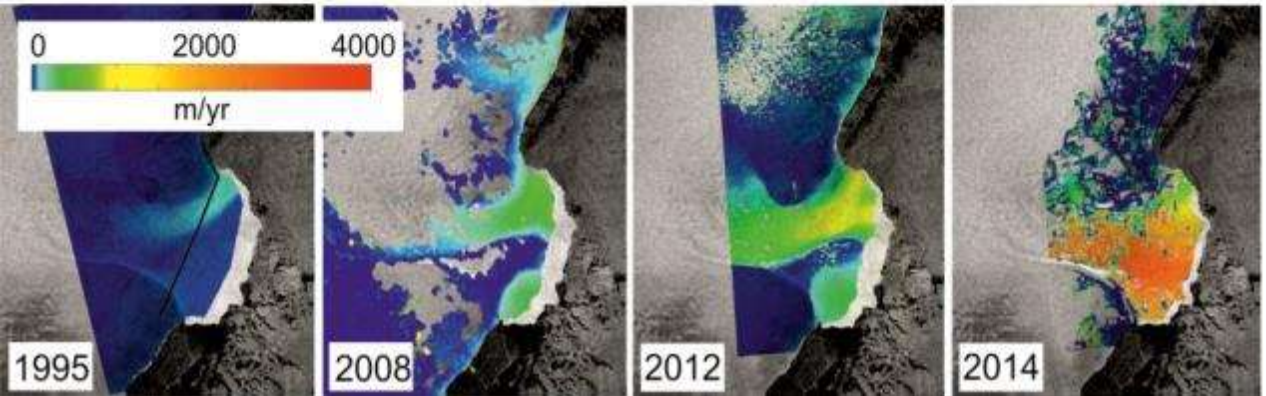


Greenland,
West Coast

January 2015

Sentinel-1A: Austfonna Ice Loss





Rapid ice loss in a remote Arctic ice cap:

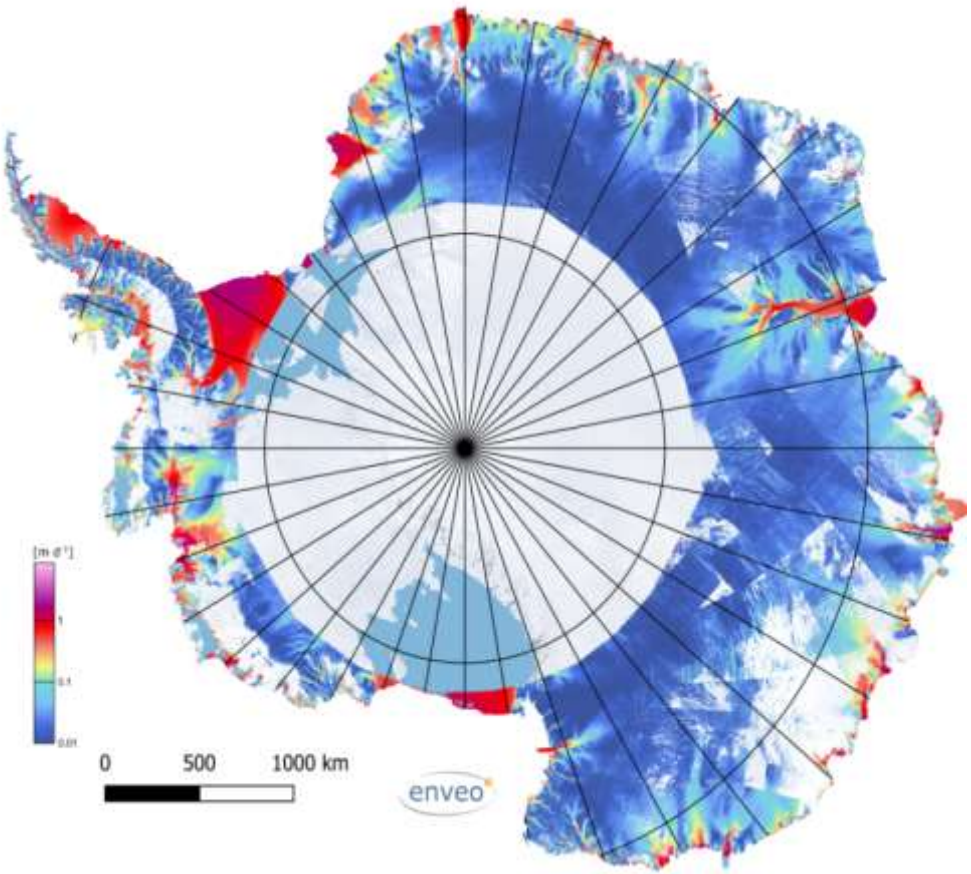
Combined observations from eight satellite missions, including **Sentinel-1A** and **Cryosat**

European Space Agency

Sentinel-1: Ice Velocity Maps

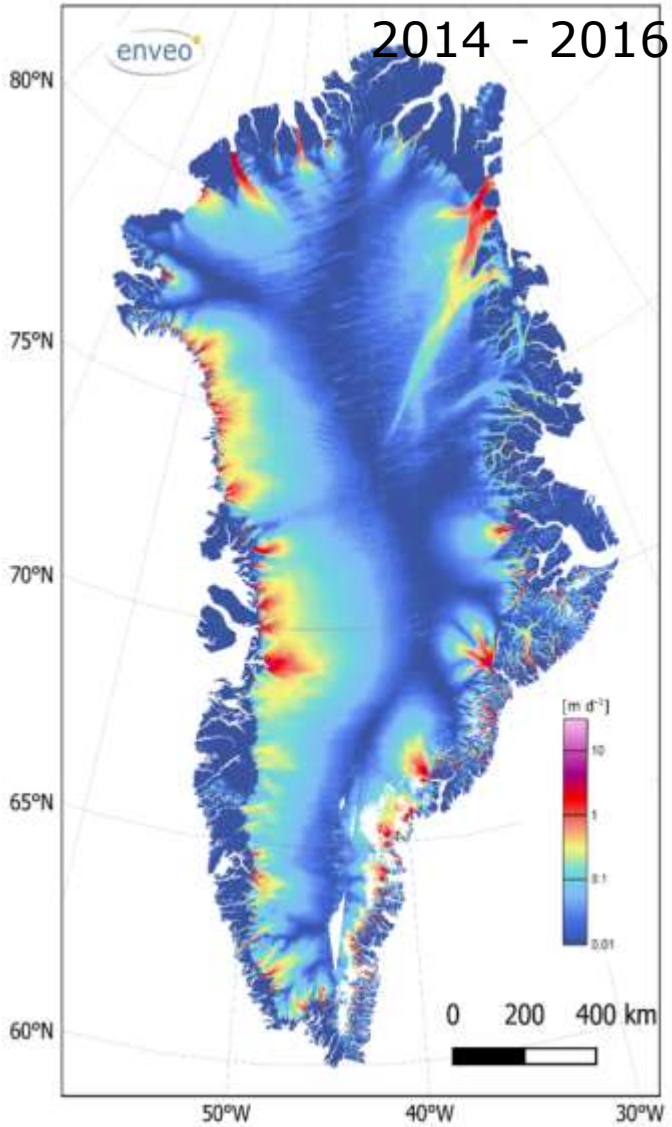
Study climate change impact on ice melting. Large ice sheets such as Greenland and Antarctica substantially contribute to the global sea level rise

2015/2016

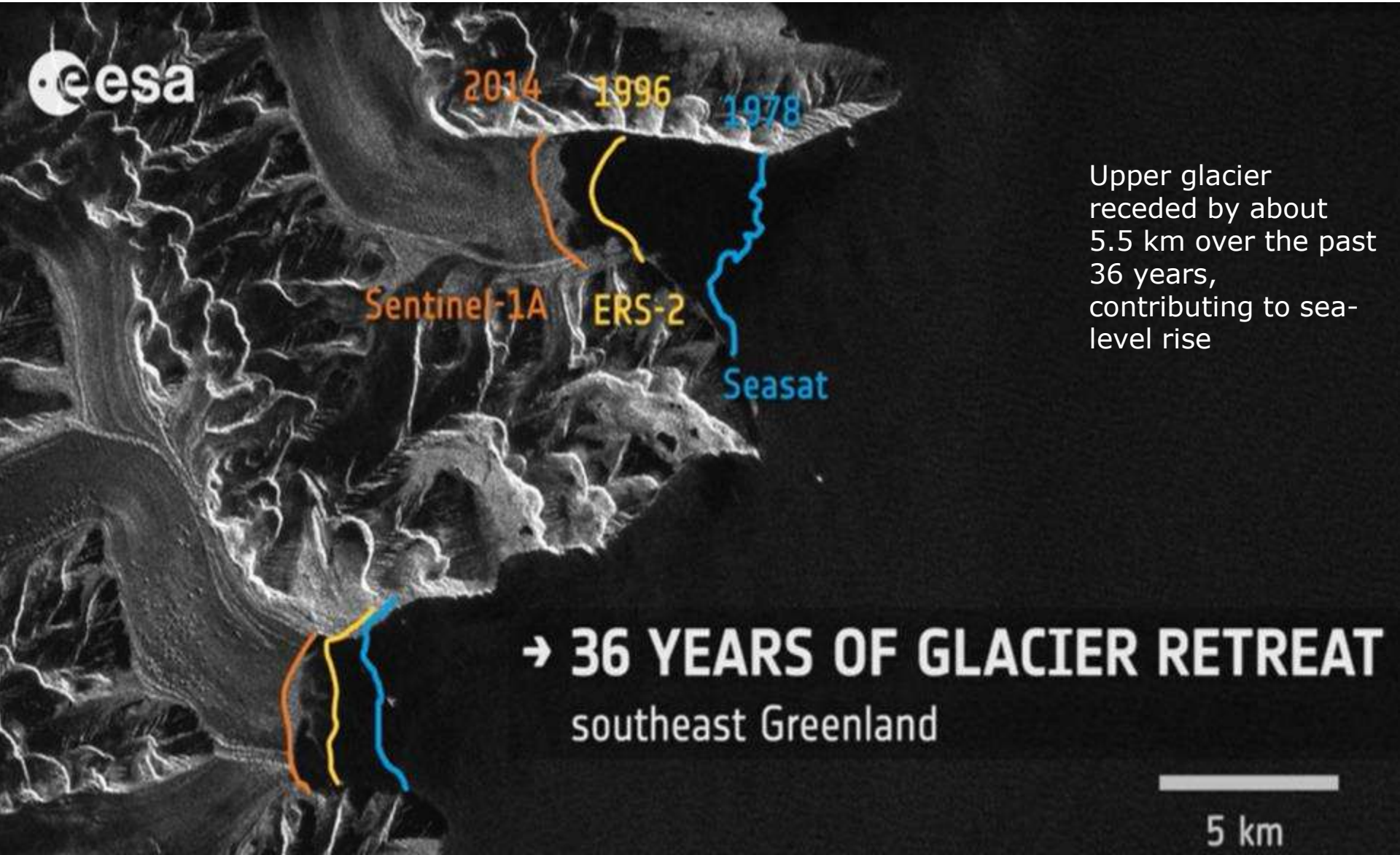


Nagler et al.

2014 - 2016



36 Years of Radar Vision



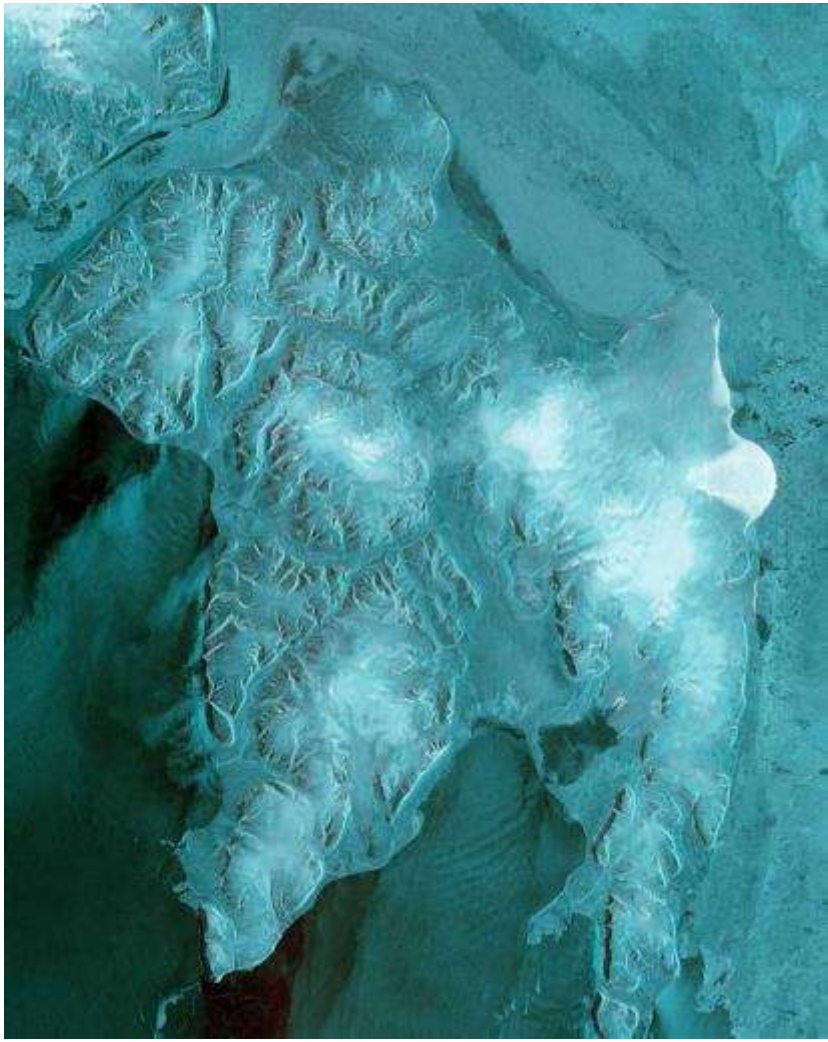
Upper glacier receded by about 5.5 km over the past 36 years, contributing to sea-level rise

Sentinel-1B's First Image

Svalbard Archipelago,
28 April 2016

full scene

subset

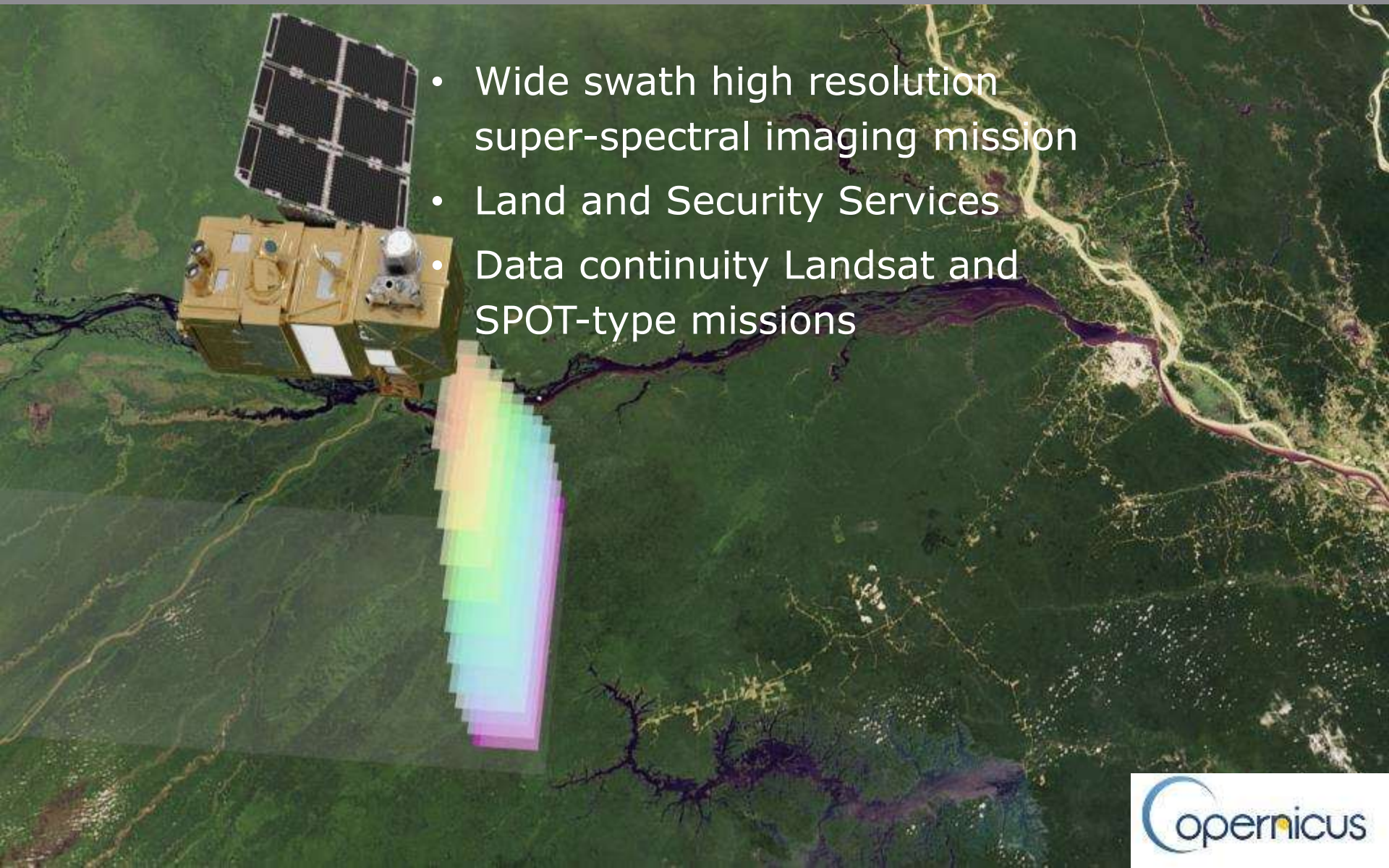


European Space Agency

Sentinel-2A launch

- 22 June 2015
- Kourou
- Vega VV05

Sentinel-2



- Wide swath high resolution super-spectral imaging mission
- Land and Security Services
- Data continuity Landsat and SPOT-type missions

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

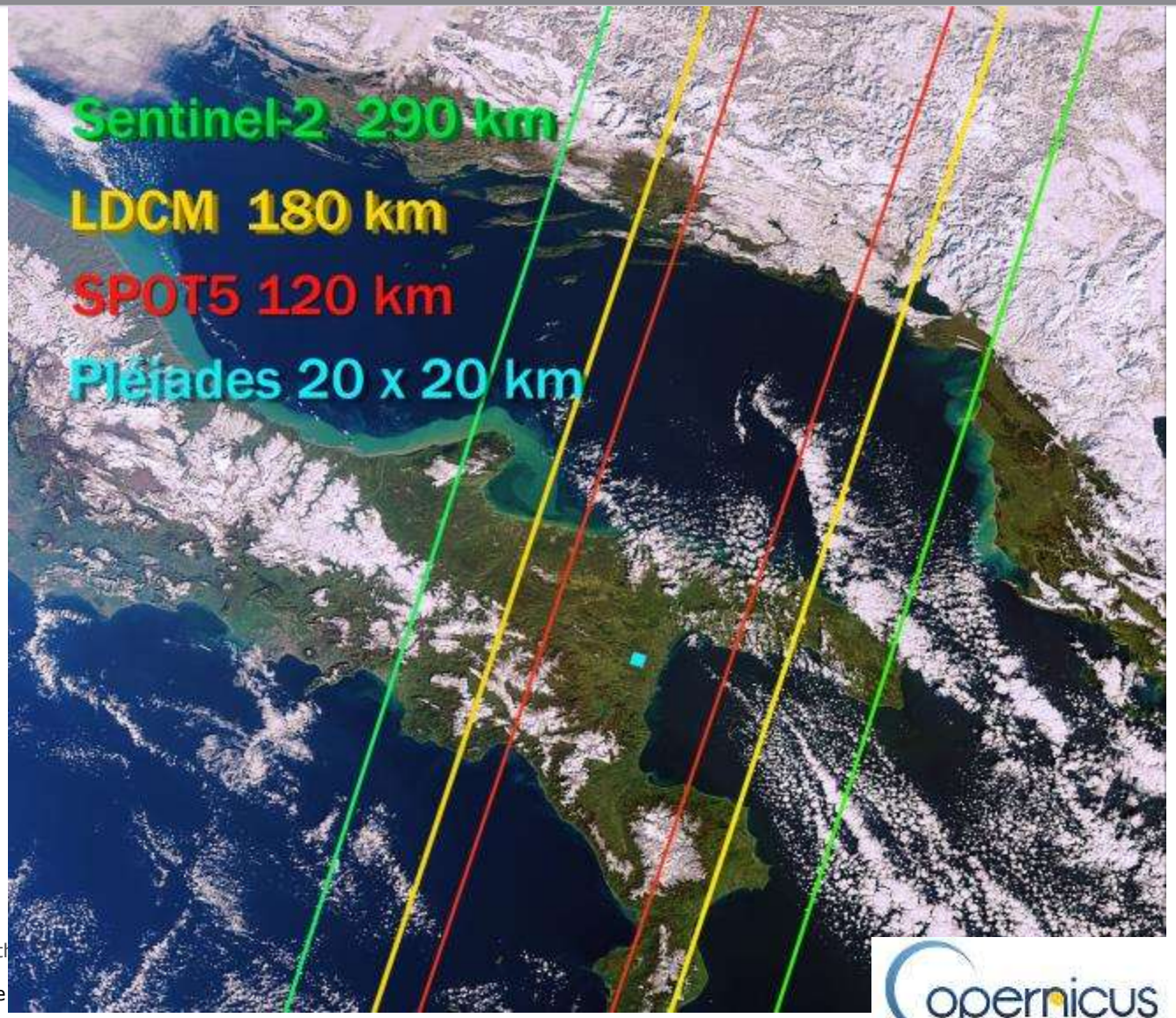
The European "Super Landsat"

Coverage (d)	26	16	**5 (2 satellites)**
Swath (km)	60	185	**290**
Spectral bands	4+1	8+1	**13**
Resolution (m)	2.5	30,(15)	**10,20,(60)**

Sentinel-2
Swath width

Sentinel-2 (A+B):
Full Earth Coverage
(at Equator) in 5 days

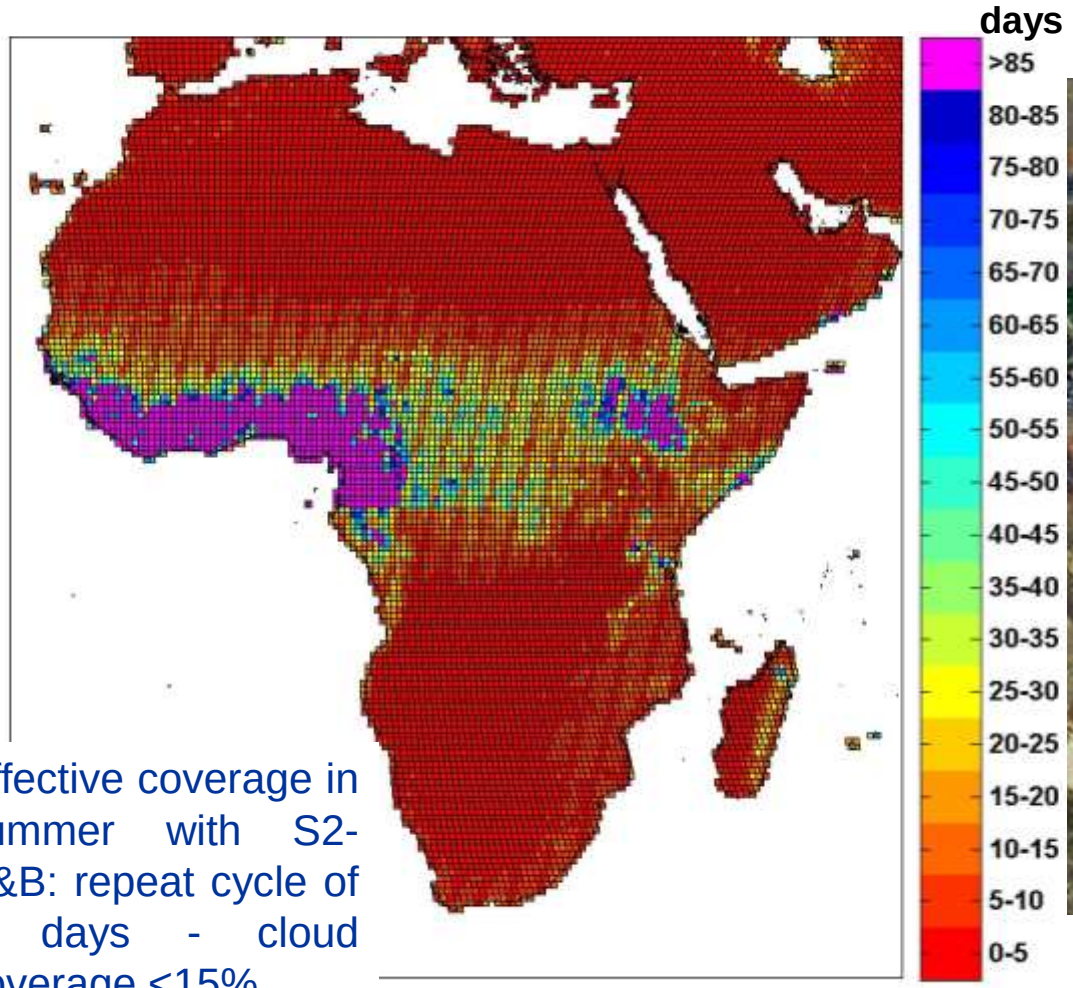
Sentinels are complementary to High-Res commercial and national missions



Sentinel-2 Revisit Time Capability

5 days revisit for crop dynamics

Sentinel-2 for agriculture http://www.esa-sen2agri.org/SitePages/Home.aspx



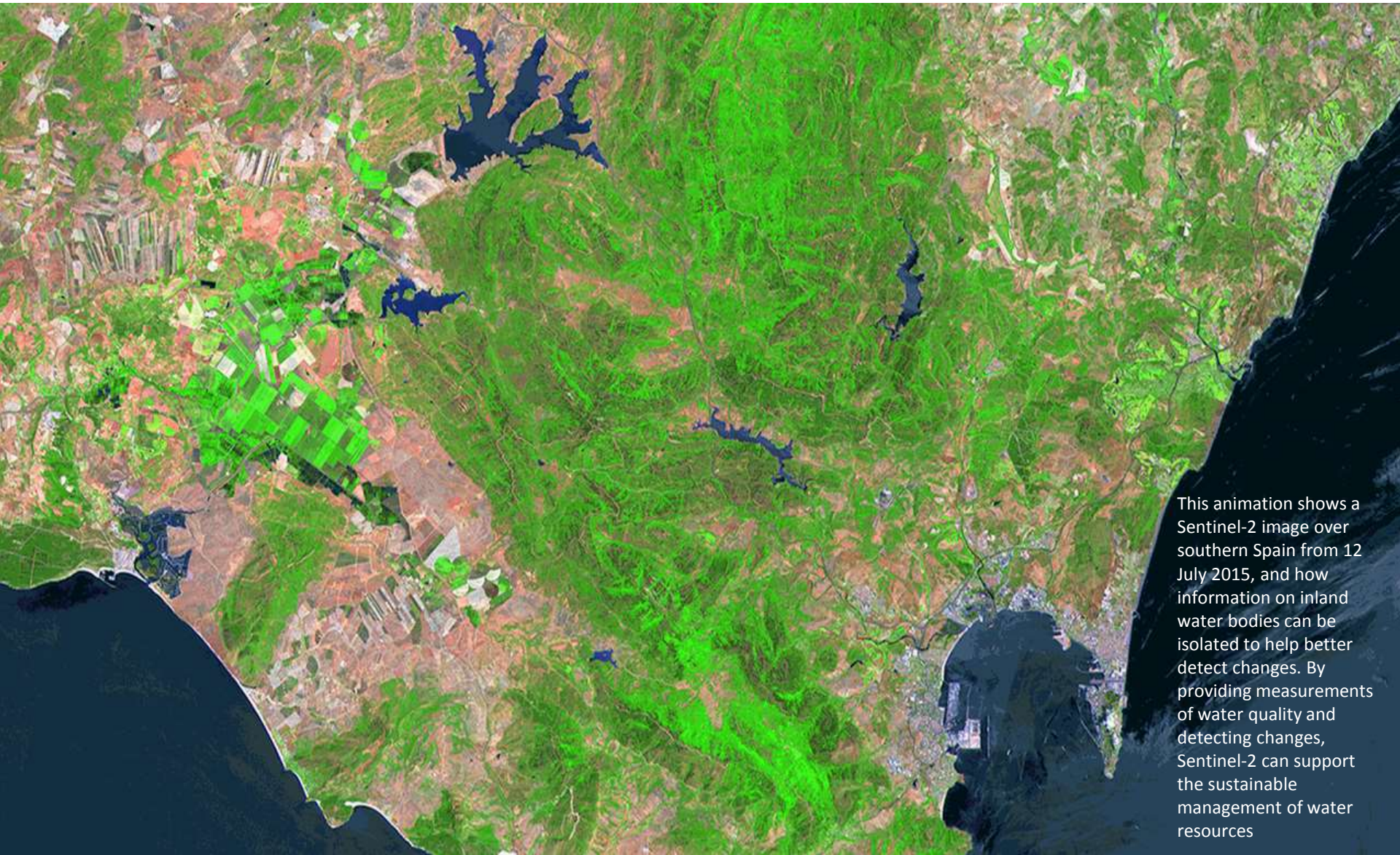
Effective coverage in summer with S2-A&B: repeat cycle of 5 days - cloud coverage <15%

South Africa JECAM site: 5 days revisit, February-June 2013 - RapidEye

Monthly cloud free composites possible for most areas

Sentinel-2A: First images

Sentinel-2A: Mapping Water Bodies

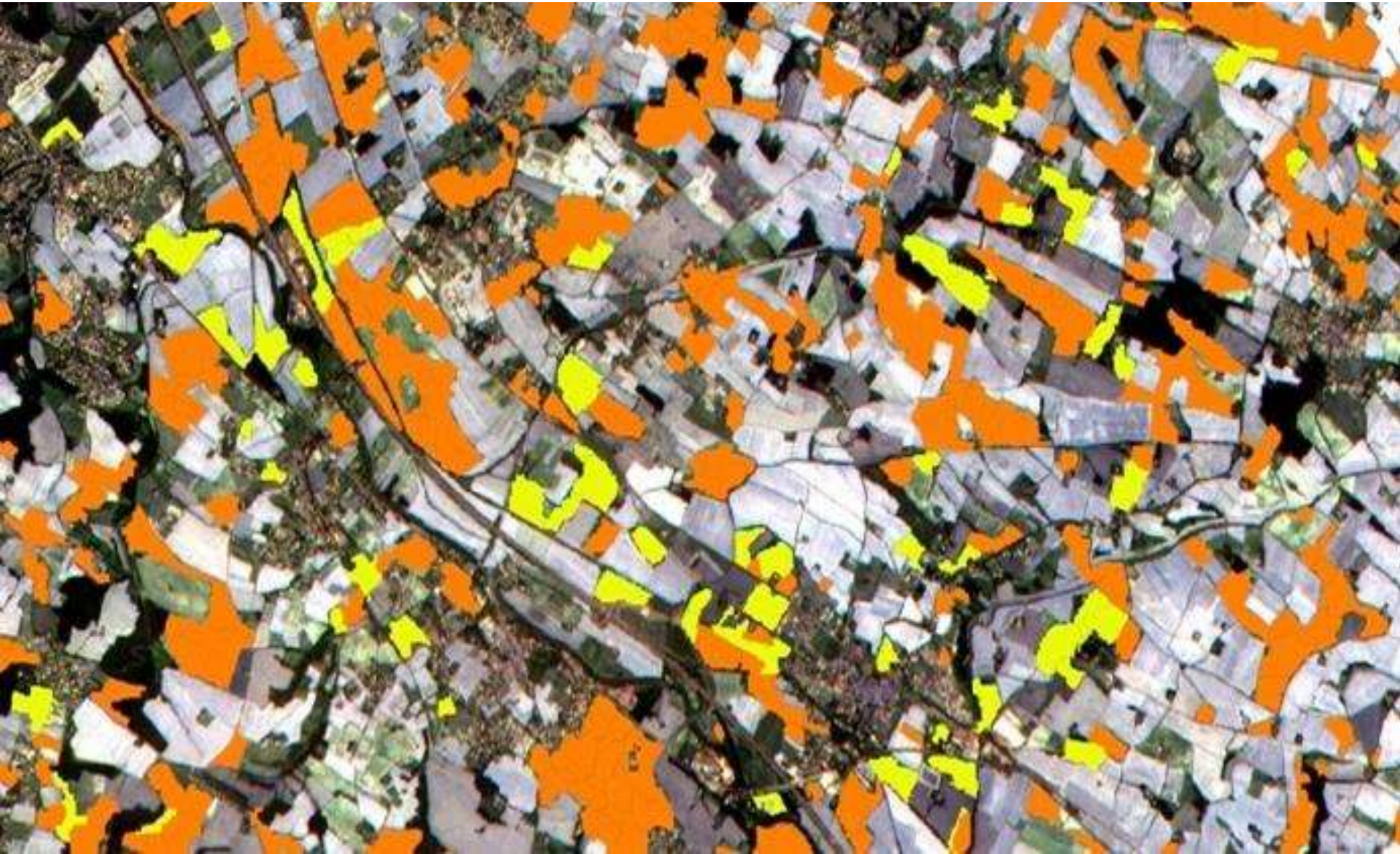


This animation shows a Sentinel-2 image over southern Spain from 12 July 2015, and how information on inland water bodies can be isolated to help better detect changes. By providing measurements of water quality and detecting changes, Sentinel-2 can support the sustainable management of water resources

Sentinel-2A: Agricultural Monitoring

See also: S-2 for vegetation http://www.esa-sen2agri.org/SitePages/Home.aspx

Sentinel-2 is the first optical mission to include 3 bands in the 'red edge', providing information on the state of vegetation. In this image (6 July 2015 near Toulouse) the multispectral instrument was able to discriminate between two types of crops: sunflower (in orange) and maize (in yellow).



See also: S-2 for vegetation http://www.esa-sen2agri.org/SitePages/Home.aspx

Contact Us Request access

sentinel-2 + AGRICULTURE

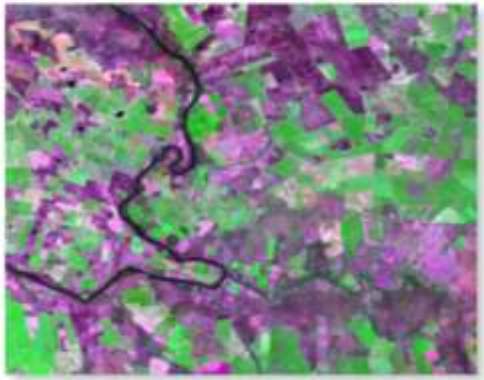
SENTINEL-2 FOR AGRICULTURE

Overview Partners Test Sites Products Publications Project Team Forum

PREPARING SENTINEL-2 EXPLOITATION FOR AGRICULTURE MONITORING

Agriculture is a key remote sensing application with high requirements. Short-term observation requirements in a global perspective for agriculture monitoring were tentatively defined by the GEO Agricultural Monitoring Community of Practice. The critical importance of the decameter resolution capabilities was highlighted to cover the whole diversity of the agricultural landscapes.

In this respect, the up-coming Sentinel-2 mission is a unique opportunity. Its 10-20m spatial resolution, its 5-day revisit frequency, its global coverage and its compatibility to the Landsat missions offer new opportunities for regional to global agriculture monitoring.



In this context, the Sentinel-2 for Agriculture (Sen2-Agri) project has recently been launched by ESA, as a major contribution to the R&D component of the GEOGLAM initiative and to the JECAM network activities. The project will demonstrate the benefit of the Sentinel-2 mission for the agriculture domain across a range of crops and agricultural practices. The intention is to provide the international user community with validated algorithms to derive Earth Observation products relevant for crop monitoring.

SPOTS TAKES to acquire a new Sentinel-2 like dataset

UPCOMING EVENTS

Sen2-Agri project at IGARSS 2015

7/26/2015,Milano,Italy

Sen2-Agri project presented at IGARSS 2015, in Milano.

Sentinel-2 for Science Workshop

5/20/2014,Frascati,Italy

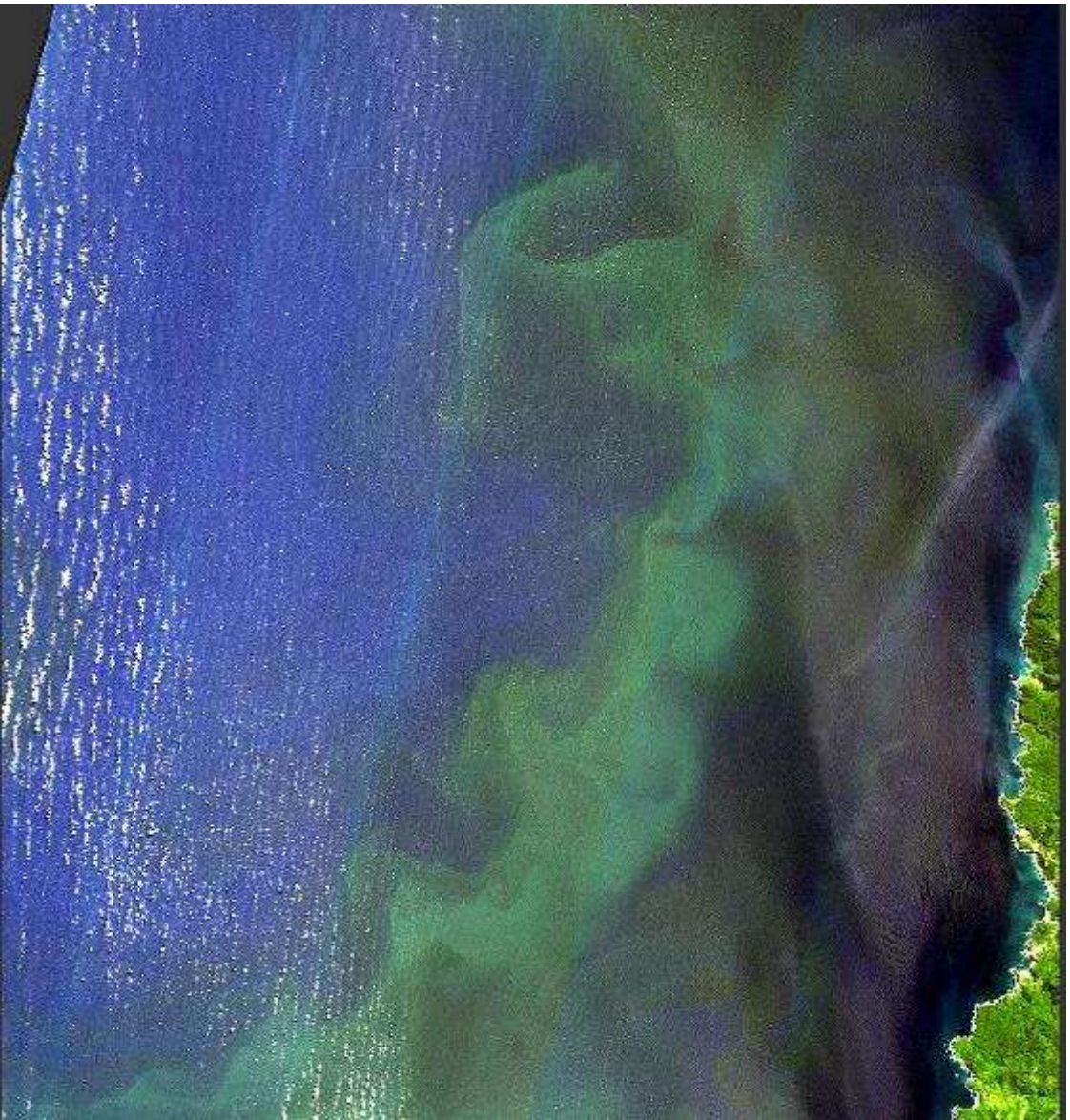
Sentinel-2 for Science Workshop hosted by ESA-ESRIN between May 20th and 22nd, 2014.

Sentinels in Co-Operation

Using both S1 and S2 data (and Landsat-8). Innovative crop type map at national scale: pilot project for potential future Copernicus service agricultural components

contains modified Copernicus Sentinel data [2016]

Sentinel-2A: Algal Bloom

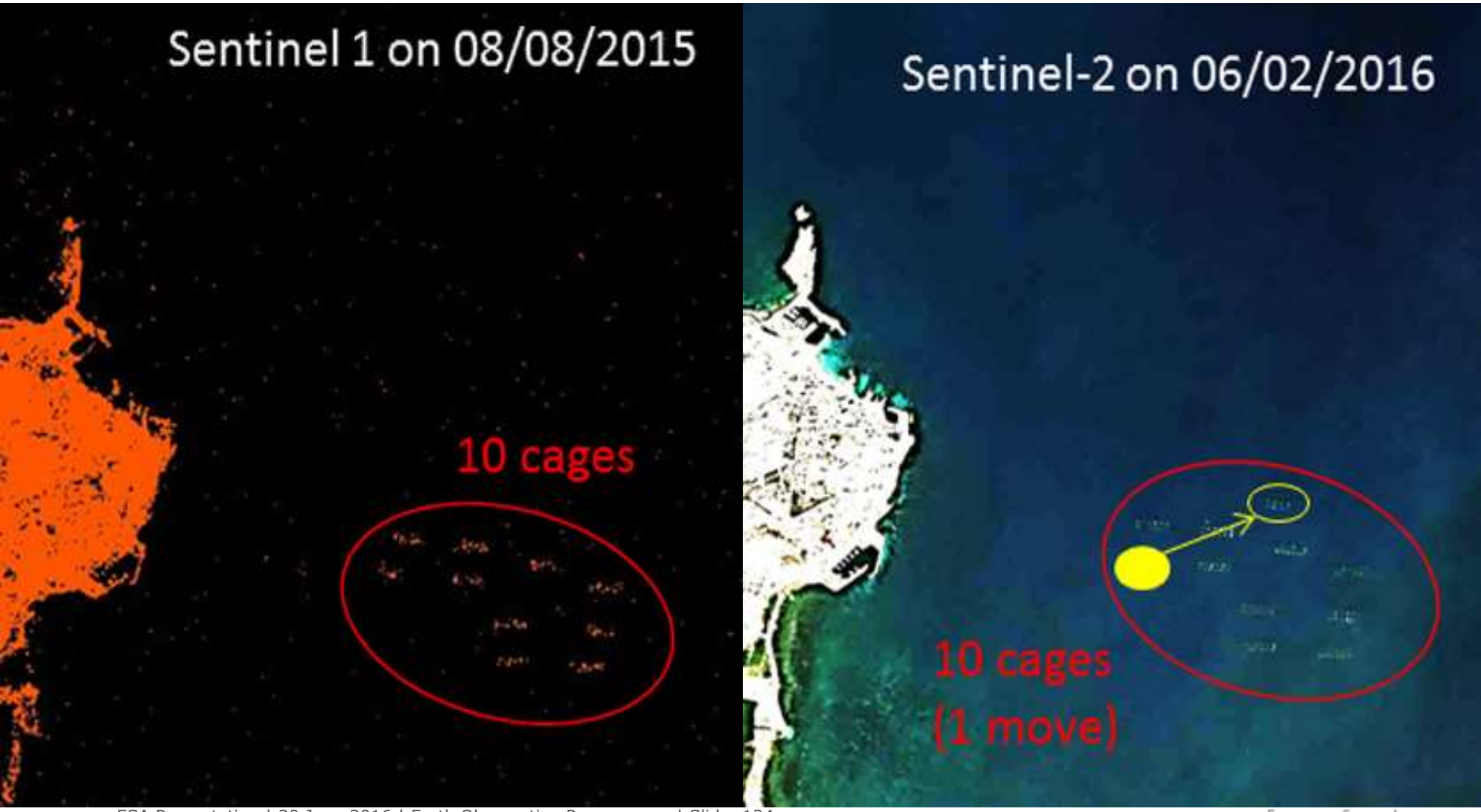


Algal bloom along the coast of Valdivia, Chile

Extreme economic impact: more than 24 Million of salmons died, more than 800 Millions of USD loss

Sentinel-2A,
5 March 2016

Sentinels in Co-Operation



Fish cages in Western Mediterranean Sea

contains modified Copernicus Sentinel data [2015/2016]/ESA/ACRI

A specific commercial serviced developed in France for precision farming is FARMSTAR: https://www.farmstar-conseil.fr/agriculture_teledetection.html

Sentinel-3 (3-A launched)

March 2016

- Medium resolution imaging and altimetry mission
- Land and ocean applications

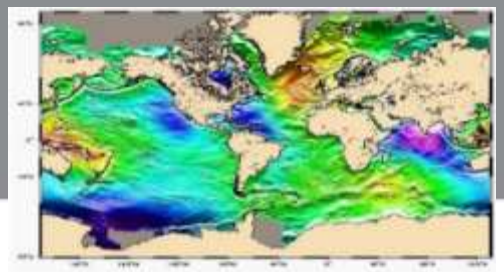
Sentinel-3 Payload

Optical Mission Payload

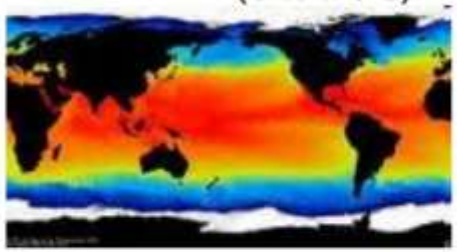
- Ocean and Land Colour Instrument (OLCI)
- Sea and Land Surface Temperature Radiometer (SLSTR)

Topography Mission Payload

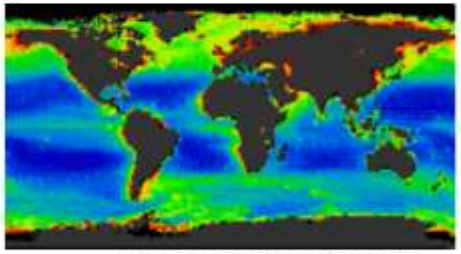
- Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL)
- MicroWave Radiometer (Bi-frequency)
- Precise Orbit Determination (POD) including:
  - GNSS Receiver
  - DORIS
  - Laser Retro-Reflector



Sea Surface Height products
(Credit: CLS)



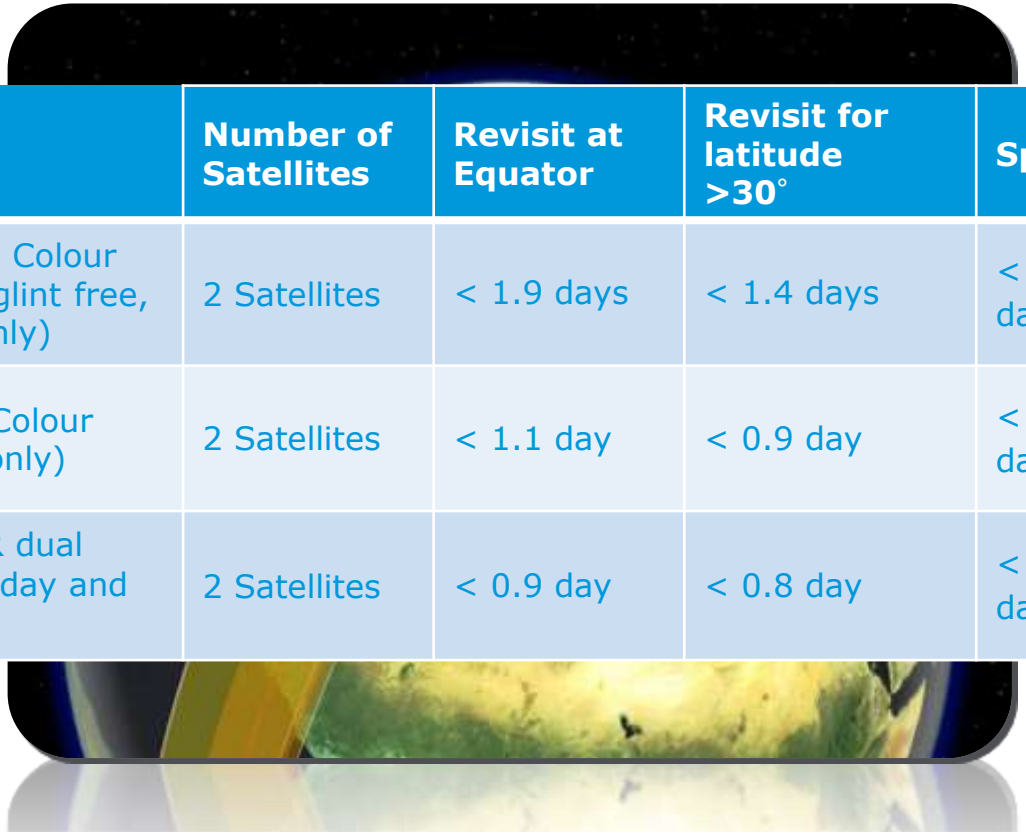
Sea Surface Temperature products
(Credit: Met Office)



Ocean colour products
(Credit: MyOcean)

Land cover products
(Credit: ESA)

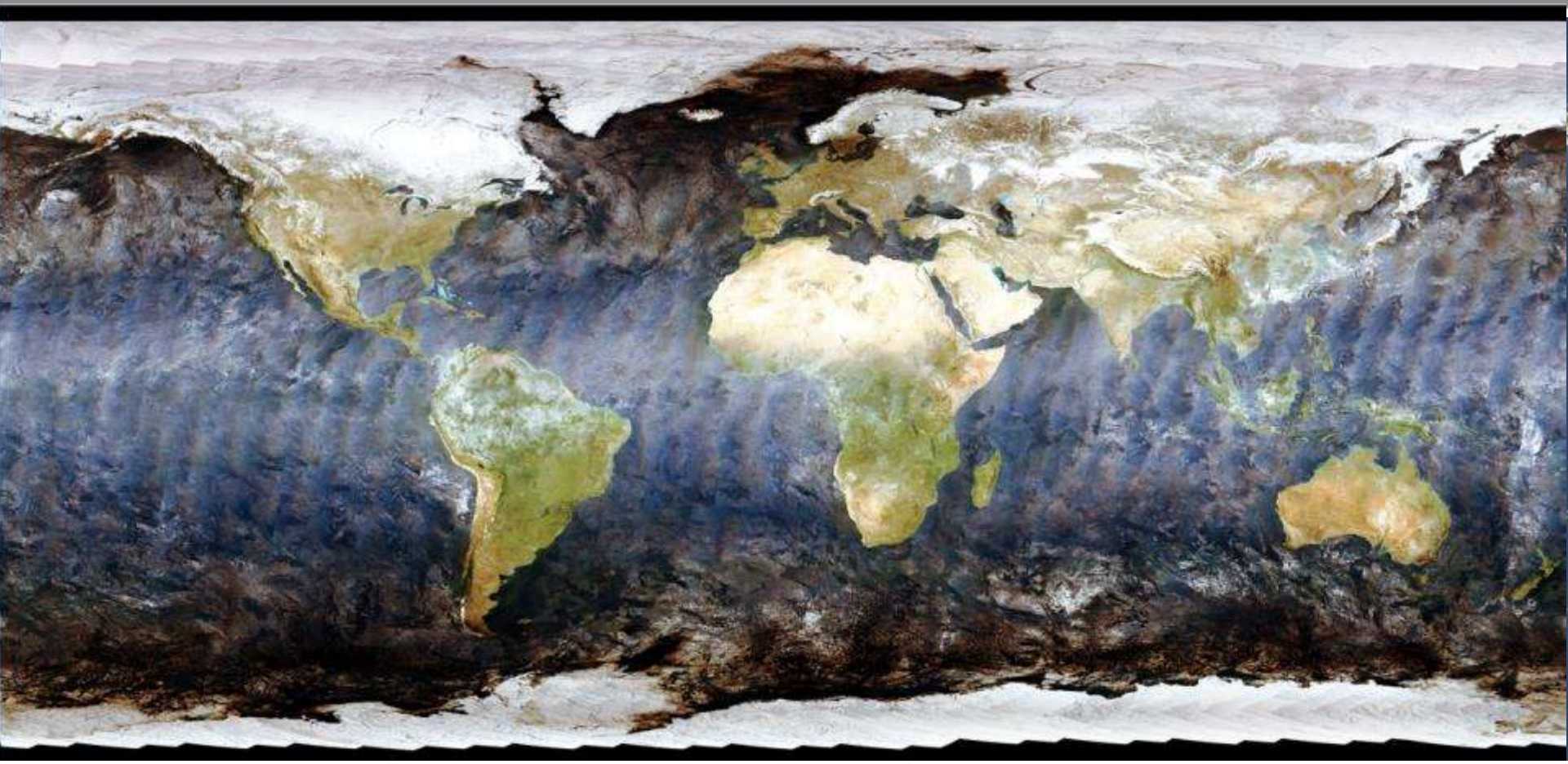
Sentinel-3 Revisit Time & Coverage: Optical Mission



	Number of Satellites	Revisit at Equator	Revisit for latitude >30°	Spec.
Ocean Colour (Sun-glint free, day only)	2 Satellites	< 1.9 days	< 1.4 days	< 2 days
Land Colour (day only)	2 Satellites	< 1.1 day	< 0.9 day	< 2 days
SLSTR dual view (day and night)	2 Satellites	< 0.9 day	< 0.8 day	< 4 days

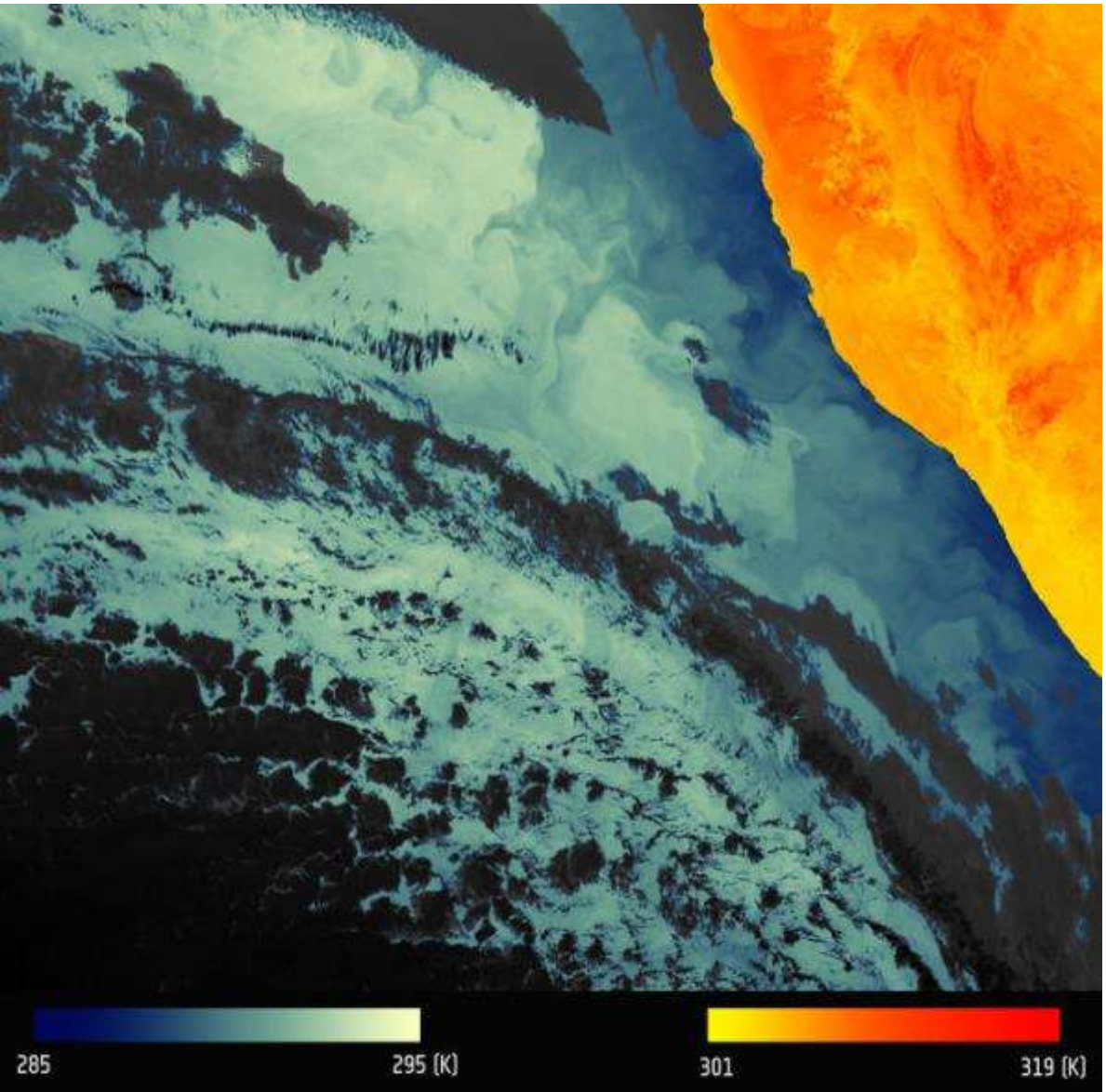
➢ **Short Revisit times for optical payload**

Sentinel-3 Applications



True colour composite mosaic of MERIS data for March 2003. OLCI will provide global coverage data for 21 spectral bands (400 -1020nm) at a spatial resolution of ~300m

Sentinel-3A: Thermal Signatures



Namibian Coastline,
29 March 2016

Contains modified Copernicus Sentinel data [2016]

European Space Agency

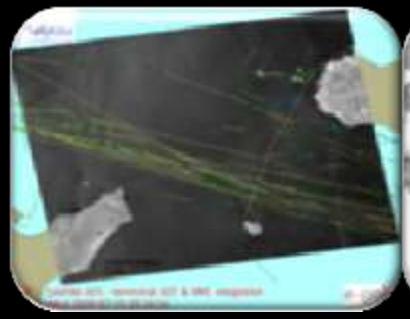
Sentinel-4/5/5p

- Atmospheric chemistry missions
- Instruments to be flown on
  - MTG (Sentinel 4)
  - MetOp SG (Sentinel 5)
- Separate precursor mission for Sentinel 5

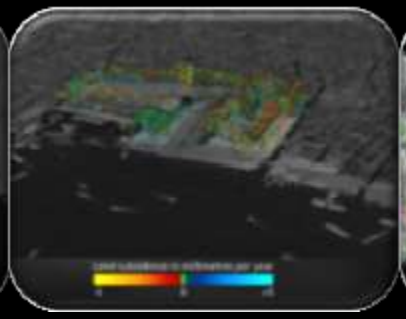
MTG

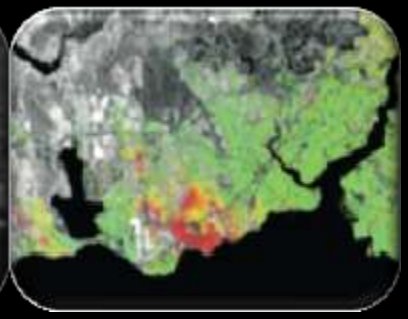
MetOp SG

Some Sentinel Application Areas


Maritime surveillance


Oil spills


Land subsidence

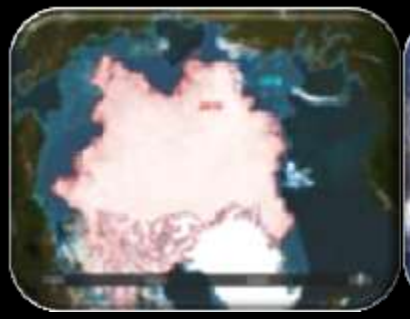

Tectonics

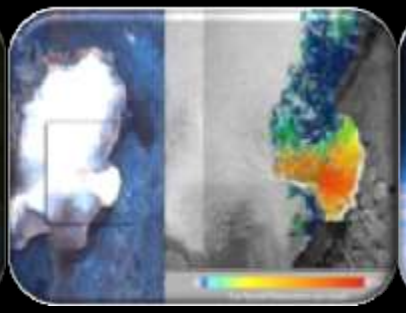

Volcanoes


Floods


Deforestation


Vegetation

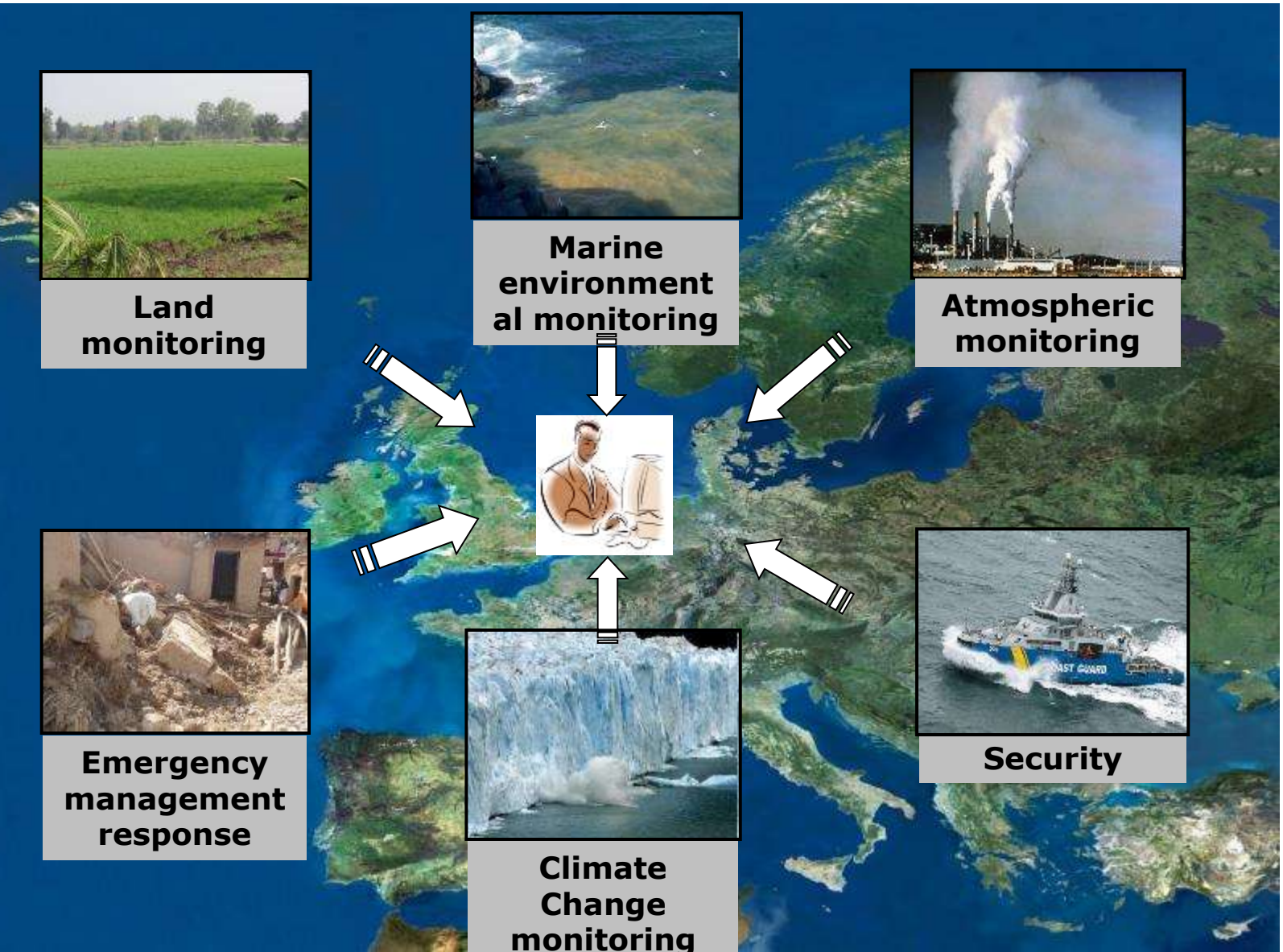

Sea ice extent


Ice speed

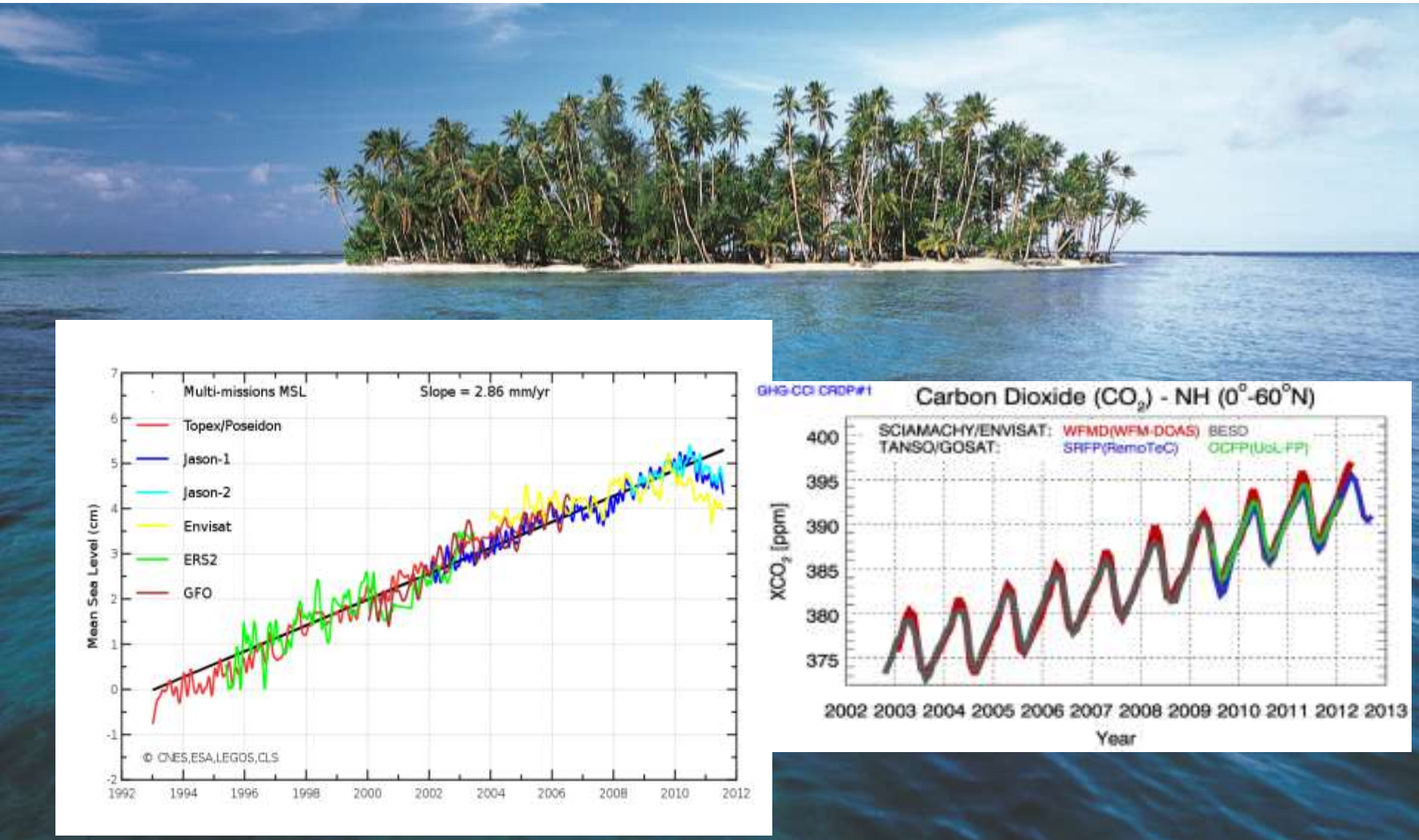

Atmosphere


Ocean colour

GMES/ Copernicus Services domains

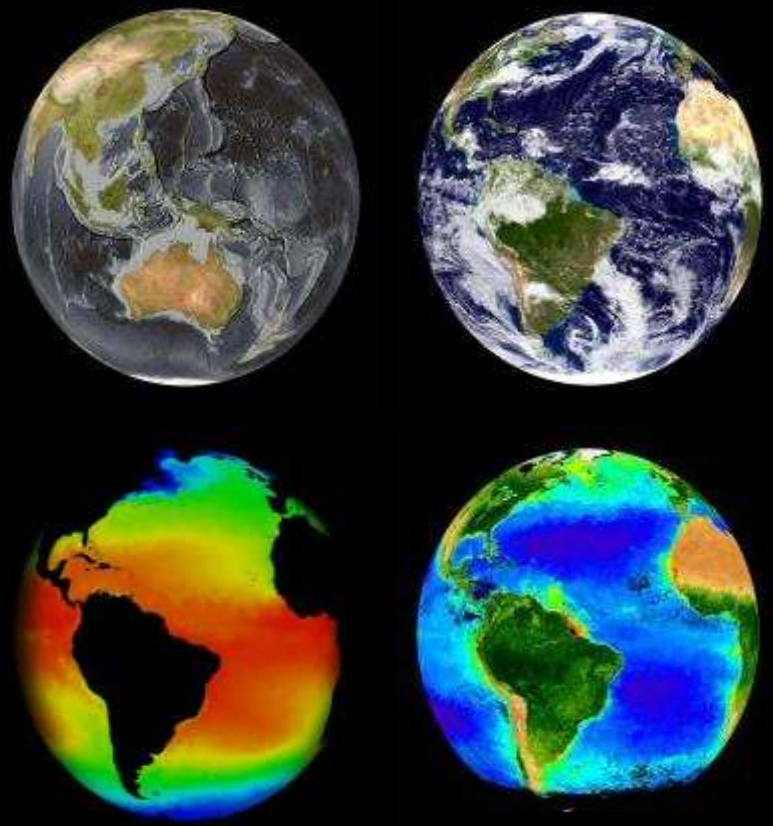


The ESA Climate Change Initiative (CCI)



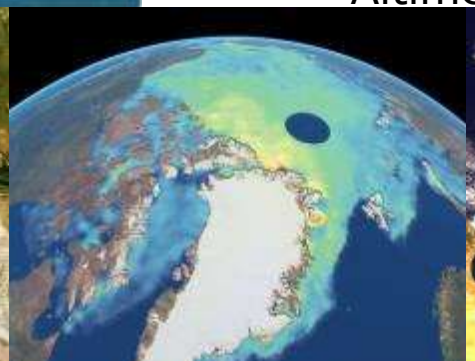
CCI: Essential Climate Variables

- Cloud Properties
- Carbon Dioxide, Methane & other GHGs
- Ozone
- Aerosol properties
- Sea Surface Temperature
- Sea Level; Sea Ice
- Ocean Colour
- Glaciers and ice caps
- Land cover
- Fire disturbance
- Soil moisture



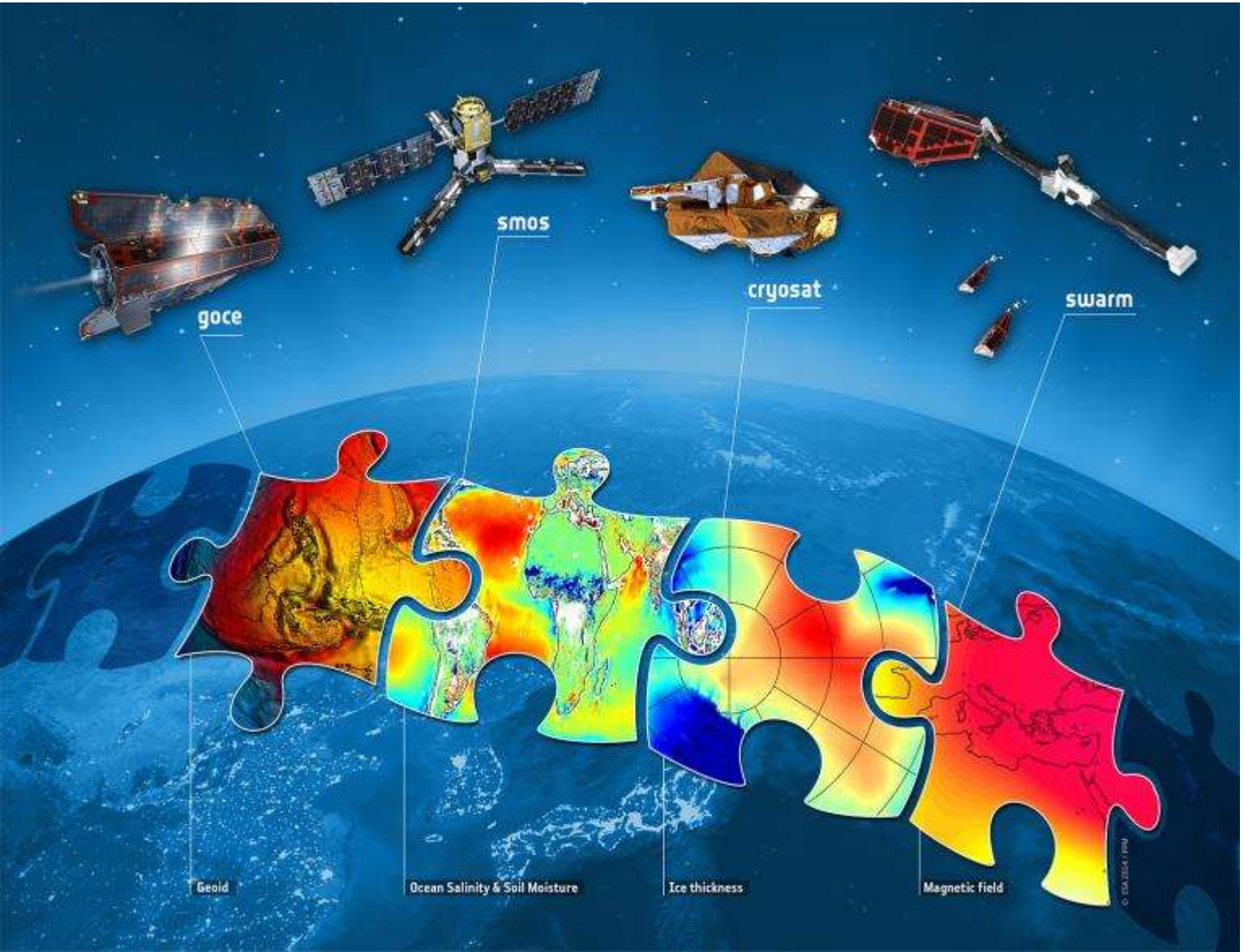
EOEP Impact on IPCC

- "Satellites have improved the capabilities of observations for climate science, in terms of volume and quality"
- Chapter 2: Observations: Atmosphere and Surface
  - ATSR series
- Chapter 4: Observations: Cryosphere
  - Altimetry/SAR (ERS-1/2; Envisat); Cryosat-2; IMBIE
- Chapter 13: Sea Level Change
  - Altimetry (ERS-1/2; Envisat)

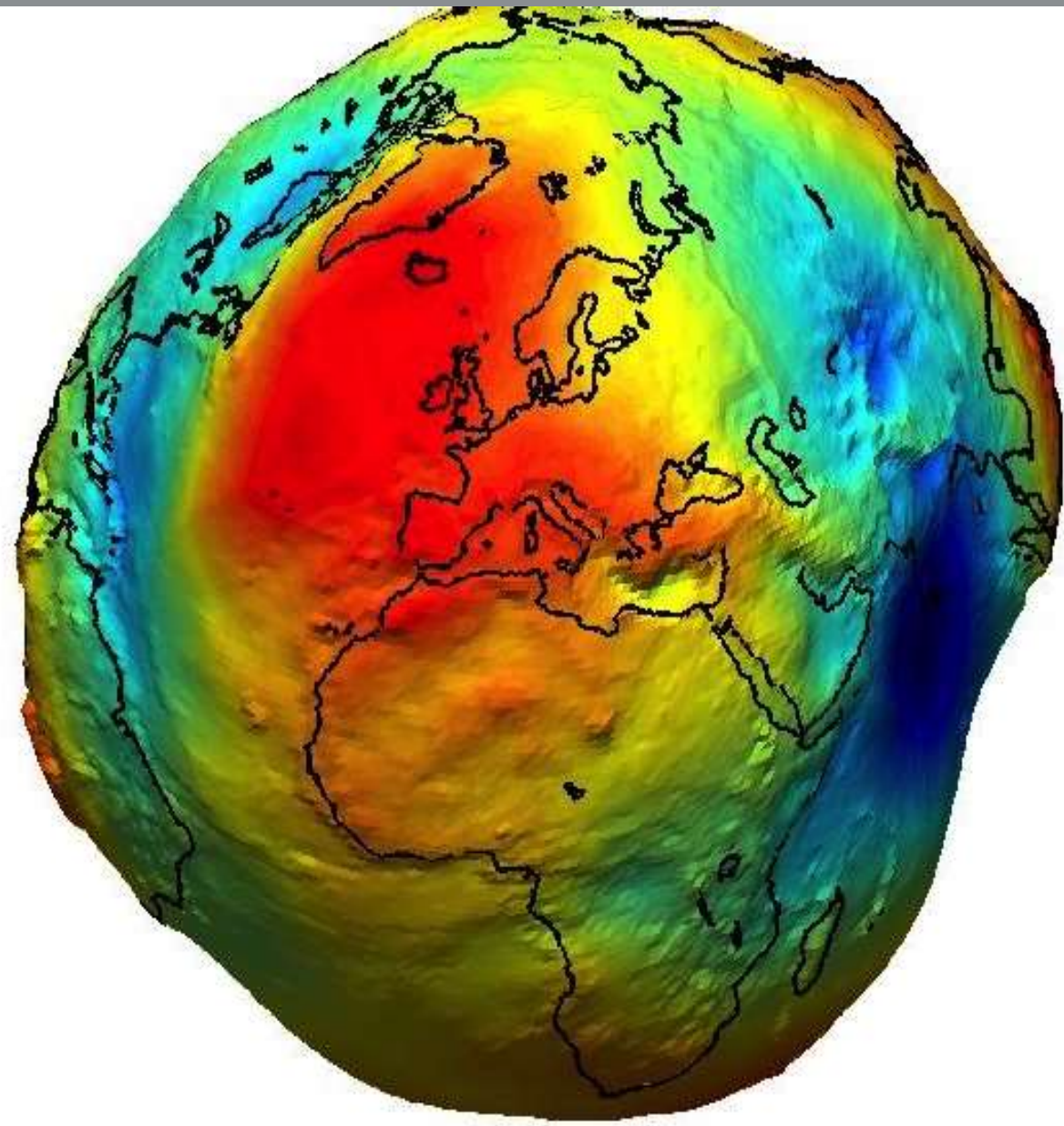
Science – the Earth Explorers

Science – the Earth Explorers



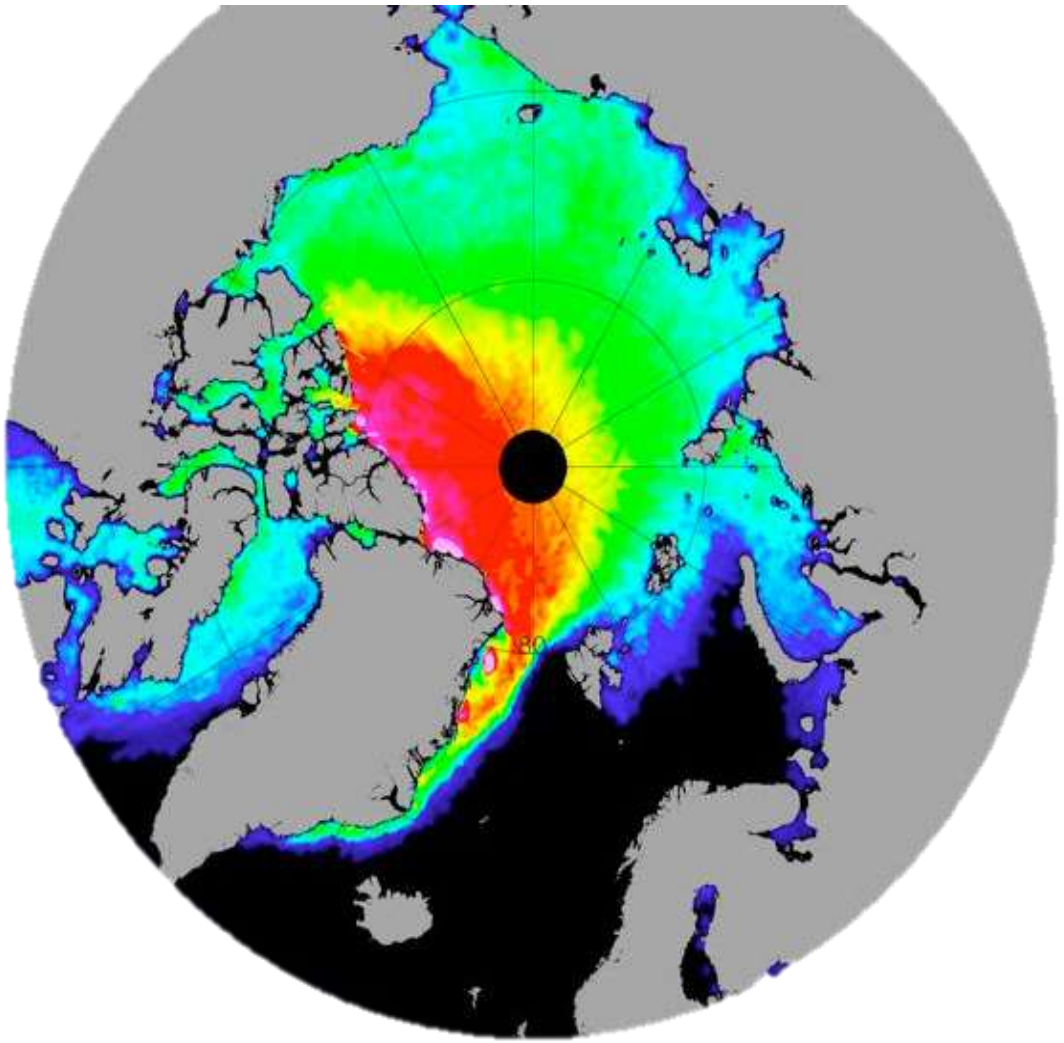
Earth Explorers launched so far

GOCE: Mission accomplished



Most precise geoid to date

Cryosat: Mission accomplished and ongoing

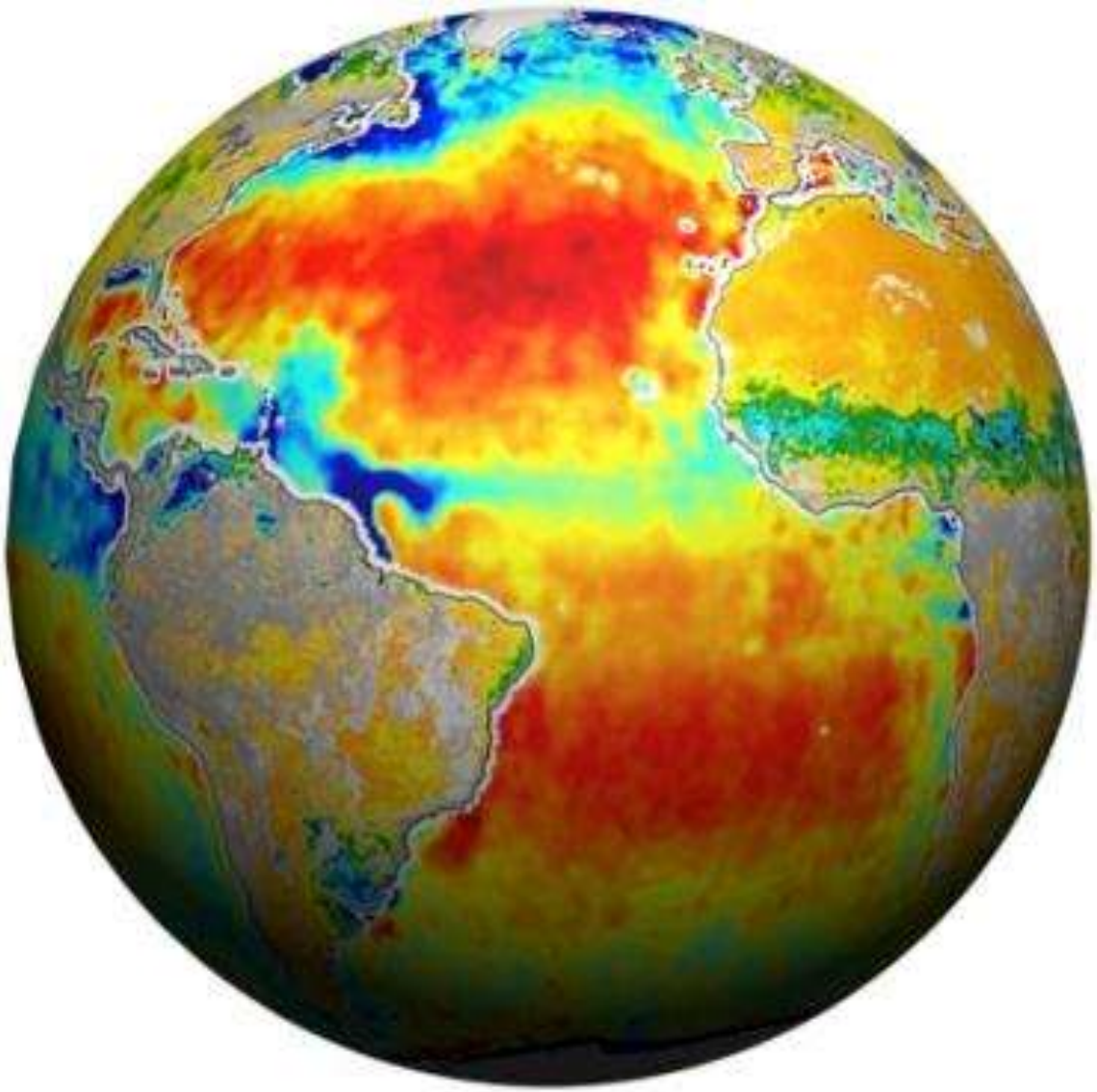


Surveyed sea ice thickness

Average spring sea ice thickness 2010-2015

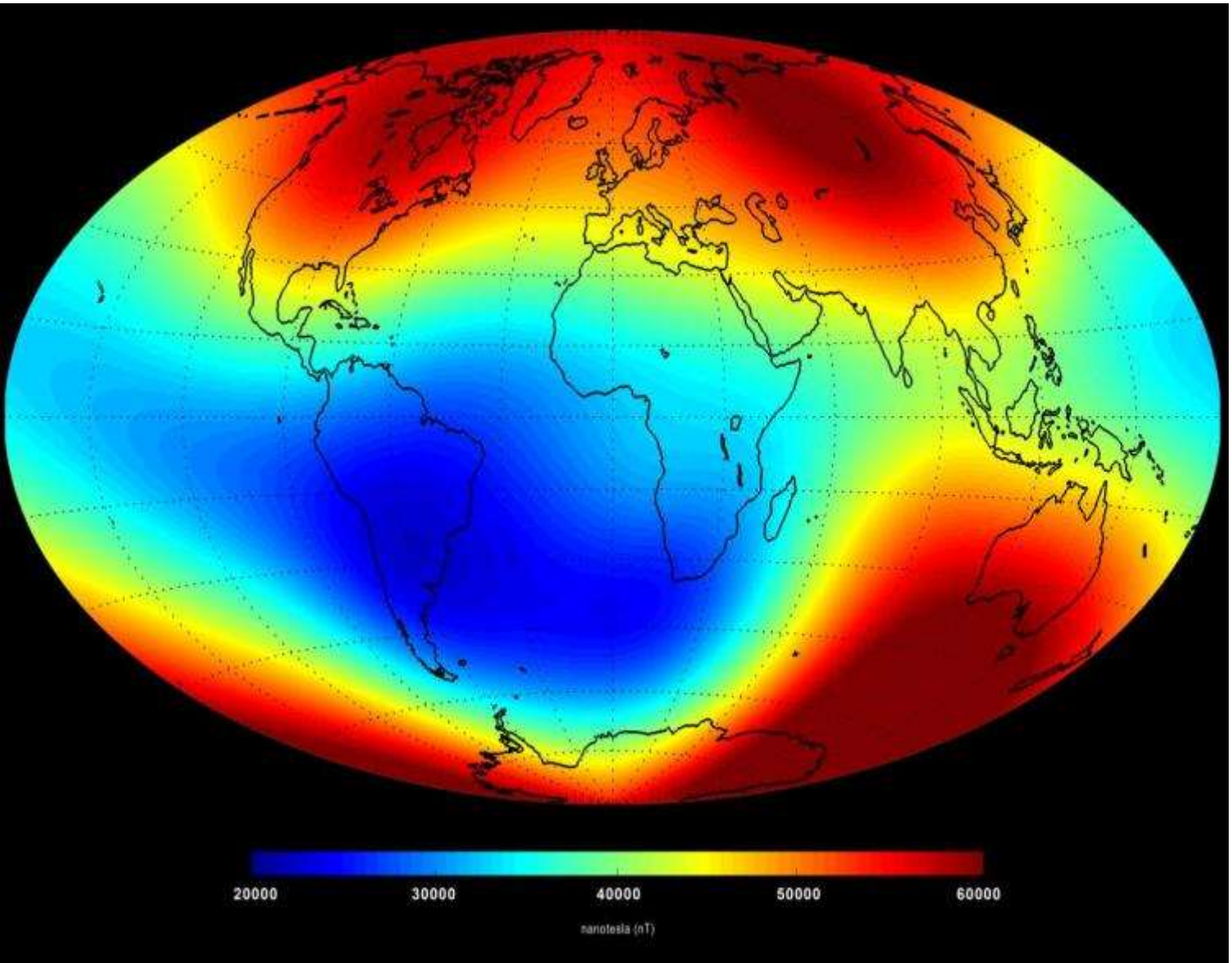
0 3.5m

SMOS: Mission accomplished and ongoing



Monitoring soil moisture and ocean salinity. Globally.

Swarm: Mission accomplished and ongoing



Tracking Earth's dynamic magnetic field.

ADM-Aeolus and EarthCARE

ADM-Aeolus

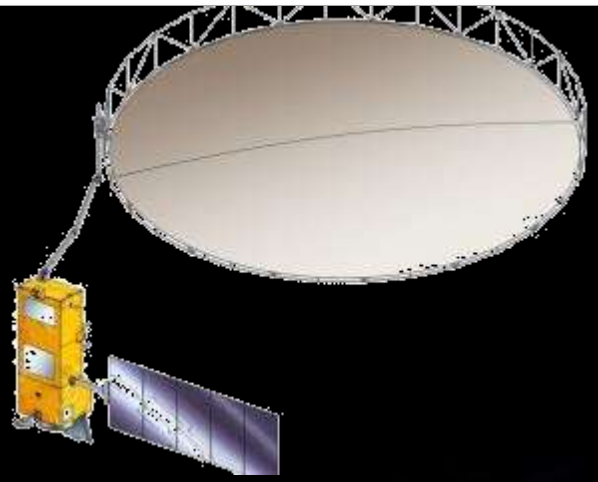
- Global observations of wind profiles for analysis of global 3D wind field
- Launch end 2017

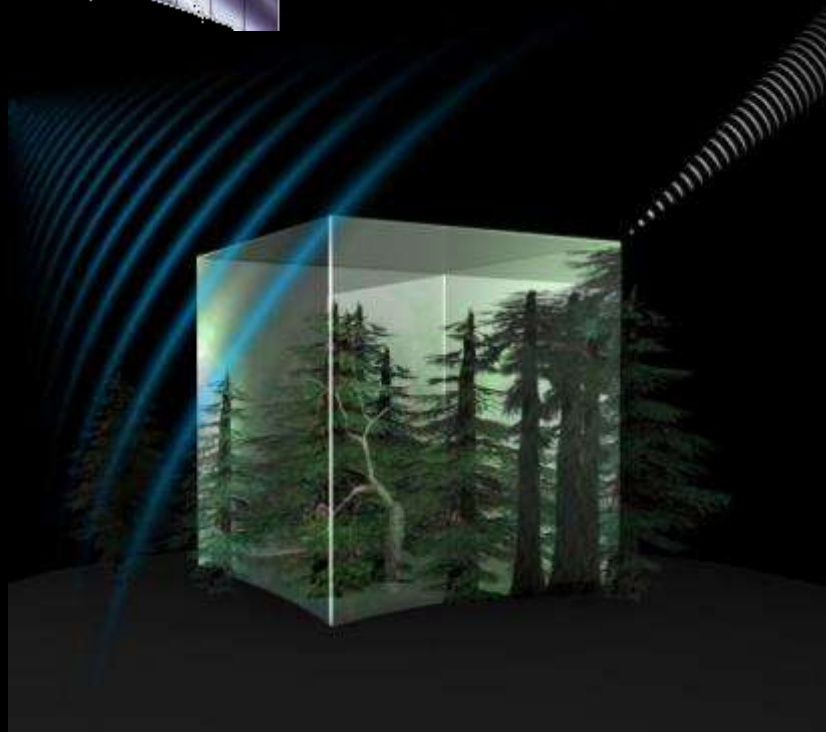
EarthCARE

- Global observations of clouds, aerosols and radiation
- Launch planned for 2018

Biomass, the 7th Earth Explorer

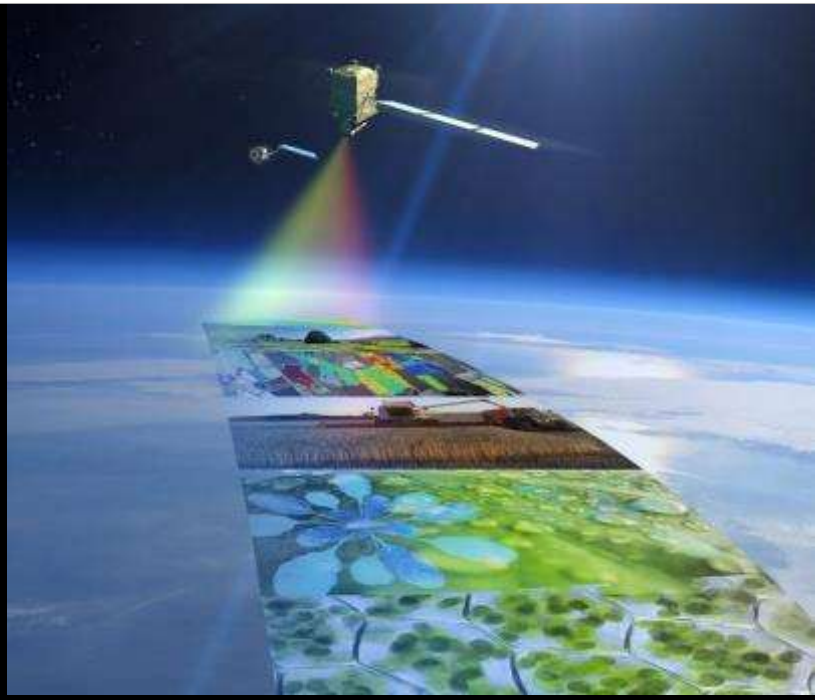
- Implementation decided by ESA's Earth Observation Programme Board in February 2015
- Biomass estimates based on global interferometric and polarimetric P-Band Radar observations
- Essential to understand the Earth's carbon cycle
- To be launched in 2020

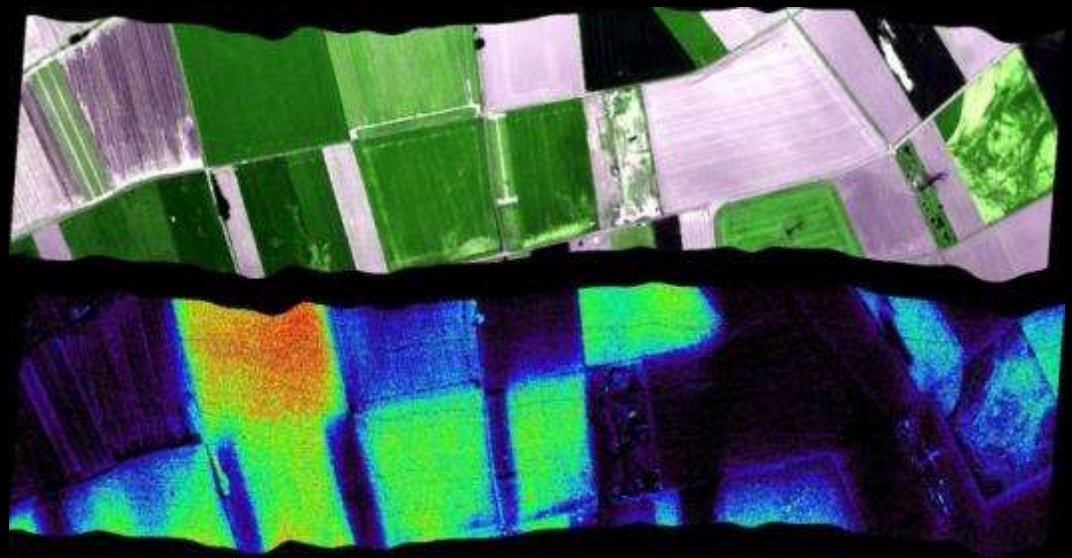




FLEX, the 8th Earth Explorer

- decision by PB-EO in November 2015
- global maps of vegetation fluorescence, which can be converted into an indicator of photosynthetic activity





ESA LPS 2016

PRAGUE 09-13 MAY 2016

Main Objective: Presentation of Exploitation Results based on ESA Earth Observation Measurements

living planet symposium | PRAGUE 09-13 May 2016

http://lps16.esa.int

European Space Agency

EO Tools for Education

Overview of ESA EO Training

- E-learning tools
  - ESA kids *(primary)*
  - Eduspace *(secondary)*
  - SEOS *(secondary)*
  - LearnEO! *(secondary/undergraduate)*
  - Bilko *(secondary/undergraduate)*
- Printed resources
  - ESA School Atlas and Water Atlas *(secondary)*
  - ESA EO Teacher's Pack *(secondary)*
- Training courses
  - EO summer schools *(graduate)*
  - Advanced training courses (land, ocean, atmosphere) *(graduate)*
  - Other EO training Courses *(graduate and undergraduate)*
- Training within programmes
  - DRAGON
  - TIGER

Firefox | EO Education and Training Home - Eart... | +

https://earth.esa.int/web/guest/eo-education-and-training

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esa Earthnet Online

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Need Help? Contact here | European Space Agency

Data Access | Missions | Earth Topics | PI Community | Explore more...

You are here: Home › EO Education and Training

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- EO Education News

Participate in the ESA LearnEO! competition

23 September 2013

Participate in the ESA LearnEO! lesson-writing competition, bring your work to a world audience and take a chance to win up to 5.000 euros!

Find out more on the LearnEO! competition webpage

- EO Education and Training

Overview of Earth Observation Training at ESA

ESA undertakes a wide range of activities in the field of Earth Observation education, training and capacity building. The scope of these activities ranges from high level training in state-of-the-art processing for the next generation of Principal Investigators to more general outreach activities and Earth Observation education for schools.

The aim of this website is to provide a single portal that supplies information about these activities, and enables access to resources produced in their framework.

- LearnEO!

LearnEO! is an Earth observation education project funded by ESA. Its aim is to increase the understanding of satellite data from ESA missions and show how these can be used to tackle environmental problems in the real world.

» Read more

- Education for Schools

ESA has developed an EO educational website "Eduspace" that mainly targets secondary schools. In addition to this, ESA provides workshops for teachers and has funded the development of many tools for EO education.

» Read more

- EO Summer Schools

- TIGER Training

EO Education and Training

- EO Education and Training Home
- EO Education for Schools
- Advanced EO Training for PIs
- Other EO Training

- EO data

- EO data distributed by ESA
- Access data online
- Access GMES data
- How to apply for data
- Eoli Catalogue
- ESA Multimedia Gallery

- EO training activities

- Education for Schools
- EO Summer Schools
- Dragon Programme
- Tiger Initiative
- Advanced Training
- Other EO Training
- Upcoming / Past Events

- EO software

- NEST Training
- LEOWorks Download (15.5mb)
- Beam
- SLVIS

- Key Resources

- Sample data
- Auxiliary data
- Catalogue access
- Document Library
- Upcoming Events
- Events Catalogue
- Software Tools
- Online Archives
- EO Software Toolboxes

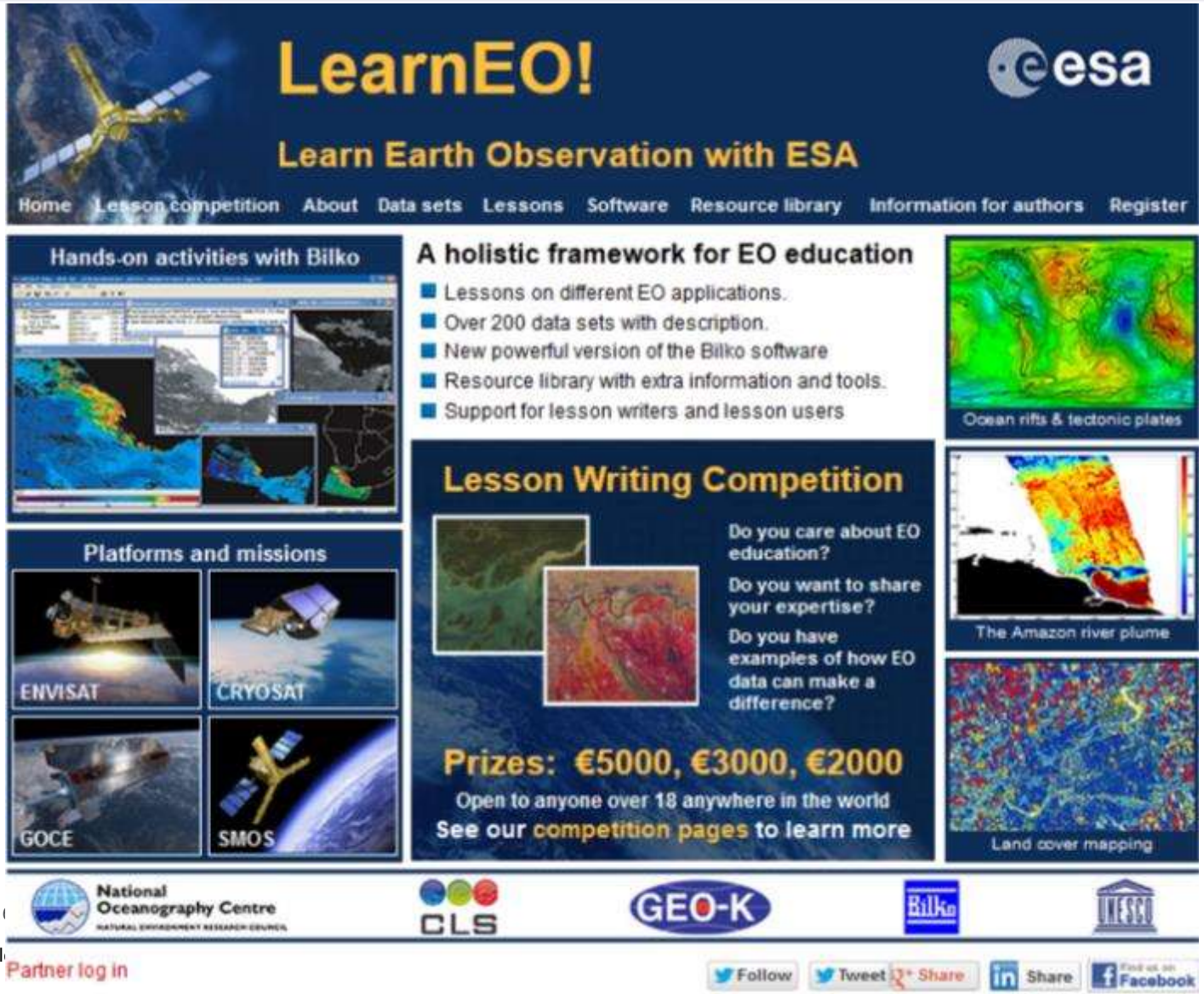
LearnEO!

http://www.learn-eo.org/index.php

1. LeanEO! is an Earth observation education project funded by the European Space Agency. Its aim is to increase the understanding of satellite data from ESA missions and show how these can be used to tackle environmental problems in the real world.

2. Lessons use Bilko software.

3. **The Amazon river plume**
4. **Monitoring oil pollution at sea**
5. **El Niño and the Southern Oscillation (ENSO)**
6. **Monitoring Atlantic storms**
7. **Observing Earth gravity:**
8. **Monitoring Arctic sea ice**
9. **Forest monitoring**
10. **Monitoring urban growth**
11. **Land cover mapping**
12. **Monitoring soil moisture**



SNAP = Sentinels Application Platform

http://step.esa.int/main/toolboxes/snap/

- **Optical exercise (S-2):**
  a. Application: spectral analysis & vegetation mapping
  b. Data: Sentinel-2
  c. Processing steps:
     - Sentinel-2 metadata
     - Band visualisations
     - Spectral analysis
     - Band maths (NDVI)

- **SAR exercise (S-1):**
  a. Application: Flood mapping
  b. Data: Sentinel-1
  c. Processing steps:
     - Sentinel-1 import
     - Multilook
     - Calibrate
     - Geocode
     - Stack
     - Flood map creatio
     - Export to Google Earth

Thanks for your attention!!!

Web sites of interest for EO Education:

International Charter: www.disasterscharter.org

GMES / Copernicus: http://copernicus.eu/

ESA Earth Watching: http://ew.eo.esa.int/web/guest/home

ESA Education: http://www.esa.int/Education

ESA Earth Observation: http://www.esa.int/Our_Activities/Observing_the_Earth

ESA Earth Observation Education: https://earth.esa.int/web/guest/eo-education-and-training

Eduspace: http://www.esa.int/SPECIALS/Eduspace_EN/

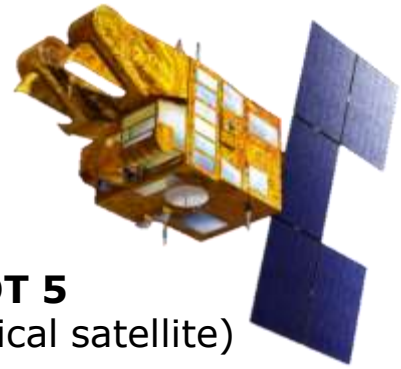
SEOS Project: http://www.seos-project.eu/home.html

8th ESA Training Course on Radar and Optical Remote Sensing, 5 - 9 September, 2016

1. An Introduction on SAR remote sensing and its applications to forestry – *Christian Thiel*
2. Optical land applications, focus on agriculture - *Pierre Defourny*
3. Practical exercises on Sentinel 1 and Sentinel 2 application using SNAP Toolbox - *Chris Stewart*
4. SAR land applications - *Francesco Holecz*
5. SAR marine applications - *Martin Gade*

Several social events organised by our host

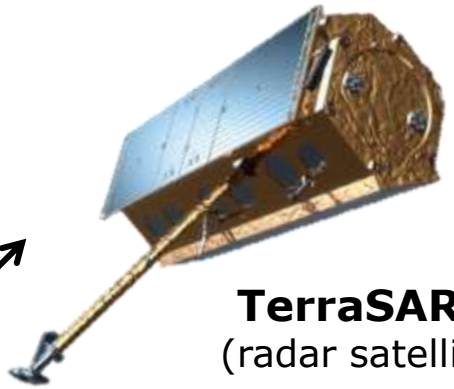
What is Remote Sensing/Earth



SPOT 5
(optical satellite)

passive

active



TerraSAR-X
(radar satellite)

Further Examples:

Non-imaging: radiometer, magnetic sensor

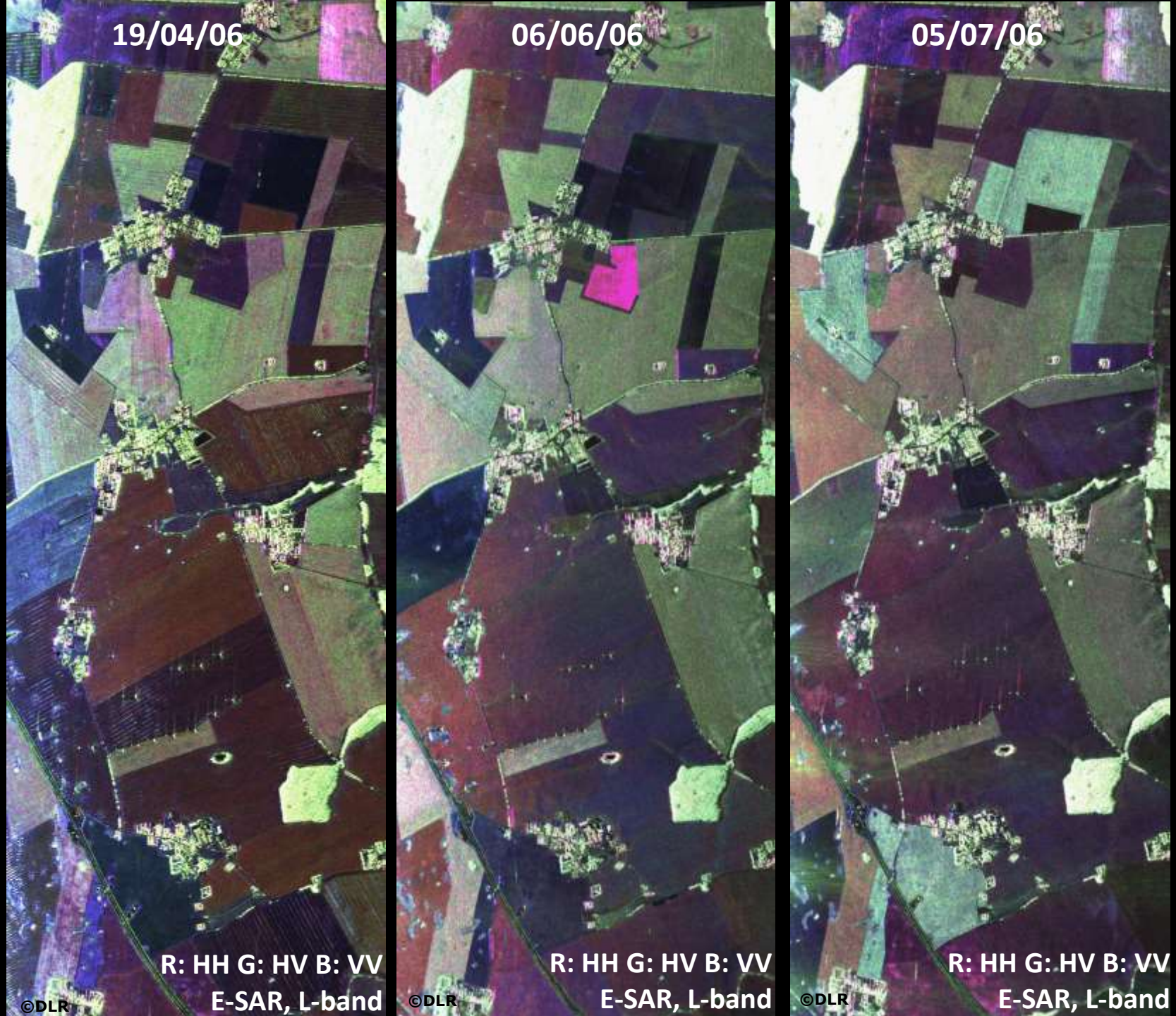
Imaging: cameras, optical mechanical scanner, spectrometer, radiometer

Further Examples:

Non-imaging: scatterometer, altimeter, laser

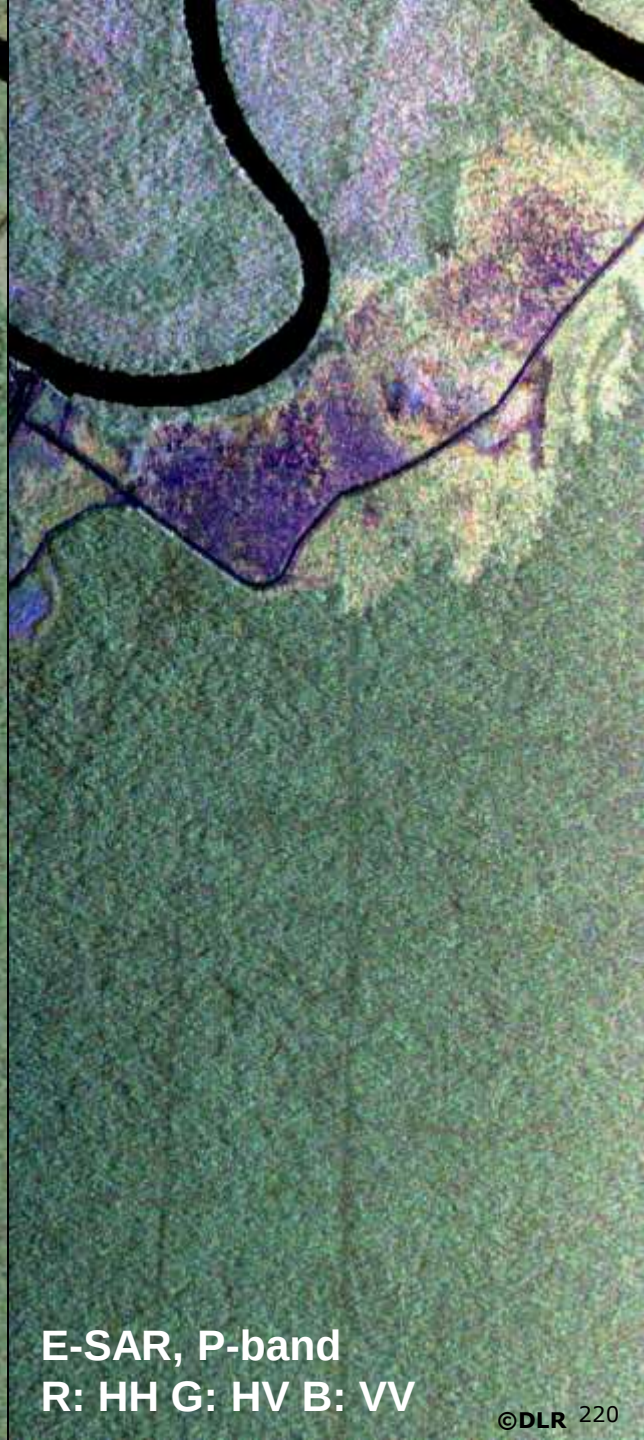
Imaging: Real Aperture Radar, Synthetic Aperture Radar

Crop monitoring with several observations

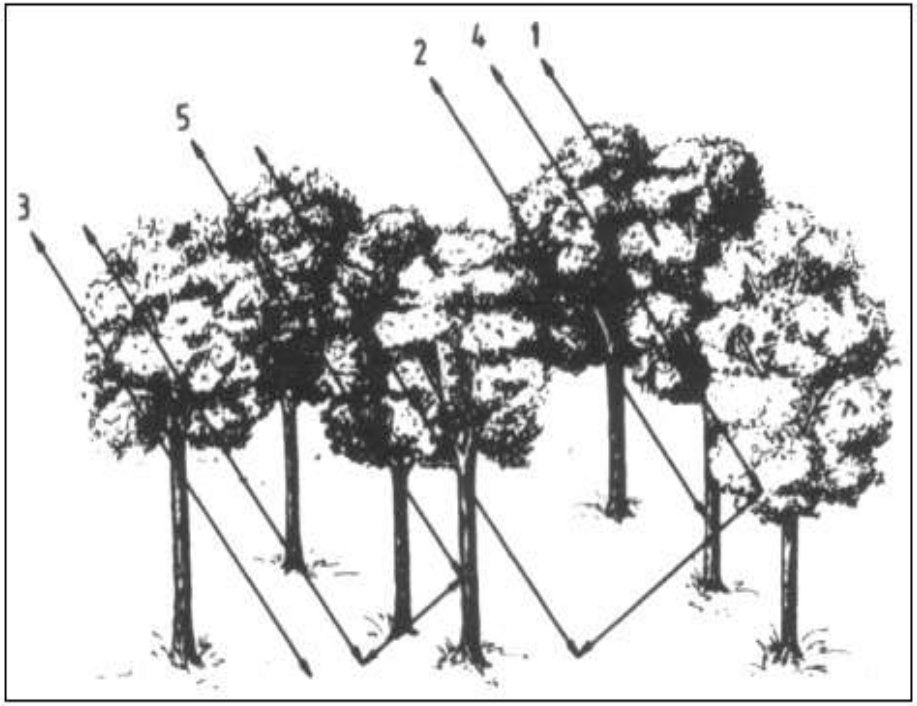



Kalimantan -
Indonesia
Balikpapan
Samarinda
Palangkaraya
Banjarmasin
E-SAR, C-band
R: HH G: HV B: VV
©DLR

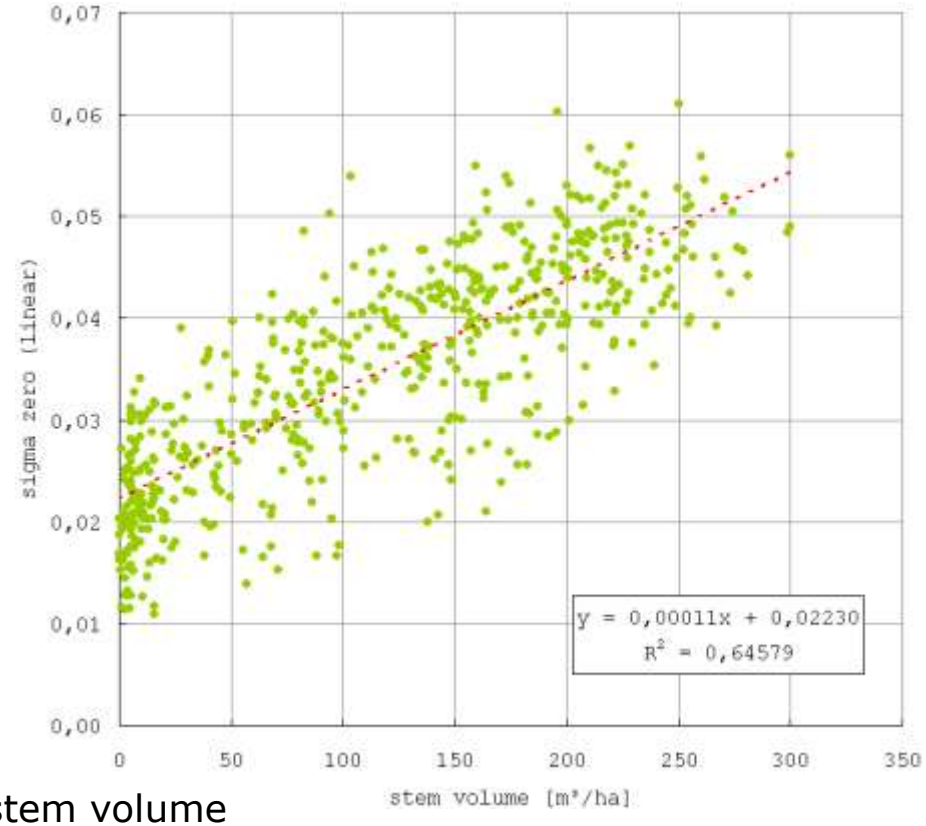

E-SAR, L-band
R: HH G: HV B: VV
©DLR


E-SAR, P-band
R: HH G: HV B: VV
©DLR

SAR Techniques: Backscatter analysis

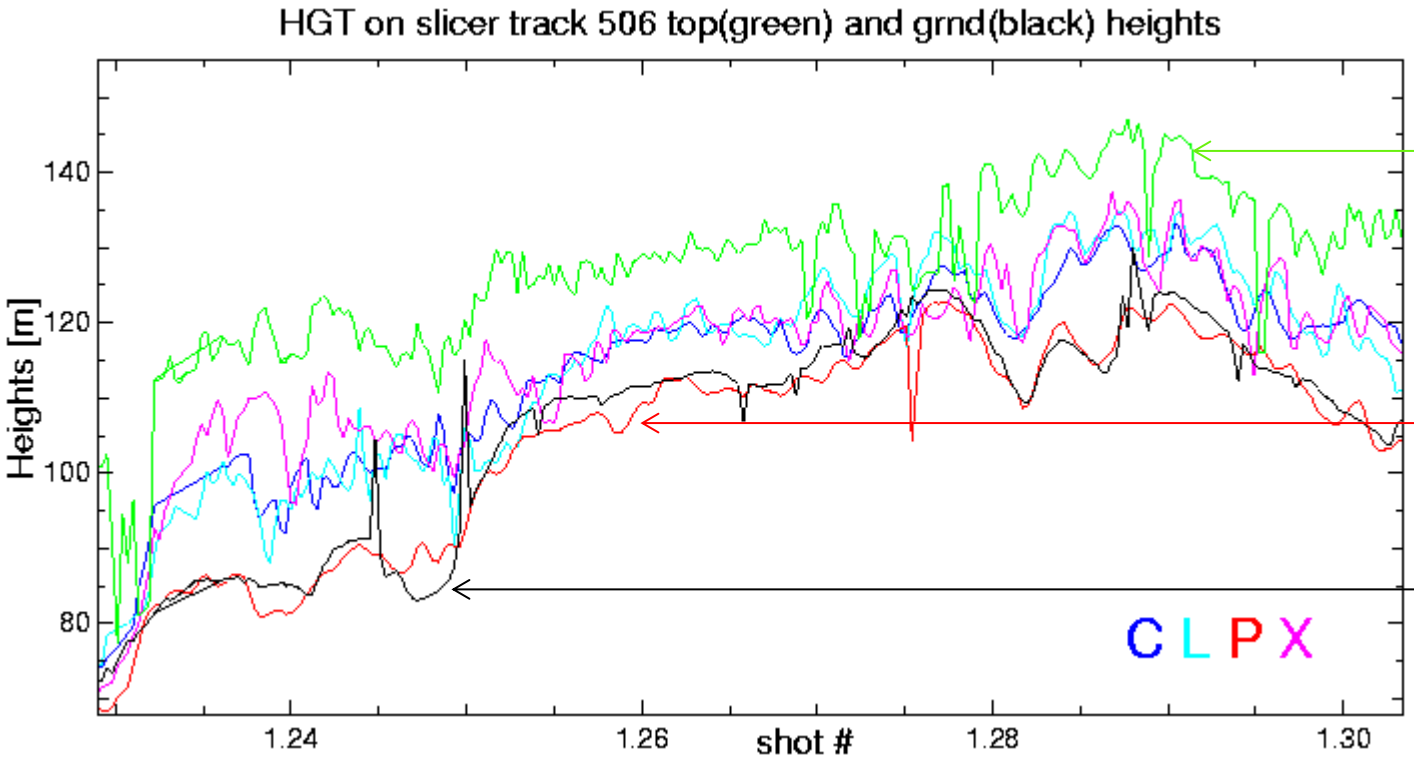


Stem volume vs. backscatter (HV) (05aug2007) – 12.5 m data



Correlation between SAR data and stem volume

Forest Height based on EO Data



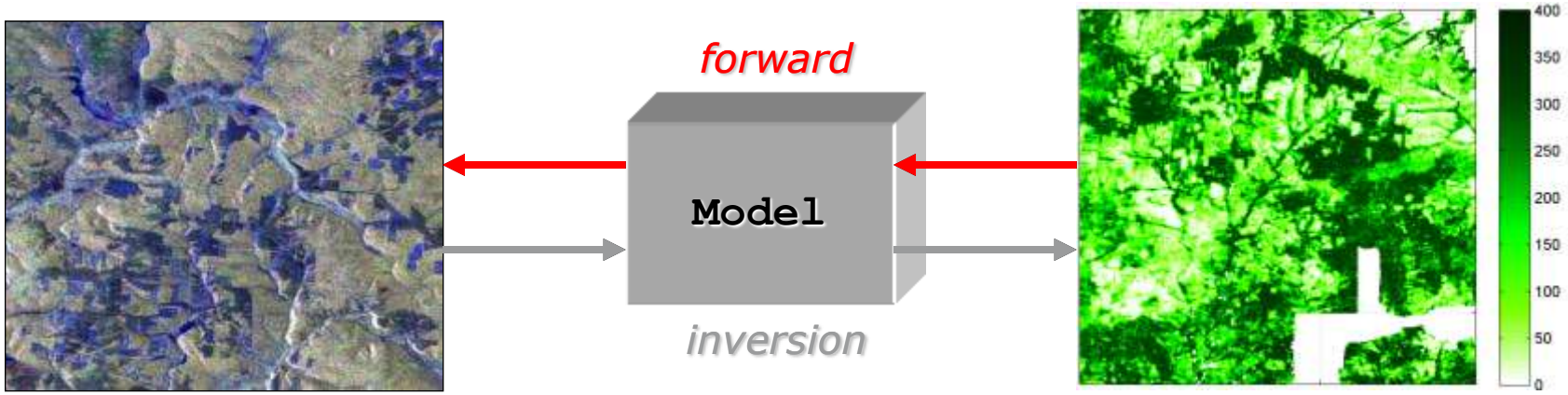
LIDAR first return from forest canopy

P-band return from forest floor

LIDAR last return from forest floor

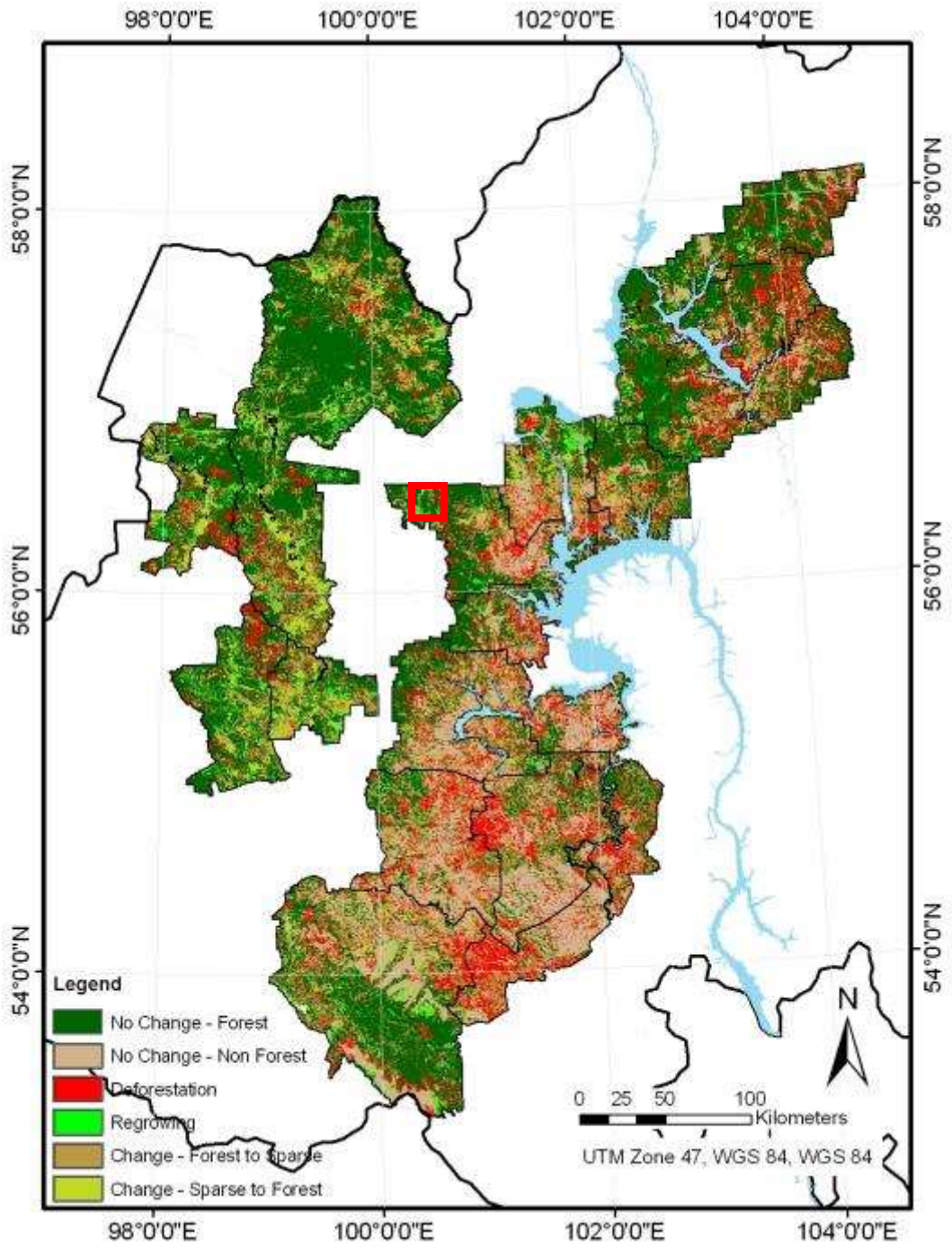
(WOODHOUSE; Data from SASSAN SAATCHI, JPL).

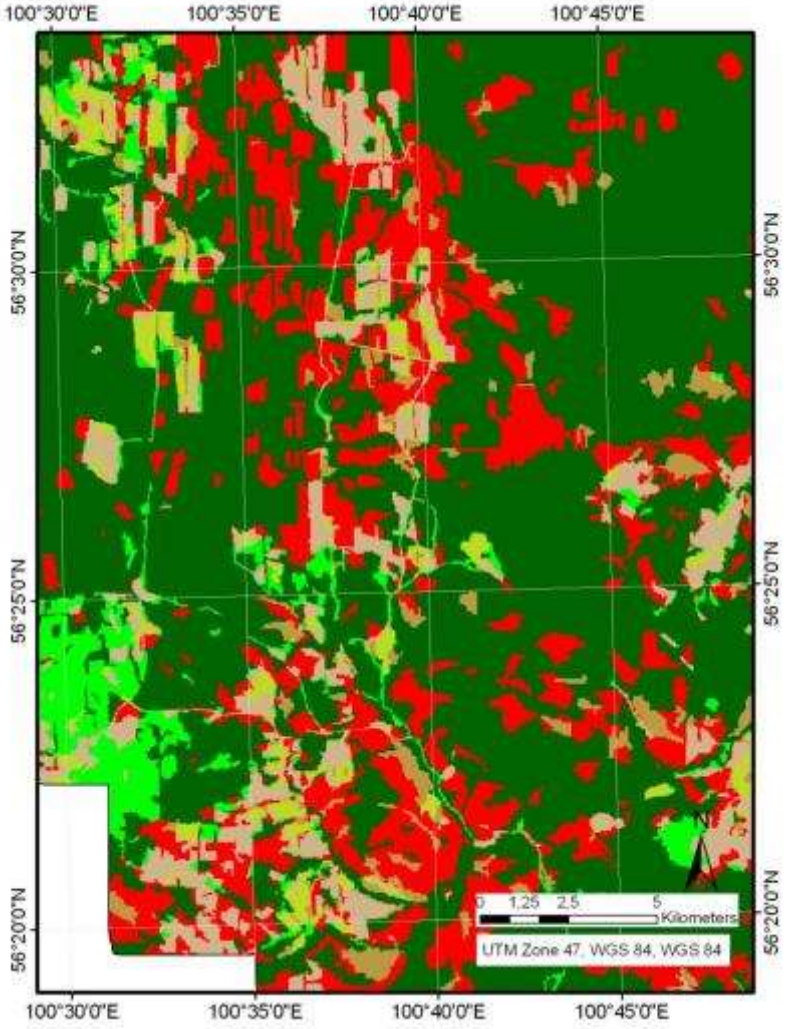
Linking SAR measures and Forest Parameters



SAR measures

Forest Parameters





Final Map Product of ESA-Project GSE Forest Monitoring

European Space Agency