Earth Observation Principles and Applications

Introduction to the 2016 ESA PECS SAR Course in Sofia, Bulgaria

Francesco Sarti, ESA

30 May 2016

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).

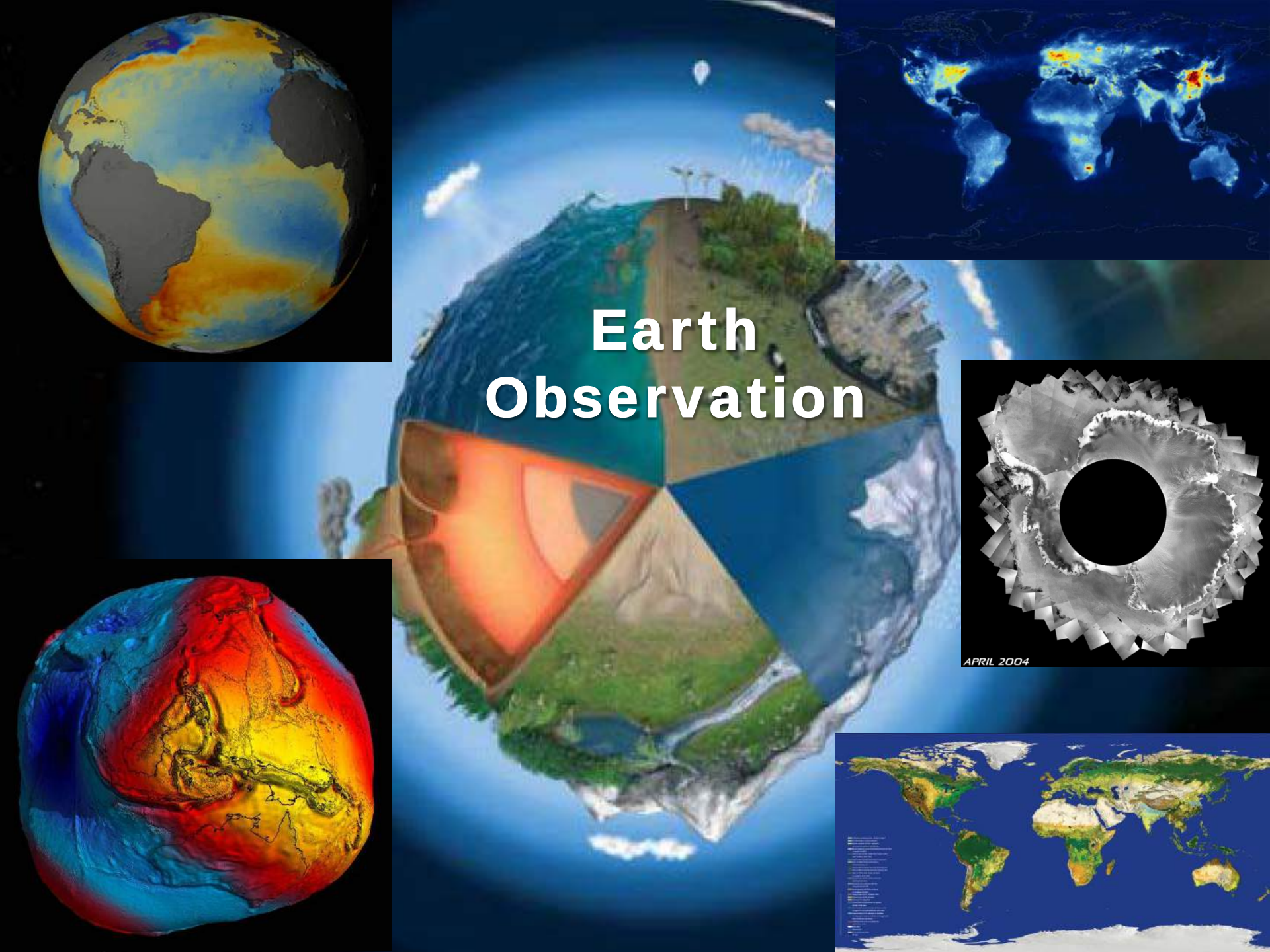
Canada takes part in some programmes under a Cooperation Agreement.

ACTIVITIES

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

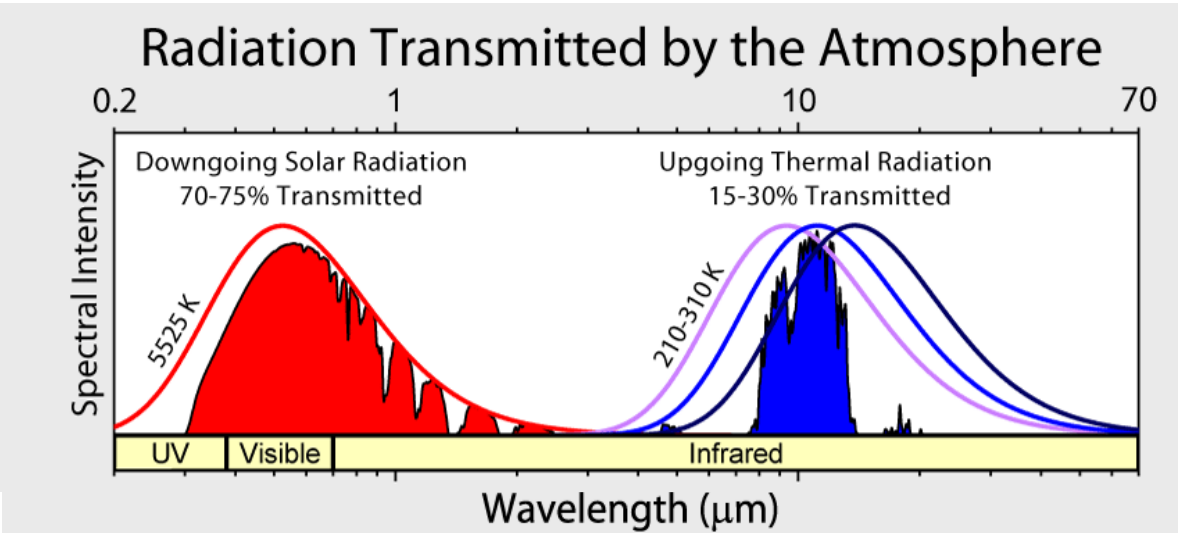
1. Space science
2. Human spaceflight
3. Exploration
4. Earth observation
5. Launchers

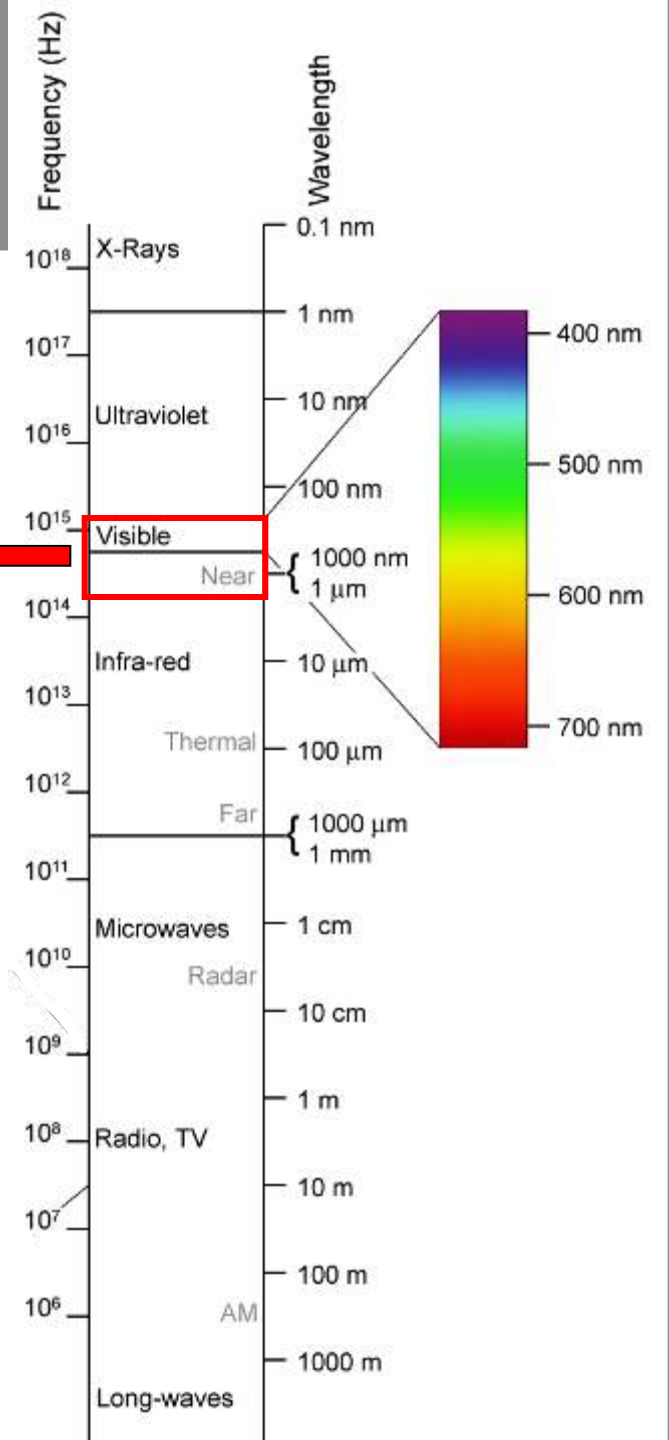
- Navigation
- Telecommunications
- Technology
- Operations


Earth
Observation
APRIL 2004

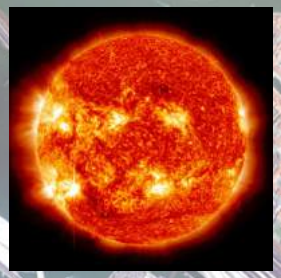
The electromagnetic spectrum

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





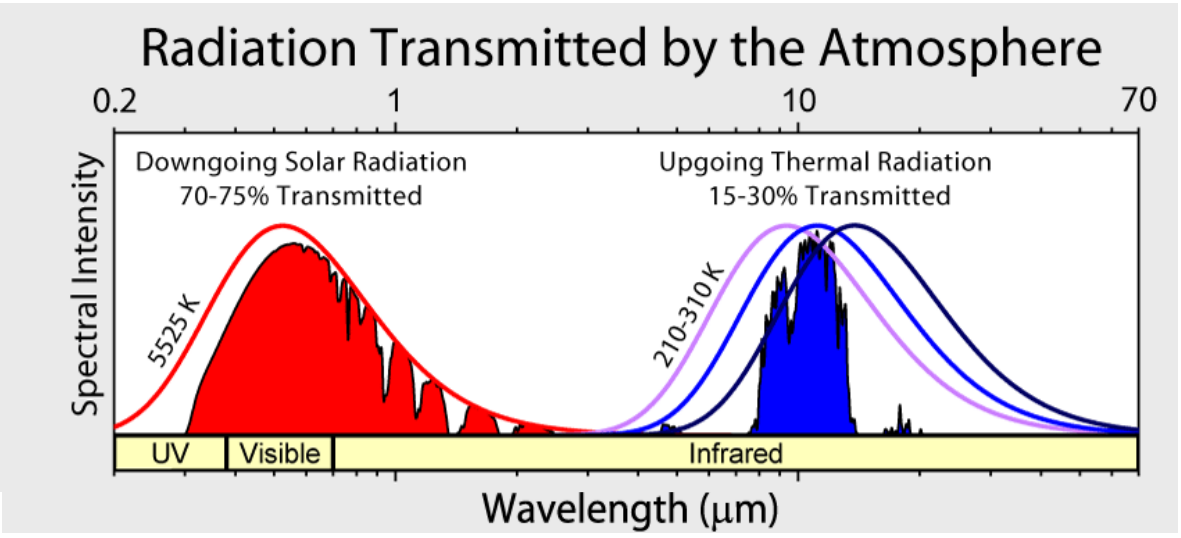
Passive Sensors



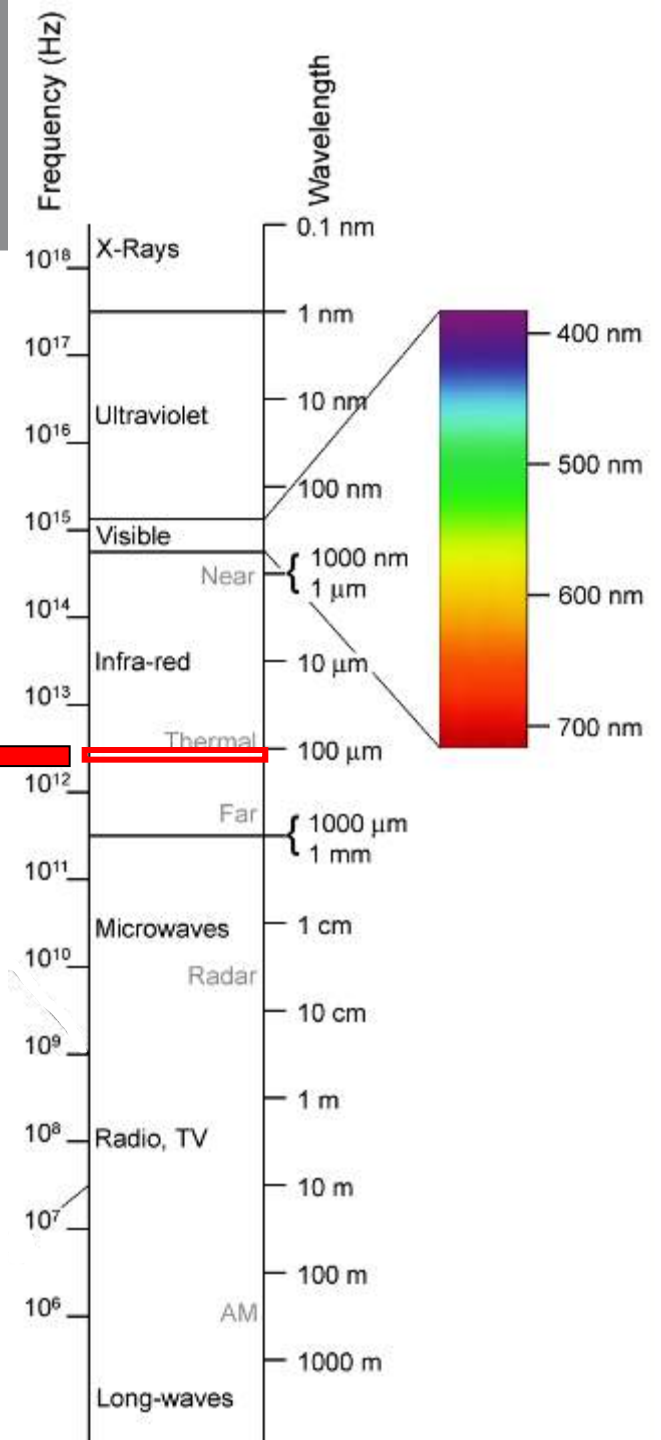
Primary source of energy: *Sun*

ESA UNCLASSIFIED – Releasable to the Public

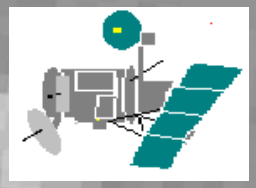
The electromagnetic spectrum



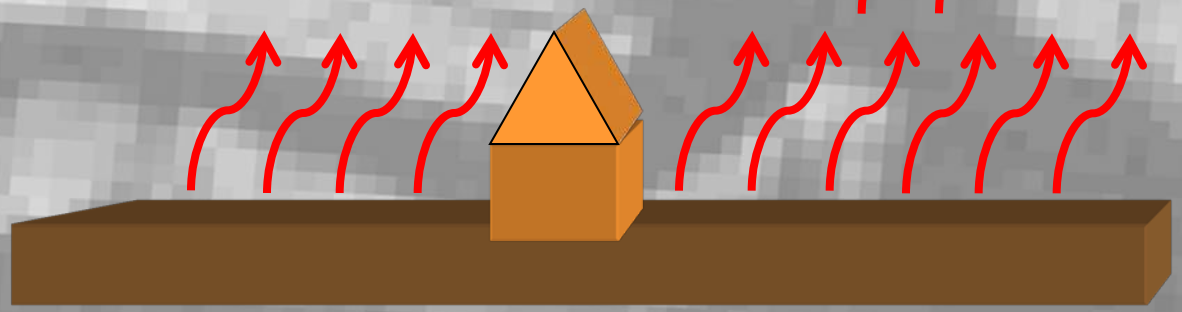
Thermal Infrared (TIR)



Passive Sensors



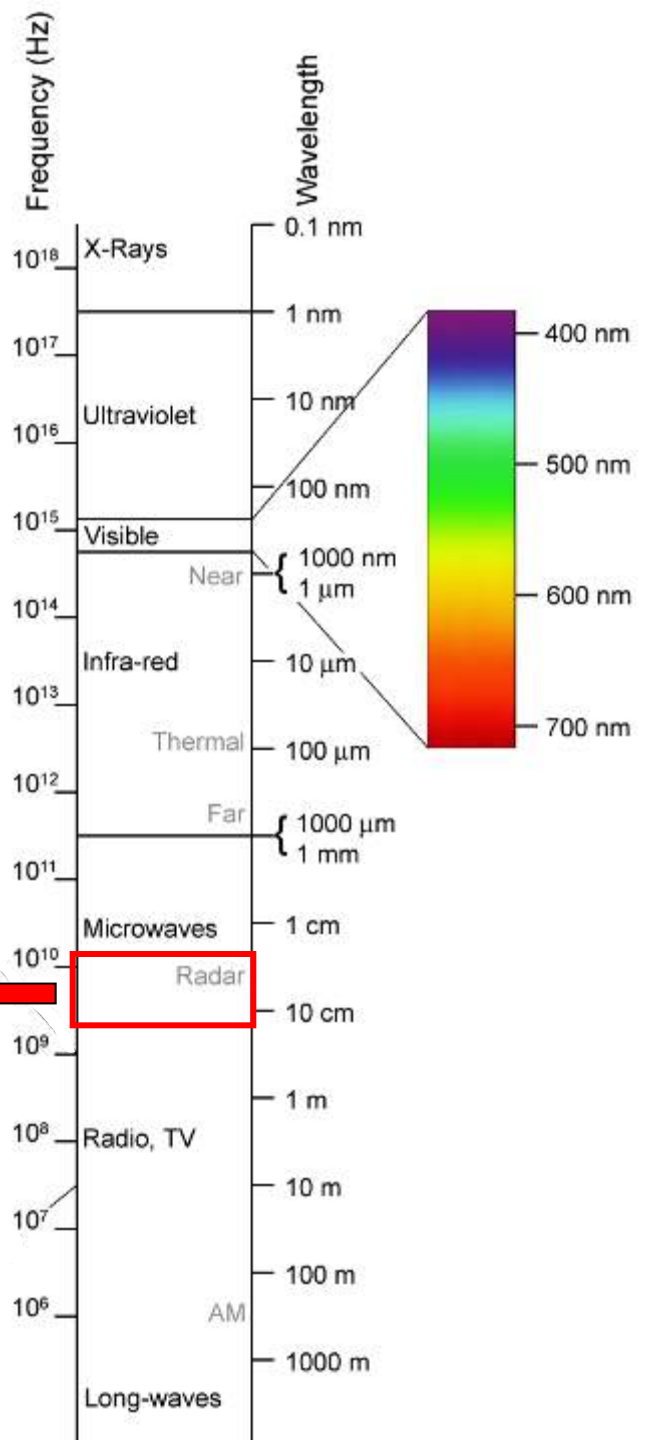
Primary source of energy: *Earth*



ESA UNCLASSIFIED – Releasable to the Public

The electromagnetic spectrum

Synthetic Aperture Radar (SAR)



Active Sensors

esa

Source of energy:
Satellite

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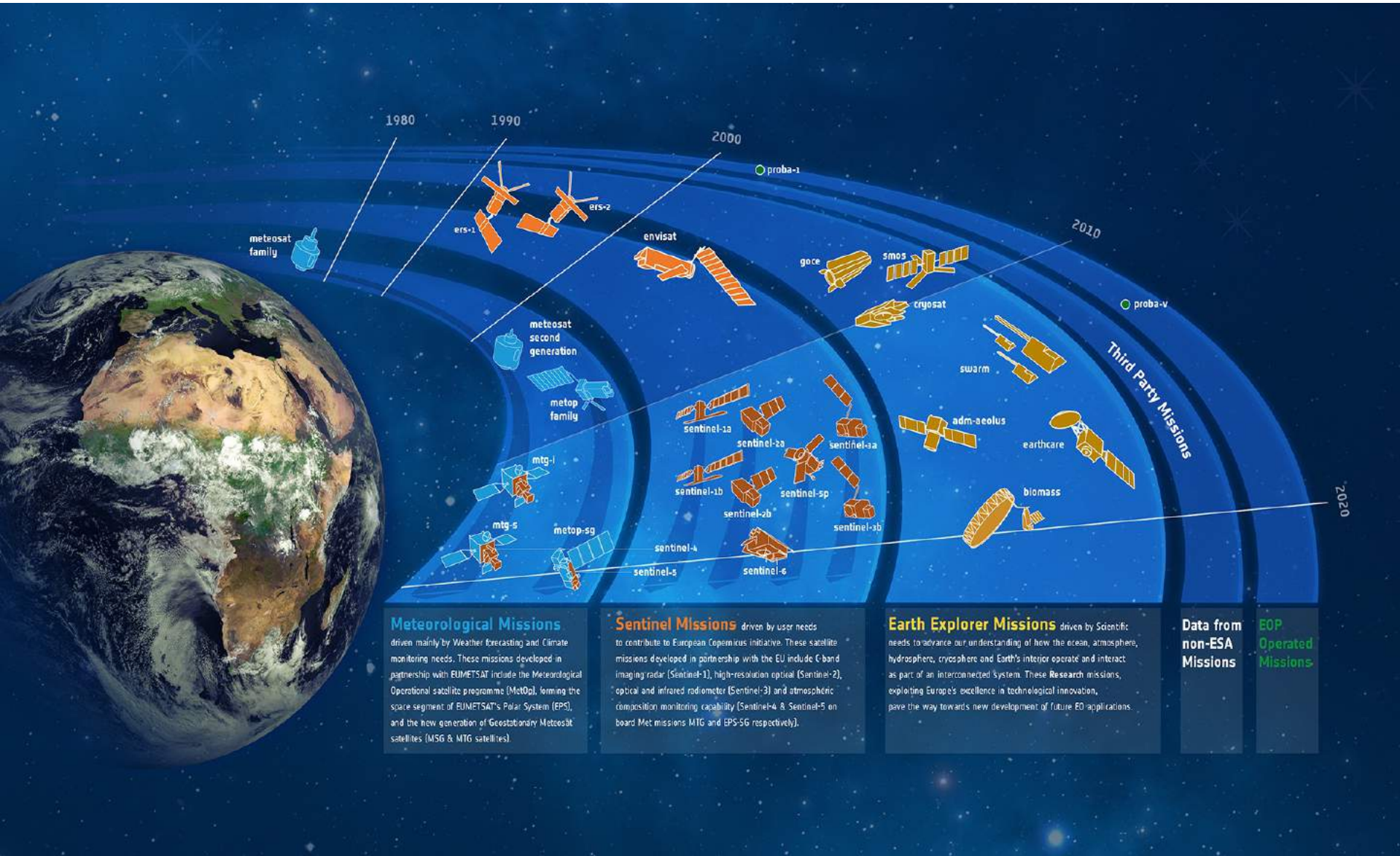
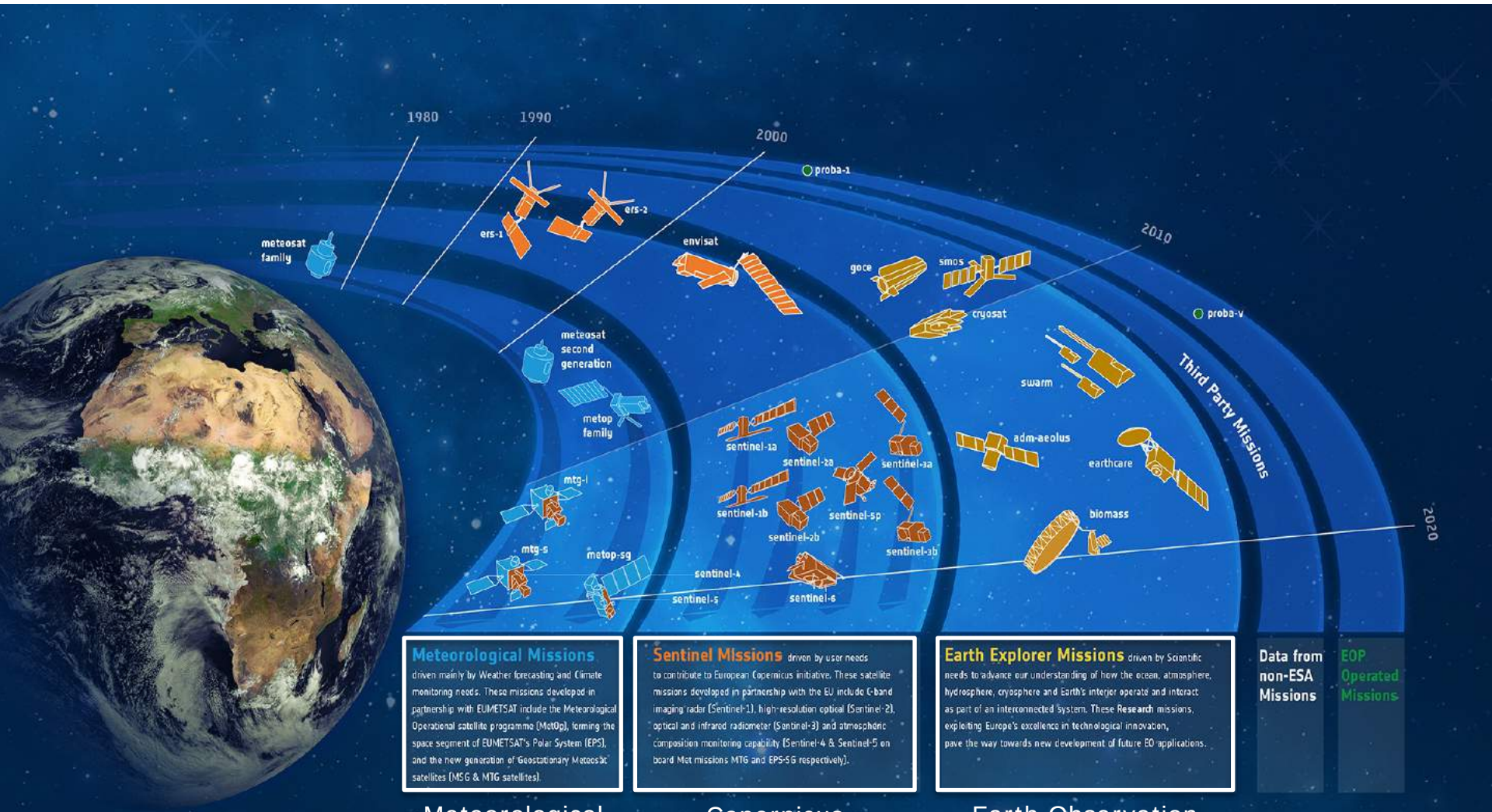
ESA Earth Observation Programmes



ESA Earth Observation Programmes

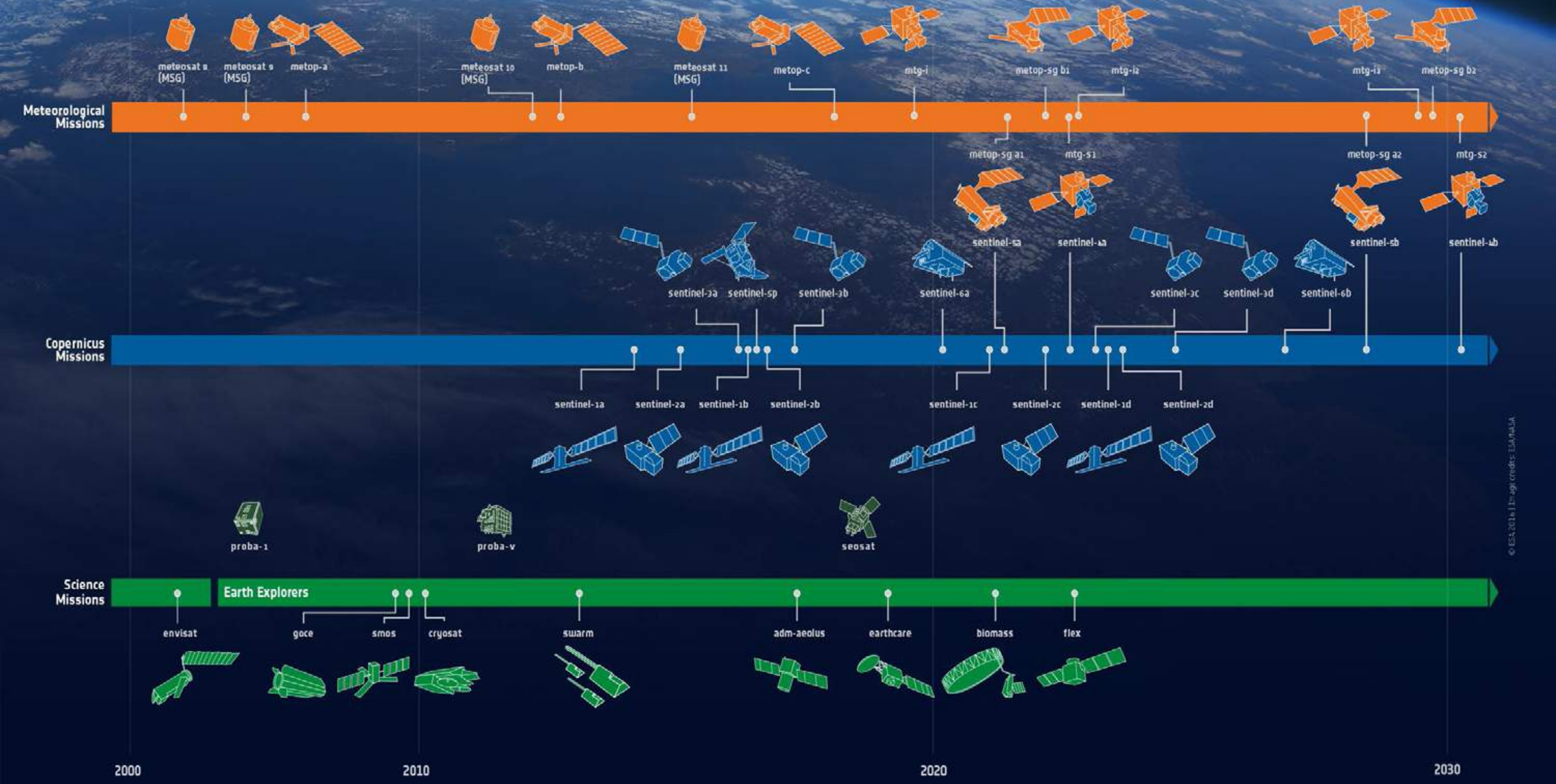


Meteorological Programme

Copernicus Programme

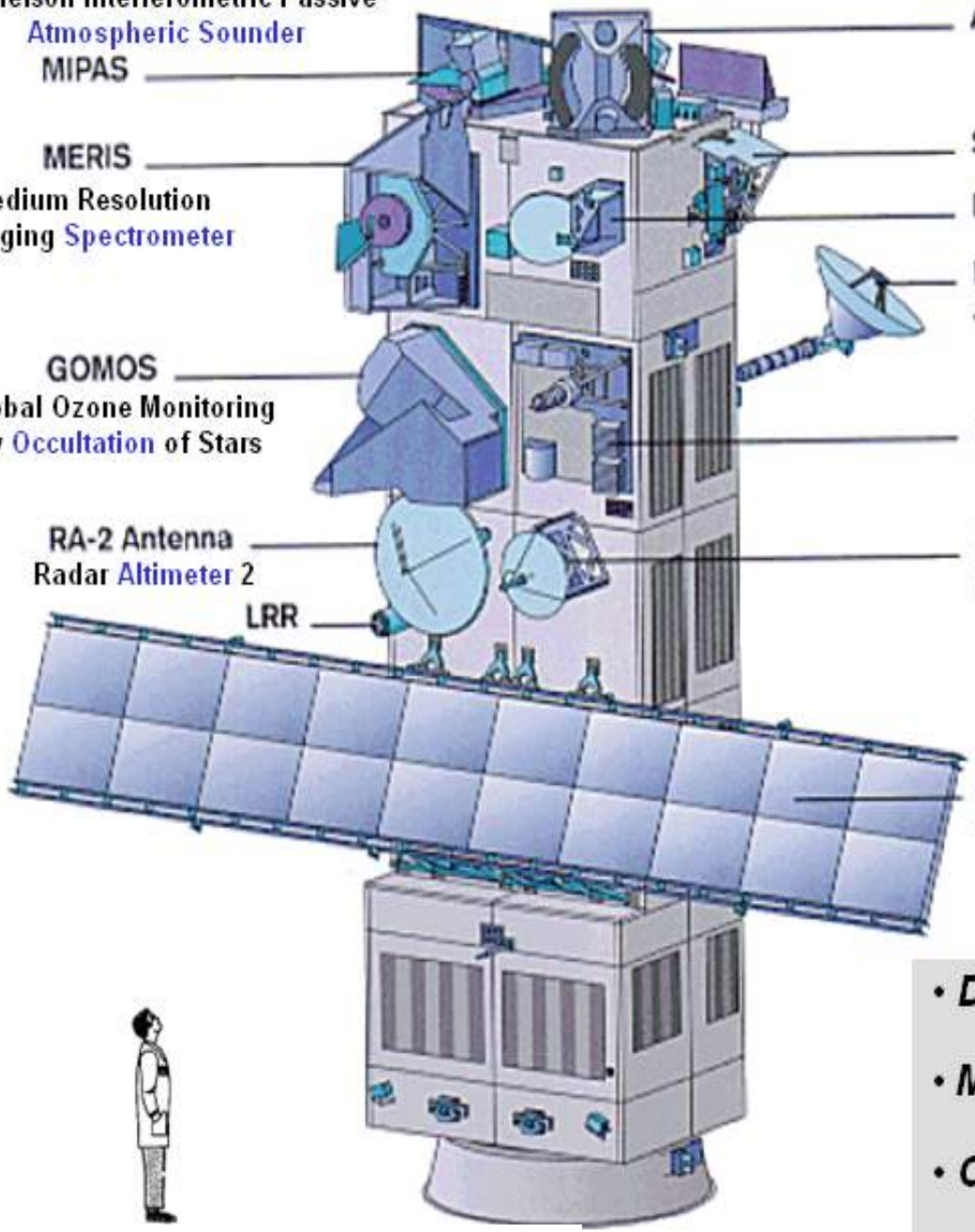
Earth Observation Envelope Programme

→ ESA DEVELOPED EARTH OBSERVATION MISSIONS



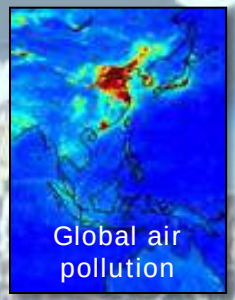
The Heritage: ERS and Envisat data

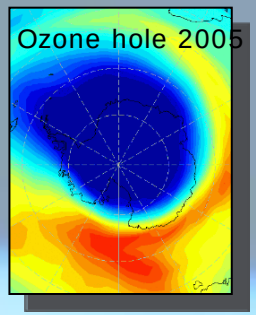
- ERS and Envisat missions 1991-2012
- More than 2 Petabytes of data
- Two decades of global change records
- Need for preservation, availability and exploitation

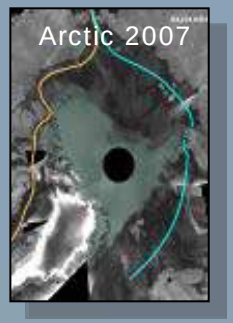


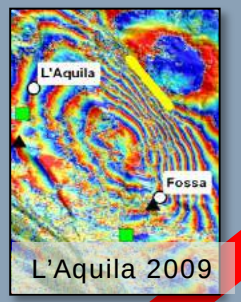
- ***Dimensions*** *(in orbit)*
  26m x 10m x 5m
- ***Mass***
  8140 Kg
- ***Orbit***
  800 km as ERS, sun synchronous
  10:00, i.e. 30 minutes before ERS-2

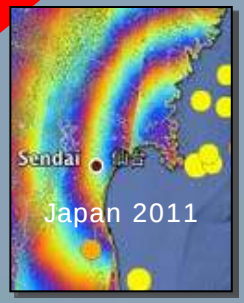
ENVISAT mission: 10 years

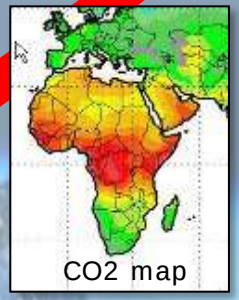


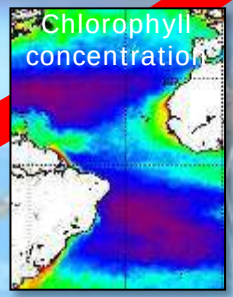


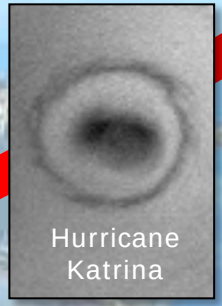


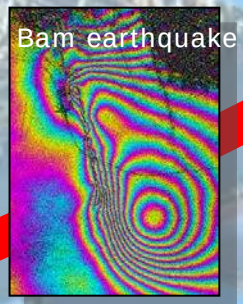












Serving
4000 scientific projects and many operational users.
Many applications for disaster monitoring

Envisat Symposium
Salzburg (A)

Envisat Symposium
Montreux (CH)

Living Planet Symposium
Bergen (N)

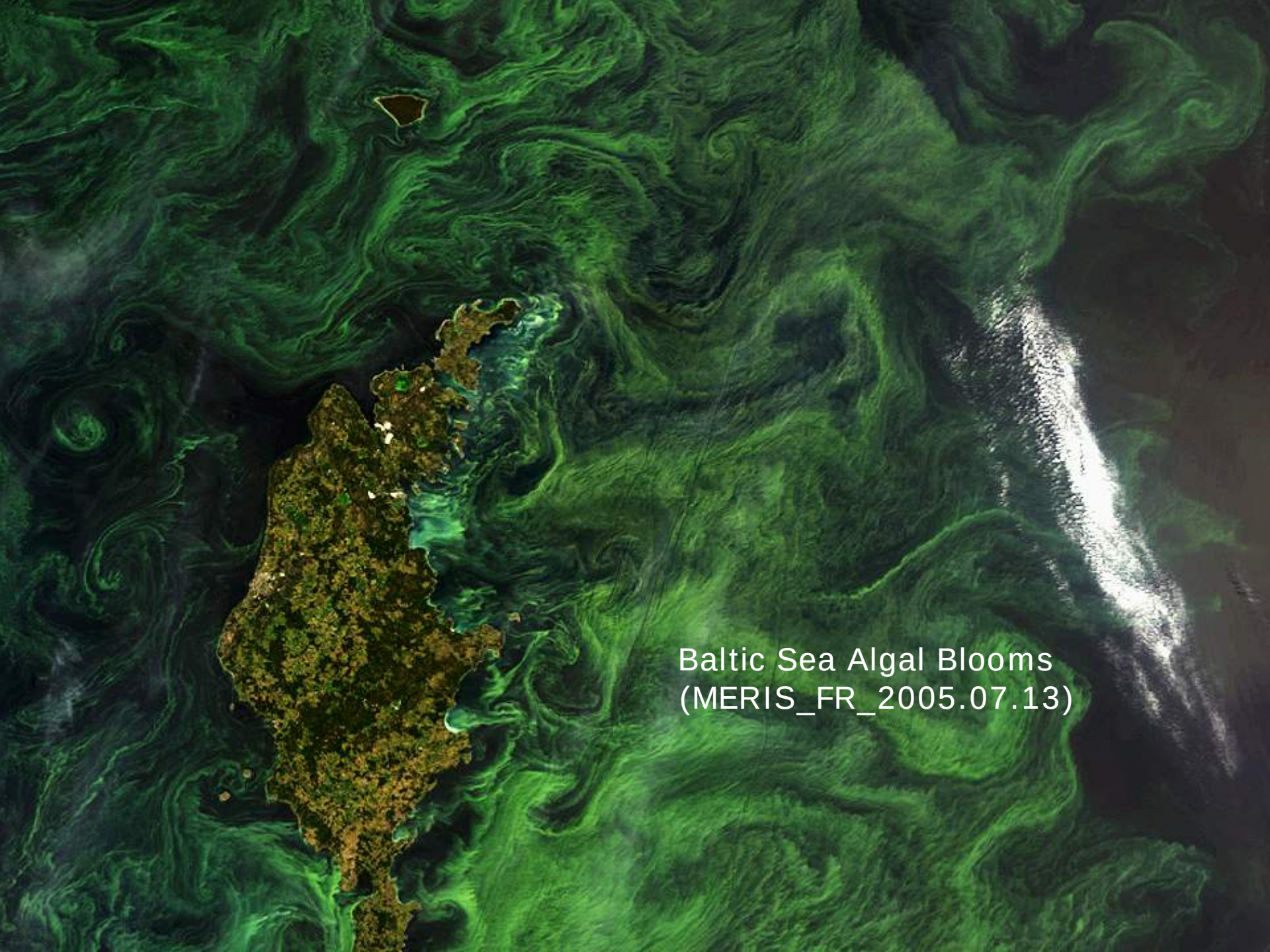
Mar 02 — **Sep 04** — **Apr 07** — **Jun 10** — **Mar 12**

and many workshops dedicated to specific Envisat user communities

ENVISAT
An example of application: Risk Management

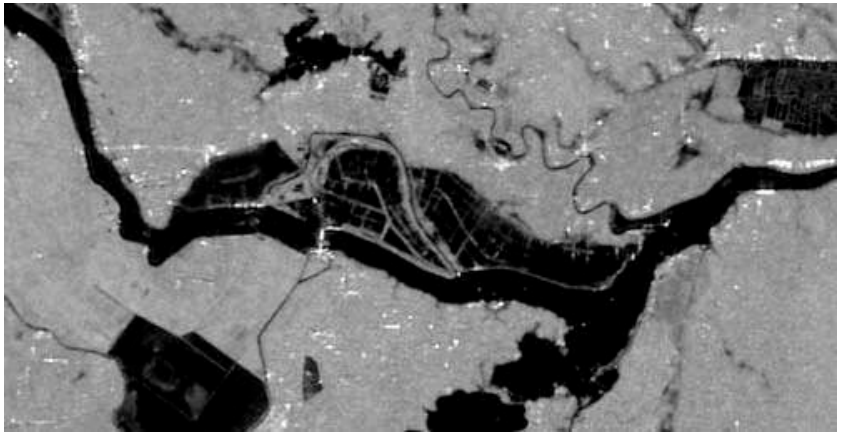
1) Use of optical data for Risk Management


Moscow Fires (Meris FR 2011)

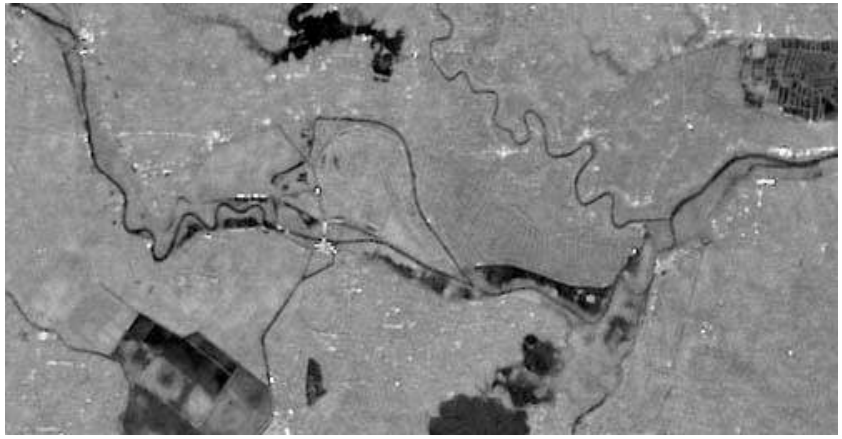

Baltic Sea Algal Blooms
(MERIS_FR_2005.07.13)

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.

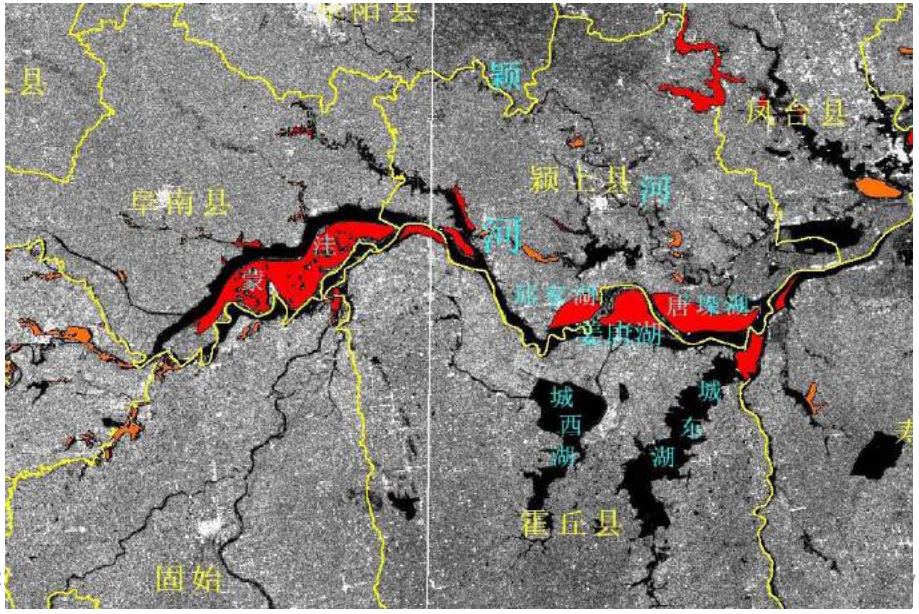


ASAR WSM 150m spatial resolution acquired 12th August 2006, descending pass, polarisation HH.

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

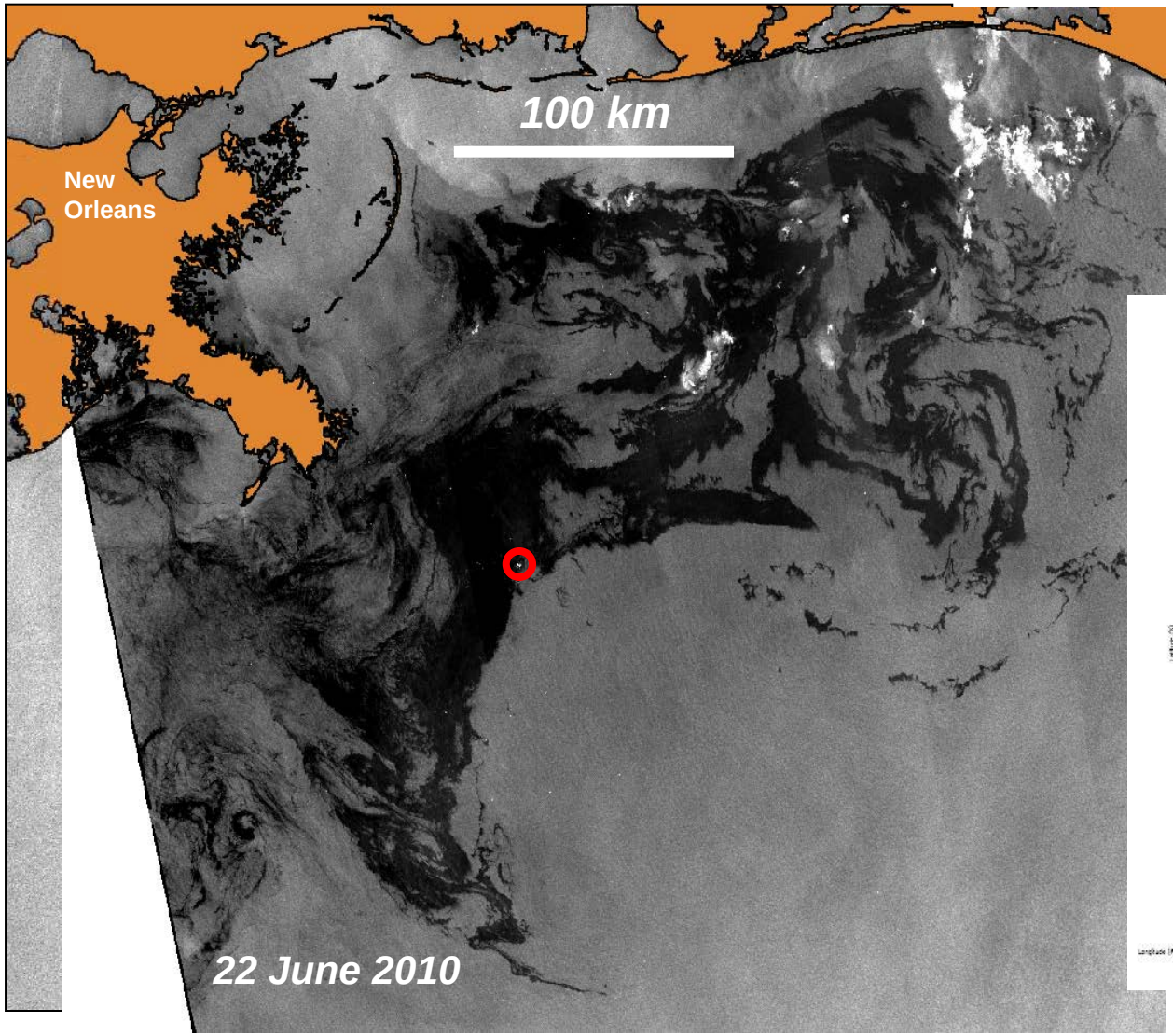
FLOODING IN CHINA JULY 2007

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.

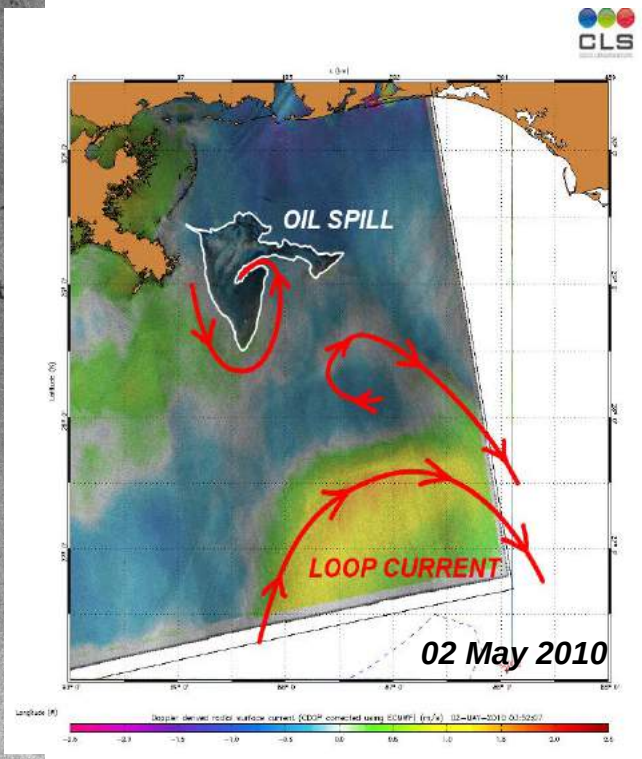


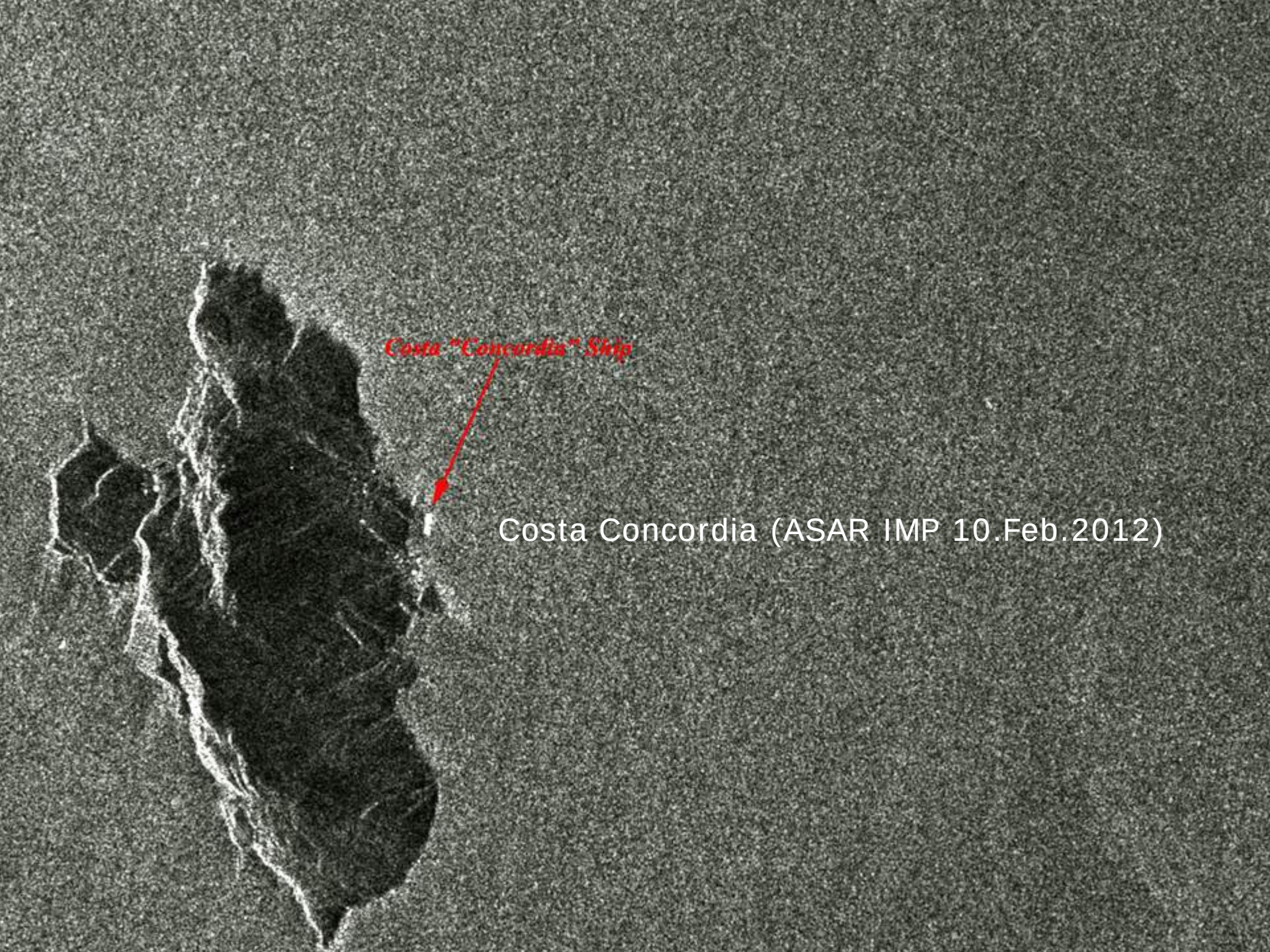
Courtesy of IWHR, Beijing

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)

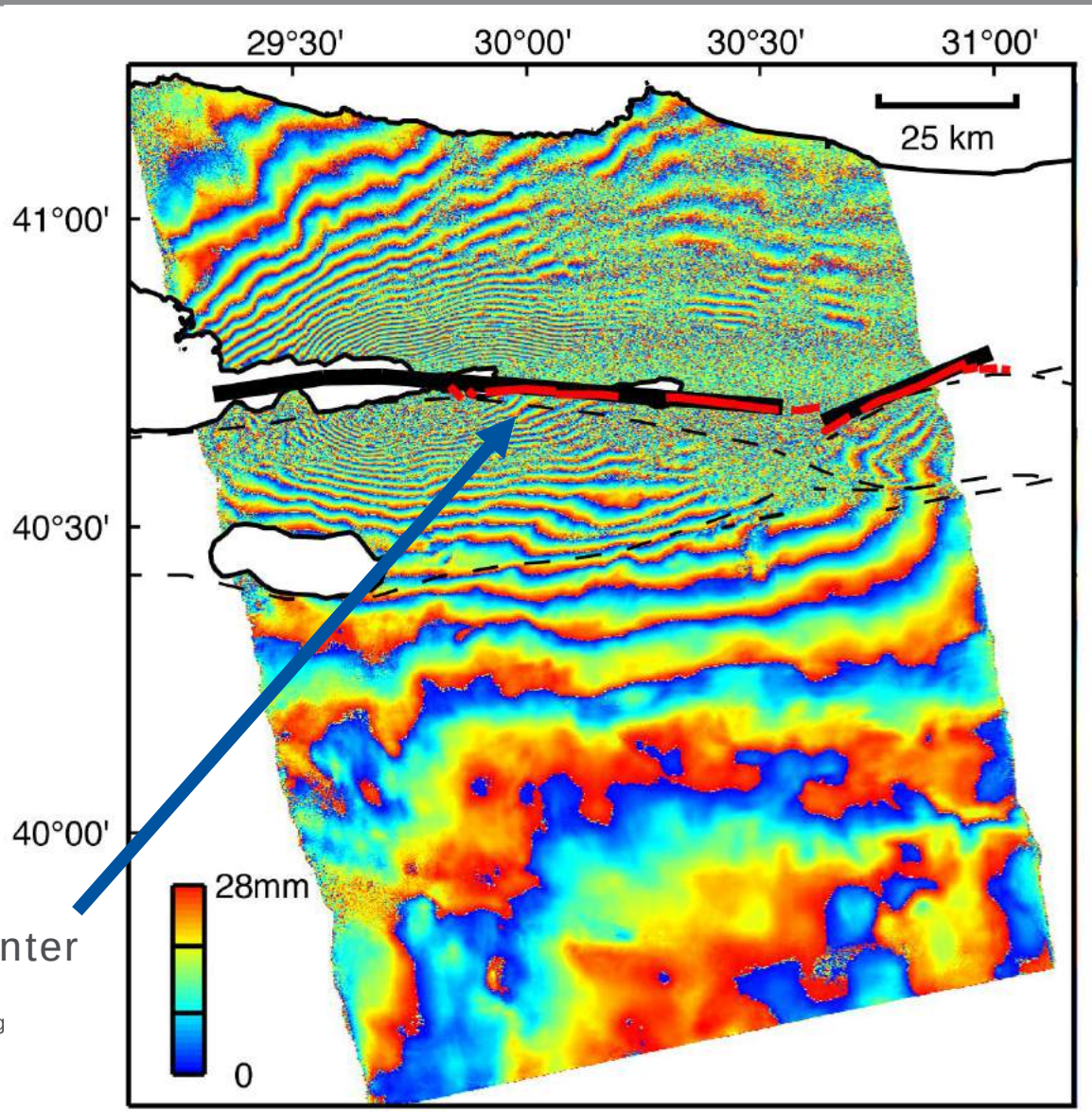
Iceberg B-15A Antarctic (ASAR_WSM from 4th to 20th Apr 05)

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

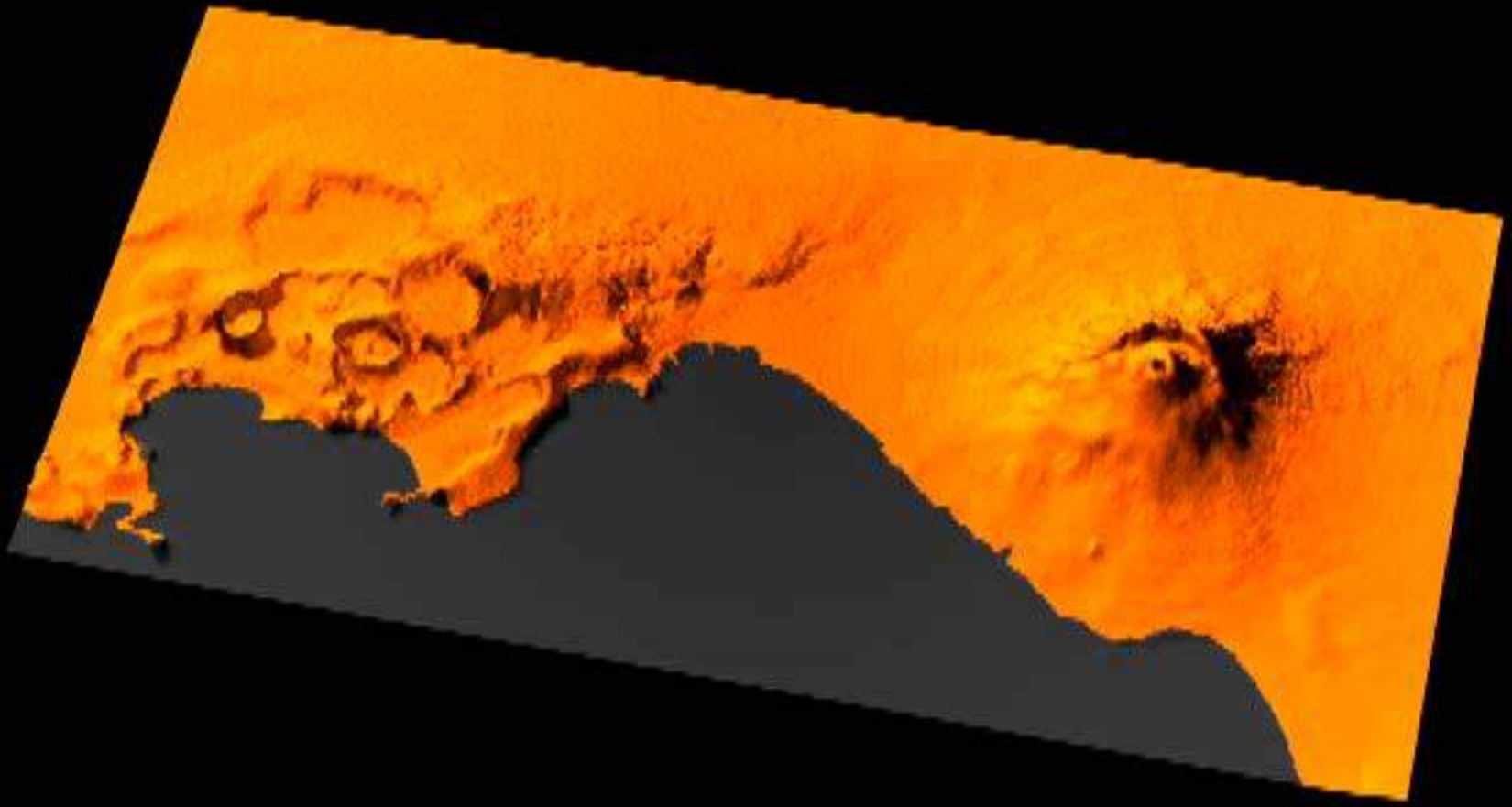
Earthquake in Izmit, Turkey (1999)

Post-seismic deformation measured by Interferometric SAR

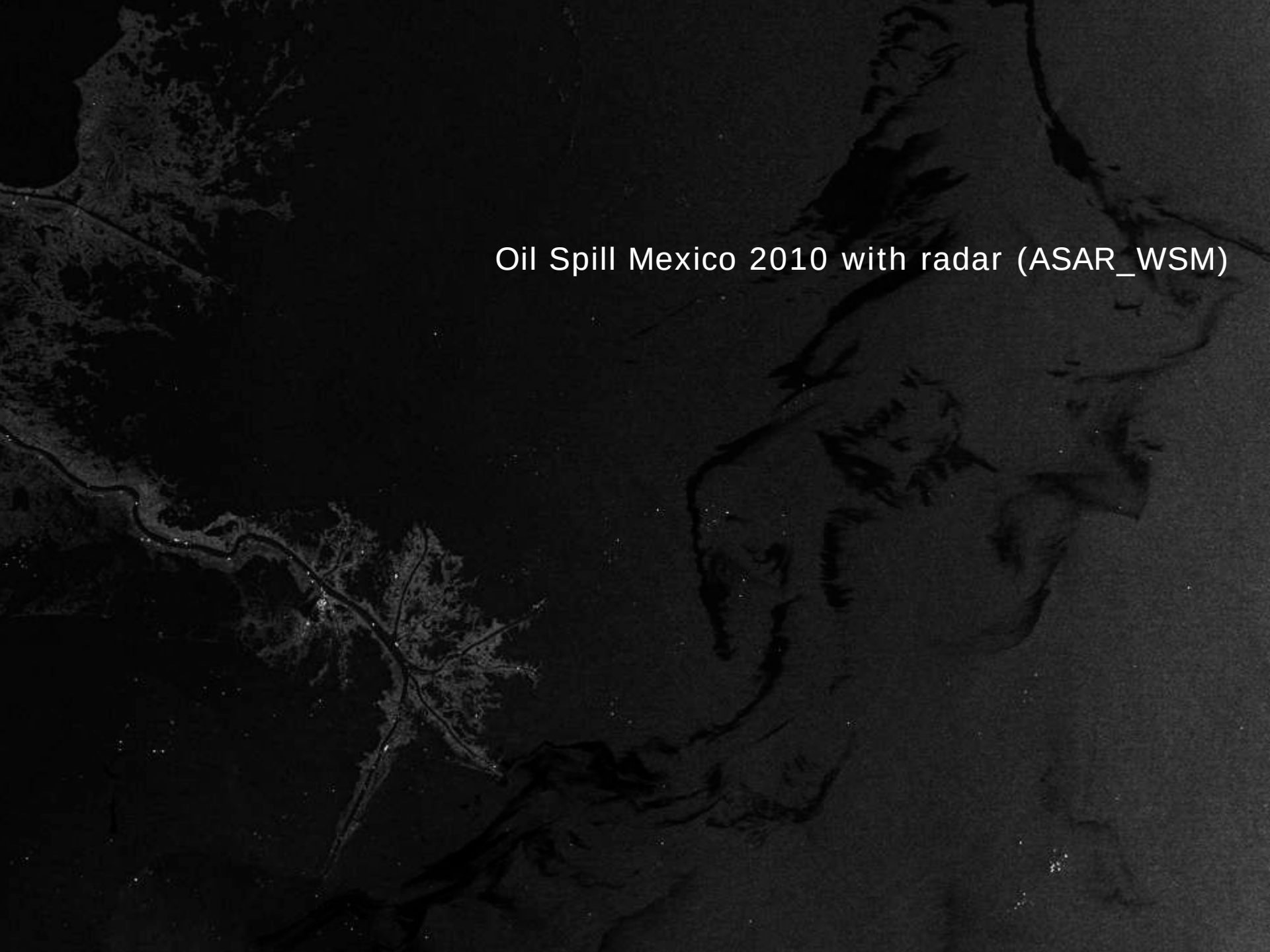
- Synthetic Aperture Radar (ERS-1, ERS-2)
- Generation of Interferogram (phase difference between two SAR images)
- One colour pattern (fringe) corresponds to 28 mm deformation along the line of sight
- This works through clouds or darkness (Radar Data)

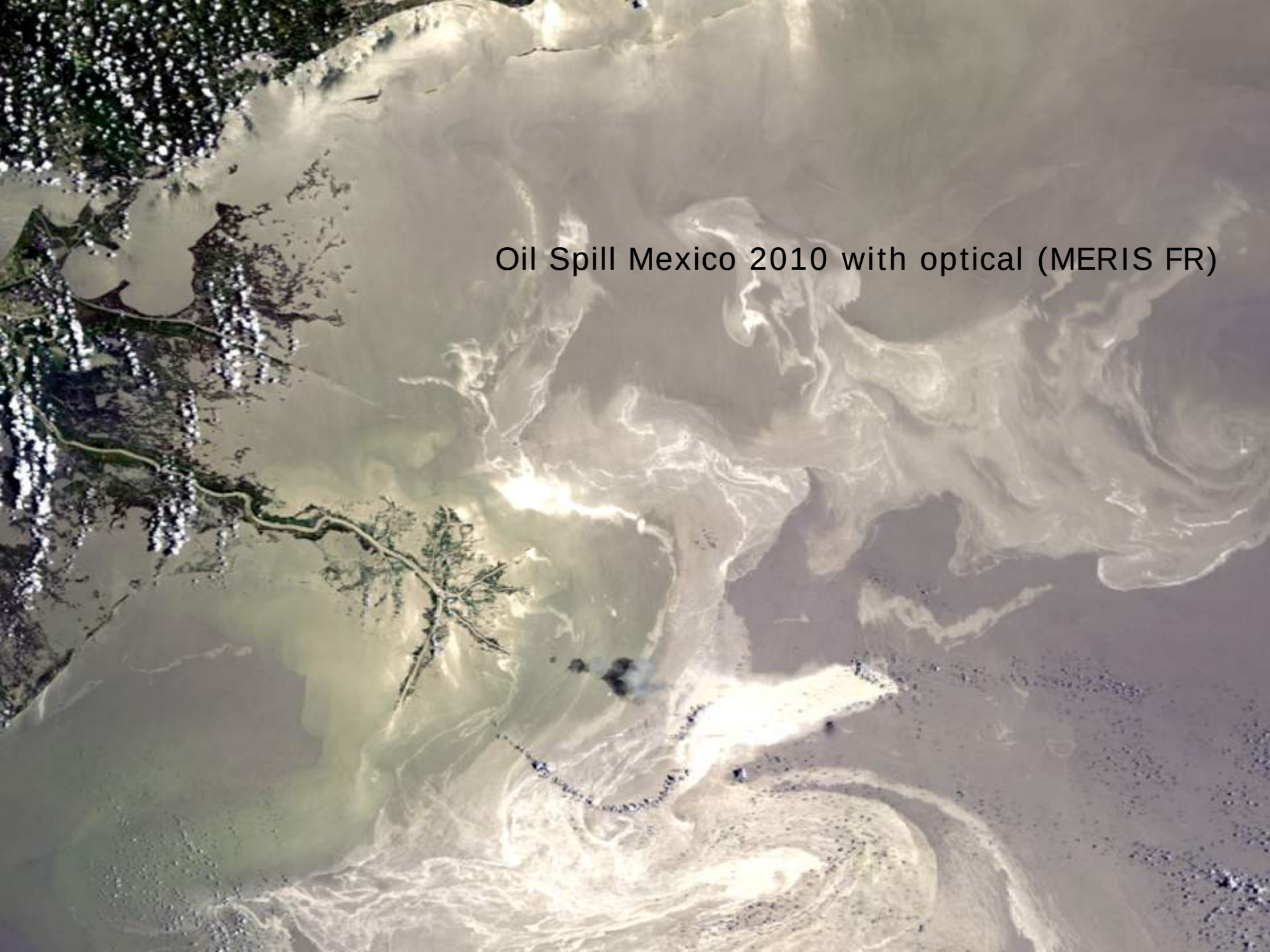


Campi Flegrei: observation by InSAR

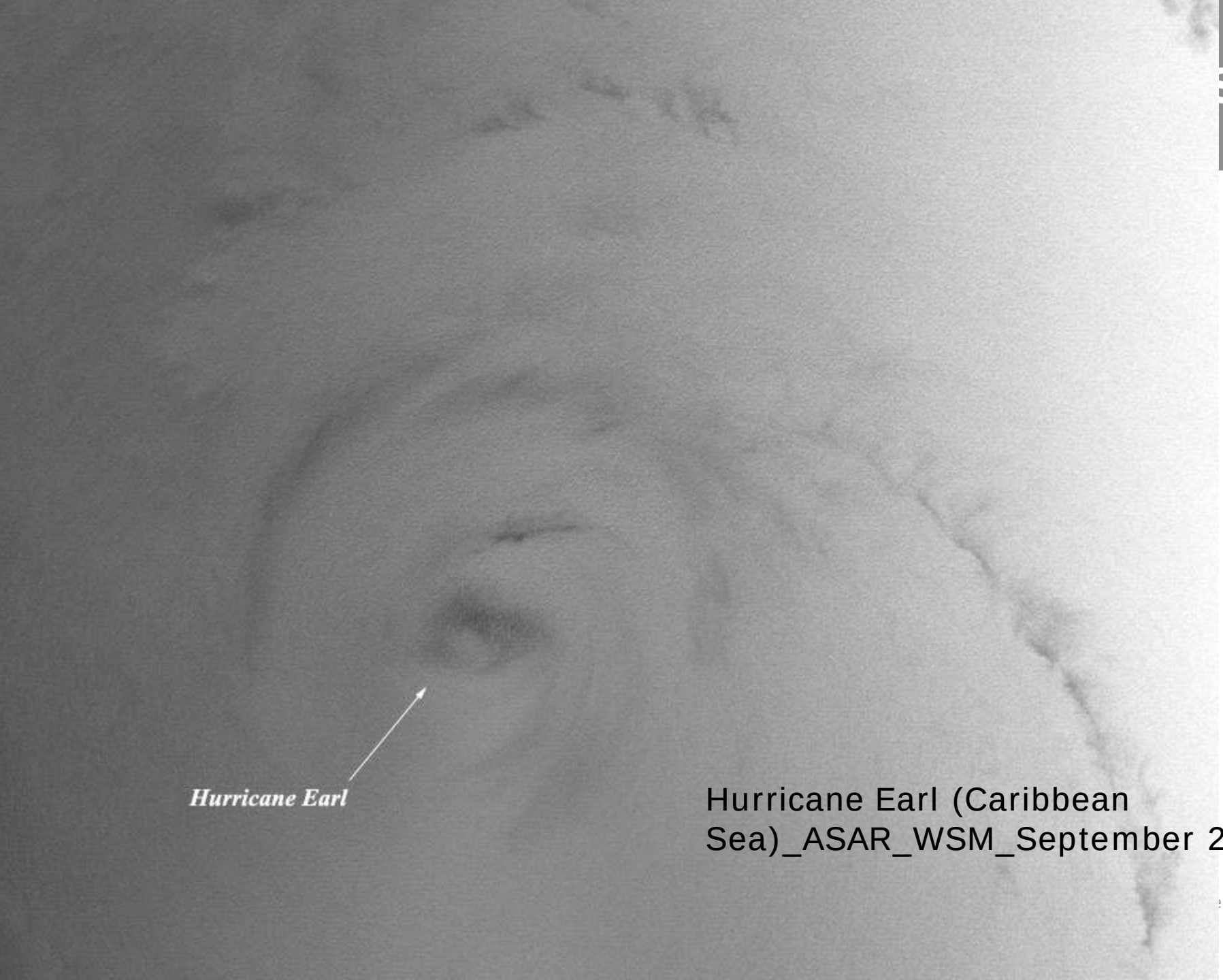


3) Use of radar backscatter, combined with optical data, for Risk Management


Oil Spill Mexico 2010 with radar (ASAR_WSM)

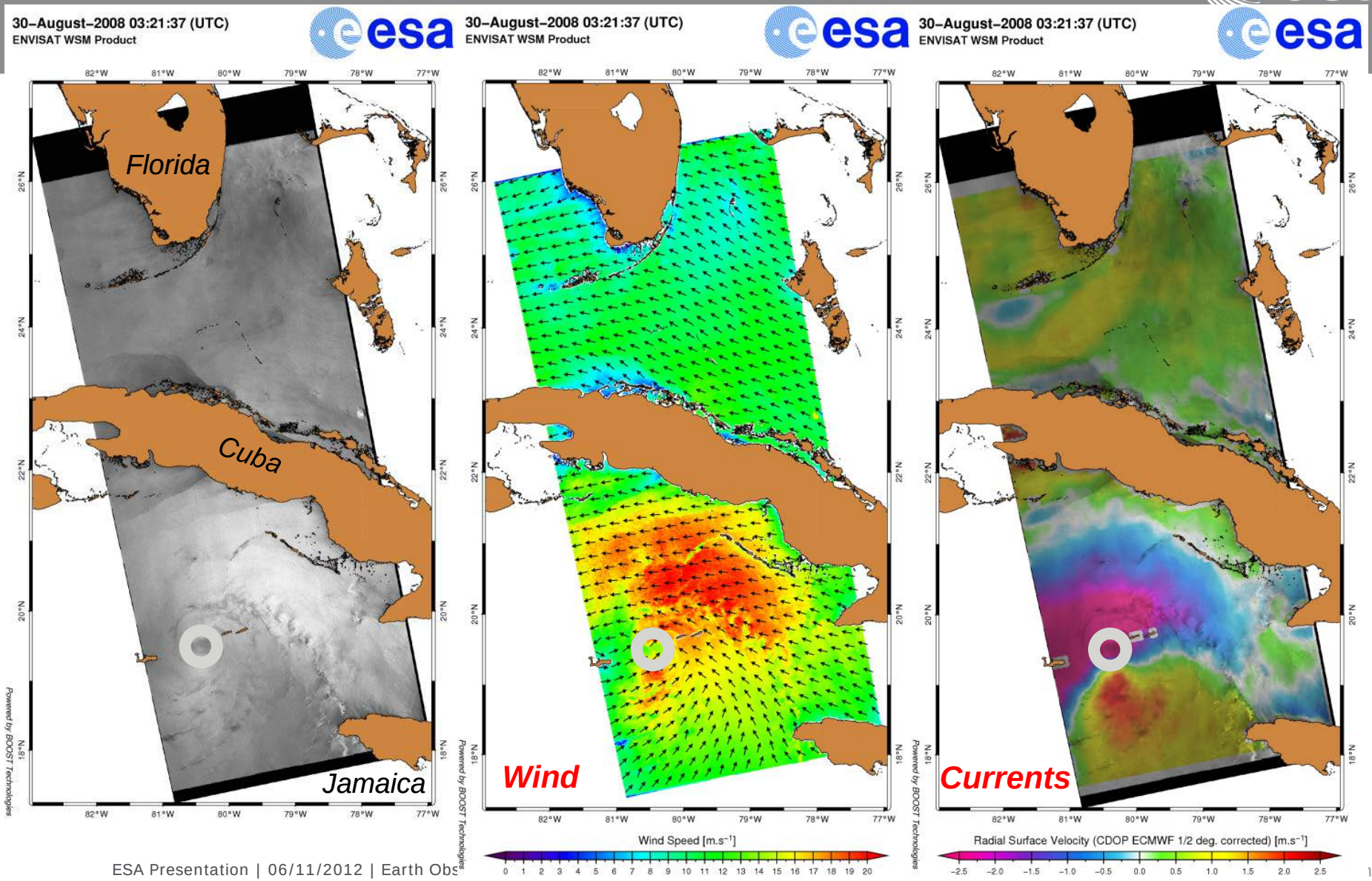

Oil Spill Mexico 2010 with optical (MERIS FR)

Hurricane Earl (Caribbean Sea)_Meris_FR_September 2010



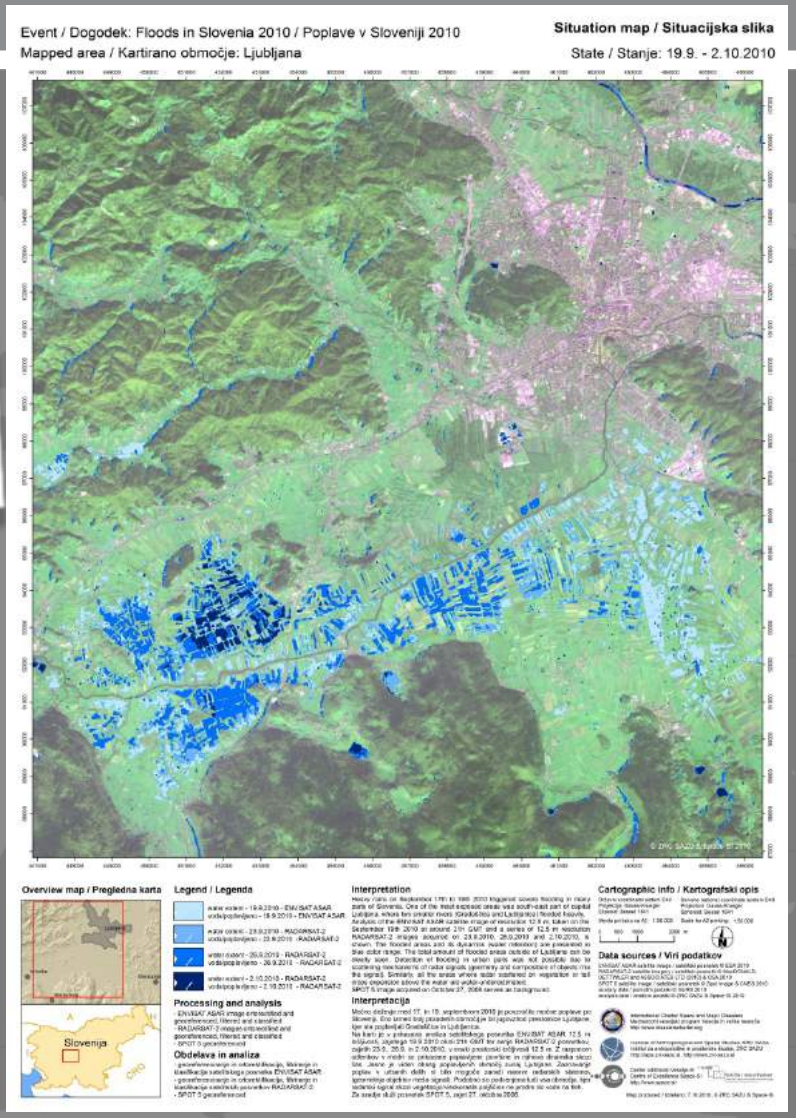
Hurricane Earl (Caribbean Sea)_ASAR_WSM_September 2010

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

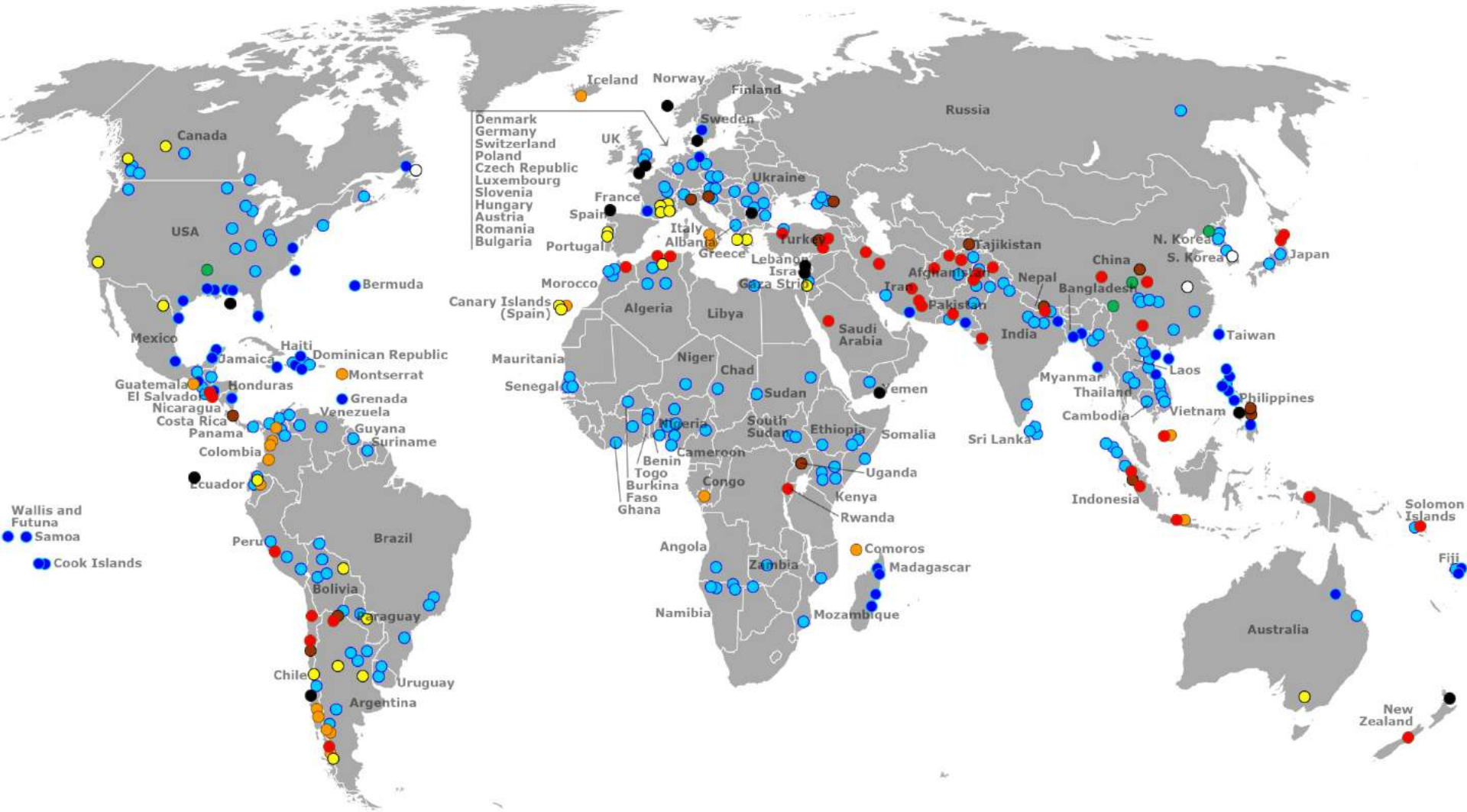
Man-made events

- Oil spills
- Industrial accidents





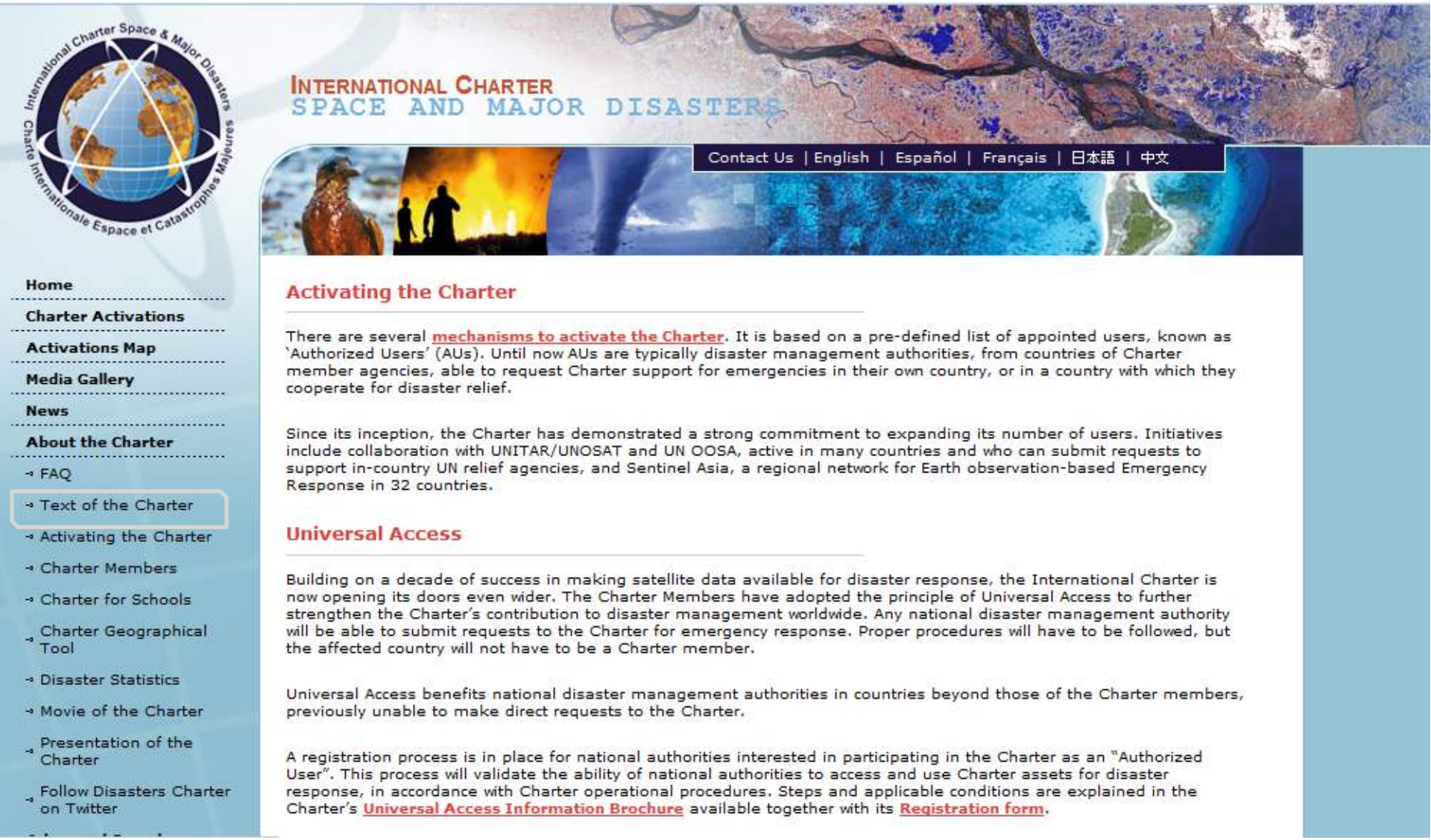
Activation Distribution



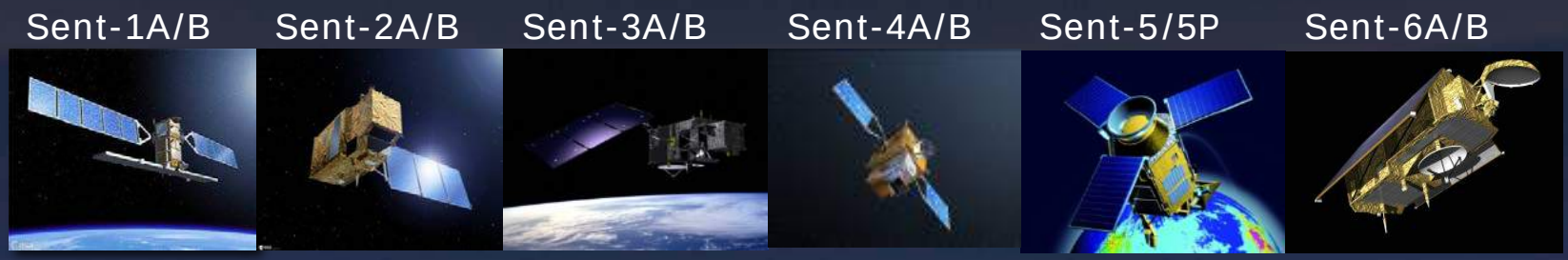
As of October 15, 2012

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

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

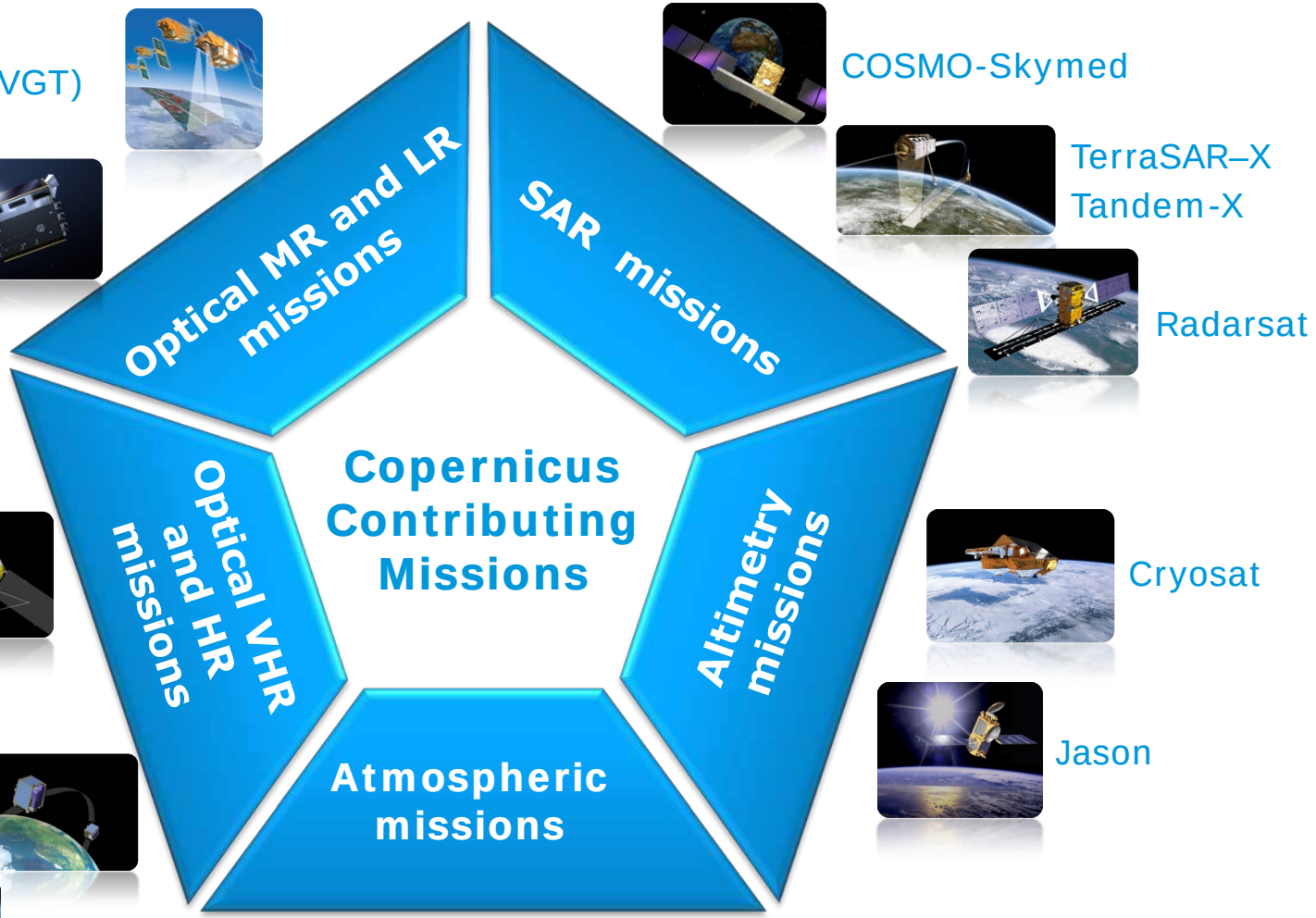
S4A/B: Geostationary Atmospheric Chemistry Mission 2019/2027

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

Copernicus Contributing Missions

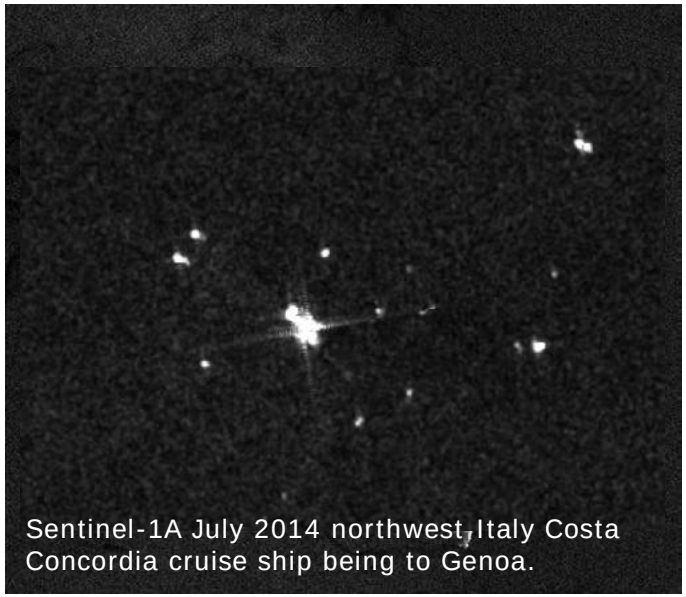


Sentinel-1 mission objectives

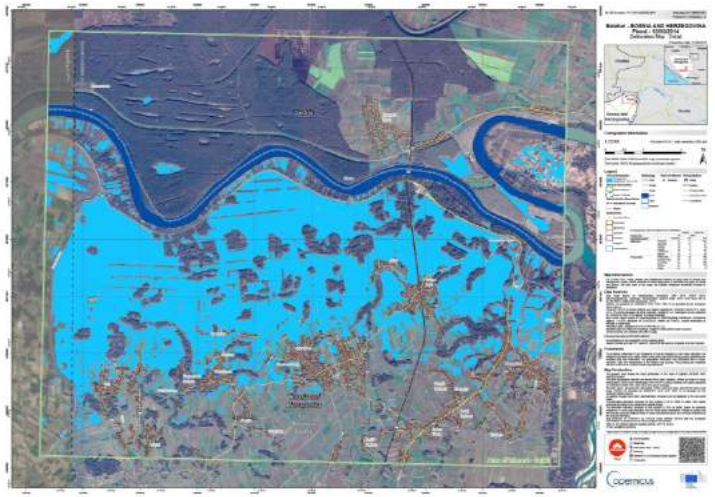
✓**Data continuity of ERS and ENVISAT missions**

✓ **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.



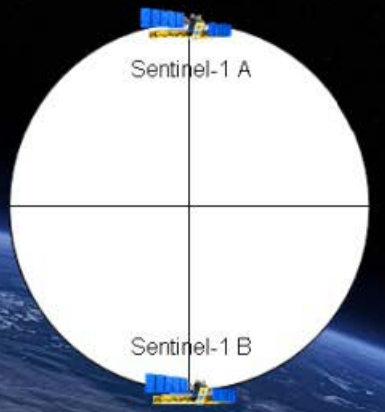
Sentinel-1A July 2014 northwest Italy Costa Concordia cruise ship being to Genoa.



Flood delineation map over Balatun Bosnia and Herzegovina

Sentinel-1
Mission Overview

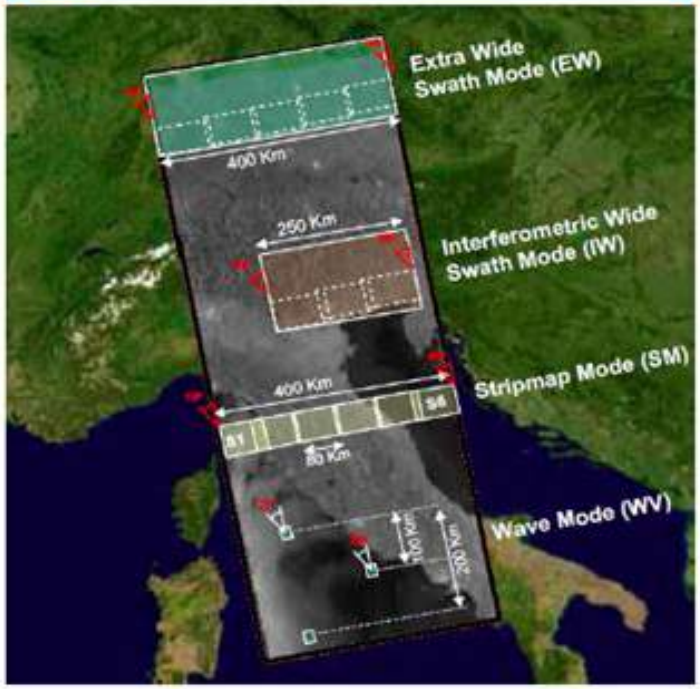
- Two satellites
- C-band Radar instrument
- Sun-synchronous orbit at 693 km altitude
- Inclination: 98.18°
- 7 years lifetime
- Consumables for 12 years
- Mean LST: 18:00h at ascending node
- 12-day repeat cycle at Equator (with 1 satellite)



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

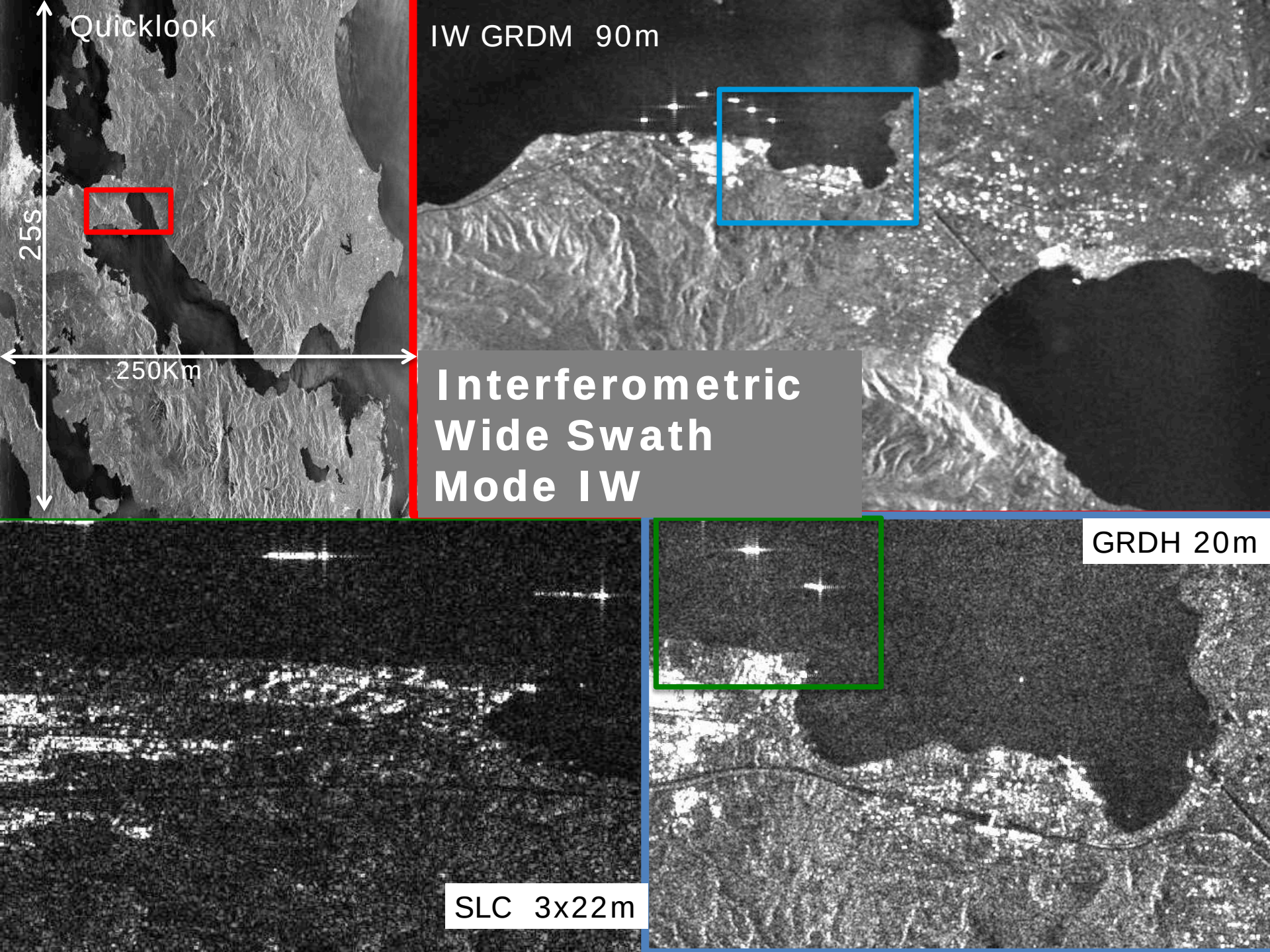
Sentinel-1
SAR Operational Modes

Operational Modes



Resolution	Swath Width	Polarisation
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**


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

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)

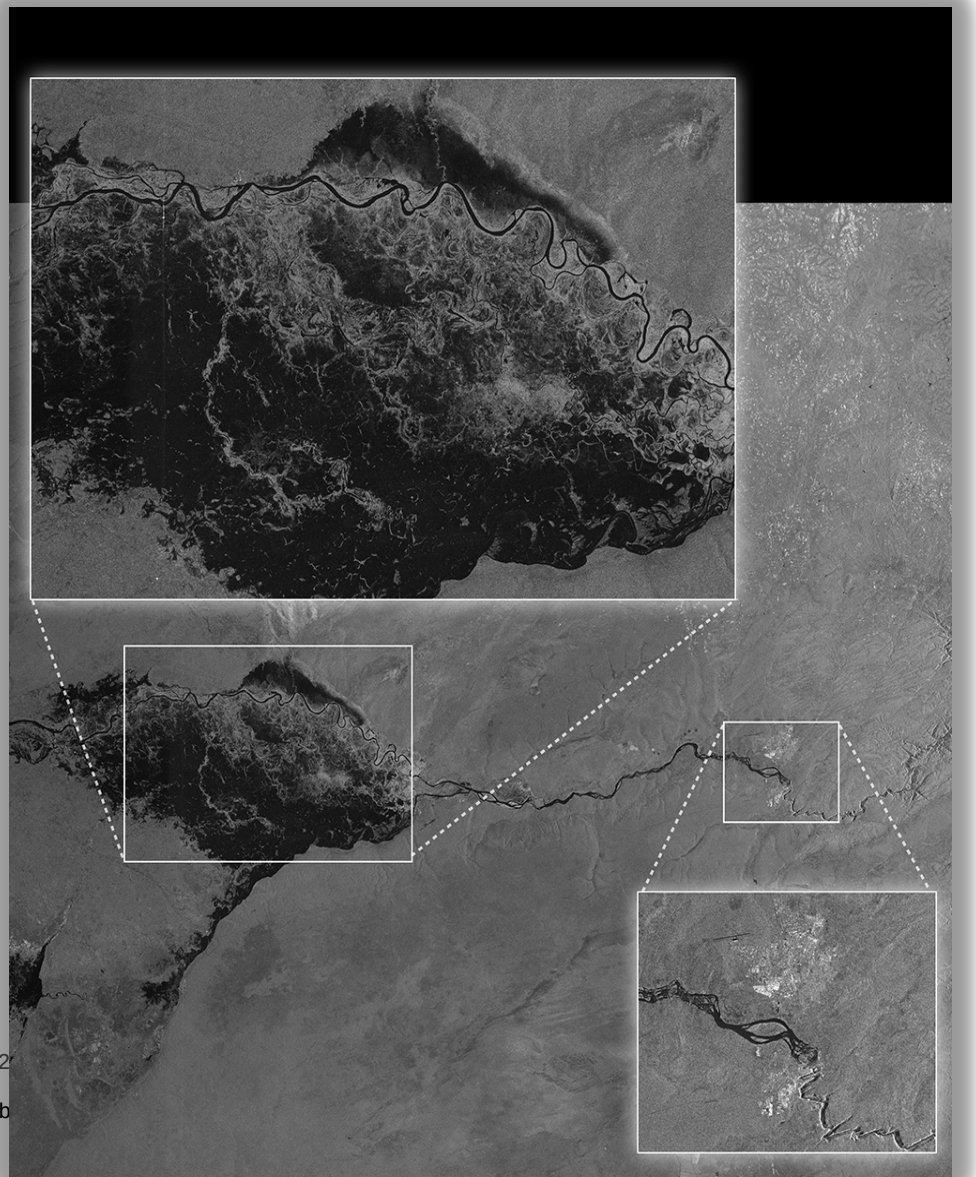
Envisat ASAR

- **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

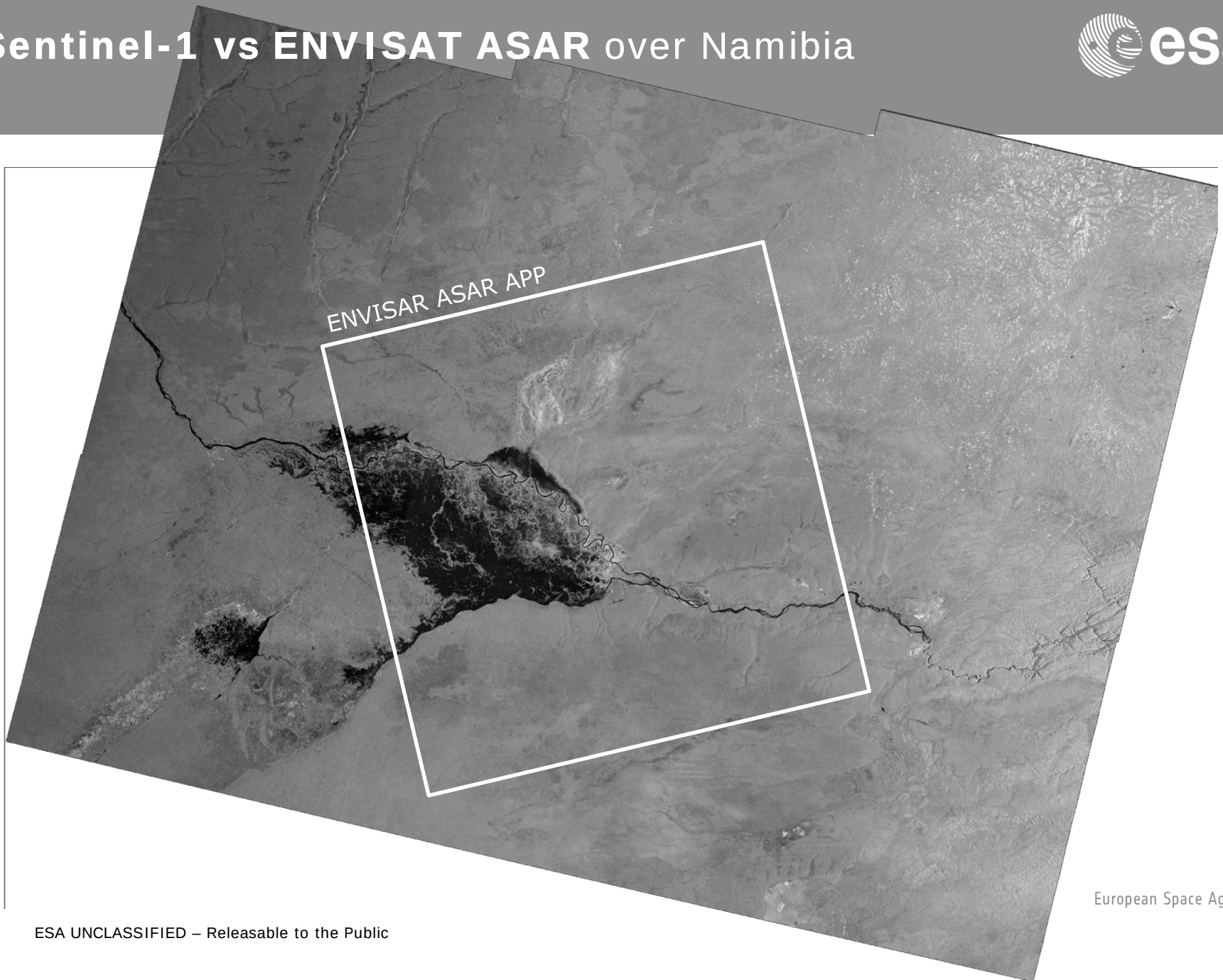
First Images of Sentinel-1A

Zambezi River Flooding and Victoria Falls, Namibia

13 April 2014

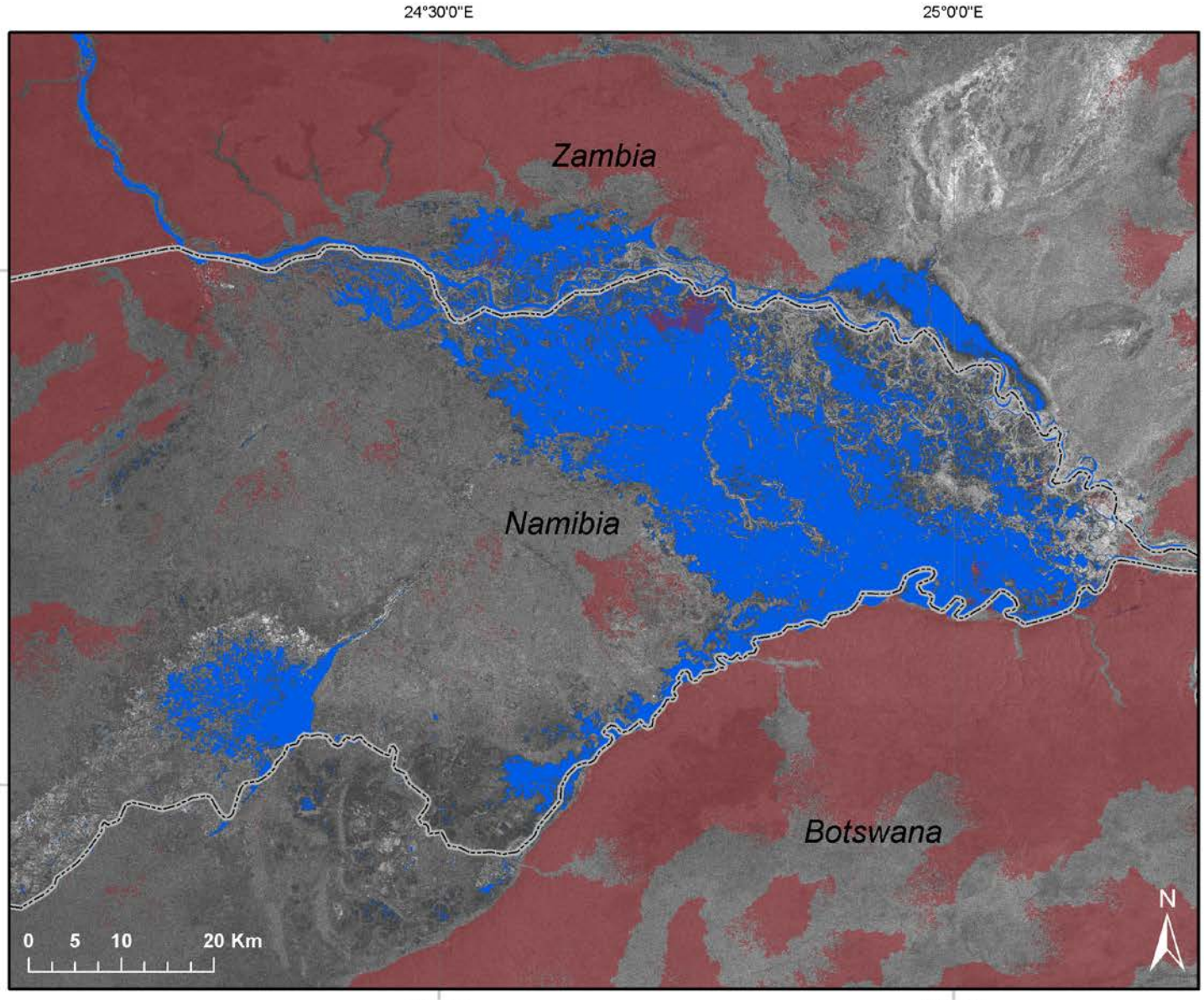


Sentinel-1 vs ENVISAT ASAR over Namibia



European Space Agency

Sentinel-1 Flood Monitoring of Caprivi Flood Plain, Namibia



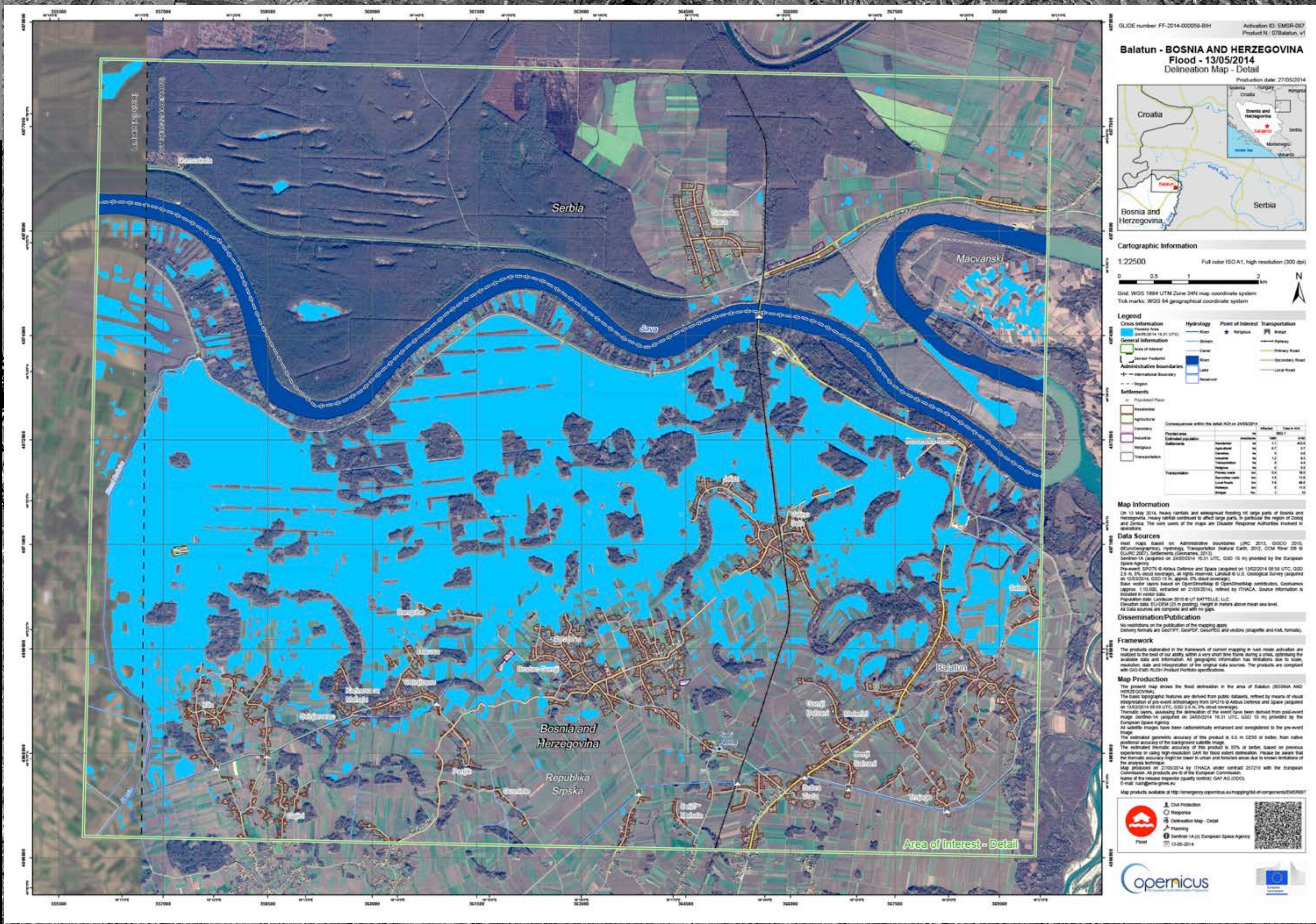
Legend

- 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.

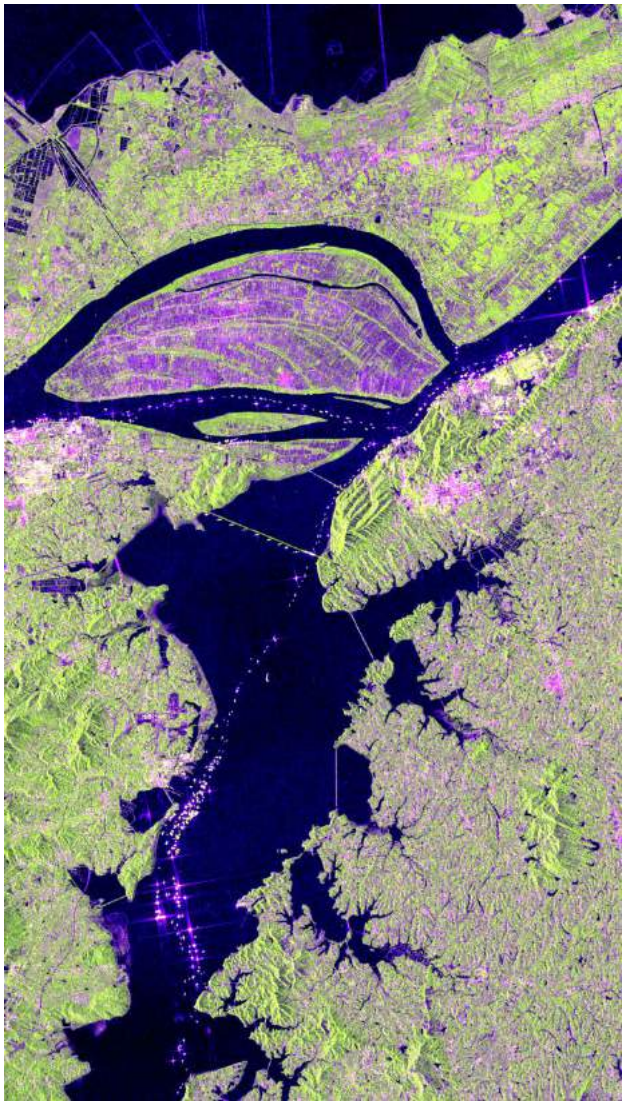
Source data:
SENTINEL-1A IW mode, 20 m resolution, acquired on 13th of April, 2014 at 03:50 GMT.
SENTINEL-1 image was provided by the European Space Agency.

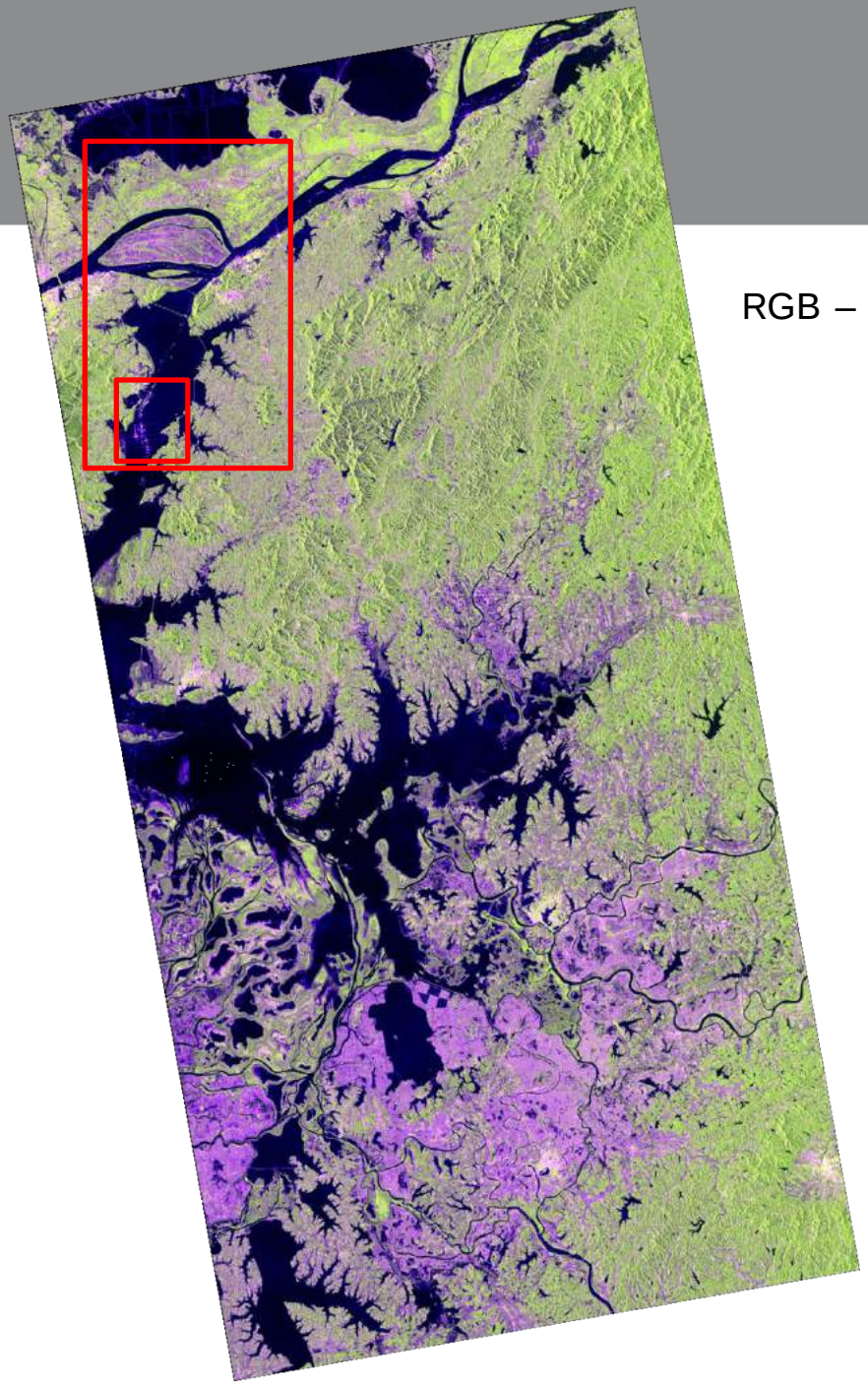
Cartographic Reference
Projection: EPSG:4326
Datum: WGS 84


GLIDE number: FF-2014-000059-BIH
Activation ID: EMSR-087
Product N.: 07Balatun, v1
Balatun - BOSNIA AND HERZEGOVINA
Flood - 13/05/2014
Delineation Map - Detail
Production date: 27/05/2014
Croatia
Bosnia and Herzegovina
Serbia
Cartographic Information
1:22500
Full color ISO A1, high resolution (300 dpi)
Grid: WGS 1984 UTM Zone 34N map coordinate system
Tick marks: WGS 84 geographical coordinate system
Legend
Map Information
Data Sources
Dissemination/Publication
Framework
Map Production
Serbia
Macvanski
Sava
Bosnia and Herzegovina
Republika Srpska
Balatun
Area of Interest - Detail
Copernicus

S1A Polarimetric Composition

Poyang Lake



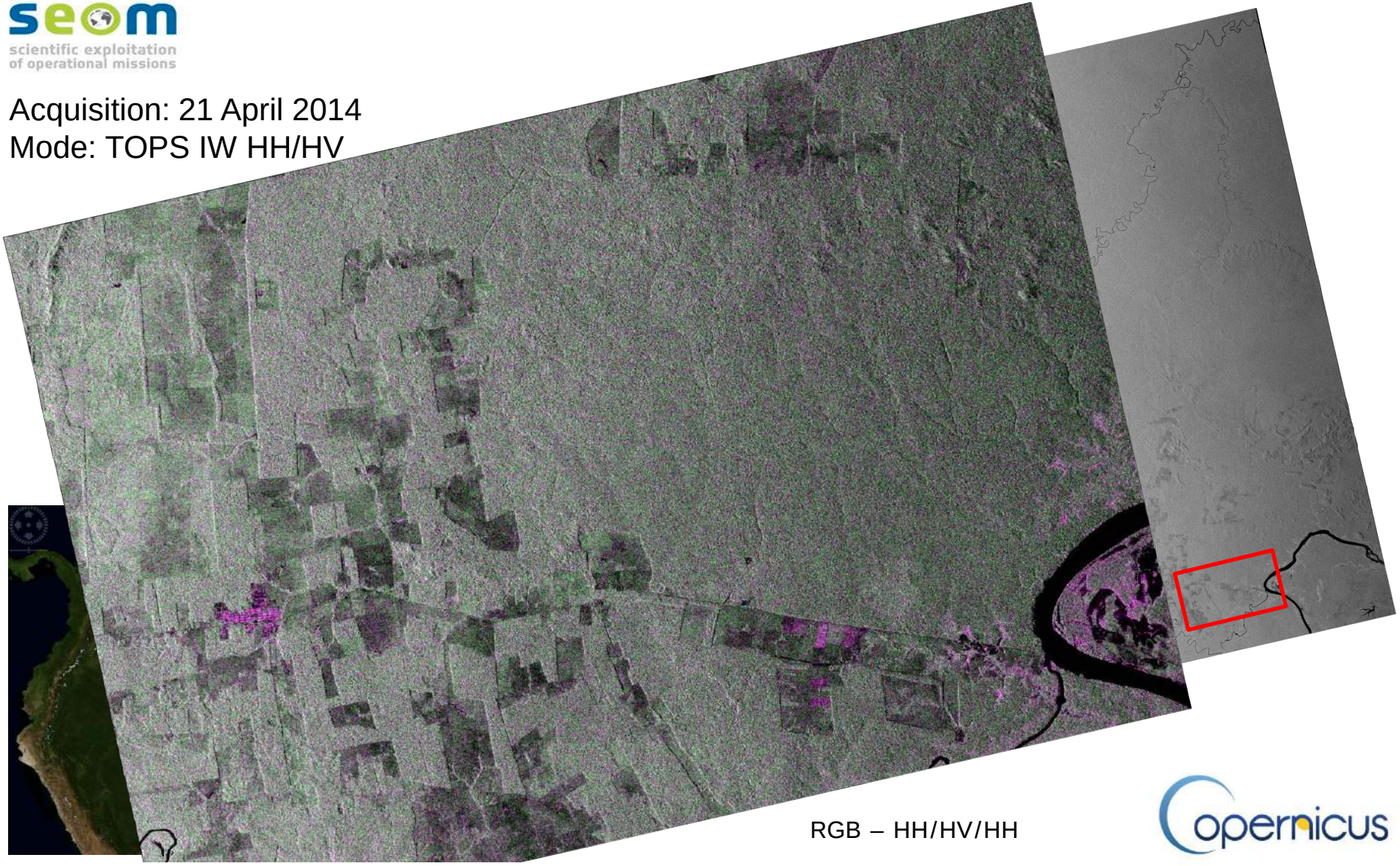


RGB – VV VH VV/VH

Sentinel-1
Deforestation over Brazil

scientific exploitation of operational missions

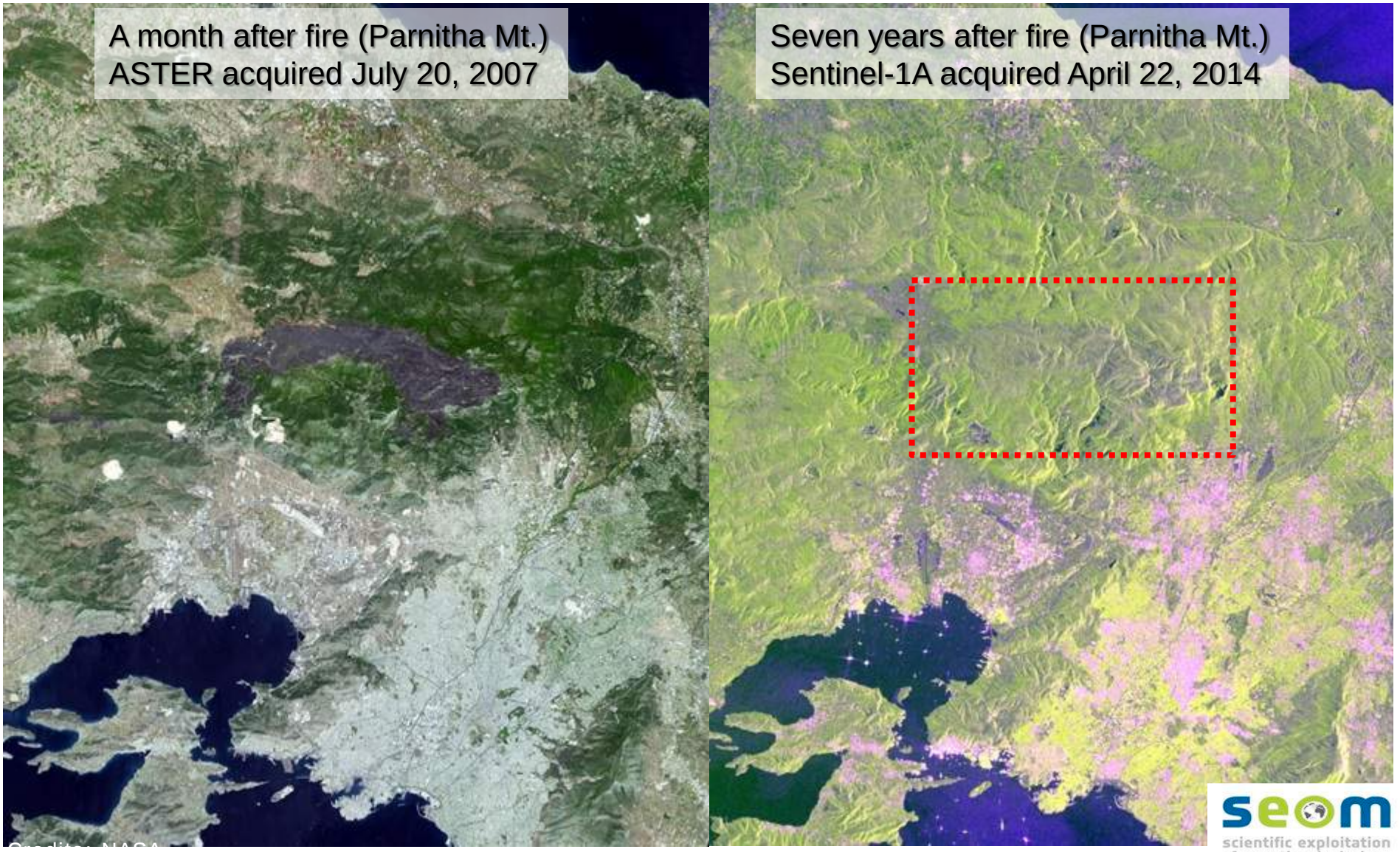
Acquisition: 21 April 2014
Mode: TOPS IW HH/HV



RGB – HH/HV/HH

Sentinel-1

Vegetation Regeneration – Burn Scar (Greece)

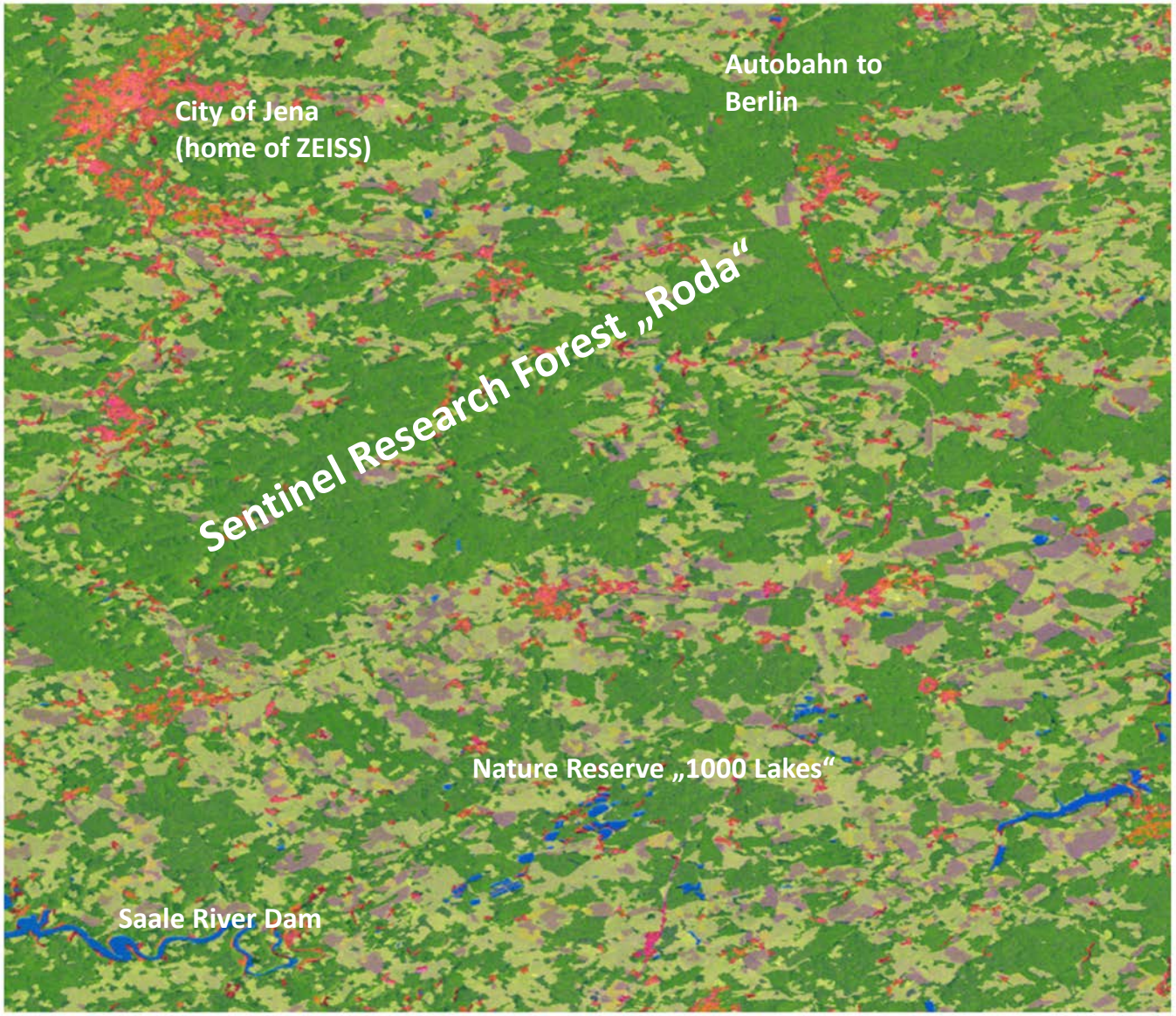


Credits: NASA

seom
scientific exploitation of operational missions

Sentinel-1

Land Classification Dual Pol HH-HV (Germany)



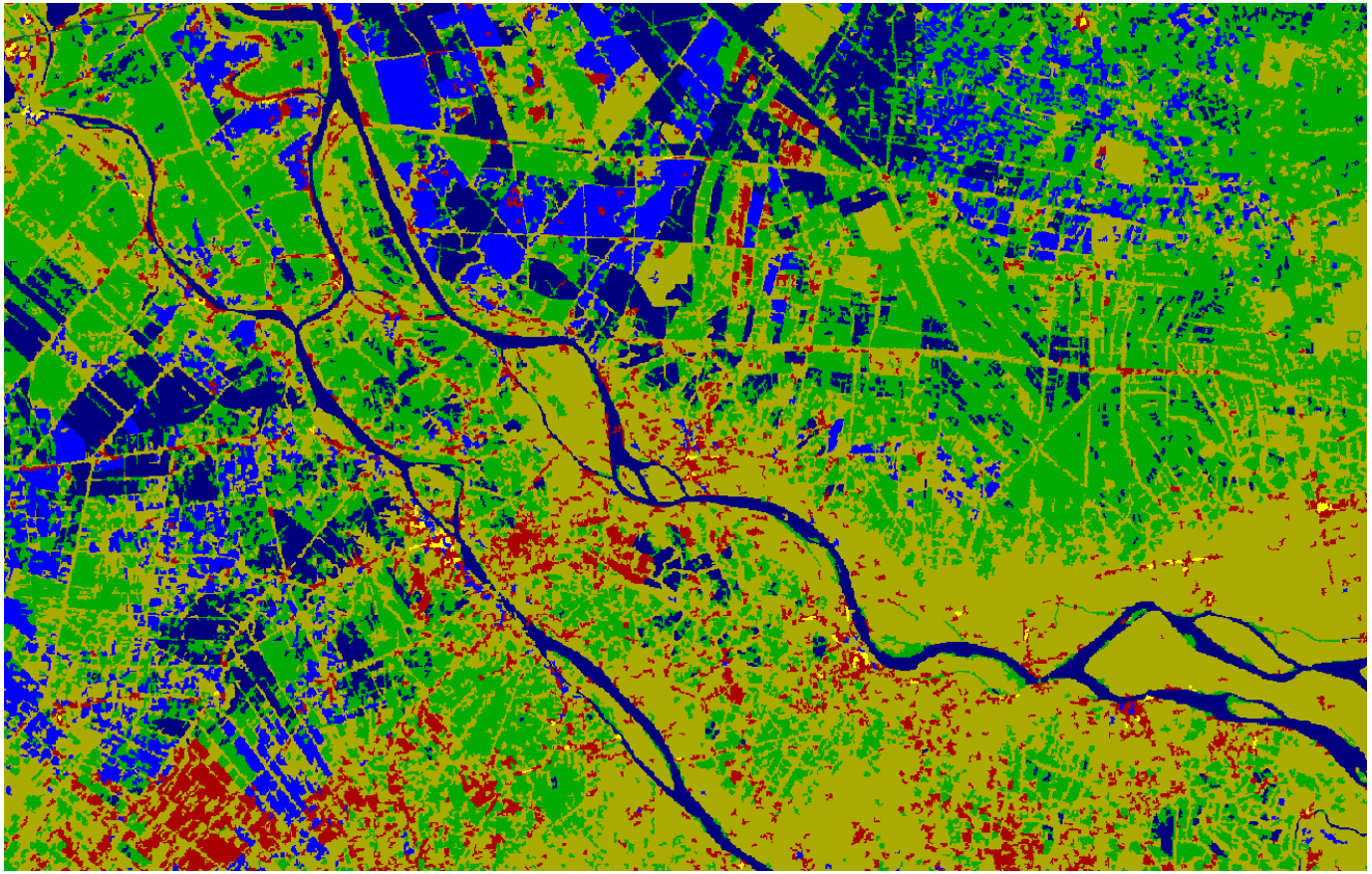
Class. Method:
Random Forest

Classes:
Forest
Water
Urban
Winter crops
Bare fields

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

PRELIMINAY RESULTS RICE MONITORING

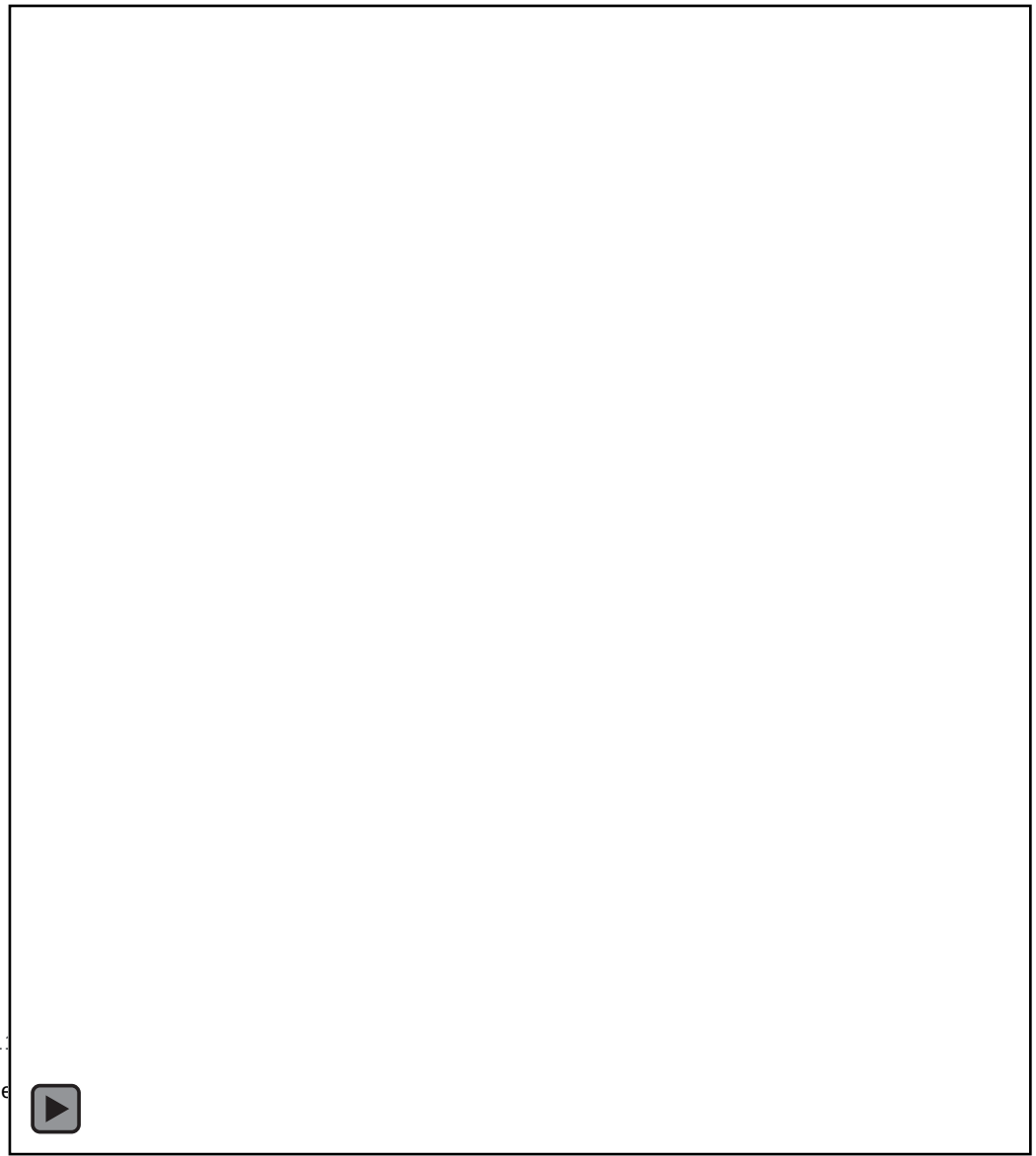
S-1A geocoded – 8 & 20 Aug, 80m (detail) – Vietnam



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

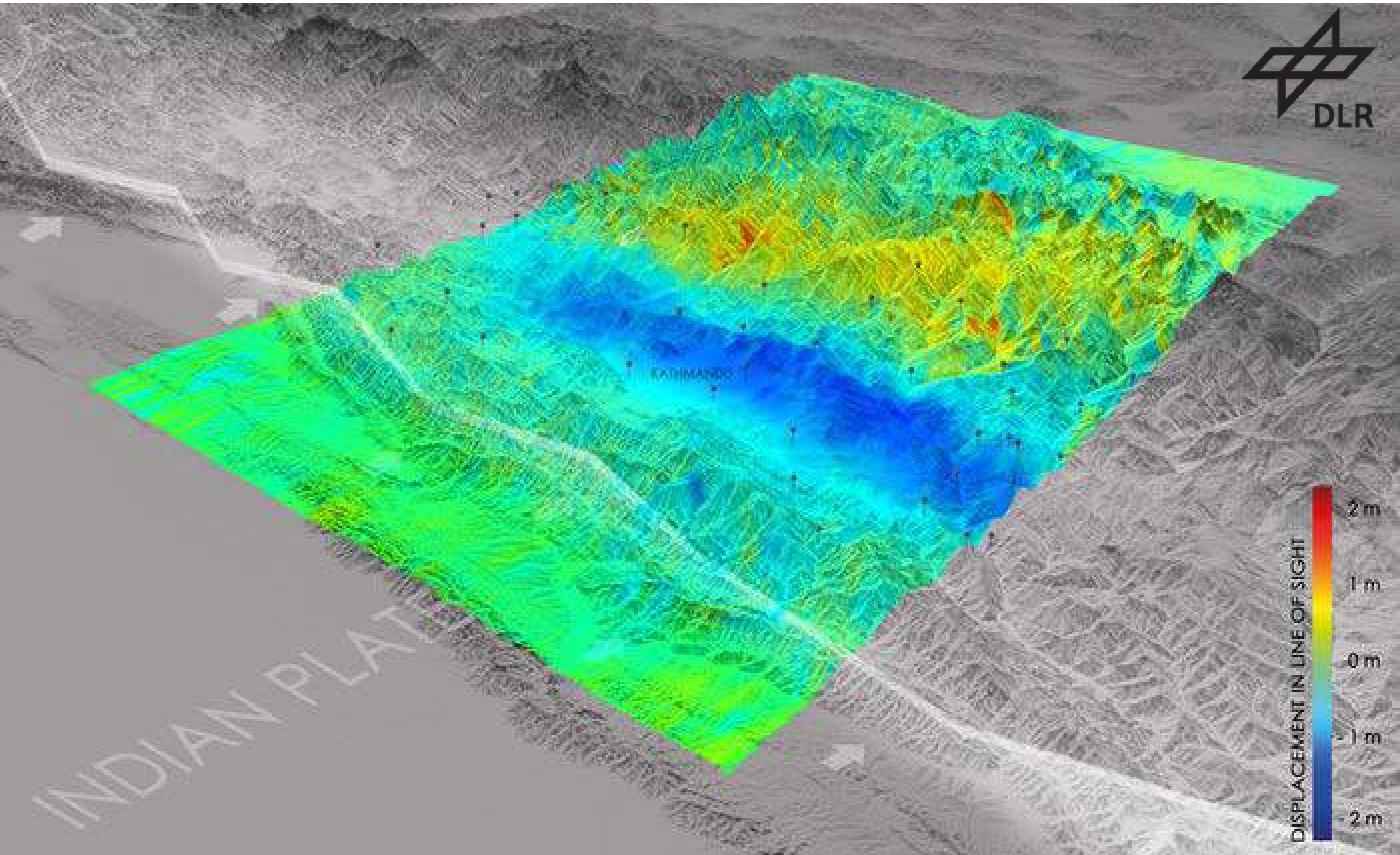
Courtesy SARMAP

Sentinel-1: Mekong Delta Rice Crops

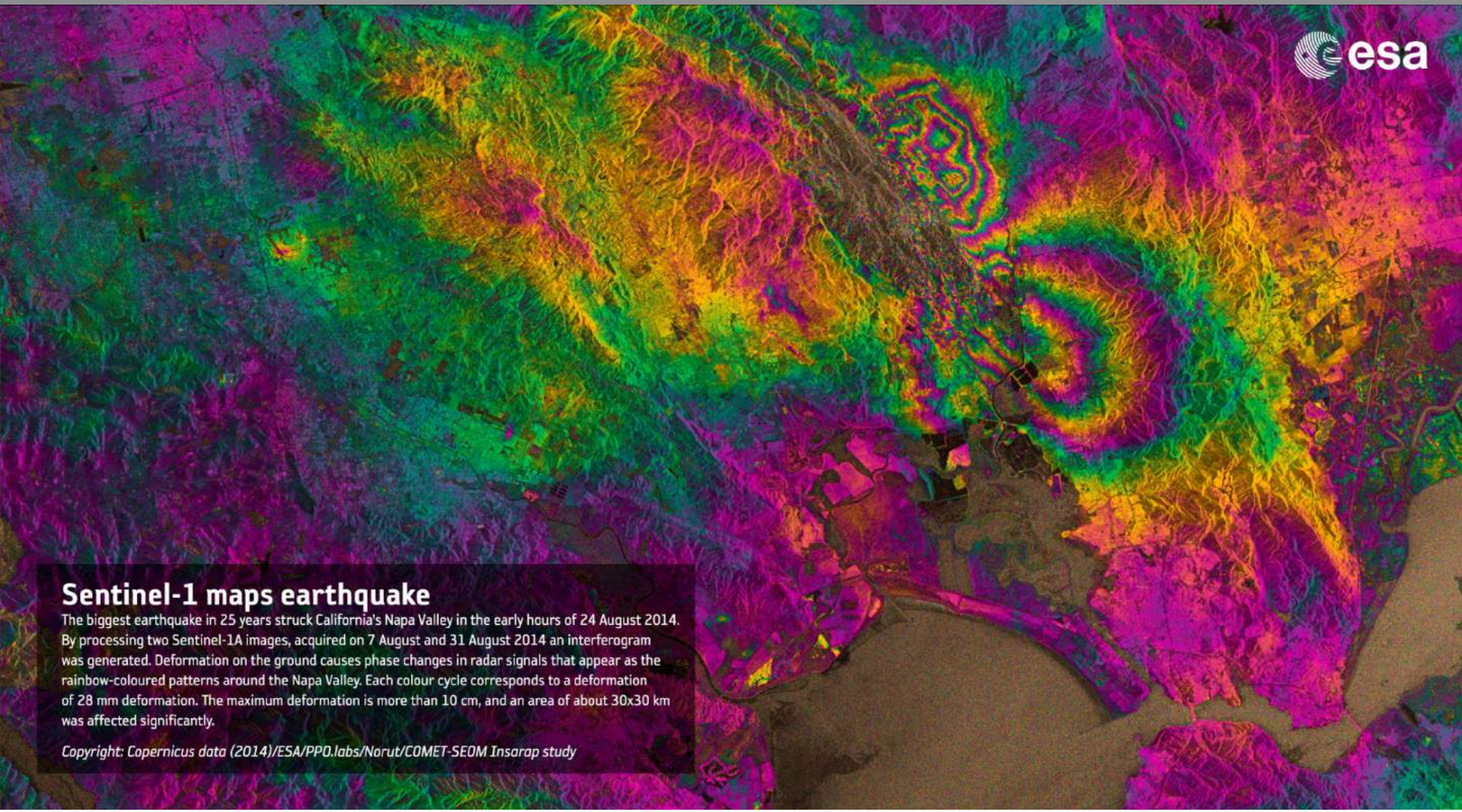


contains modified Copernicus Sentinel data (2015–16) /CESBIO/ESA DUE GEO-Rice Innovator project

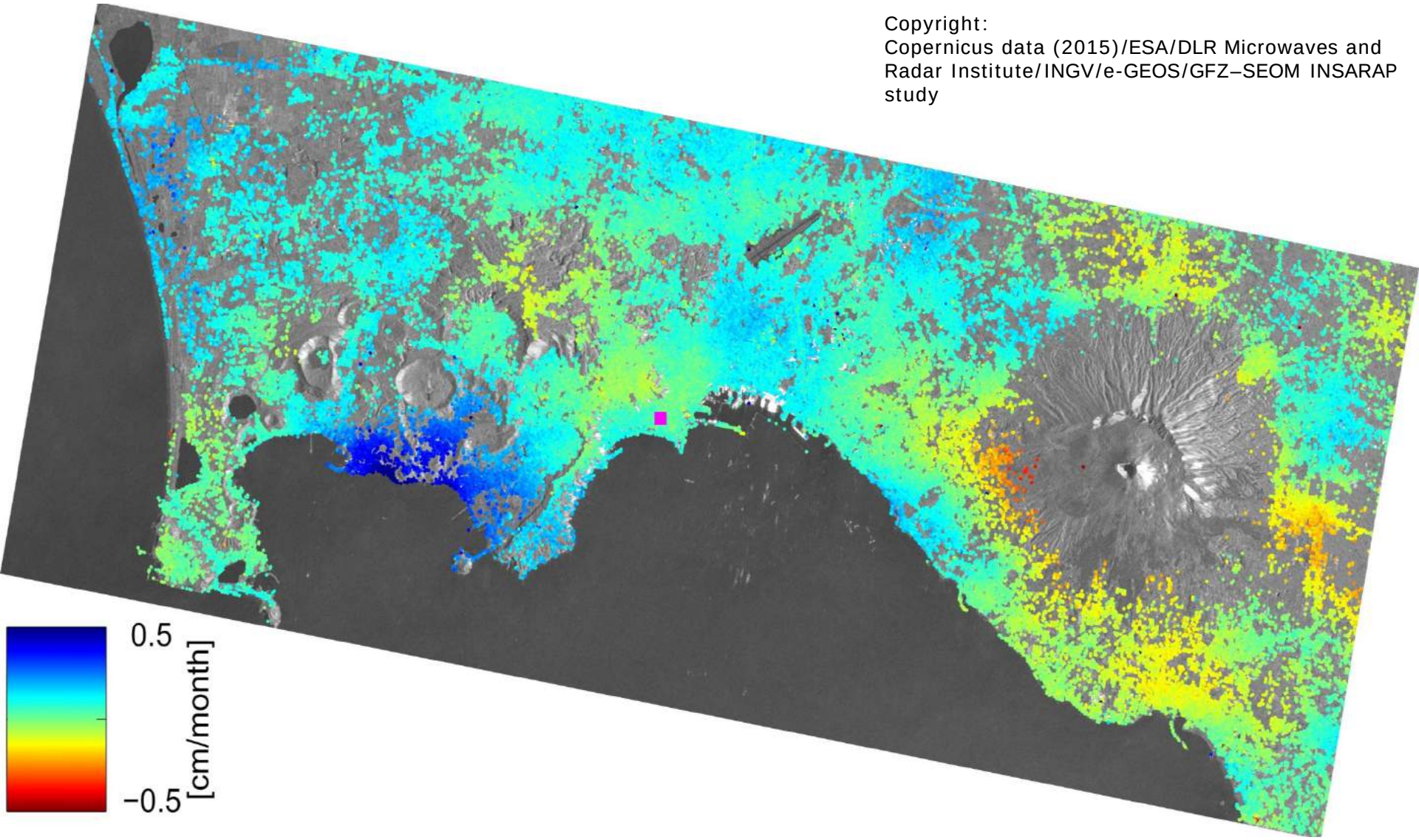
Sentinel-1A: Nepal Earthquake



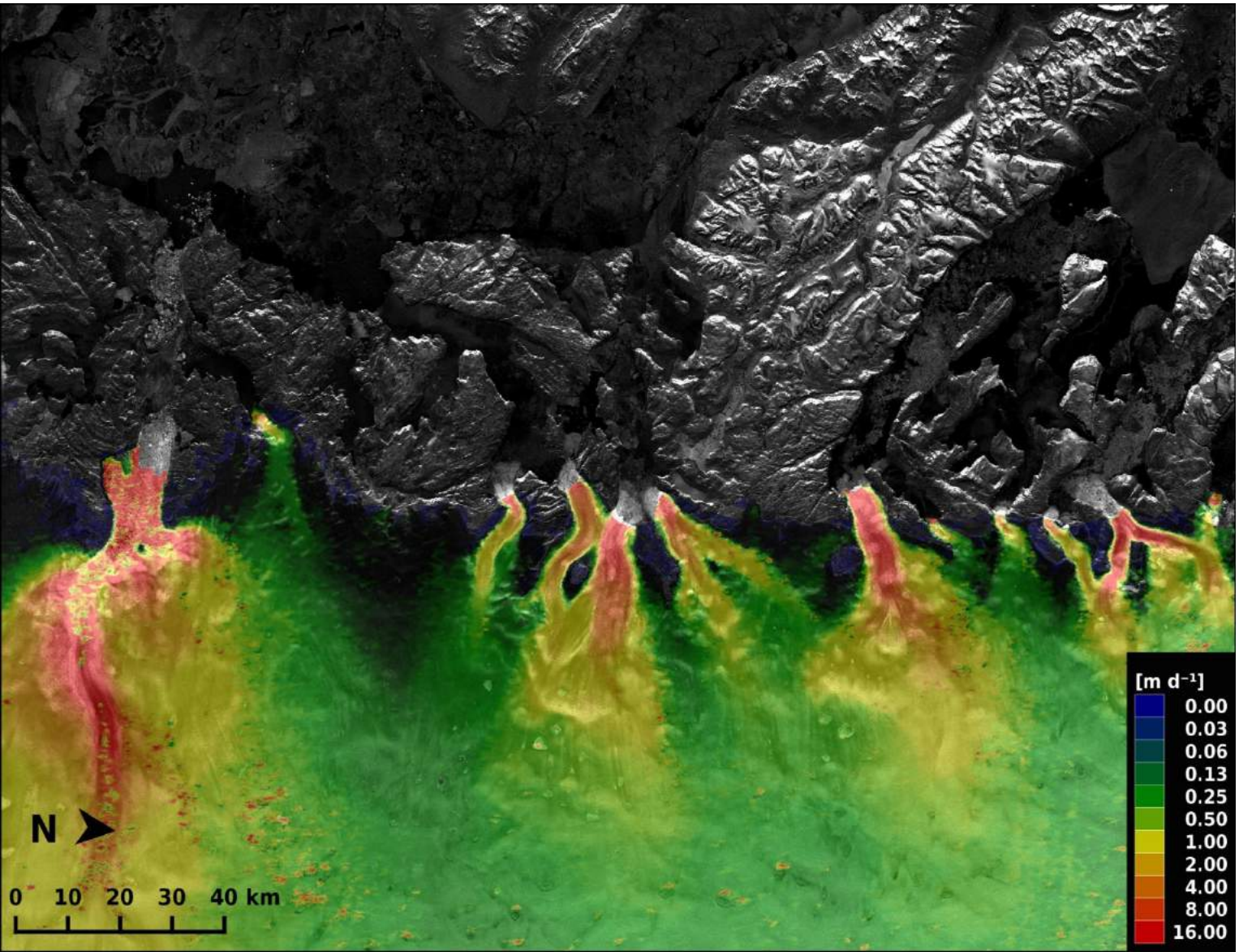
Sentinel-1 *Napa Valley Earthquake*
INSARAP (NORUT-PPO.labs-Univ. Leeds-COMET)



Campi Flegrei seen by Sentinel-1A



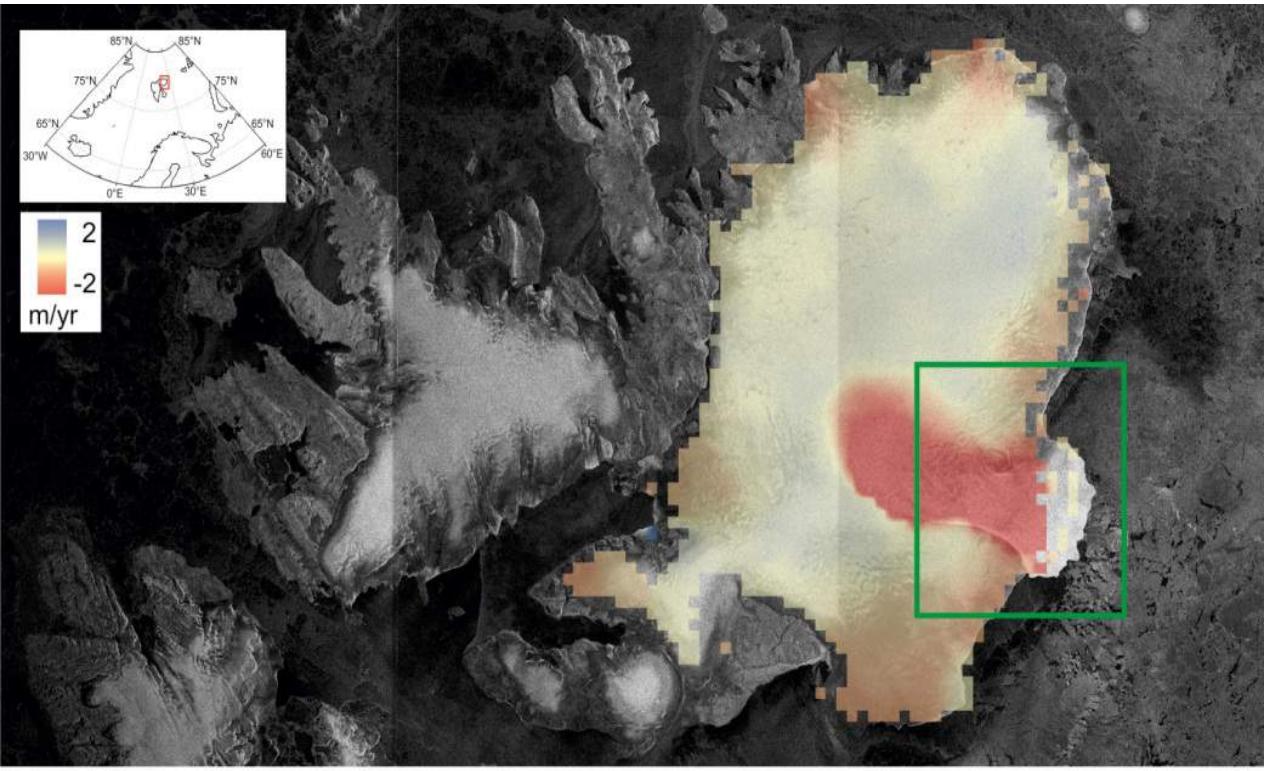
Ice Streams seen by Sentinel-1A

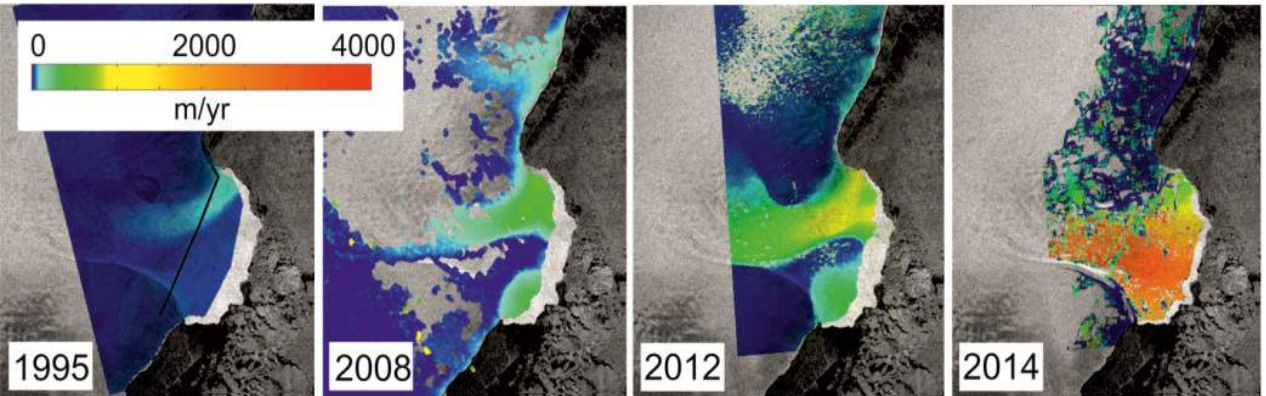


Greenland,
West Coast

January 2015

Sentinel-1A: Austfonna Ice Loss



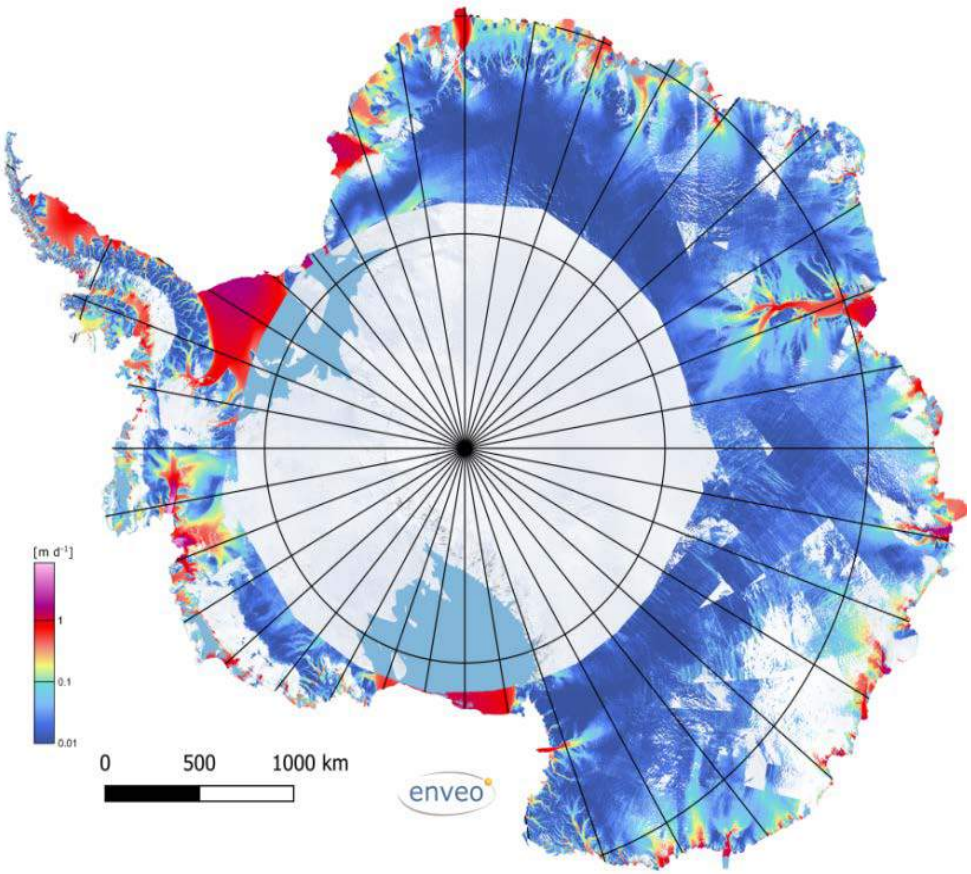


Combined observations from eight satellite missions, including **Sentinel-1A** and **Cryosat**

European Space Agency

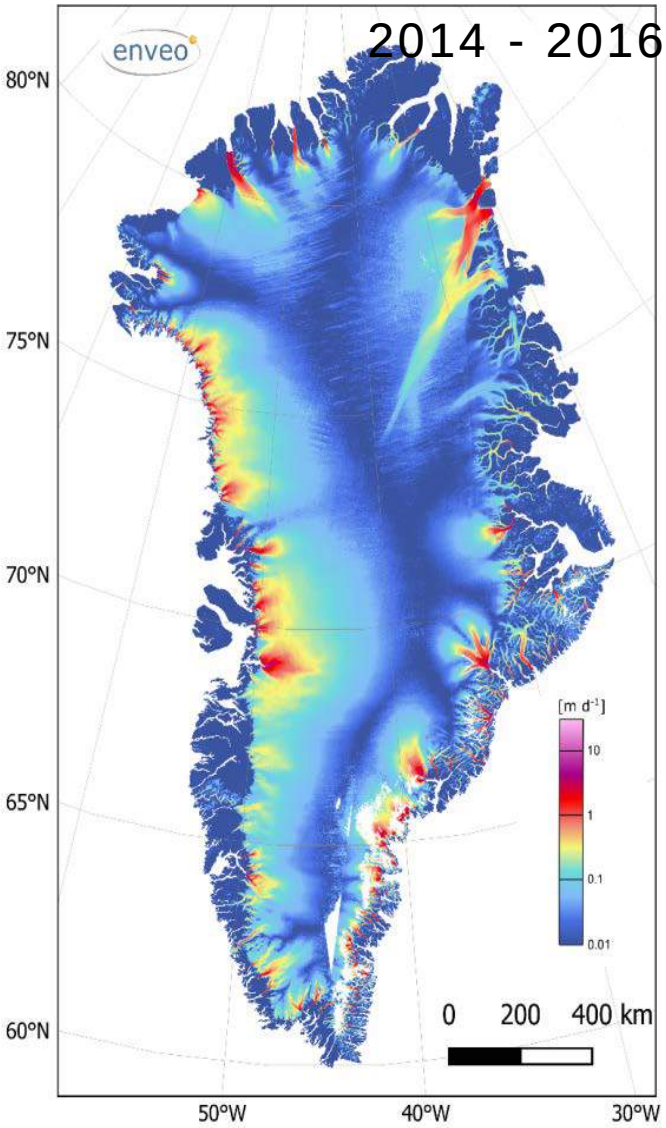
Sentinel-1: Ice Velocity Maps

2015/2016



Nagler et al.

2014 - 2016



36 Years of Radar Vision

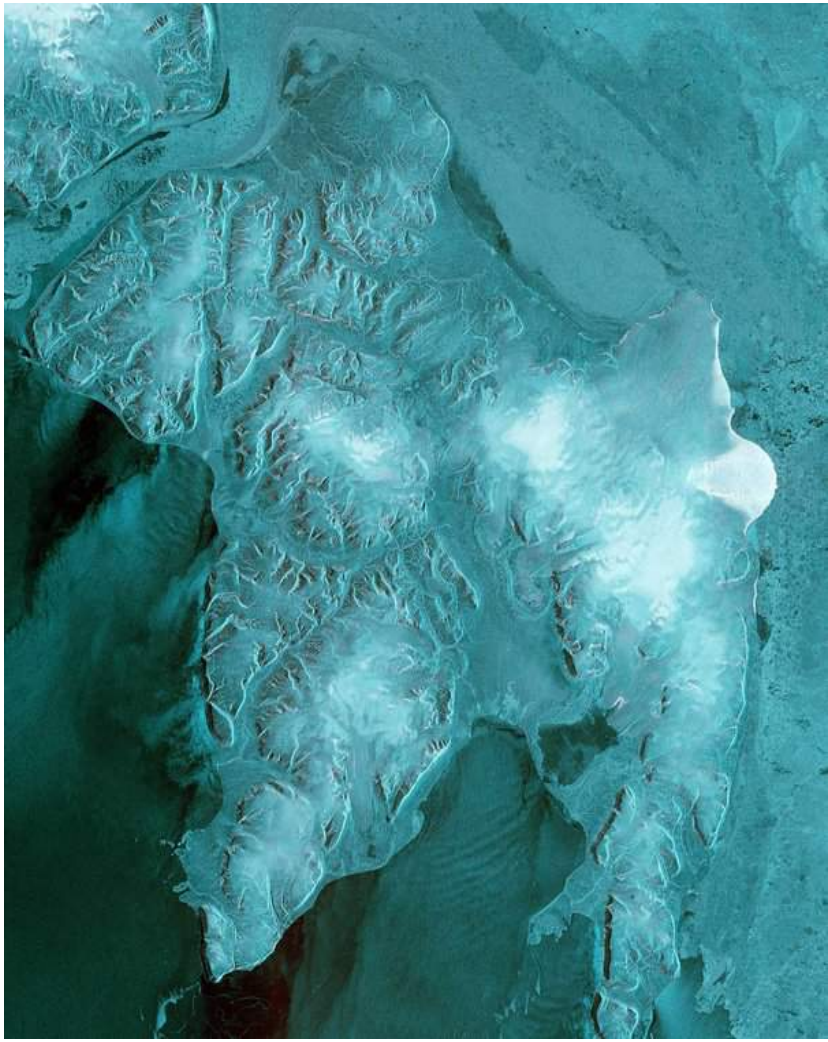
Sentinel-1B's First Image

Svalbard Archipelago,
28 April 2016

Copernicus

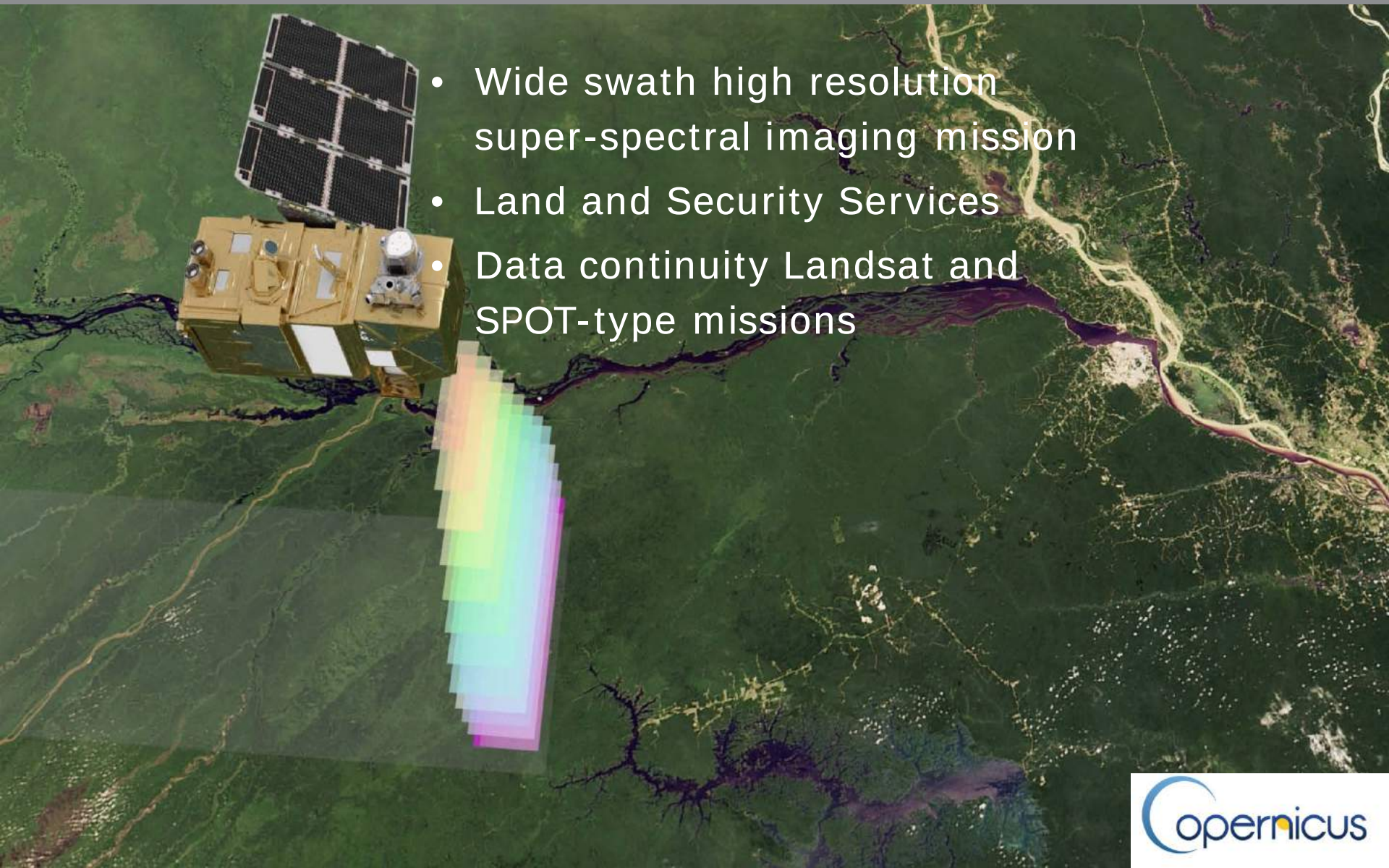
full scene

subset



European Space Agency

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

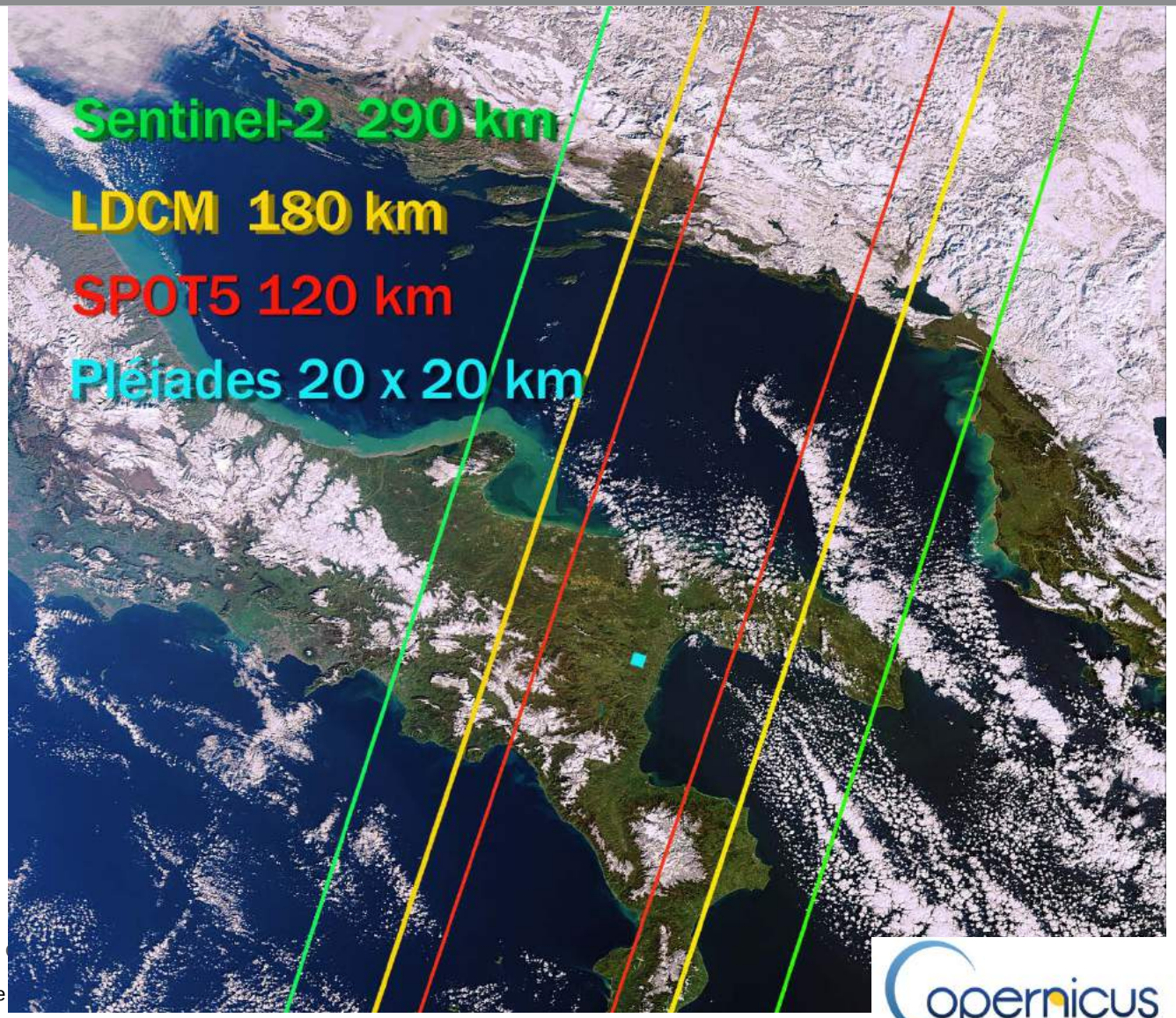
Mission objectives:

- Generic land cover maps
- Risk mapping and disaster relief

Sentinel-2
Swath width

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

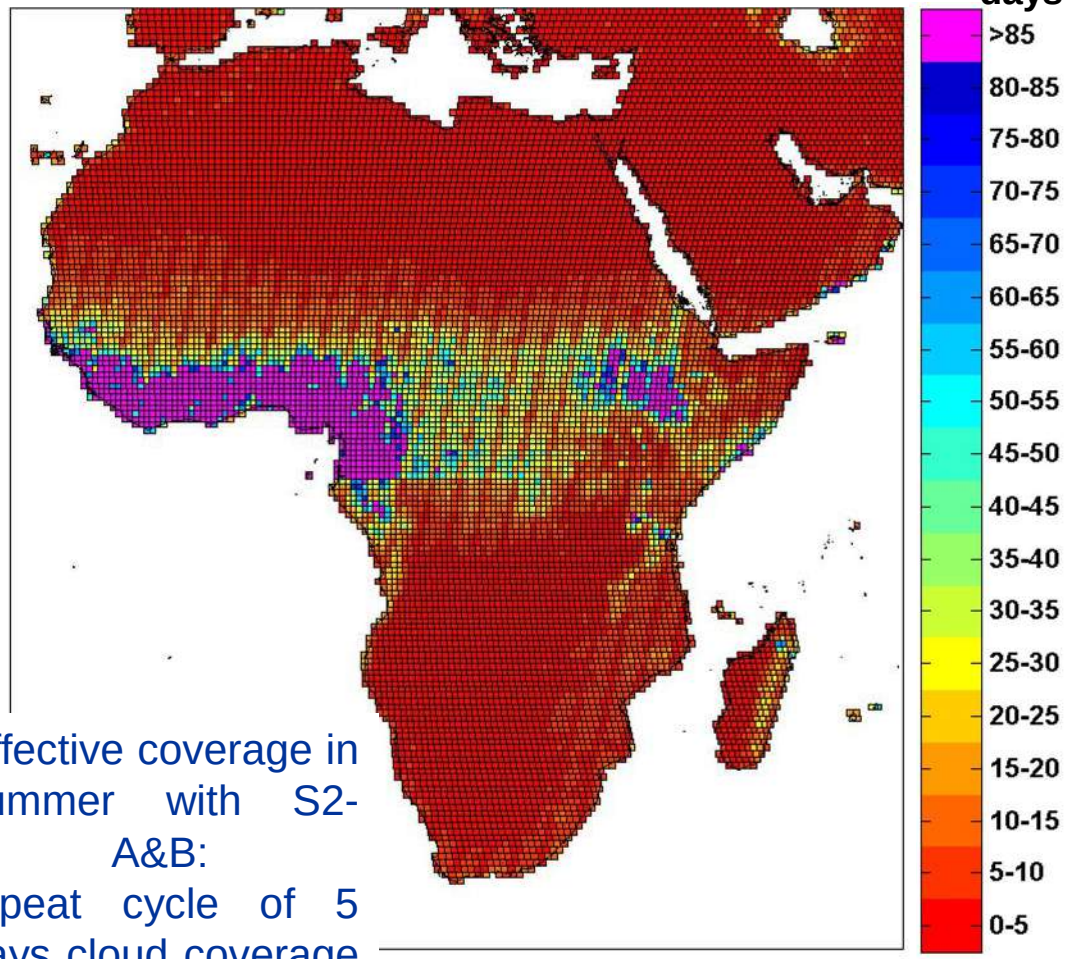
Sentinels are complementary to High-Res commercial and national missions



Sentinel-2 Revisit Time Capability

5 days revisit for crop dynamics

Sentinel-2 for agriculture: see 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

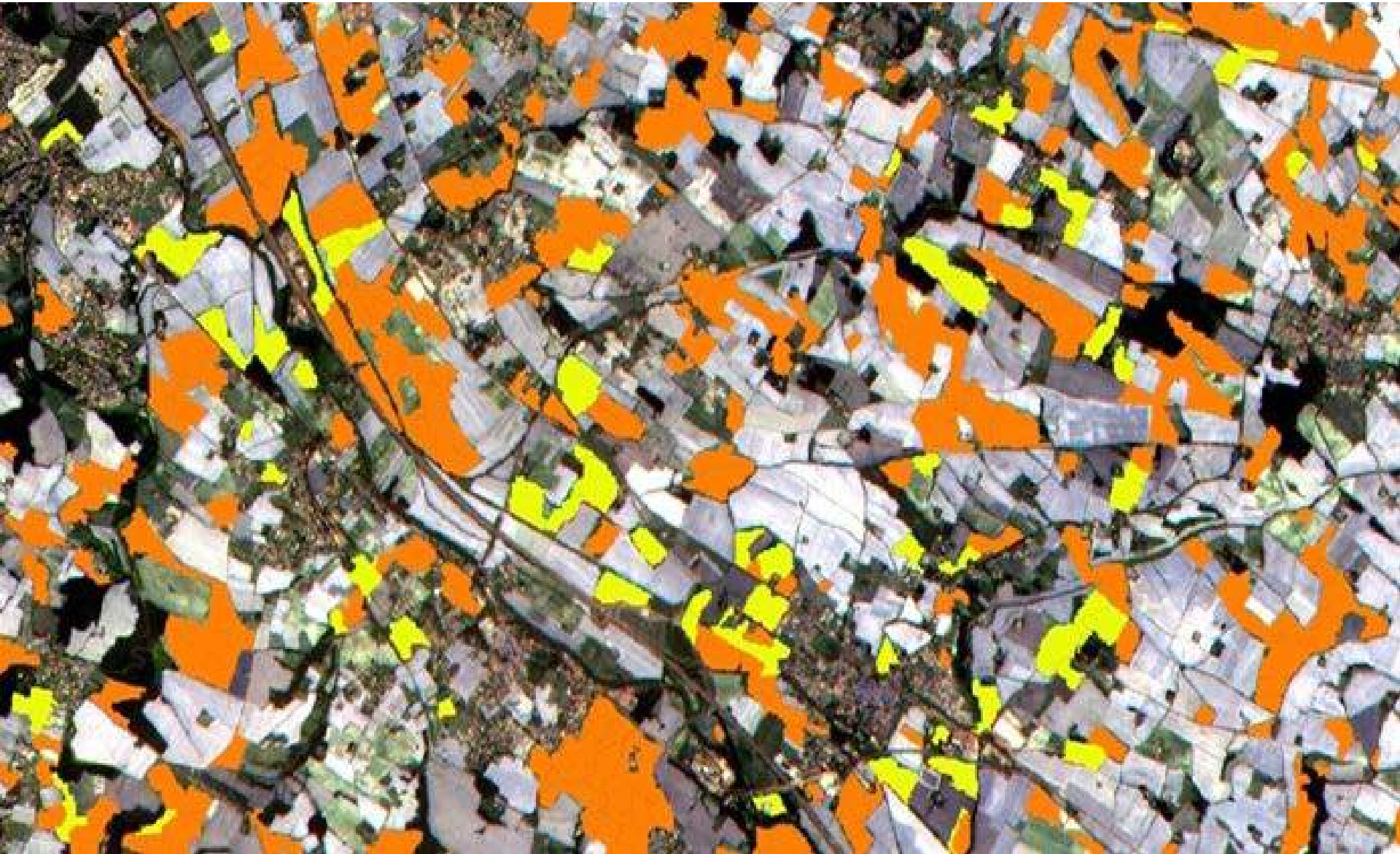
Sentinel-2A: First images

Sentinel-2A: 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 organge) and maize (in yellow).

esa



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

www.esa-sen2agri.org/SitePages/Home.aspx

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sentinel-2 → AGRICULTURE

SENTINEL-2 FOR AGRICULTURE

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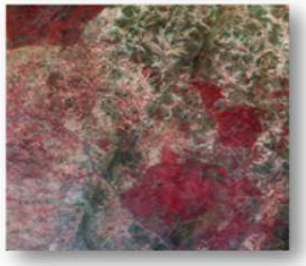
PREPARING SENTINEL-2 EXPLOITATION FOR AGRICULTURE MONITORING

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.



SPOT5 TAKE5 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

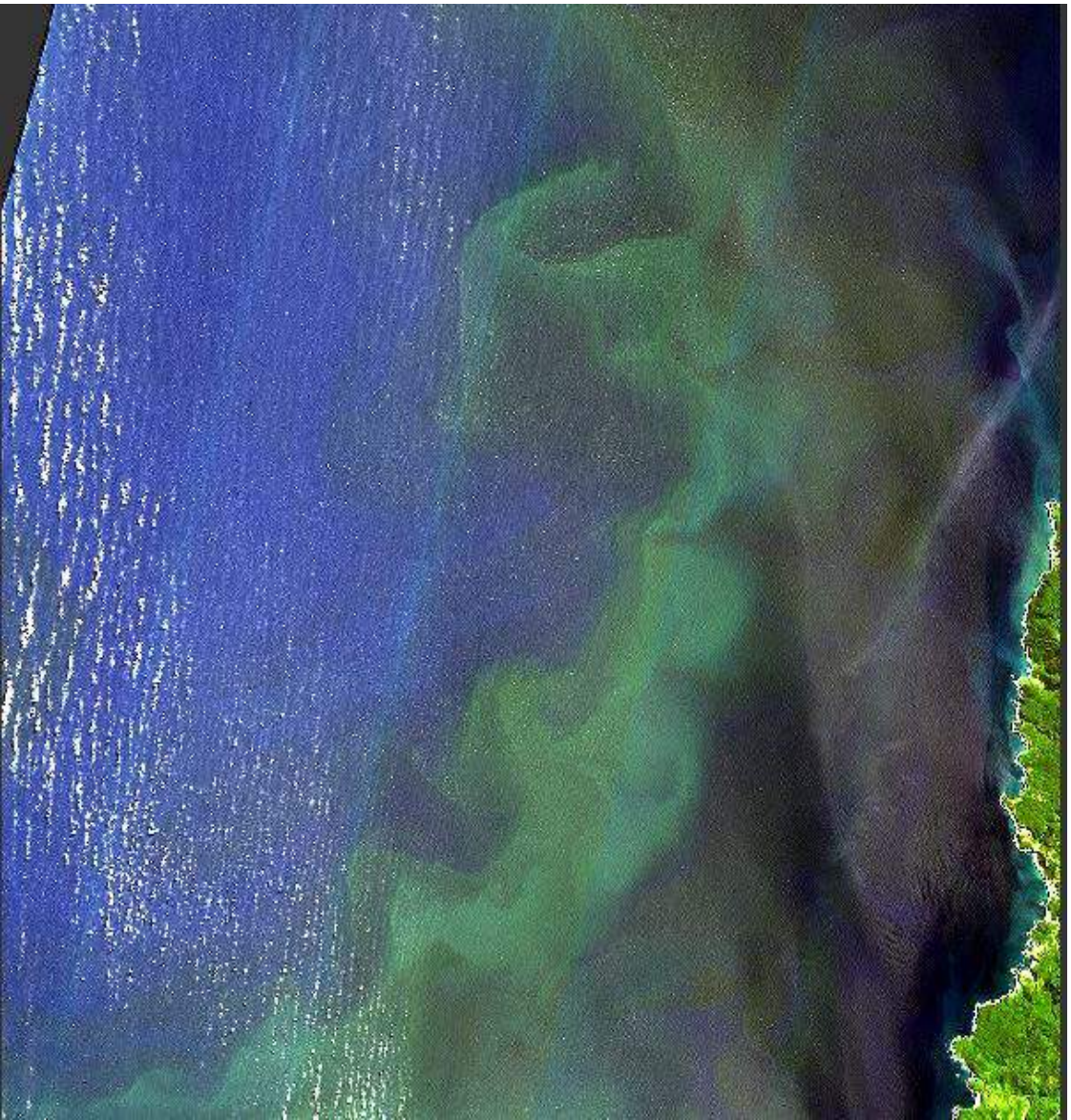
5/20/2014,Frascati,Italy

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)

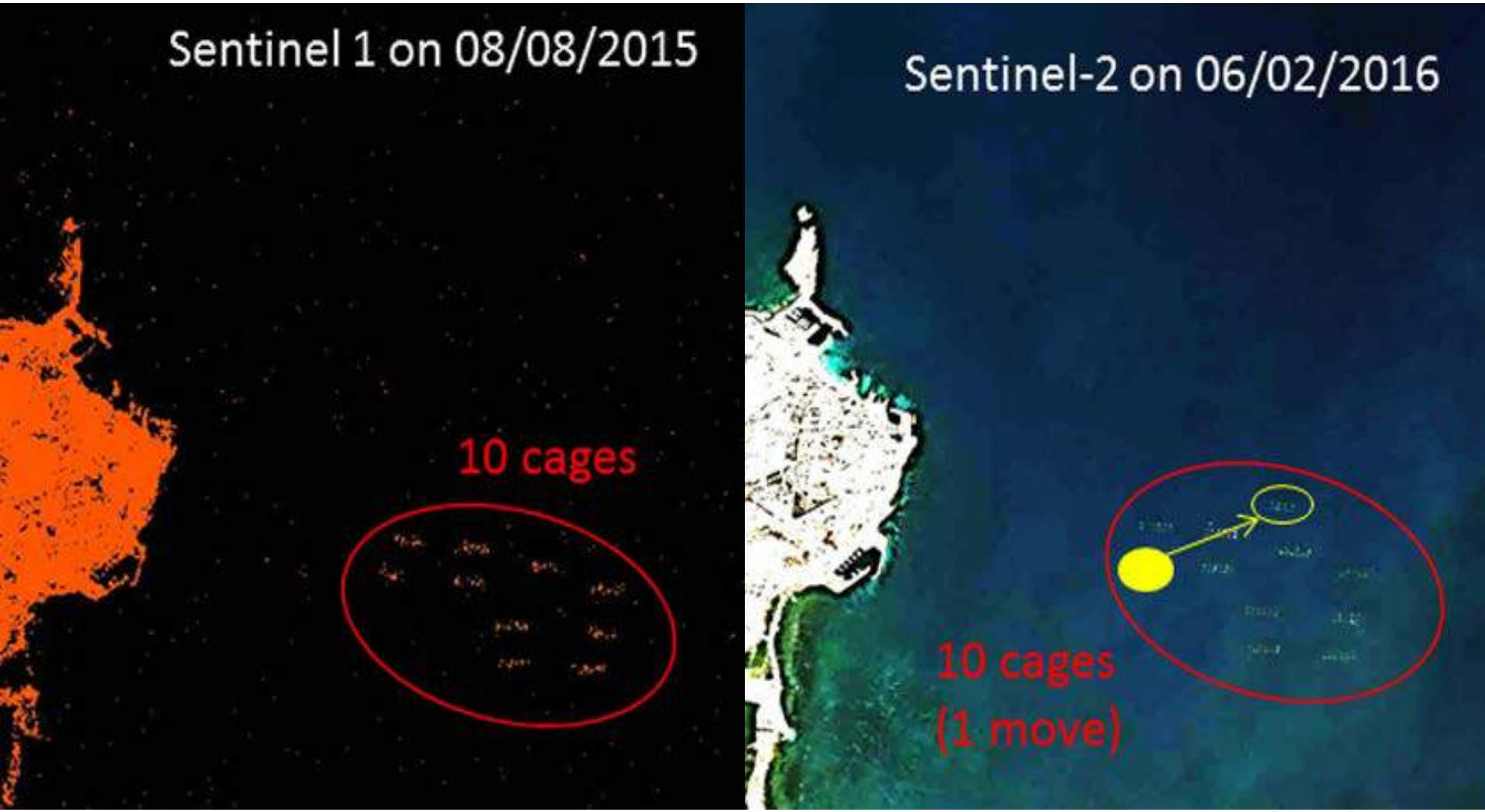
Sentinel-2A: Algal Bloom



Algal bloom along the coast of Valdivia, Chile

Sentinel-2A,
5 March 2016

Sentinels in Co-Operation



Fish cages in Western Mediterranean Sea

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

Sentinel-3 (3-A launched)

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

Sentinel-3 Ocean & Global Land Mission

Mission profile

- **3** main instrument sets: OLCI, SLSTR and RA
- Sun synchronous orbit at **814.5 km** mean altitude over geoid
- **1270 km** swath width for OLCI and **750 km** for SLSTR
- **< 1 day** repeat cycle for OLCI/SLSTR with 2 satellites, **27 days** for the topography package
- **7 years** design life time, consumables for 12 years

Mission objectives:

- Sea/land colour data
- Sea/land Surface temperature
- Sea surface and land ice topography

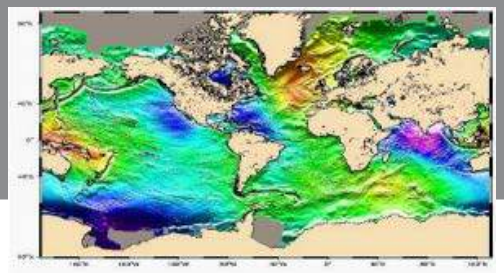
Sentinel-3 Payload

Optical Mission Payload

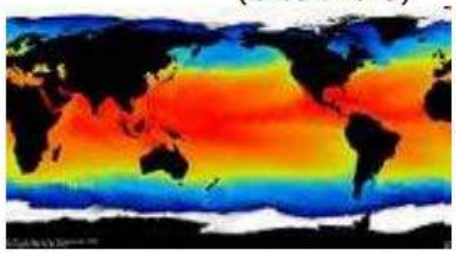
- Ocean and Land Colour Instrument (OLCI)
- Sea and Land Surface Temperature Radiometer (SLSTR)

Topography Mission Payload

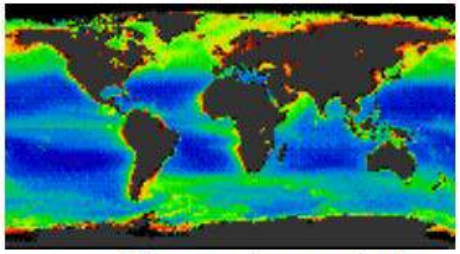
- Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL)
- MicroWave Radiometer (Bi-frequency)
- Precise Orbit Determination (POD) including:
  - GNSS Receiver
  - DORIS
  - Laser Retro-Reflector



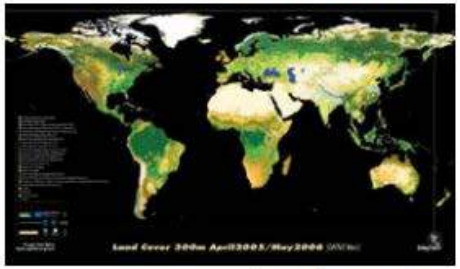
Sea Surface Height products
(Credit: CLS)



Sea Surface Temperature products
(Credit: Met Office)

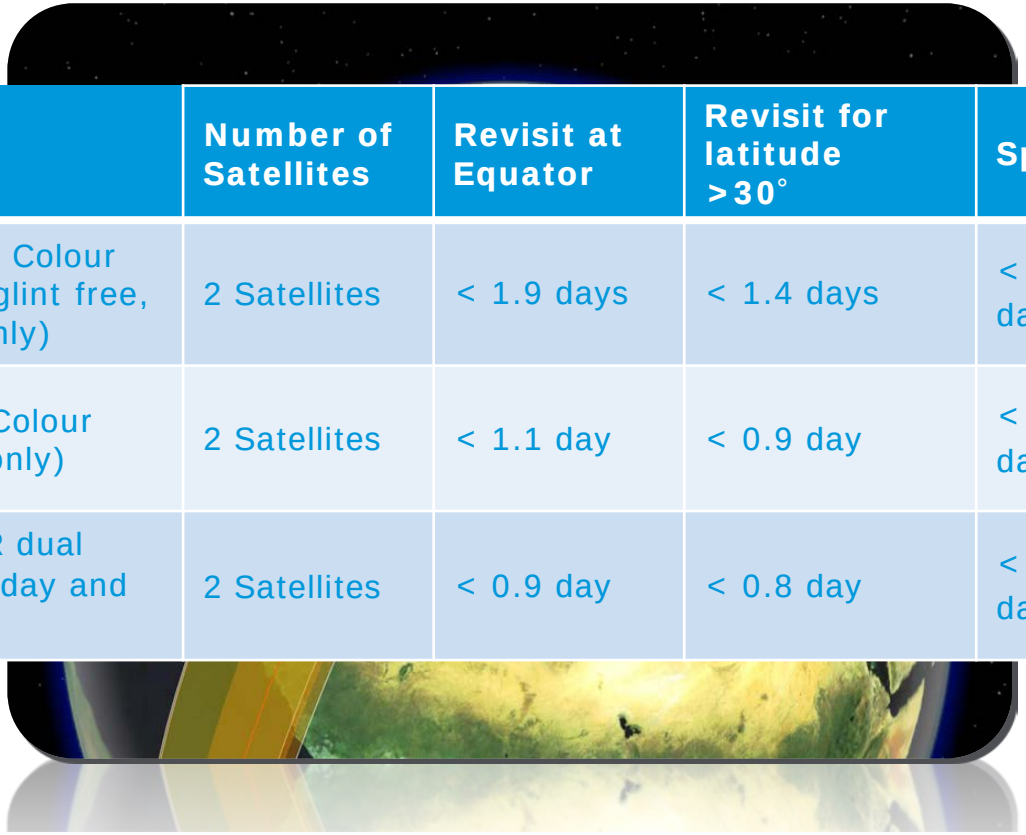


Ocean colour products
(Credit: MyOcean)



Land cover products
(Credit: ESA)

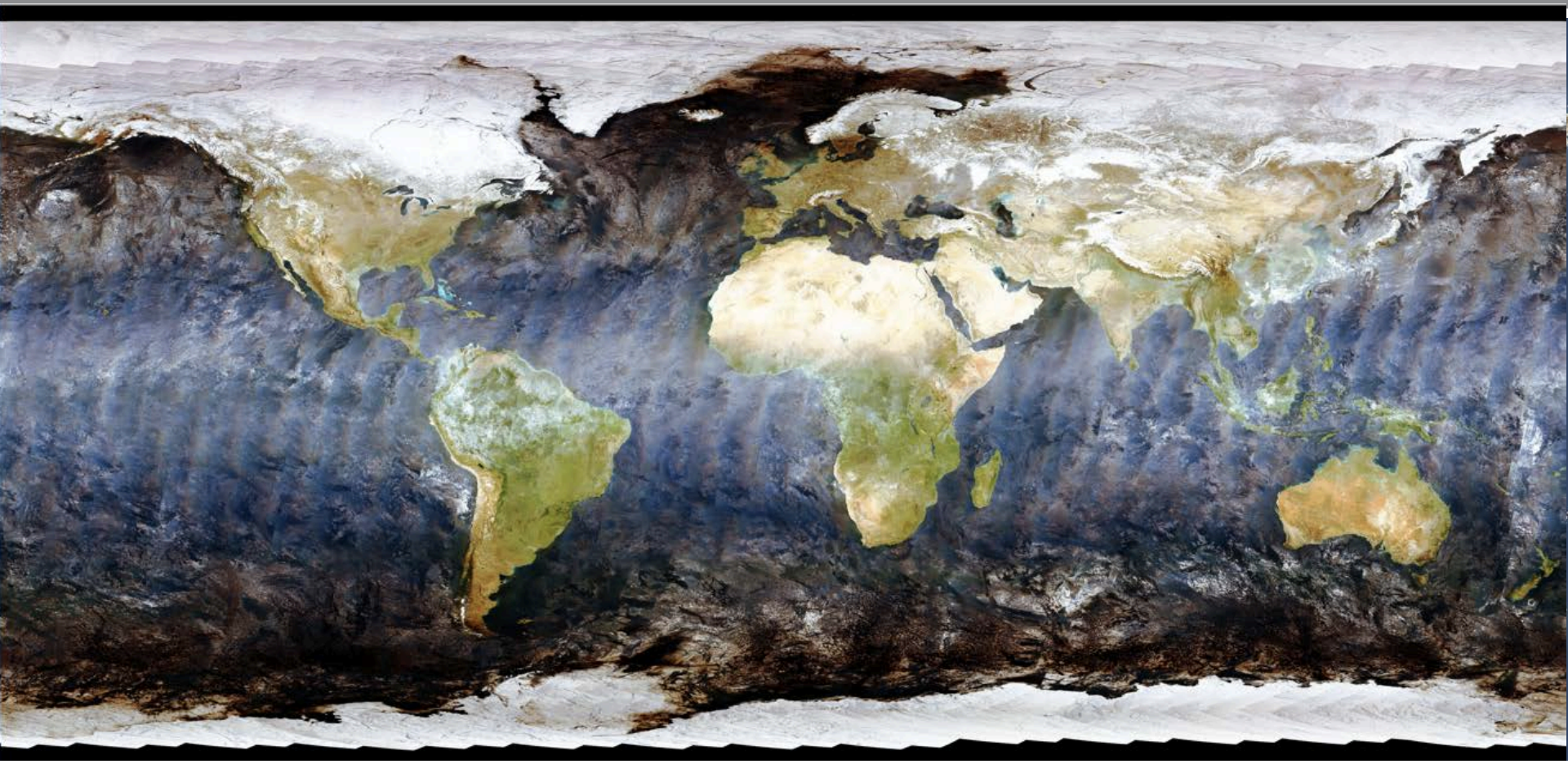
Sentinel-3 Revisit Time & Coverage: Optical Mission



	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

OLCI: Ocean and Land Colour Instrument comparison to MERIS

Pushbroom Imaging Spectrometer (VIS-NIR) – similar to MERIS

Key Improvements:

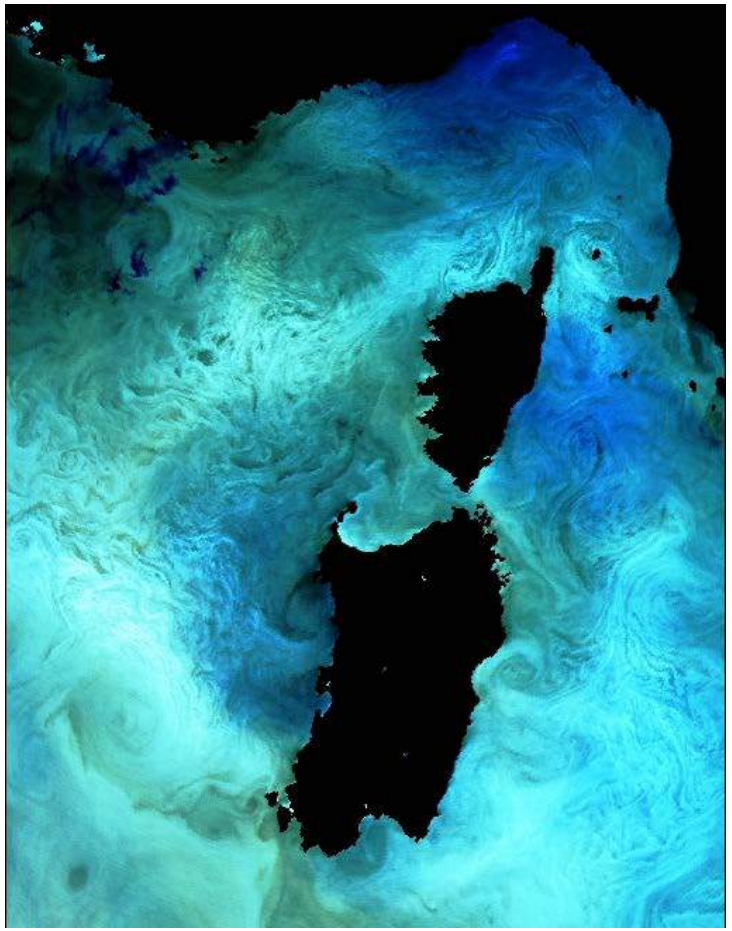
- More spectral bands (from 15 to 21) 400-1020 nm
- Broader swath: 1270 km
- Reduced sun glint by camera tilt in west direction (12.20°)
- Absolute (relative) accuracy of 2% (relative 0.5%)
- Polarisation sensitivity < 1%
- Full res. 300m acquired systematically for land & ocean
- Reduced res. 1200m binned on ground
- Improved characterization, e.g. straylight, camera boundary characterization
- Timeliness: 3 hours NRT Level 2 product
- 100% overlap with SLSTR

MERIS Bands	λ center	Width
Yellow substanace/detrital pigments	412.5	10
Chl.. Abs. Max	442.5	10
Chl & other pigments	490	10
Susp. Sediments, red tide	510	10
Chl. Abs. Min	560	10
Suspended sediment	620	10
Chl. Abs, Chl. fluorescence	665	10
Chl. fluorescence peak	681.25	7.5
Chl. fluorescence ref., Atm. Corr.	708.75	10
Vegetation, clouds	753.75	7.5
O_2 R-branch abs.	761.25	2.5
O_2 P-branch abs.	778.75	15
Atm corr	865	20
Vegetation, H_2O vap. Ref.	885	10
New OLCI bands	**λ center**	**Width**
Aerosol, in-water property	400	15
Fluorescence retrieval	673.75	7.5
Atmospheric parameter	764.375	3.75
Cloud top pressure	767.5	2.5
Atmos./aerosol correction	940	20
Atmos./aerosol correction	1020	40

S3: Sea and Land Surface Temperature Radiometer (SLSTR) Comparison AATSR

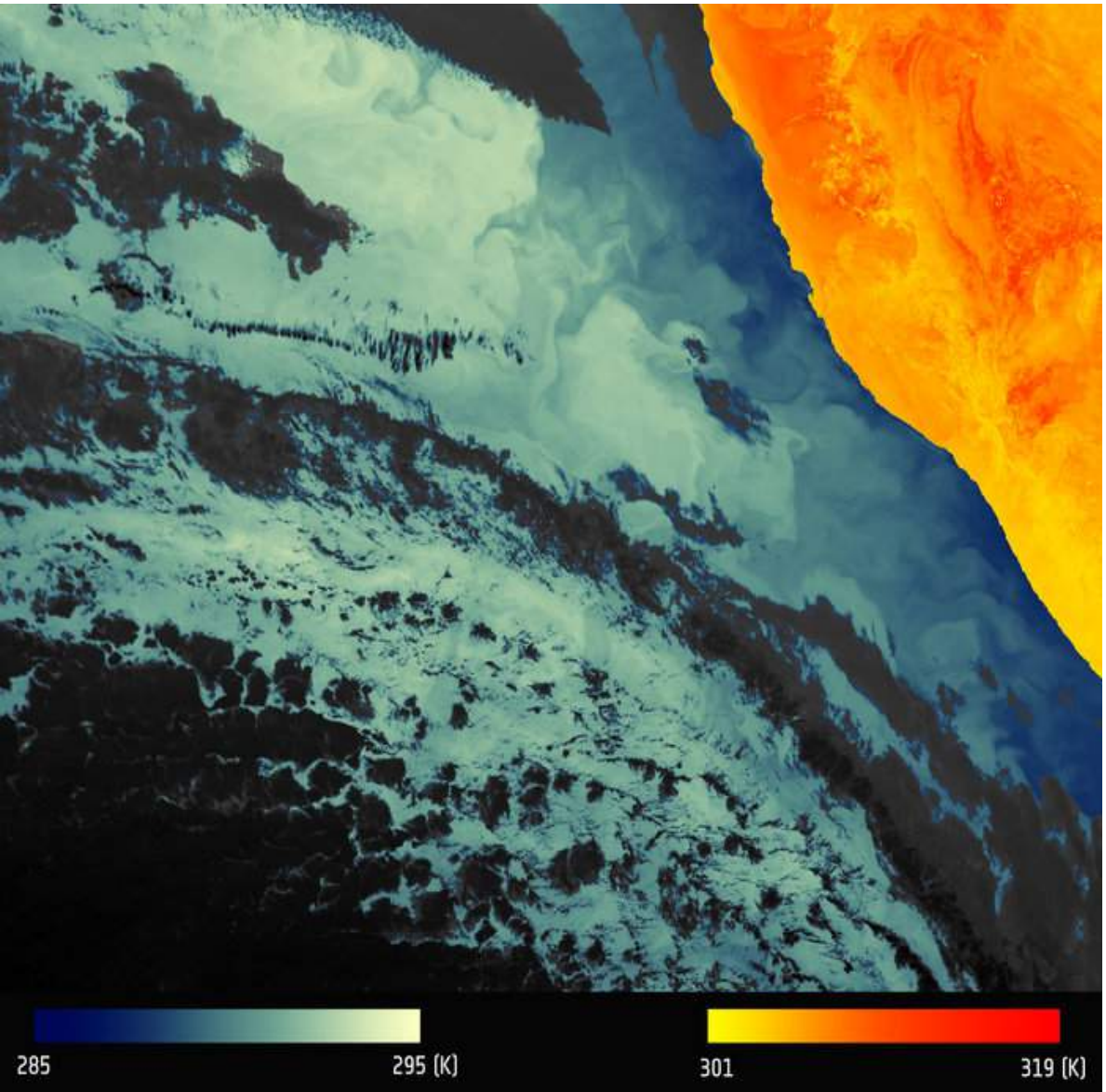
Key Improvements:

- number of spectral bands from 7 to 9 (new 1.3 and 2.2um) for better Ci Cloud detection
- increased resolution for VIS and SWIR channels (0.5 km @ nadir, TIR 1 km @nadir)
- maintain along track scanning with increased swath of oblique view to 750 km
- increased nadir swath coverage to 1400 km
- 100% overlap with OLCI
- improved coverage Ocean < 4 days (practically ~ 2 days)
- dedicated Active Fire channels
- Timeliness: 3 hours NRT Level 2 product



Thermal Structure in the Med, ENVISAT AATSR

Sentinel-3A: Thermal Signatures



Namibian Coastline,
29 March 2016

Contains modified Copernicus Sentinel data [2016]

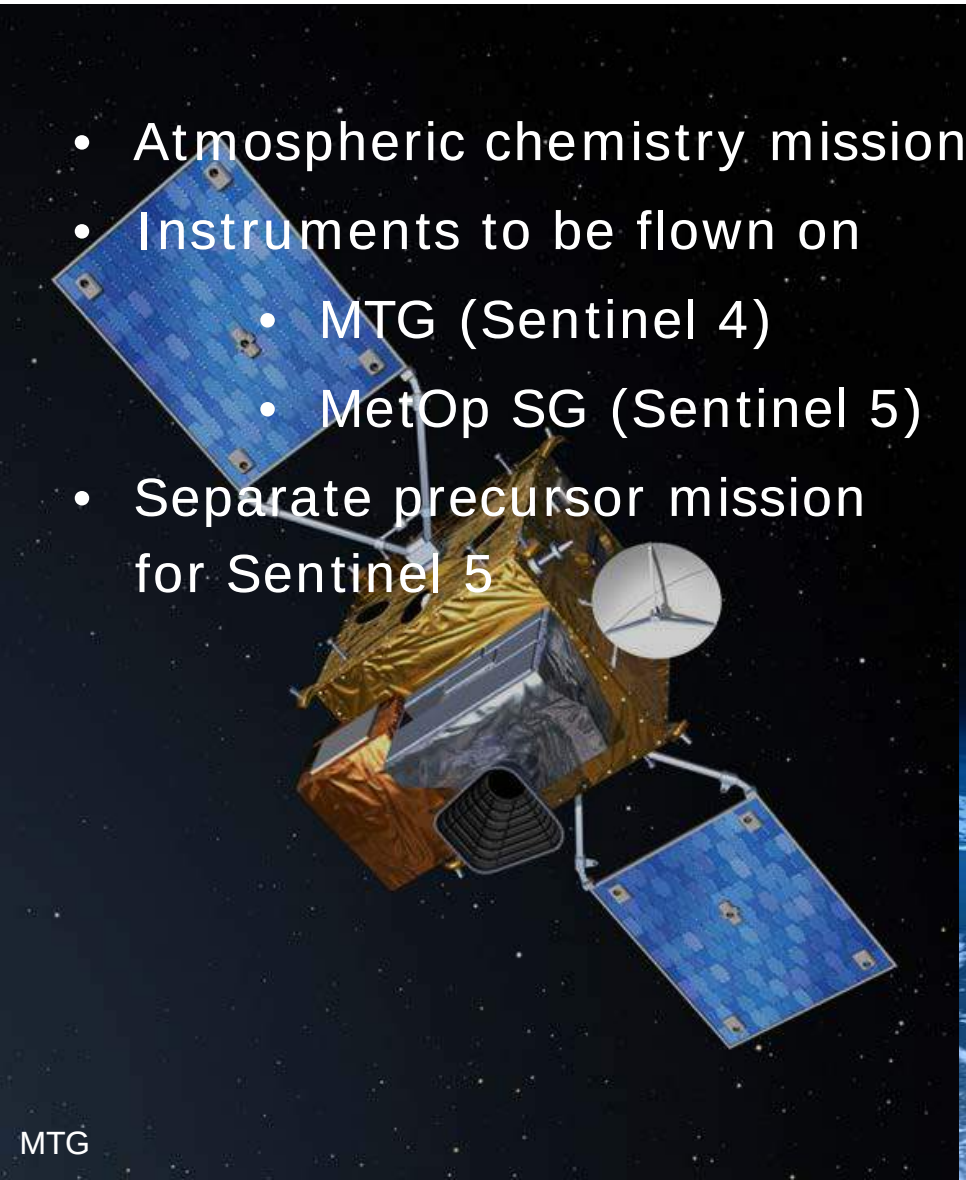
European Space Agency

Spectral Channels: (A)ATSR & SLSTR

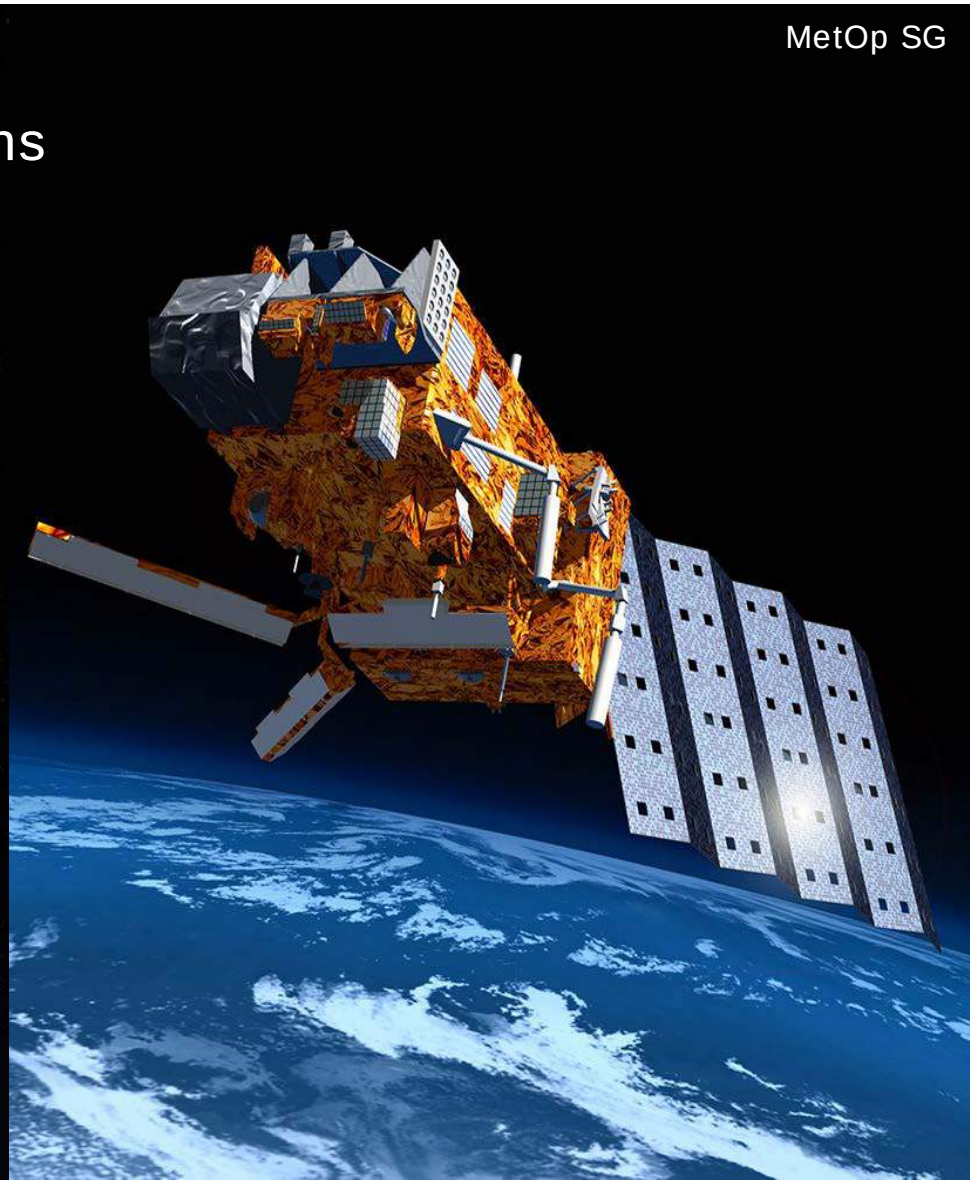
		ATSR-1	ATSR-2	AATSR	SLSTR
		ERS-1	ERS-2	ENVISAT	Sentinel3
Swath [km]	Nadir	500	500	500	1400
	oblique	500	500	500	740
SSI [km] VIS/SWIR	Resolution at sub sat point	1	1	1	0.5
SSI [km] IR		1	1	1	1
Band 1[12]	Chlorophyll	-	0.555	0.555	0.555
Band 2	Veg. Index	-	0.659	0.659	0.659
Band 3	Veg. Index	-	0.865	0.865	0.865
Band 4	Cloud clearing	-	-	-	1.375
Band 5	Cloud clearing	1.610	1.610	1.610	1.610
Band 6	Cloud clearing	-	-	-	2.250
Band 7	SST	3.740	3.740	3.740	3.740
Band 7 F	Fire	-	-	-	3.740
Band 8	SST	10.850	10.850	10.850	10.850
Band 8 F	Fire	-	-	-	10.850
Band 9	SST	12.000	12.000	12.000	12.000
Life time [years]	As designed	3	3	5	7.5
	As flown	1991-2000	1995-2008	2002-2012	

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

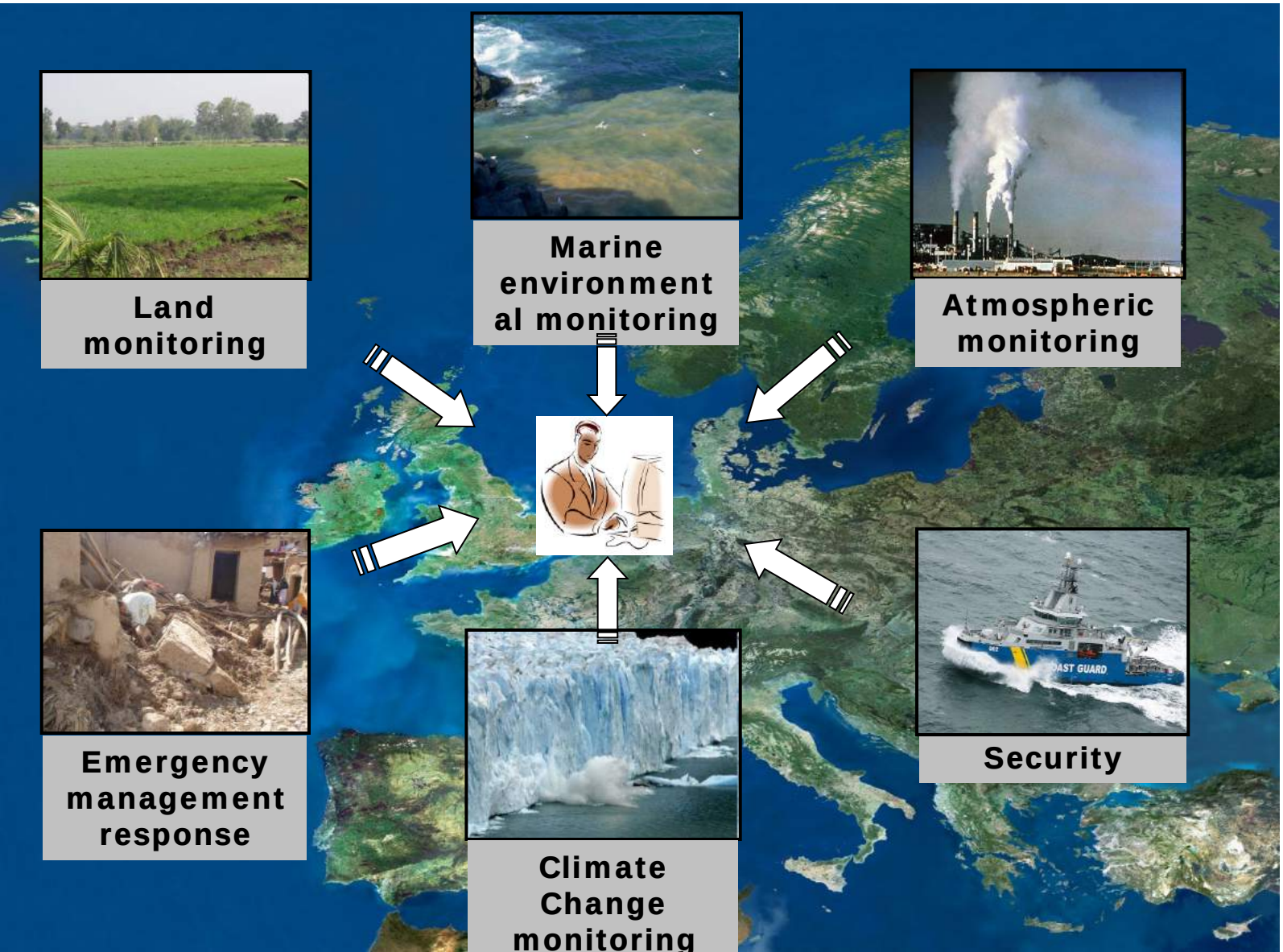


MTG



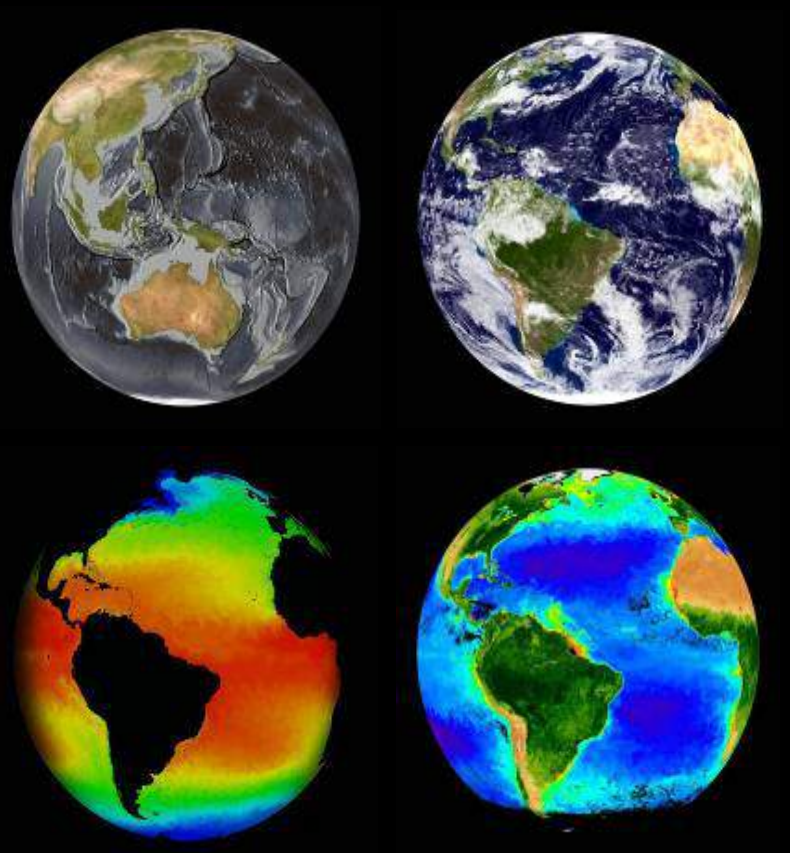
MetOp SG

GMES / Copernicus Services domains



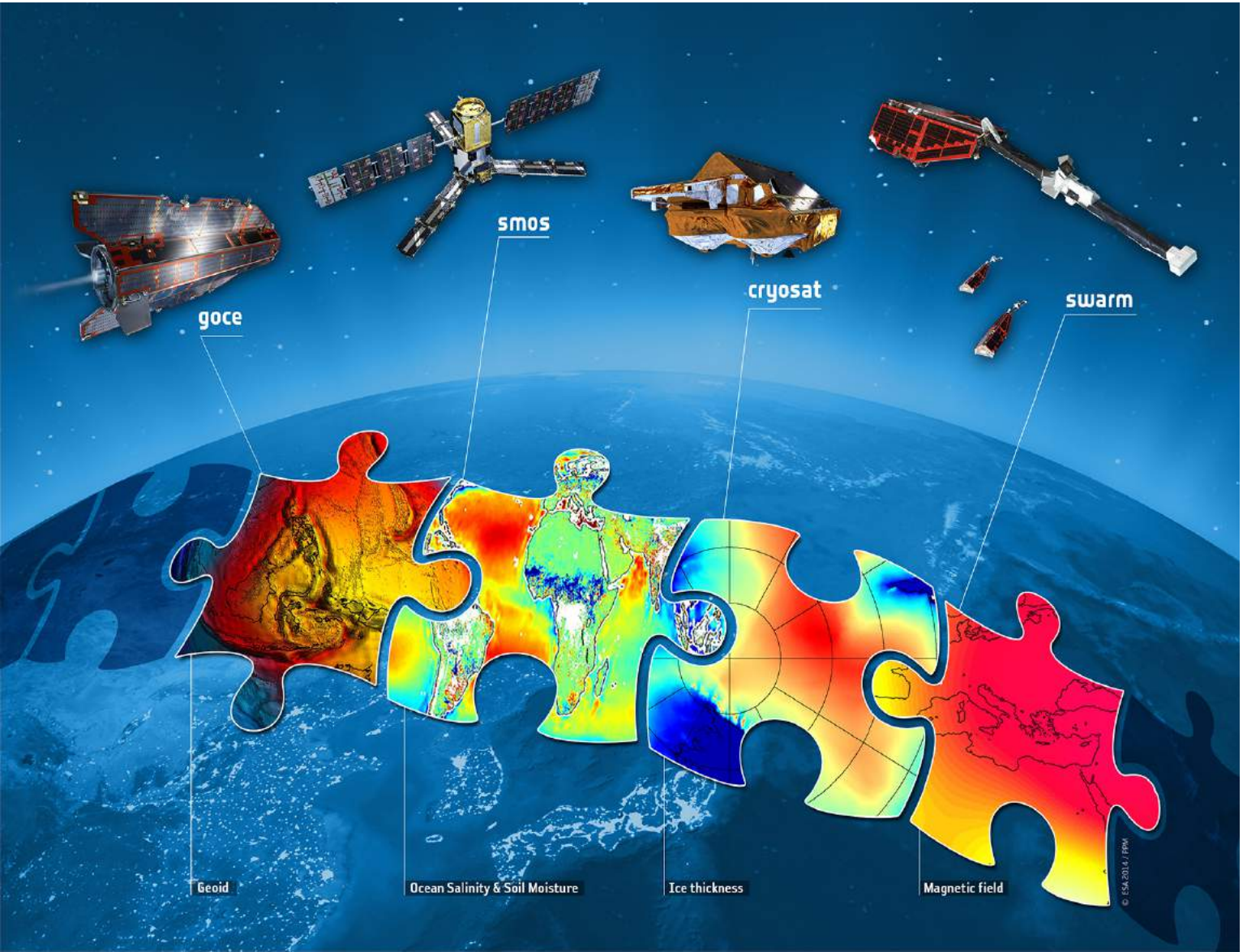
CCI: Essential Climate Variables

- 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



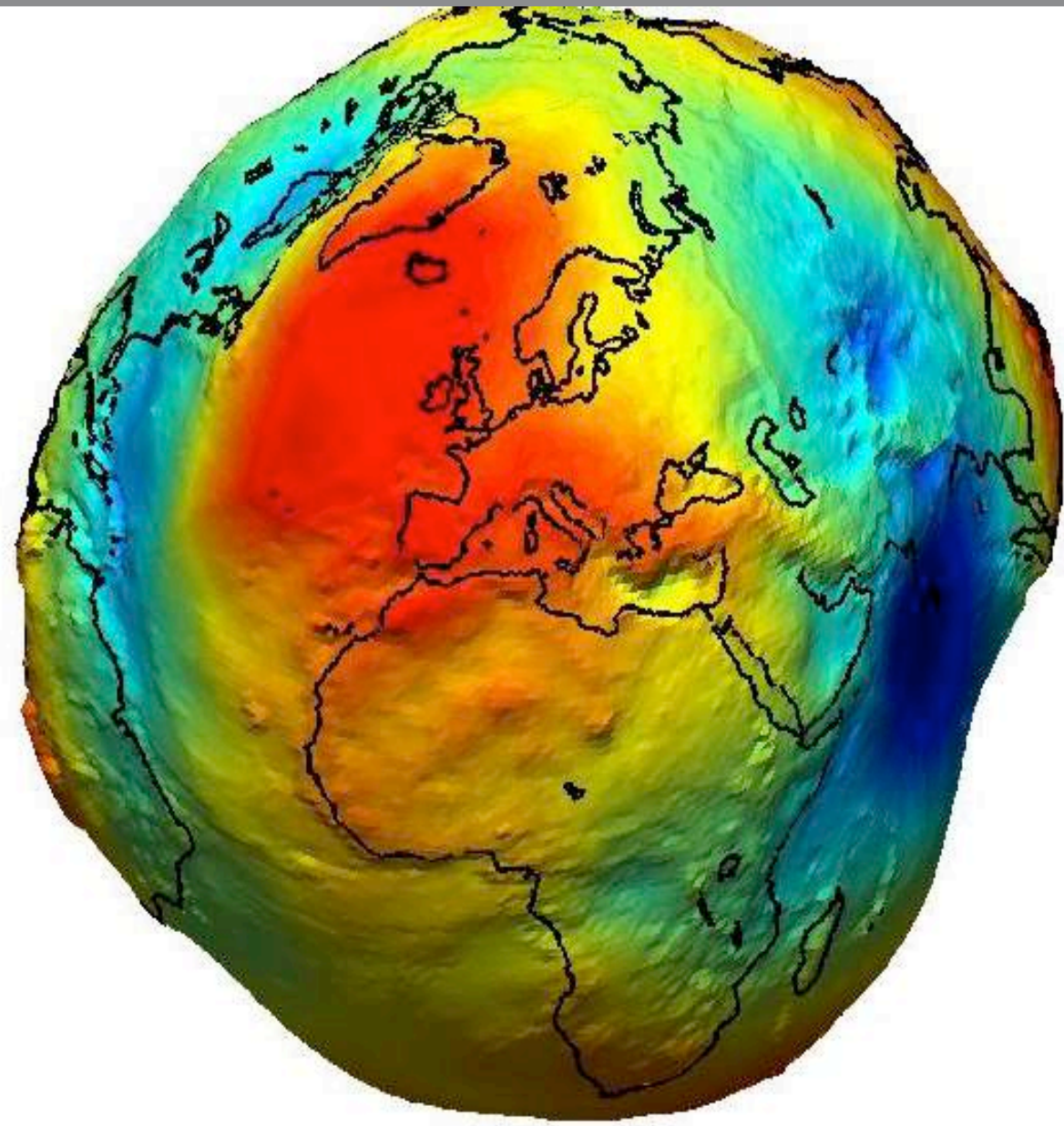
Science – the Earth Explorers

Science – the Earth Explorers



Earth Explorers launched so far

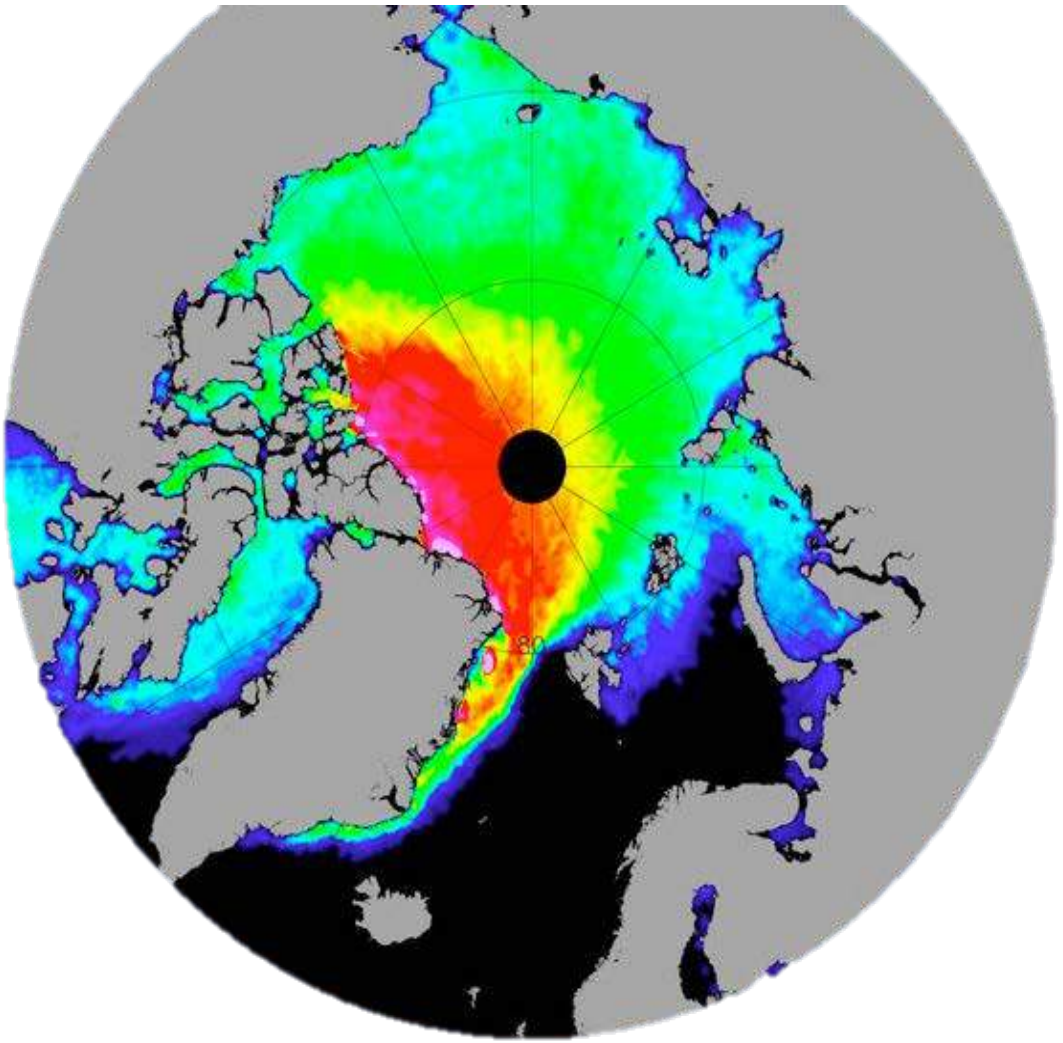
GOCE: Mission accomplished



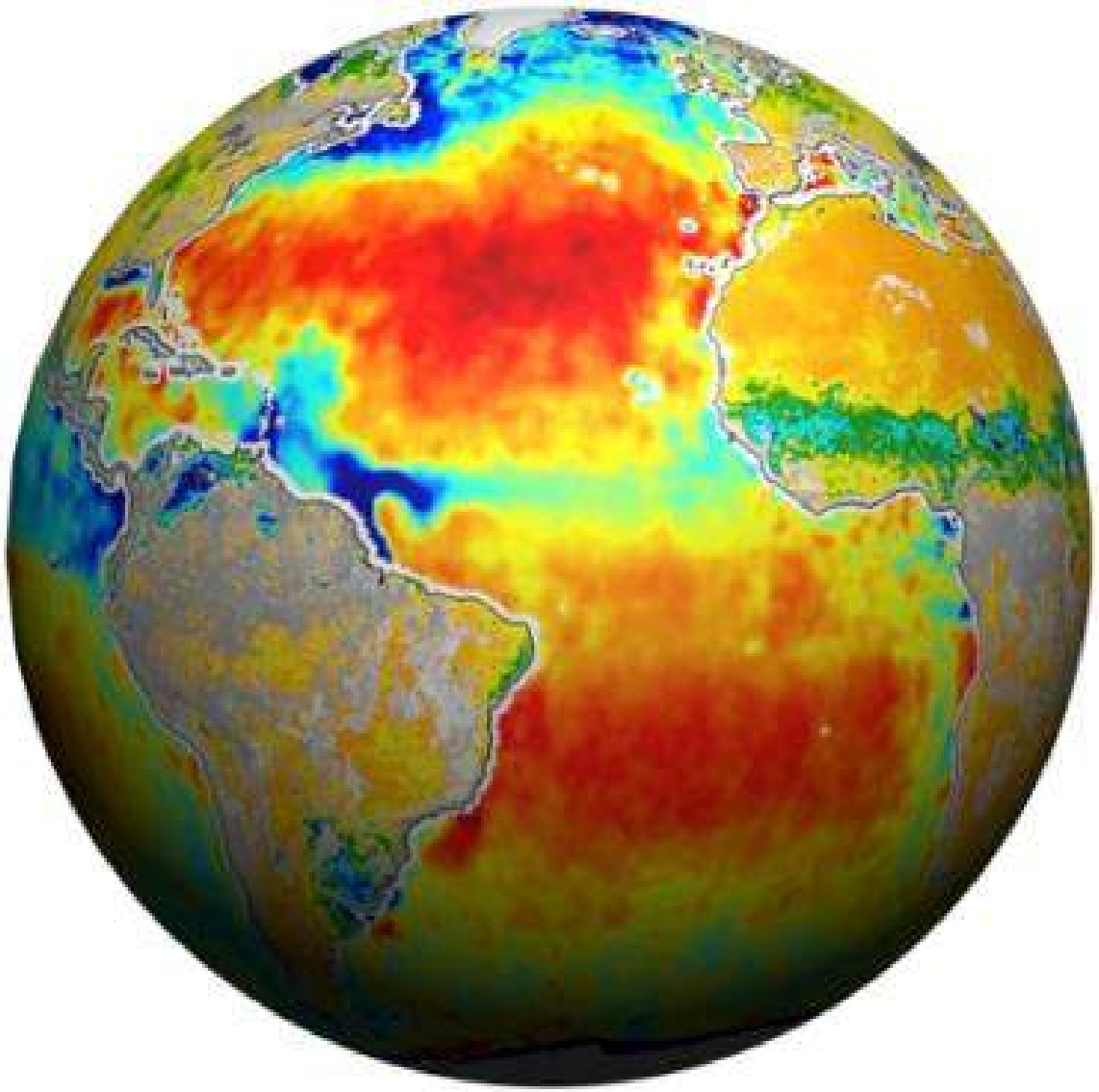
Most precise geoid to date

Cryosat: Mission accomplished and ongoing

Surveyed sea ice thickness

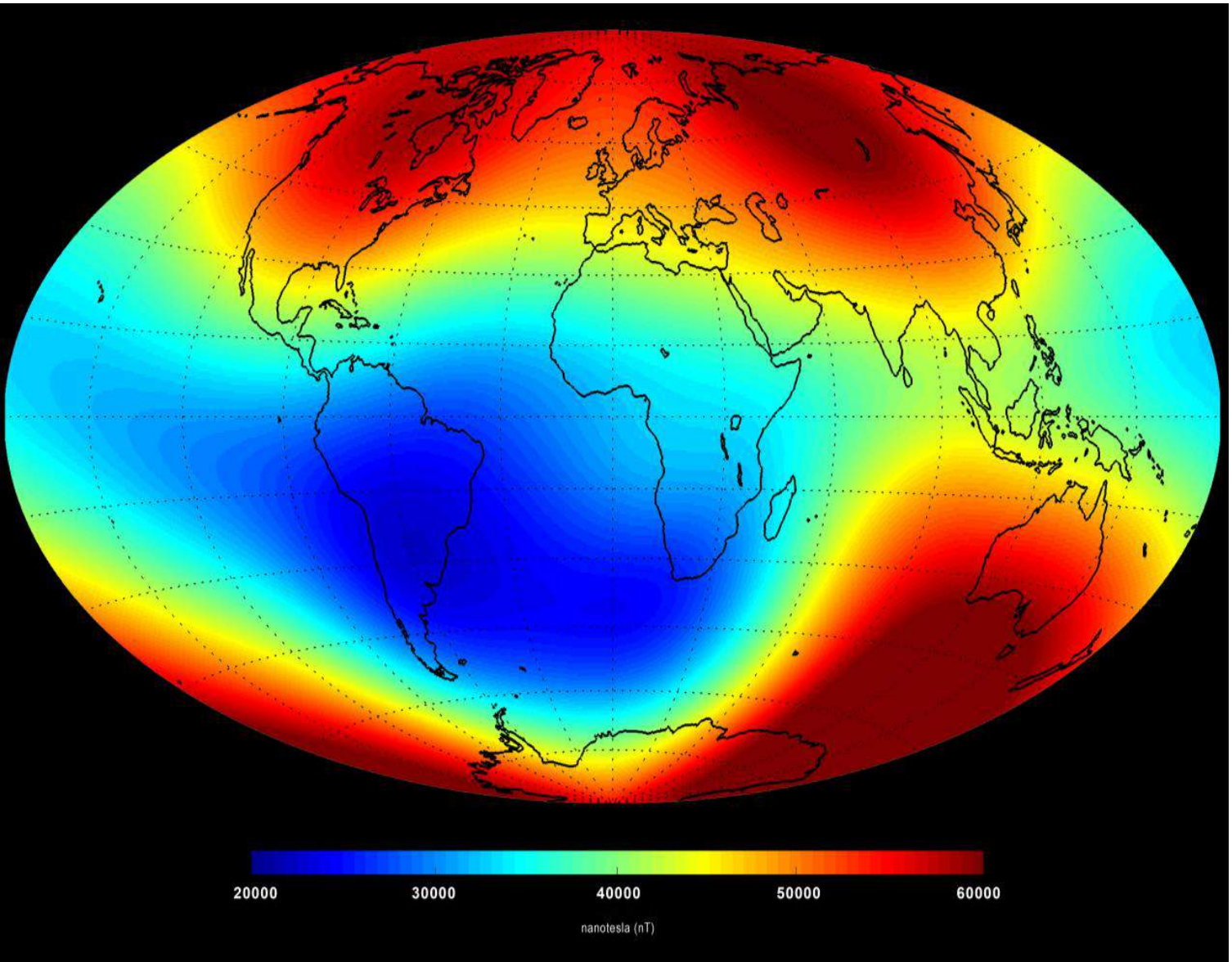


SMOS: Mission accomplished and ongoing



Monitoring soil moisture and ocean salinity. Globally.

Swarm: Mission accomplished and ongoing



Tracking Earth's dynamic magnetic field.

ADM-Aeolus and EarthCARE

ADM-Aeolus

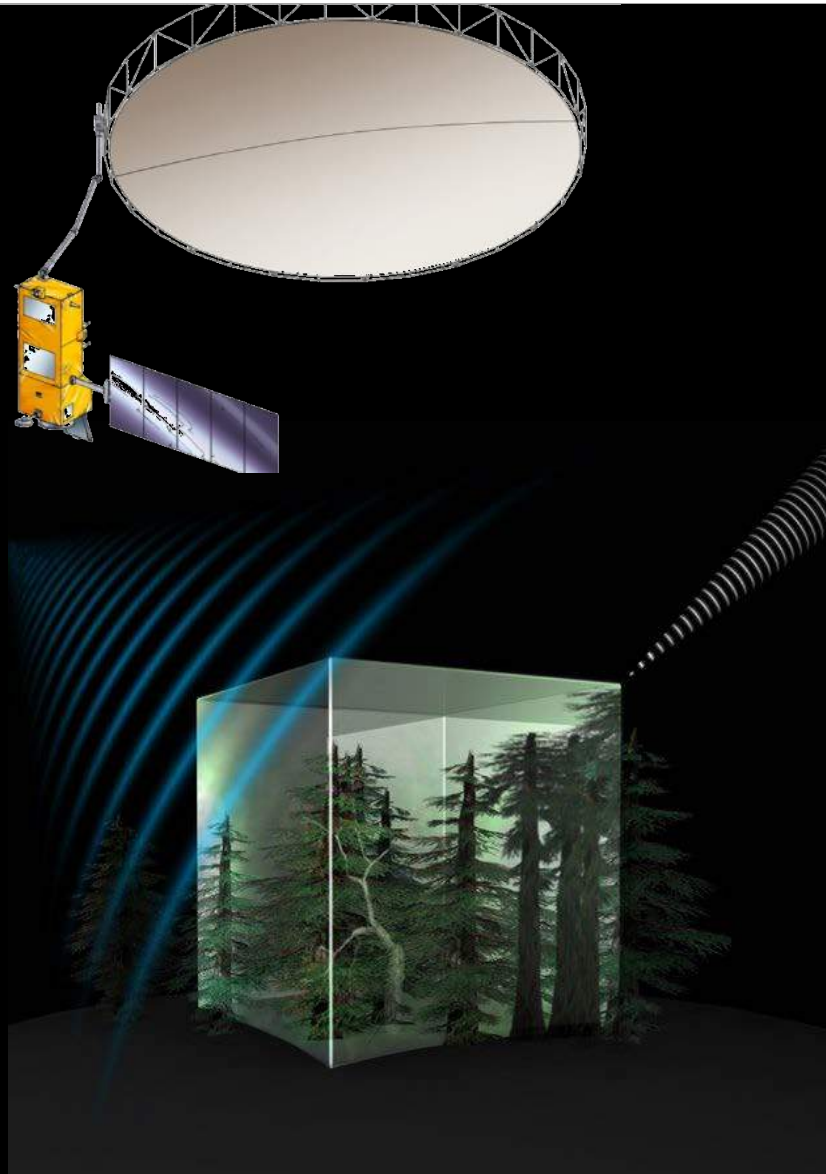
- Global observations of wind profiles for analysis of global 3D wind field
- Launch end 2017

EarthCARE

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

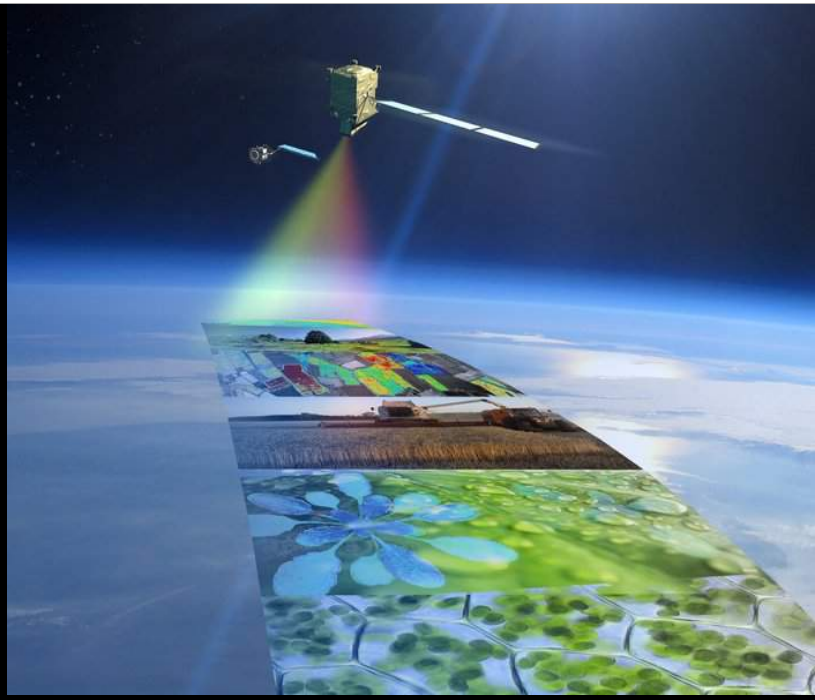
Biomass, the 7th Earth Explorer

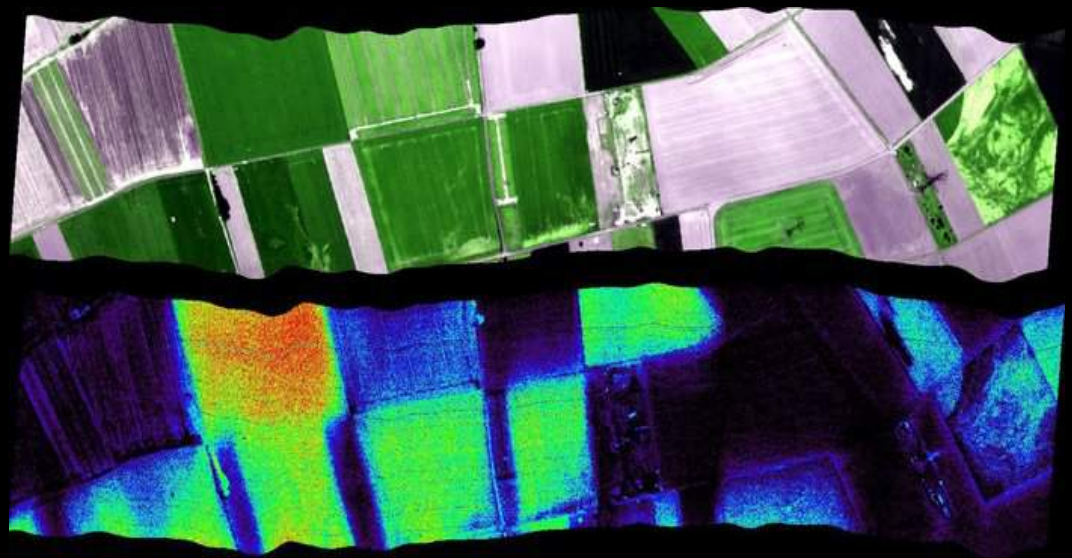
- Implementation decided by ESA's Earth Observation Programme Board in February 2015
- Biomass estimates based on global interferometric and polarimetric P-Band Radar observations
- Essential to understand the Earth's carbon cycle
- To be launched in 2020



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






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 | Google | Most Visited | Getting Started

esa Earthnet Online

Login My Earthnet | Register | 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 (19.5mb)
- Bilko
- ILWIS

Key Resources

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

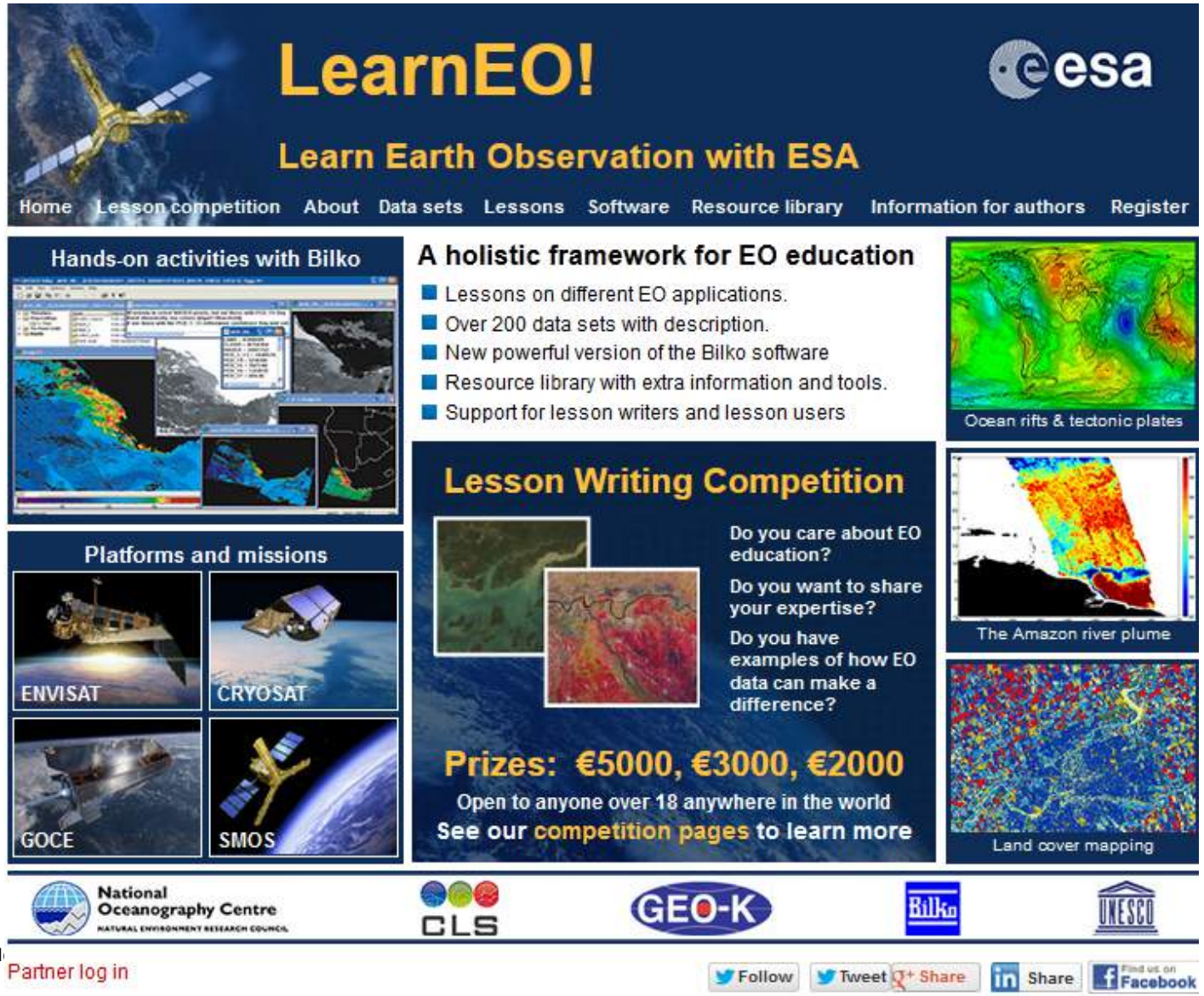
LearnEO!

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**



ESA Living Planet Symposium 2016

PRAGUE 09-13 MAY 2016

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

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

Programme of this course

	Monday, May 30	Tuesday, May 31	Wednesday, June 1	Thursday, June 2	Friday, June 3	Saturday, June 4
8:30-10:00	Welcome and Introduction Fr. Sarti SAR Introduction Chr. Thiel	SAR and Forestry Chr. Thiel	SAR Land applications Fr. Holecz	SAR Interferometry and applications R. Hanssen	Maritime and Water Applications M. Gade	Flood monitoring A. Mouratidis
11:00-11:15	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11:15-13:00	SAR Introduction Chr. Thiel	SAR and Forestry Chr. Thiel	SAR Land applications Fr. Holecz	SAR Interferometry and applications R. Hanssen	Maritime and Water Applications M. Gade	Synergy of EO-GNSS-GIS A. Mouratidis
13:00-14:00	Lunch	Lunch	Lunch	Lunch	Lunch	Social event: Excursion to the old town of Plovdiv
14:00-15:30	SAR Introduction Chr. Thiel	SAR and Forestry Chr. Thiel	SAR Land applications (Practicals) A. Mouratidis M. Ilieva	Earthquakes/Subsidence (Practicals) A. Mouratidis M. Ilieva	Maritime and Water Applications M. Gade	
15:30-15:45	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	
15:45-17:30	SAR Pre-processing (Practicals) Chr. Thiel	SAR and Forestry (Practicals) Chr. Thiel	SAR Land applications (Practicals) A. Mouratidis M. Ilieva	Earthquakes/Subsidence (Practicals) A. Mouratidis M. Ilieva	Maritime and Water Applications M. Gade Certificate ceremony	
18:00-20:00	Social event: Dinner for all participants and lecturers					