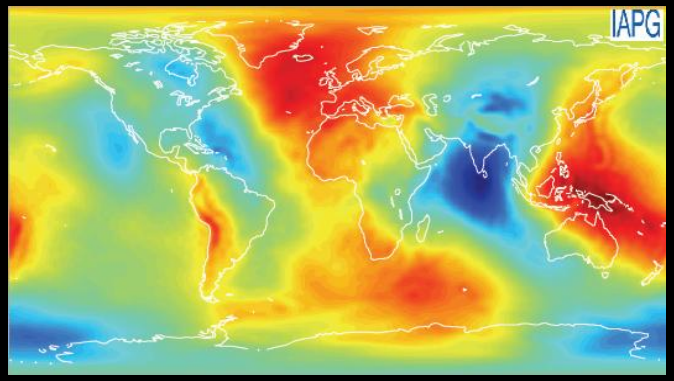
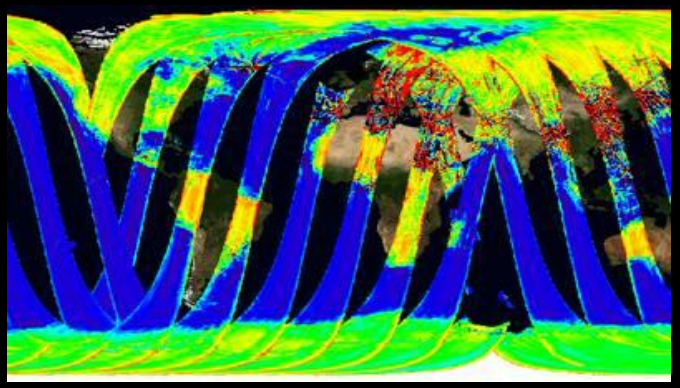
ESA Earth Observation programme and results. Educational activities





Dr. Francesco Sarti

Scientific Coordinator for Education and Training

ESA Earth Observation

20 MEMBER STATES AND GROWING

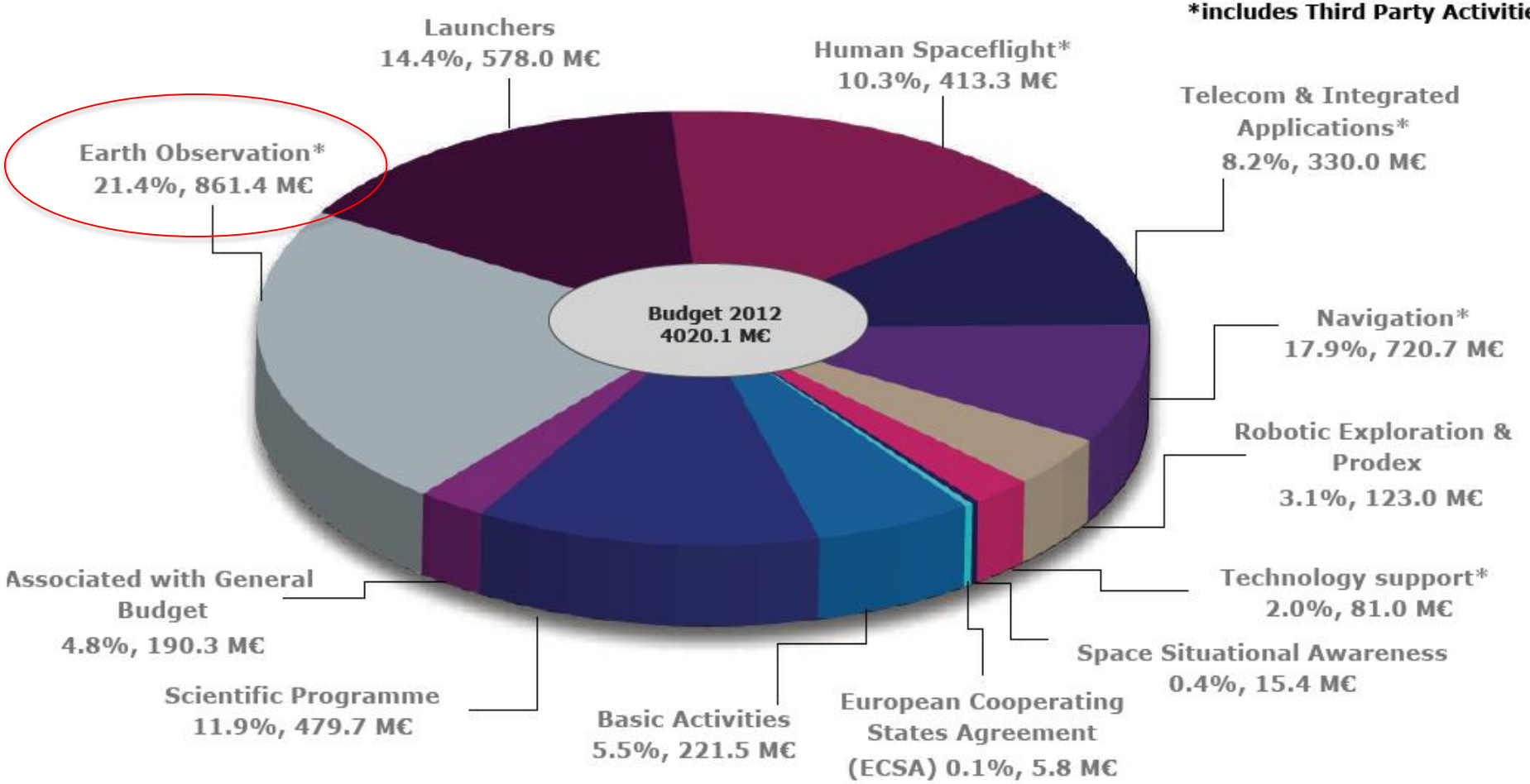
ESA has 20 Member States: 18 states of the EU (AT, BE, CZ, DE, DK, ES, FI, FR, IT, GR, IE, LU, NL, PO, PT, RO, SE, UK) plus Norway and Switzerland.

Eight other EU states have Cooperation Agreements with ESA: Estonia, Slovenia, Poland, Hungary, Cyprus, Latvia, Lithuania and the Slovak Republic. Bulgaria and Malta are negotiating Cooperation Agreements.

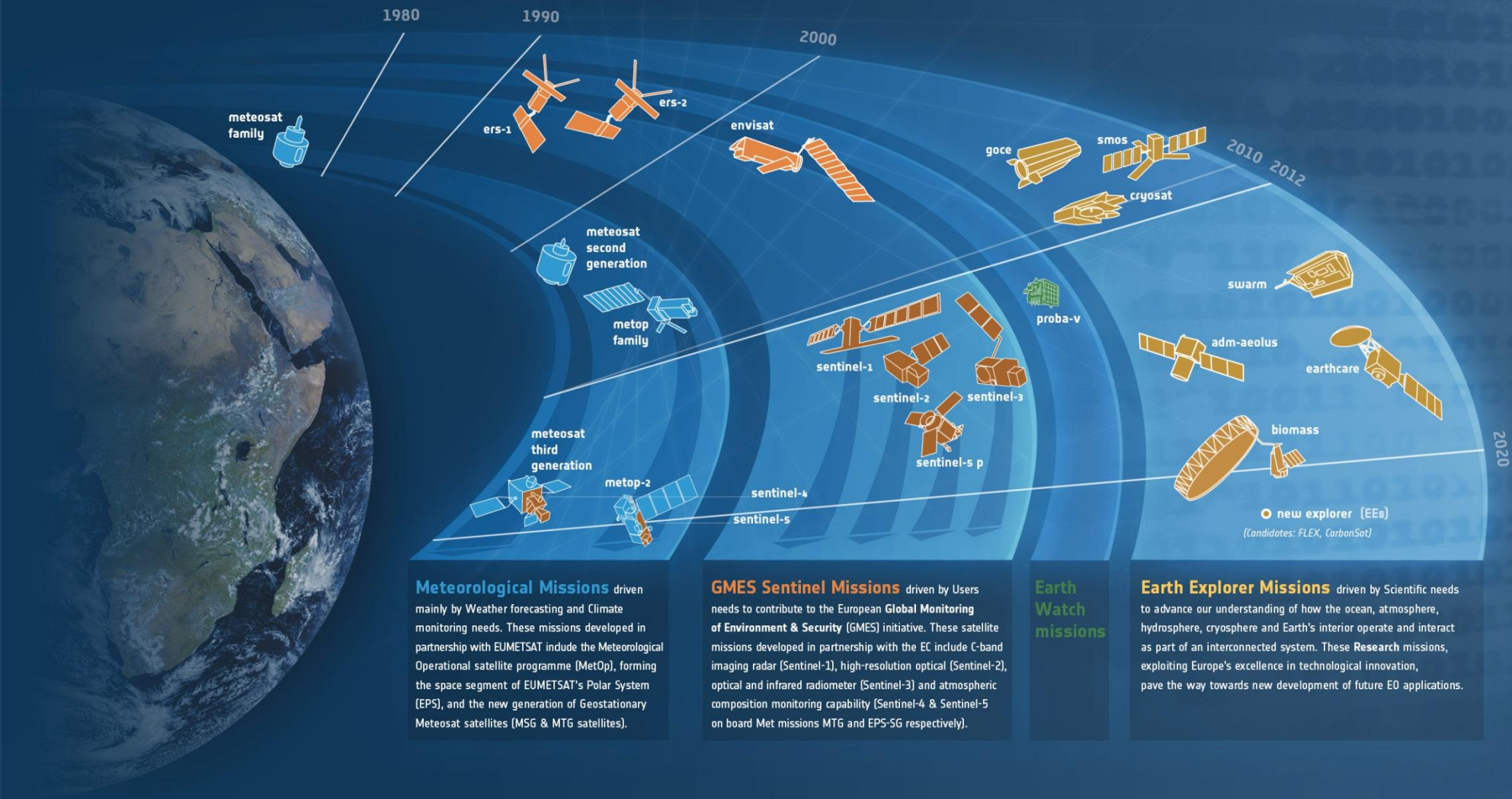
Canada takes part in some programmes under a Cooperation Agreement.

M€: Million Euro

*includes Third Party Activities



→ THE ESA EARTH OBSERVATION PROGRAMME



Meteorological Missions driven mainly by Weather forecasting and Climate monitoring needs. These missions developed in partnership with EUMETSAT include the Meteorological Operational satellite programme (MetOp), forming the space segment of EUMETSAT's Polar System (EPS), and the new generation of Geostationary Meteosat satellites (MSG & MTG satellites).

GMES Sentinel Missions driven by Users needs to contribute to the European **Global Monitoring of Environment & Security** (GMES) initiative. These satellite missions developed in partnership with the EC include C-band imaging radar (Sentinel-1), high-resolution optical (Sentinel-2), optical and infrared radiometer (Sentinel-3) and atmospheric composition monitoring capability (Sentinel-4 & Sentinel-5 on board Met missions MTG and EPS-SG respectively).

Earth Watch missions

Earth Explorer Missions driven by Scientific needs to advance our understanding of how the ocean, atmosphere, hydrosphere, cryosphere and Earth's interior operate and interact as part of an interconnected system. These **Research** missions, exploiting Europe's excellence in technological innovation, pave the way towards new development of future EO applications.

Earth Observation: *headlines*

BBC Home | News | Sport | Weather | TV | Radio | More...

NEWS Watch ONE-MINUTE WORLD NEWS

'Tuned' images from Esa's Smos water mission

Glacier-melting debate highlights importance of satellites

1 Febru
The int

FEATURES & SPECIAL REPORTS

Satellites help conserve Egypt's wildlife

5.19.2010 12:22 pm

BP Gulf Oil Spill Visible from Space (Pictures)

Envisat keeping an eye on the Eyjafjallajoekull volcano

21 April 2010

Telegraph.co.uk

Shocking new satellite images of Haiti show scale of earthquake devastation

BBC NEWS 2 WEEKS AGO

Cryosat-2 focuses on ice target

Cryosat has to be able to distinguish the floes from the leads The Cryosat-2 r
its promise to make high-precision radar measurements of polar ice. The first
spacecraft has been presented at... FULL ARTICLE AT BBC NEWS

7 March 2011 Last updated at 14:51 GMT

Christchurch quake mapped from space

By Jonathan Amos
Science correspondent, BBC

Satellite Photos Show Devastation From Japan Quake

Science News

Value Of Satellites Recognized For Conserving

ScienceDaily (Nov. 25, 2008) — Wetlands
contribute to our lives in remarkable ways by

enlarge

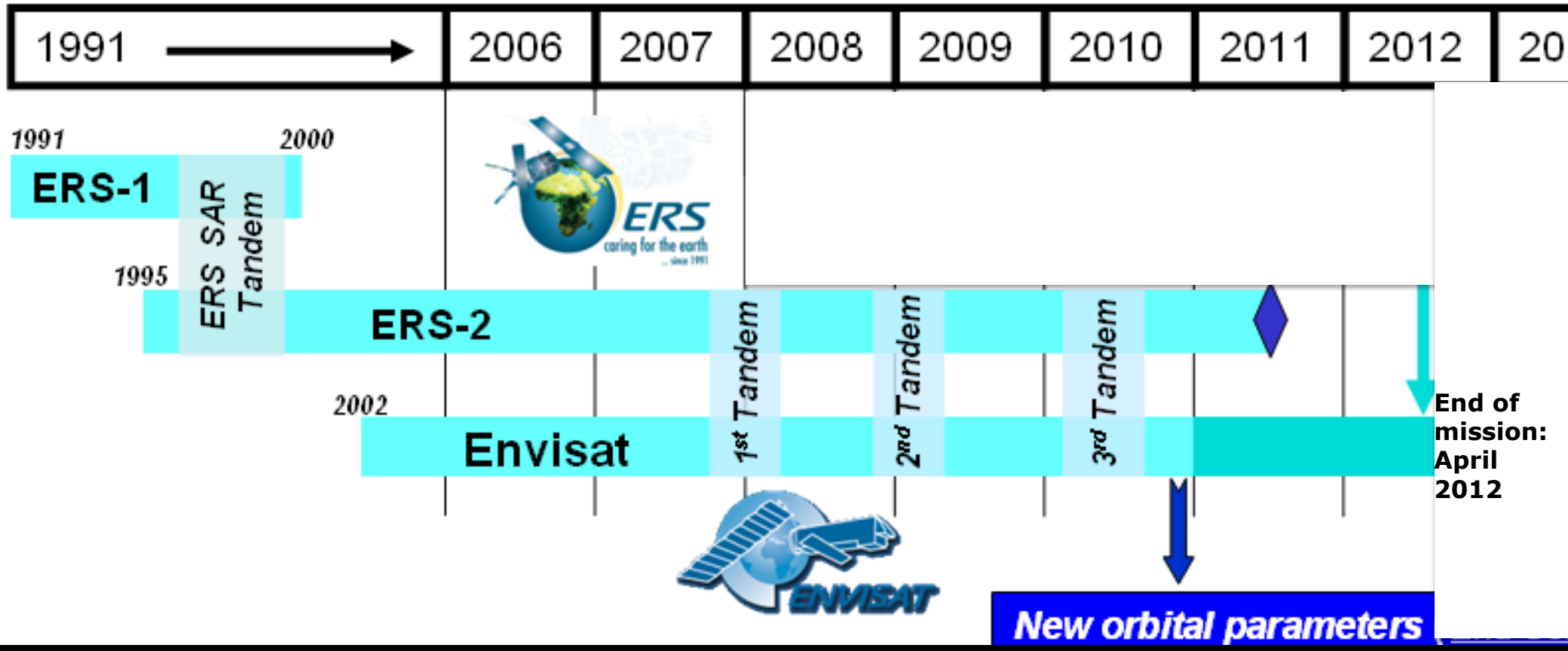
September 21, 2009 | 1 comments

http://www.scientificamerican.com/article.cfm?id=ozone-layer-depletion-lev

Ozone layer depletion levelling off

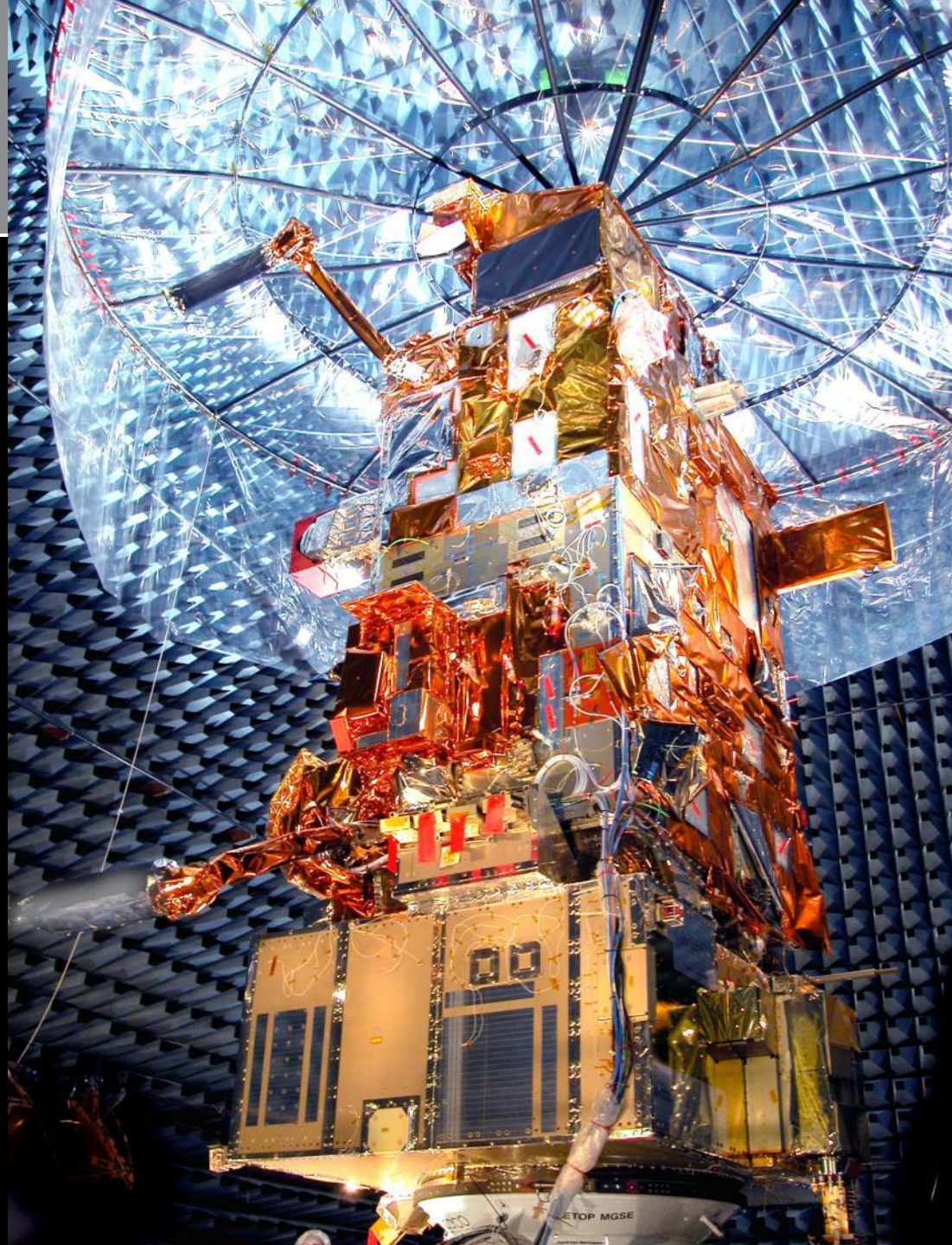
By merging more than a decade of atmospheric data from European satellites, scientists have compiled a homogeneous long-term ozone record that allows them to monitor total ozone trends on a global scale - and the findings look promising.

ERS-1: 10 years of operation
ERS-2: 16 years of operation
Envisat: 10 years of operation



ESA and meteorology

- Weather satellites: first operational field of Earth Observation *(Meteosat-1 was ESA's first EO satellite)*
- Meteosat series since 1978, now MSG, soon MTG
- Polar weather observations with MetOp satellites
- Successful cooperation with EUMETSAT



Simultaneous SAR and Optical acquisitions on ENVISAT (ASAR & MERIS) have been providing unique synergy

09–September–2008 15:29:38 (UTC)
ENVISAT WSM Product

ASAR

Currents

85°W 84°W 83°W 82°W 81°W 80°W
26°N 24°N 22°N 20°N 18°N

Radial Surface Velocity [m.s⁻¹]
−2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5

Powered by BOOST Technologies

Hurricane Ike (Sep. 2008)

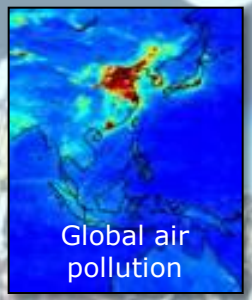
MERIS

Cuba

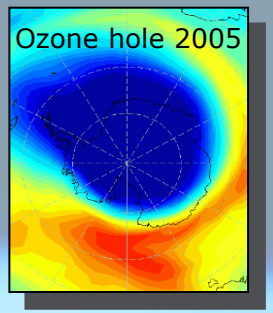
Simultaneous acquisition time

ENVISAT mission: 10 years

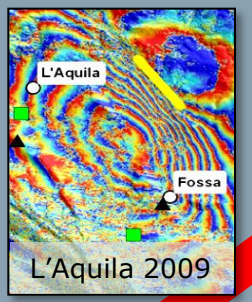

First images


Global air pollution

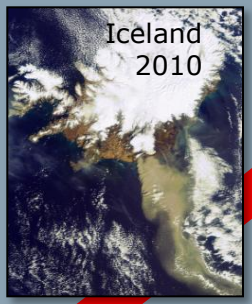

B-15A iceberg

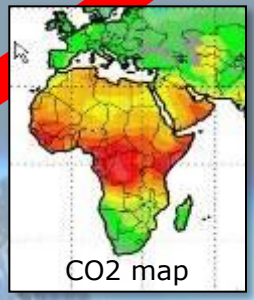

Ozone hole 2005

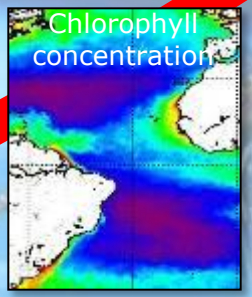

Arctic 2007

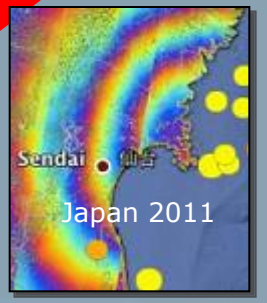


L'Aquila 2009


Iceland 2010

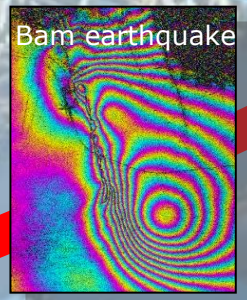

CO2 map


Chlorophyll concentration



Japan 2011


Hurricane Katrina


Bam earthquake


Prestige tanker oil slick


Launch

Serving 4000 scientific projects and many operational users

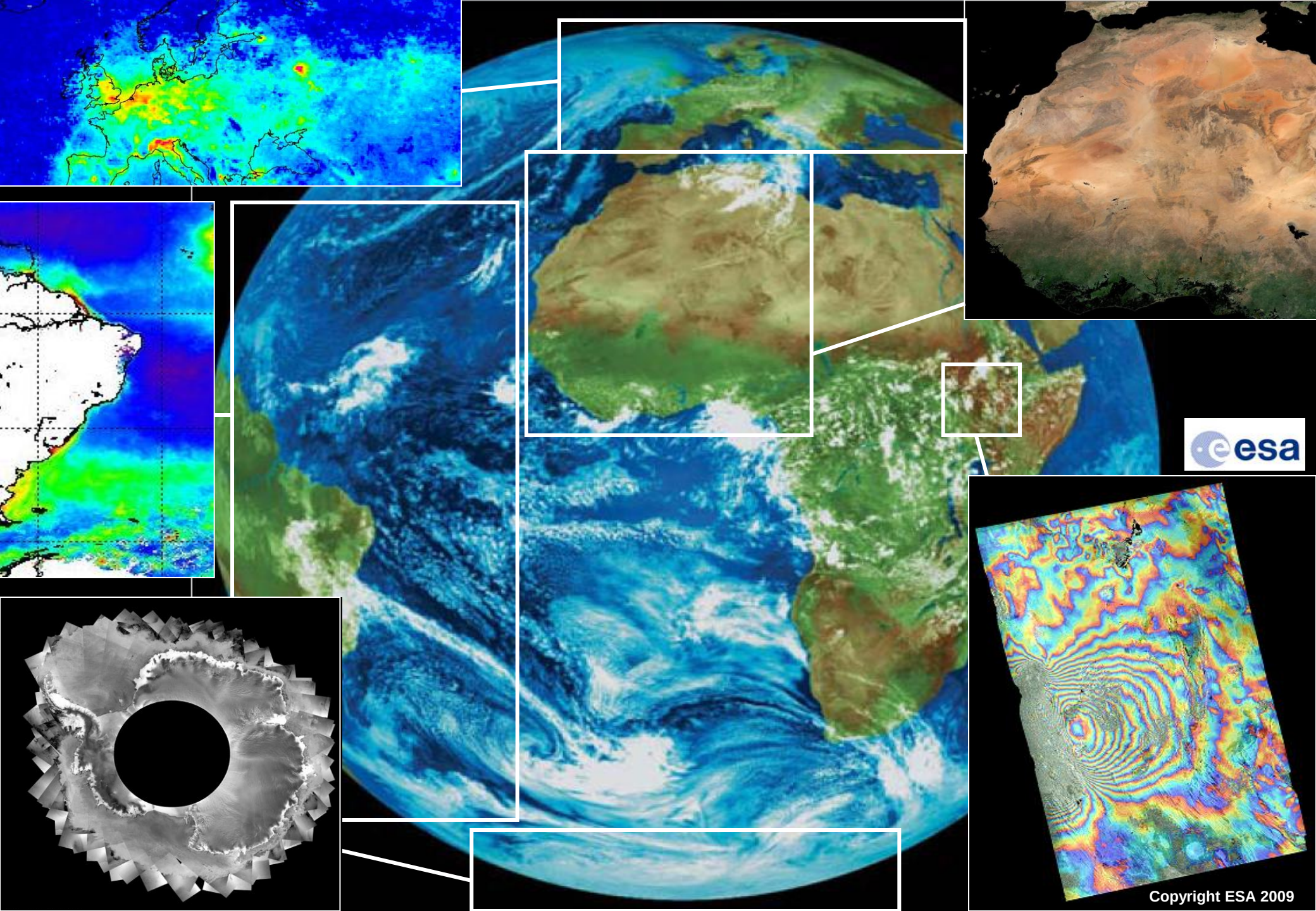
Envisat Symposium Salzburg (A)

Envisat Symposium Montreux (CH)

Living Planet Symposium Bergen (N)

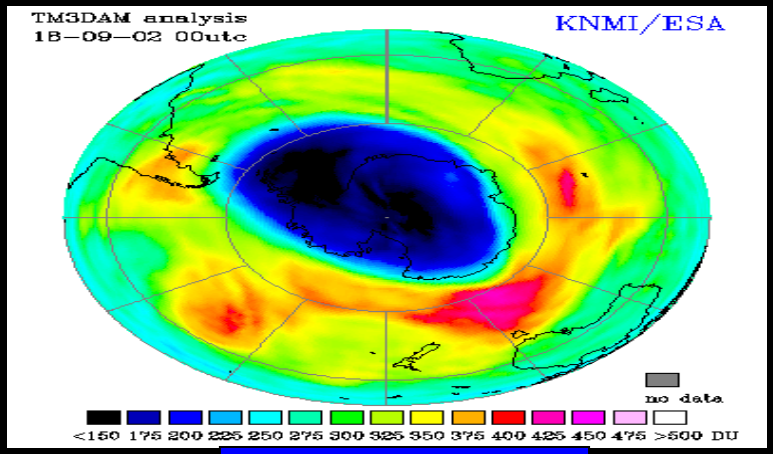
Mar 02 | **Sep 04** | **Apr 07** | **Jun 10** | **Mar 12**

and many workshops dedicated to specific Envisat user communities

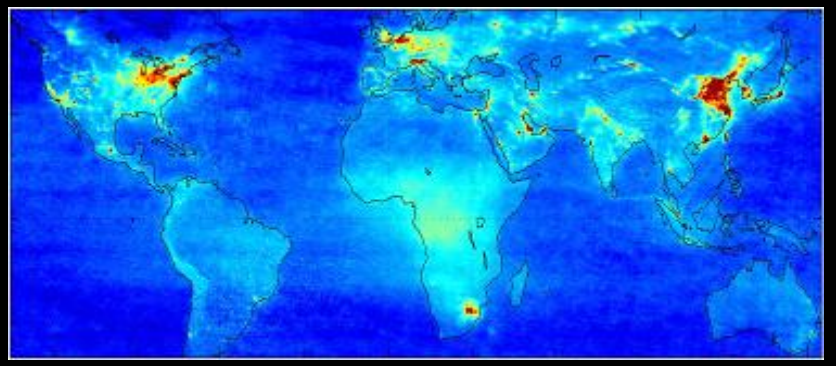

esa
Copyright ESA 2009

Major scientific results of ENVISAT and ERS

- **Atmosphere:** Worldwide monitoring of air pollution, evidence of fast growing air pollution in China since 1995
- **Climate change:** Global sea level rise of ~3mm/year and sea surface temperature increase of ~0.1 deg. C since 1992
- **Polar areas:** Daily monitoring of sea ice motion and observation of Antarctica ice-shelves collapse
- **Oceanography:** Quantification of global chlorophyll concentration, an index of the oceanic phytoplankton biomass
- **Tectonics:** Identification of the blind tectonic fault at the origin of the Bam earthquake in December 2003

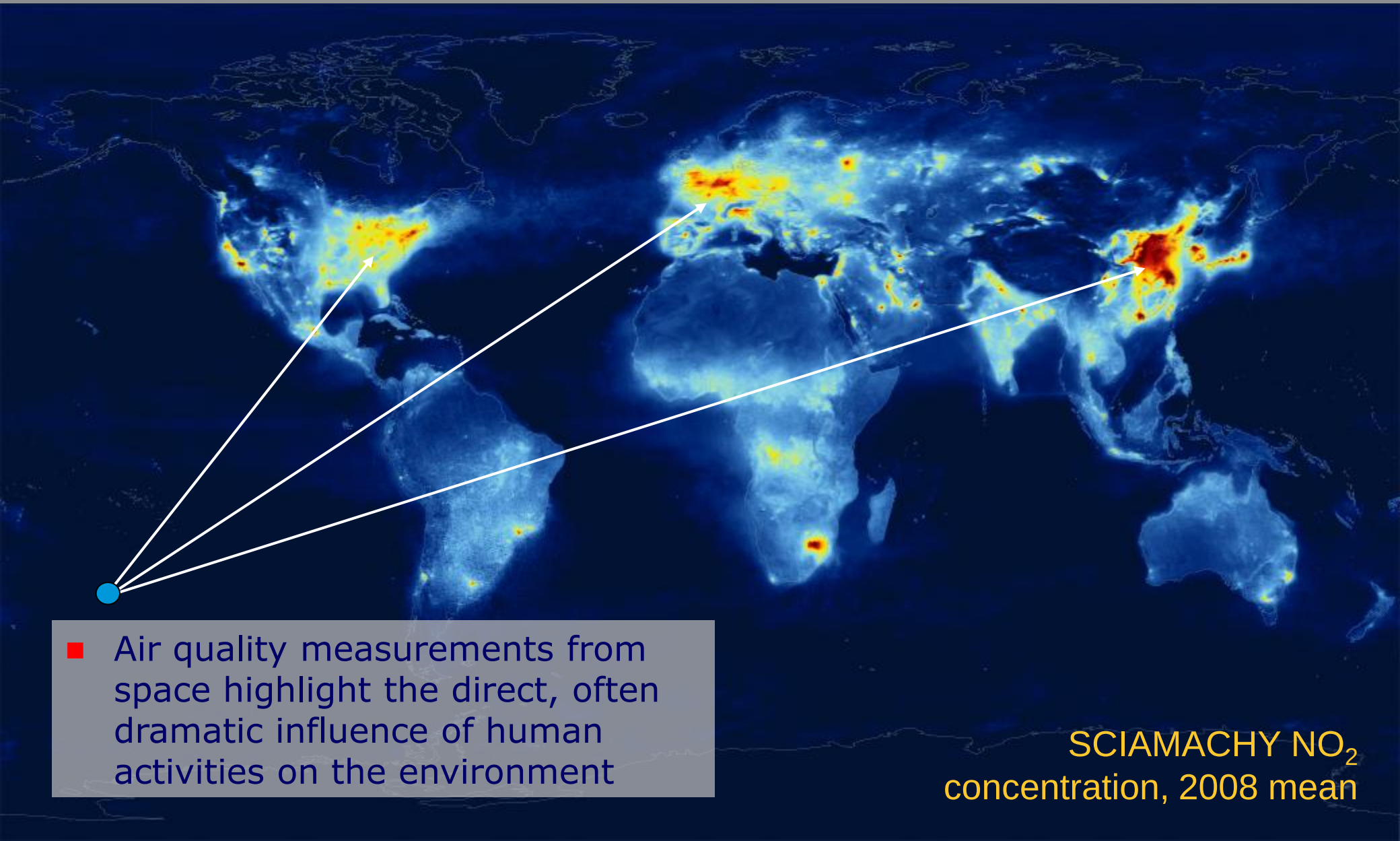


Ozone hole



NO_2 from SCIAMACHY (Jan. 2003 - June 2004)

Recent scientific headlines of Earth Observation:
The changing air quality

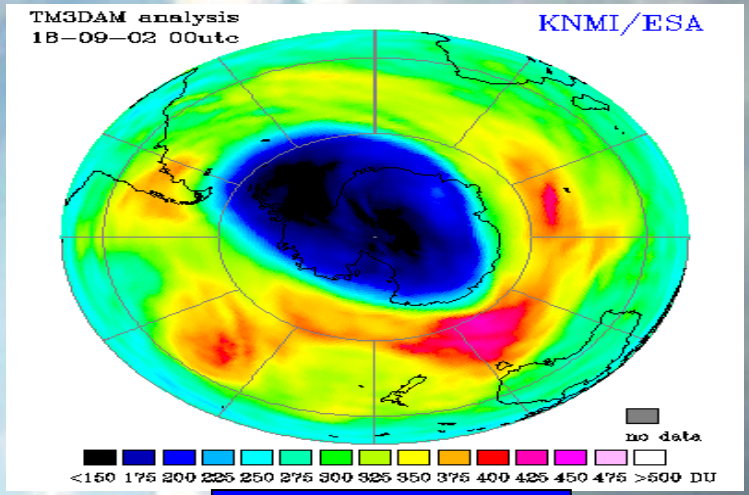


- Air quality measurements from space highlight the direct, often dramatic influence of human activities on the environment

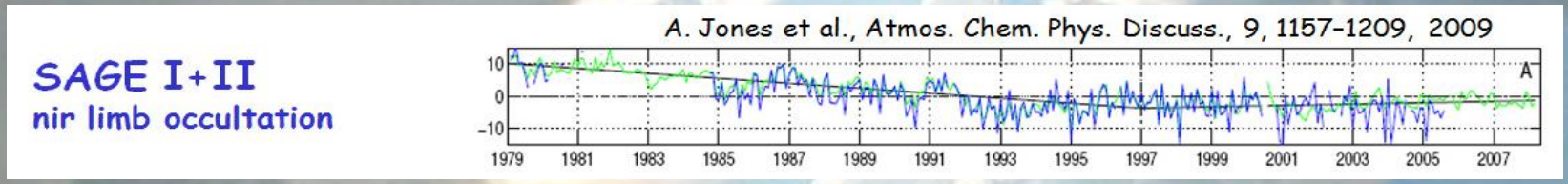
SCIAMACHY NO_2 concentration, 2008 mean

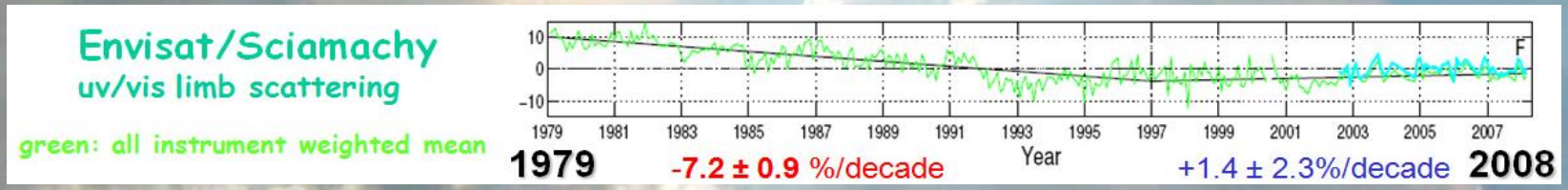
Ozone layer depletion levelling off

Slightly positive trend of global ozone increase of almost 1% per decade in the total ozone from the last 14 years
(result confirmed by comparisons with ground-based measurements)

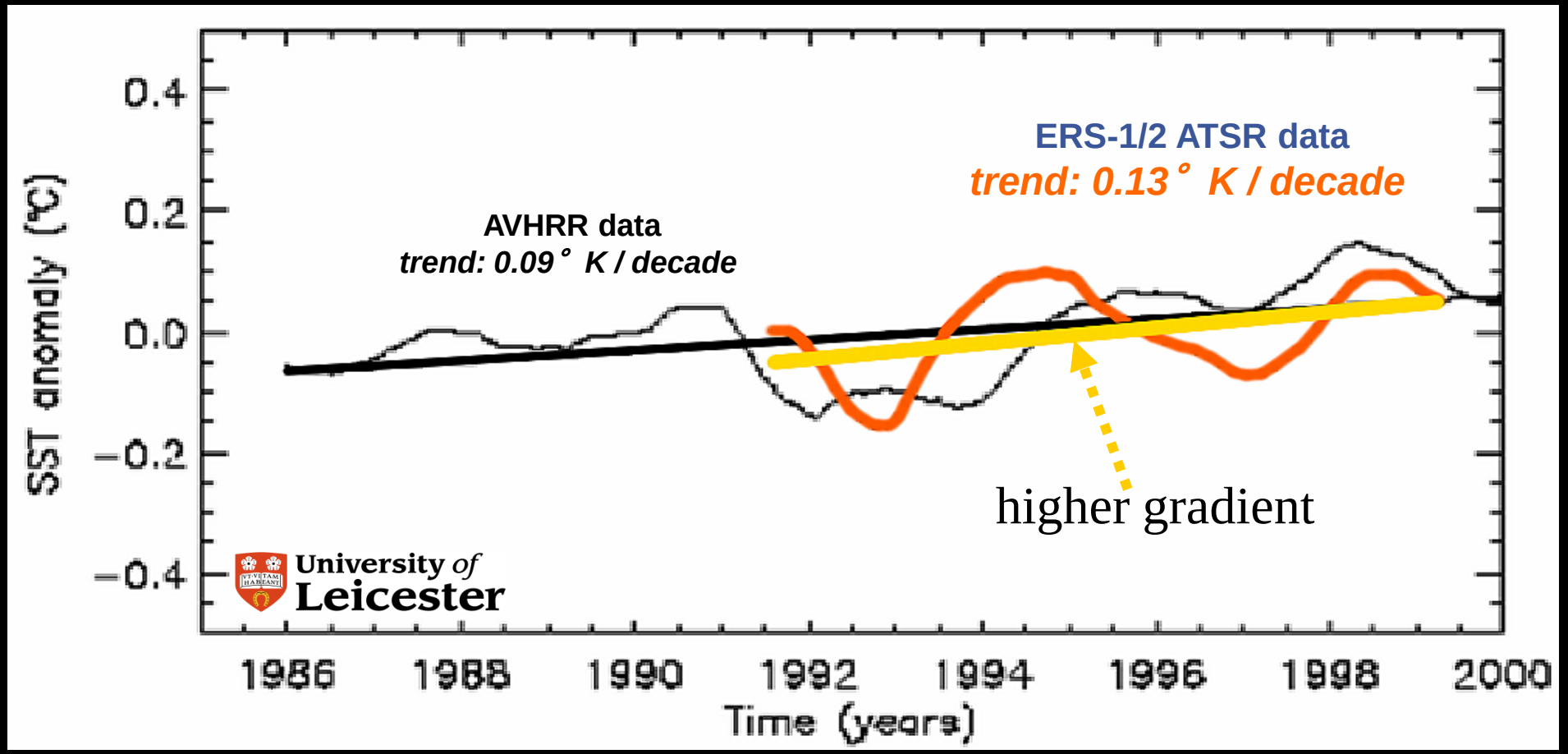


Ozone hole





Recent scientific headlines of Earth Observation:
Residual Trends in Global Sea Surface Temperature



Recent scientific headlines of Earth Observation:
Global Sea Level Rise

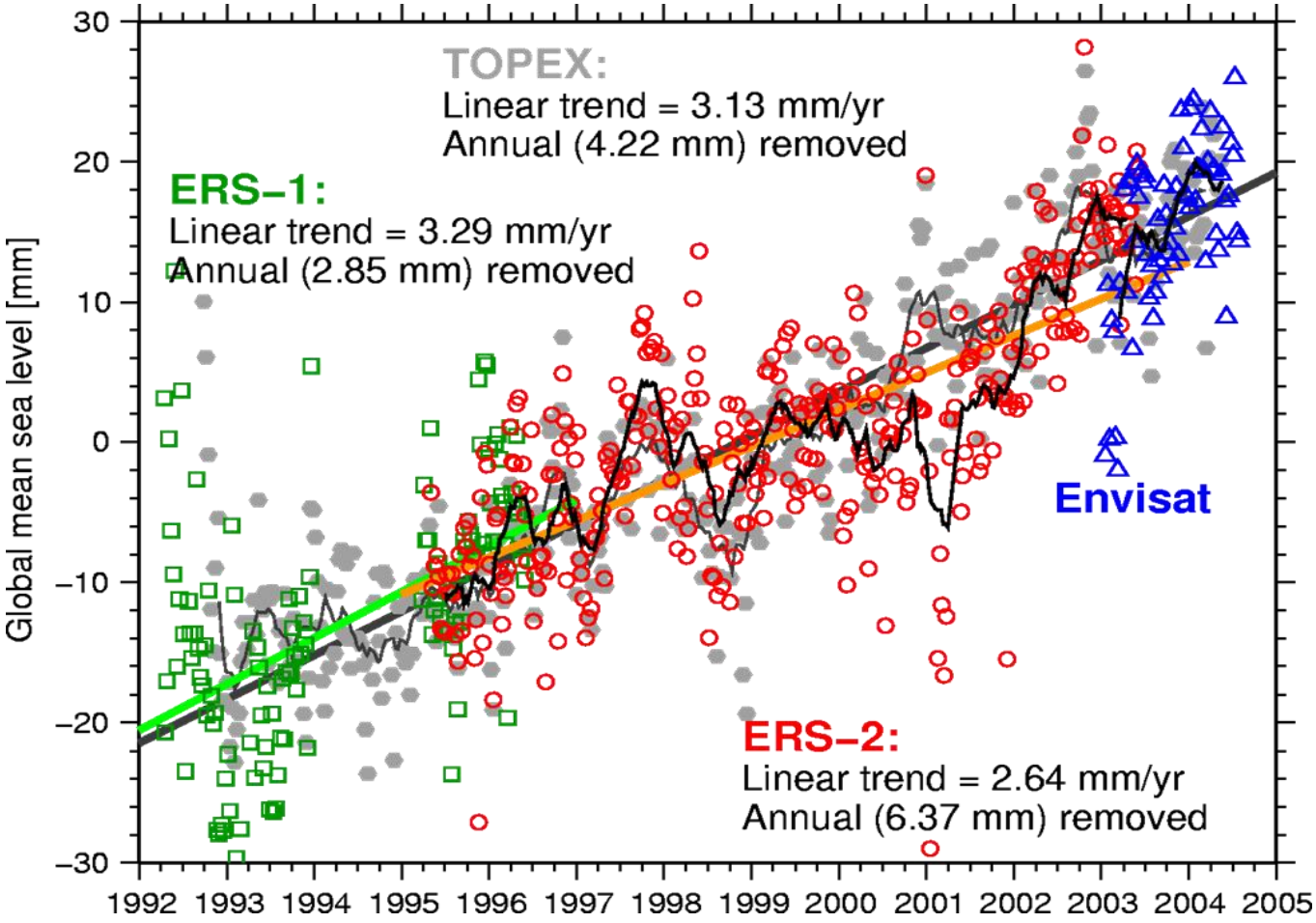
The ENVISAT altimeter has been providing continuity to the measurements initiated in the early 1990

Sea level rise

Trend: +3 mm/yr

Sea Level Rise: Thermal expansion of the oceans and melting ice

Problems for countries with low reliefs like Bangladesh (food security, etc.)

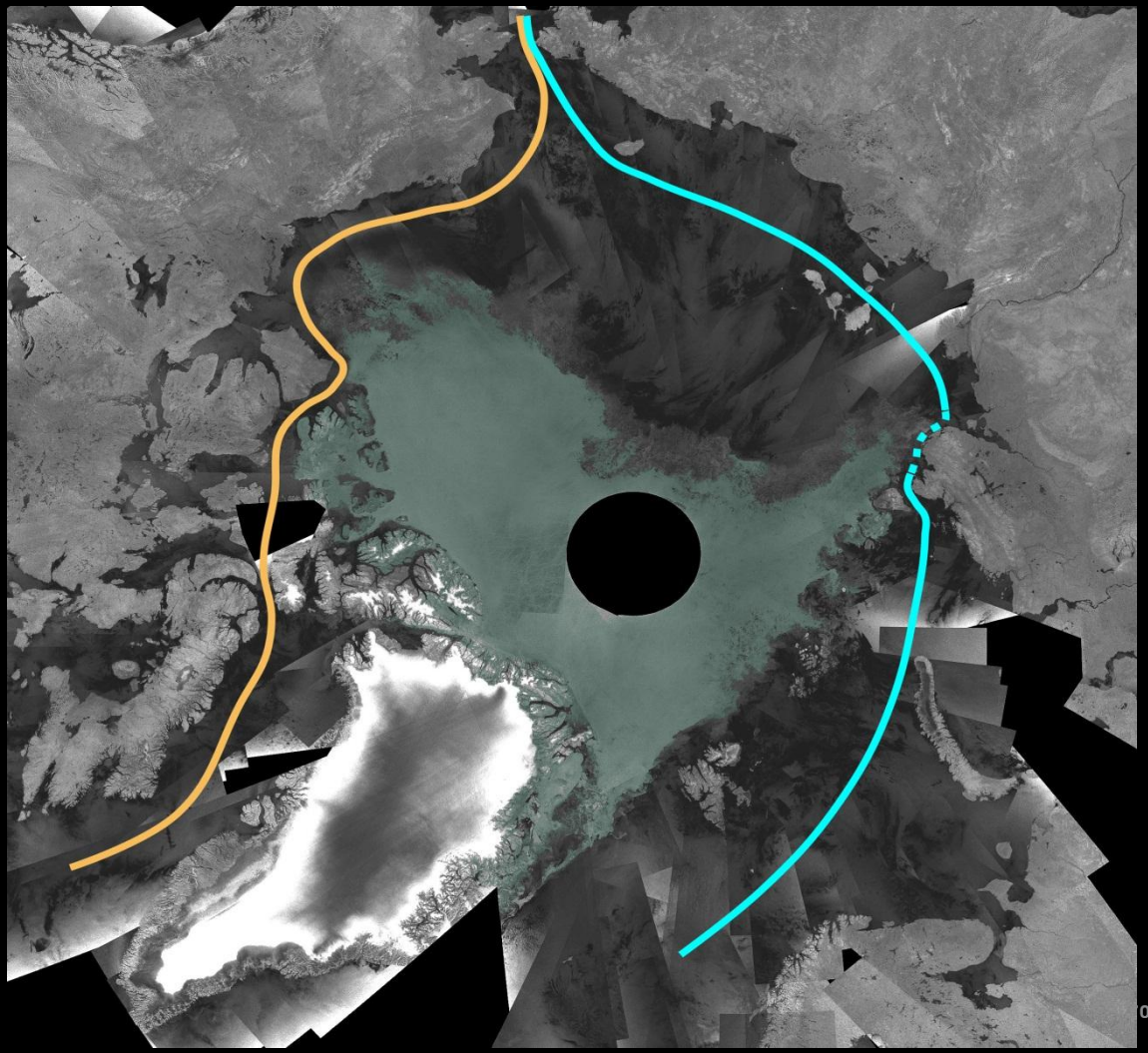


Courtesy of Remko Scharroo, NOAA,US

Recent scientific headlines of Earth Observation:
Daily monitoring of polar areas

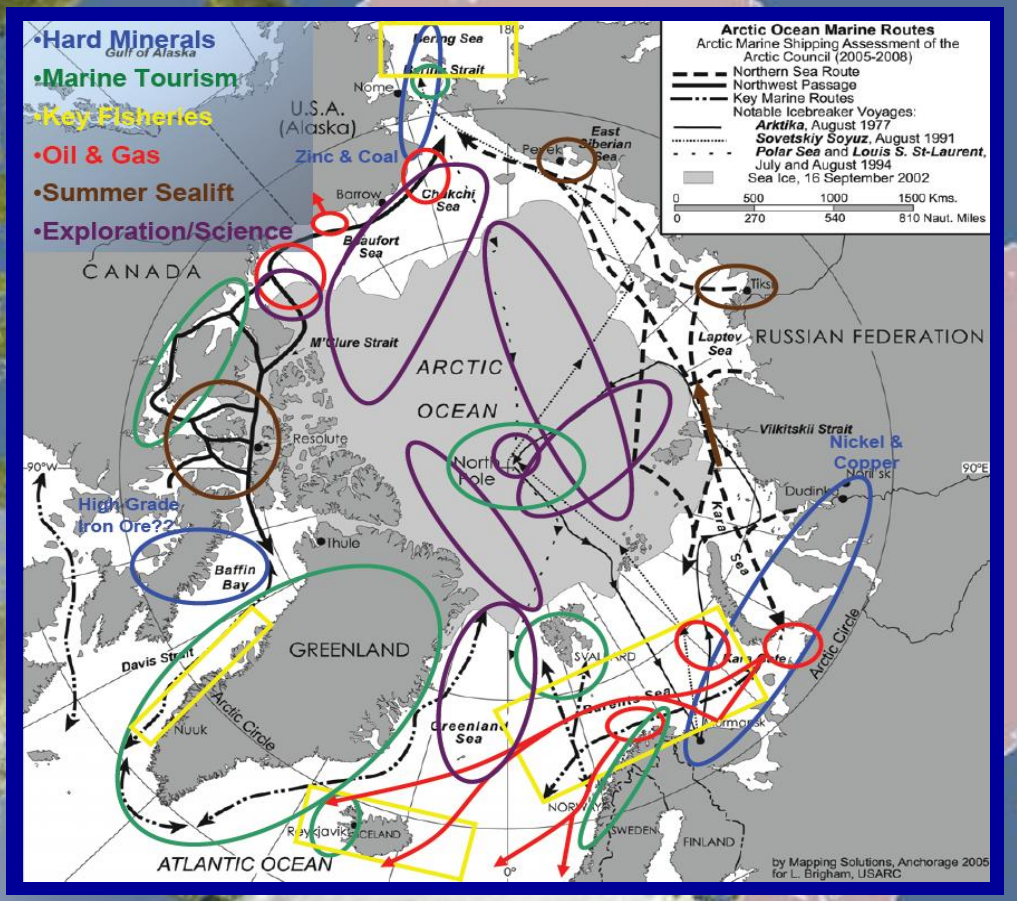
Lowest Arctic ice coverage (summer 2007)

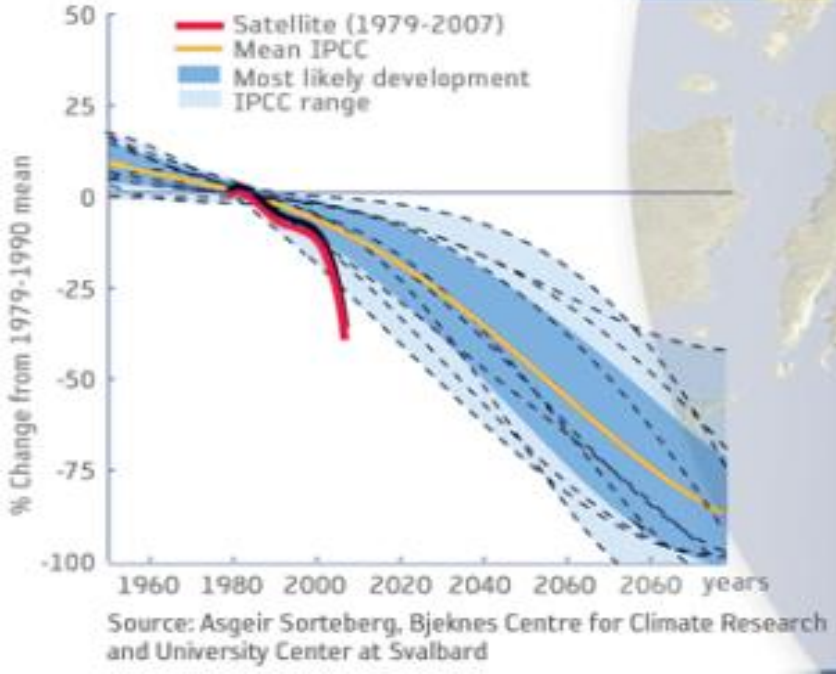
Northwest Passage open (orange line) and Northeast passage only partially blocked (blue line). The dark grey colour represents the ice-free areas, while green represents areas with sea ice.



The Changing Arctic

- Arctic sea-ice extent (September) has shrunk by 12% per decade since 1978
- The Arctic increasingly becomes an arena of high geopolitical relevance



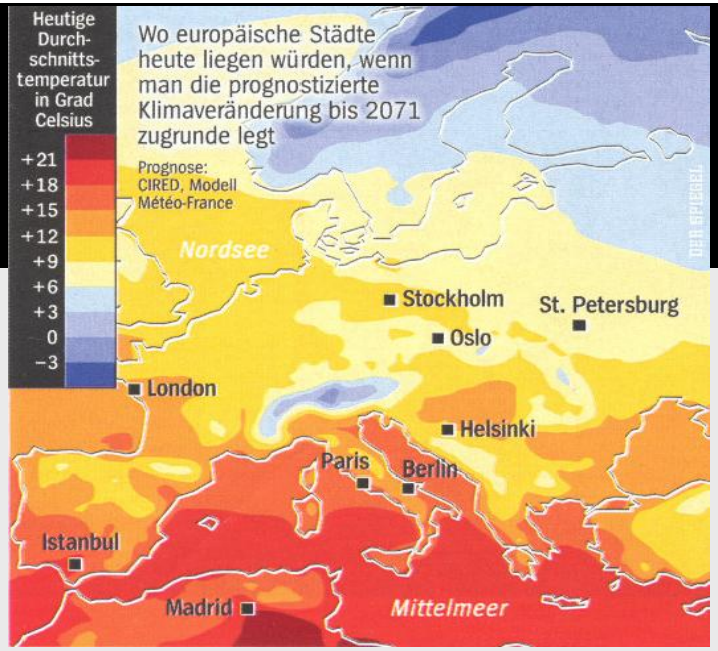


The challenge of global change

4th IPCC Report 2007
(5th Report expected in 2014)

Model: *Global temperature increase between + 2.4 and 6.4 degrees until 2100*

- **Arctic:** ice-free as of 2nd half of the century
- **Permafrost:** up to 90% melting until 2100, freeing high amounts of Methane gas
- **Precipitation:** decrease in arid regions and increase in wet areas
- **Storms and surges:** less in number but significantly stronger in intensity
- **Gulf Stream:** significantly weakened
- **Sea level rise:** up to 48cm until 2100 due to thermal expansion of water only



Space-based data contribute to global change monitoring

ESA Climate Change Initiative

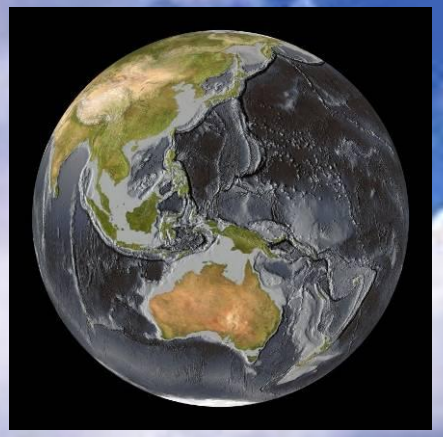
- ESA EO programmes **essential** for Climate Change monitoring
- **30 years** of EO data archived
- **20 new satellites** launched over next 10 years

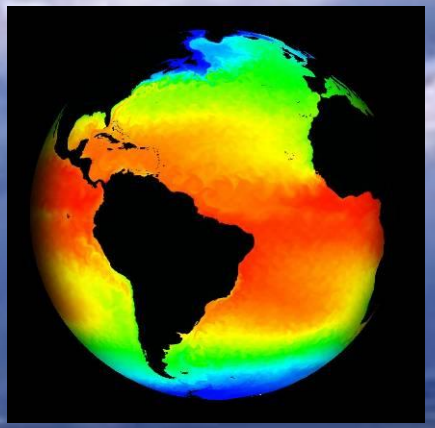
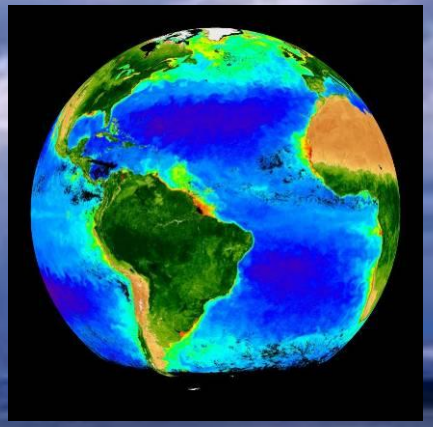
Programme goal:

to systematically generate and distribute long-term series of **"Essential Climate Variables" (ECV)** to meet needs of UNFCCC and IPCC

11 Essential Climate Variables

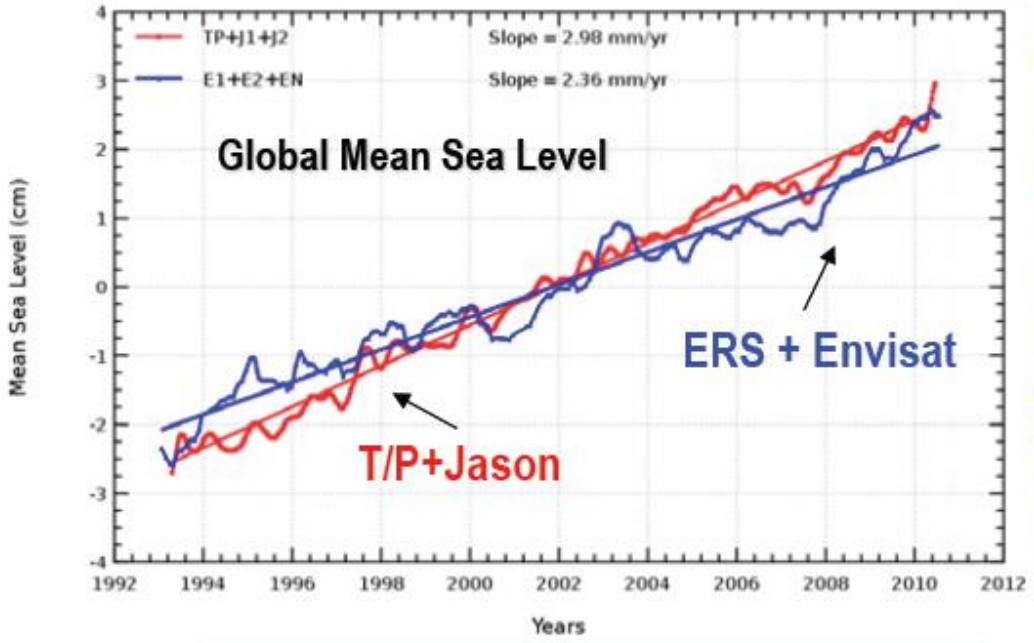
- Cloud Properties
- Carbon Dioxide, Methane & other GHGs
- Ozone
- Aerosol properties
- Sea Surface Temperature
- Sea Level
- Sea Ice
- Ocean Colour
- Glaciers and ice caps
- Land cover
- Fire disturbance

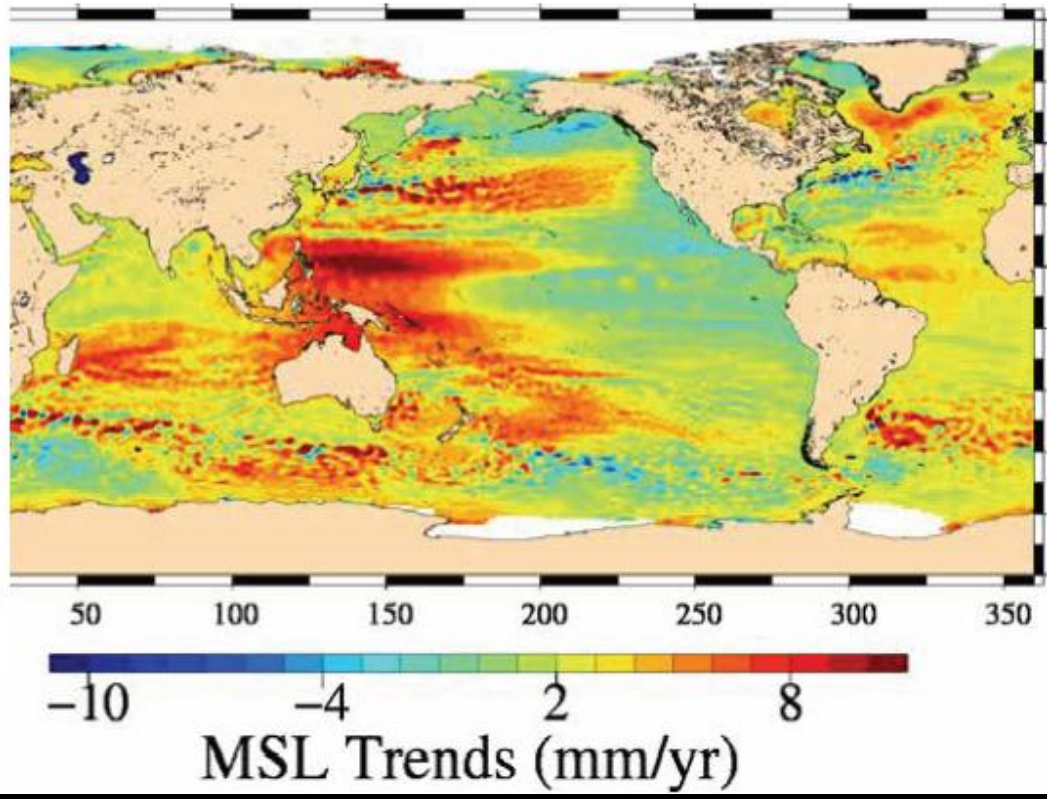


Sea Level CCI

RELEASE of the NEW
Sea Level ECV PRODUCT
18 years from 1993 to 2010





Thanks to the SLCCI project

Facilitating access to Earth Observation data

A constant ESA objective:
→ *ease access to Earth Observation data*

- **Revised ESA EO data policy:**
  → most of the data is open and free of charge

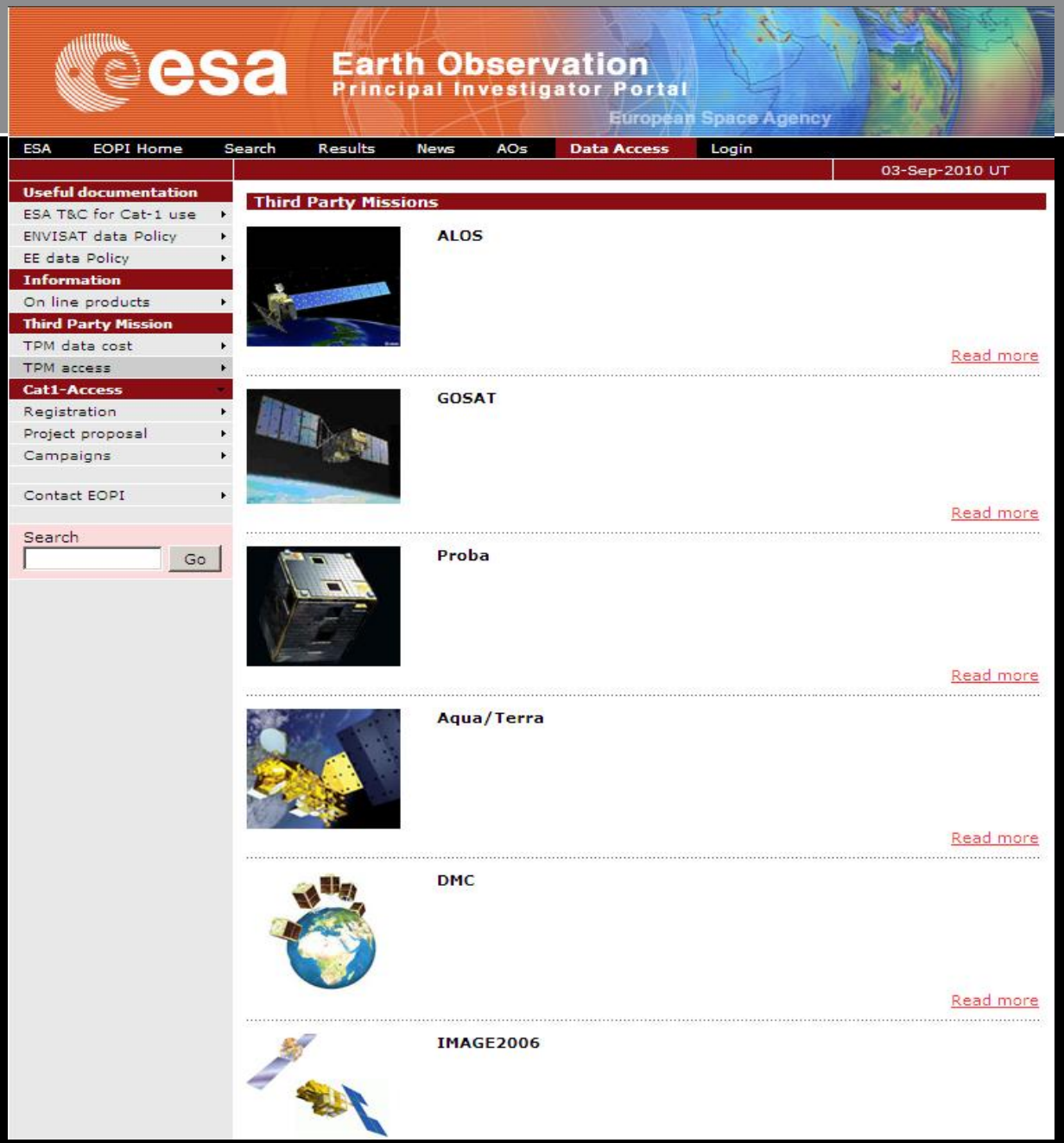
- **Constant upgrade of ground segment for easier access to data through Internet for Near Real Time (NRT) data and for archived data**

- **Development of alternative ways to provide data (e.g. processing on demand (GPOD), data toolboxes)**

- **Large effort in maintaining data quality (processing algorithms, calibration, validation)**

- **Need to preserve "old" data for future use**

Terms & Conditions for TPM data use

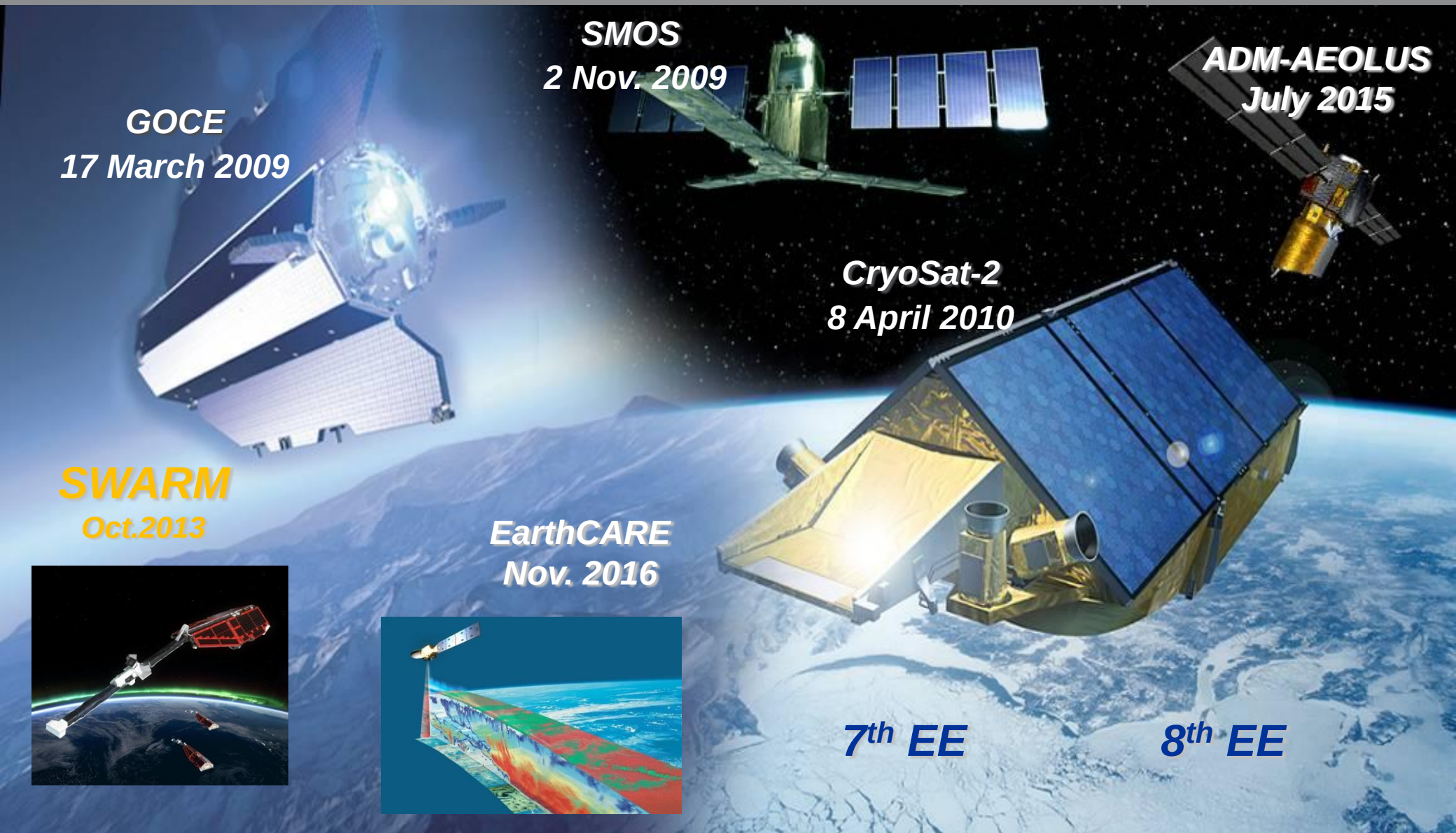


Specific restrictions to the use of data may apply for products distributed by ESA acquired by **Third Party Missions (TPM)**.

More information about such restrictions can be found here: http://eopi.esa.int/TPM

ESA's Earth Explorer satellites:

high-end science research mission



GOCE – *the gravity mission*

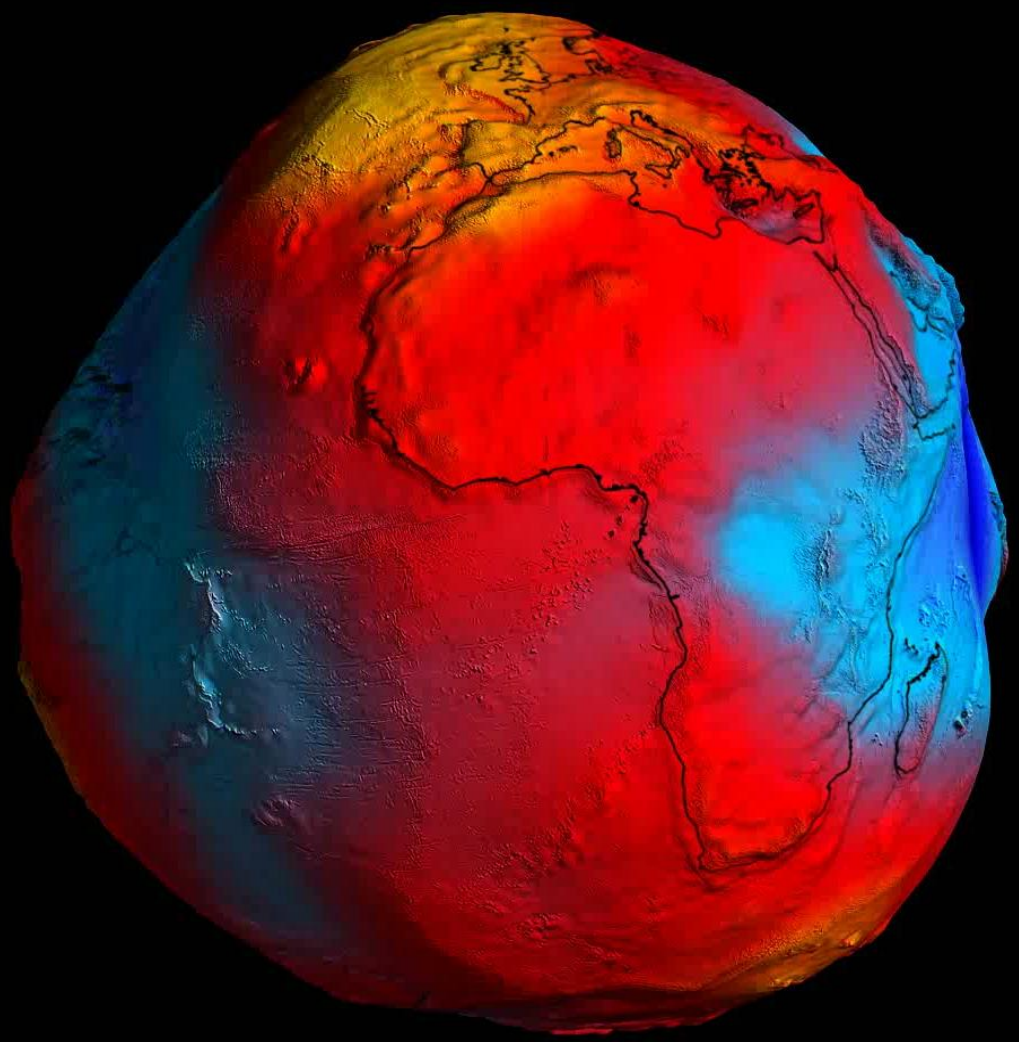
- **In space since March 2009**
- **Several measurement cycles of the Earth's gravity field**

A unique mission:

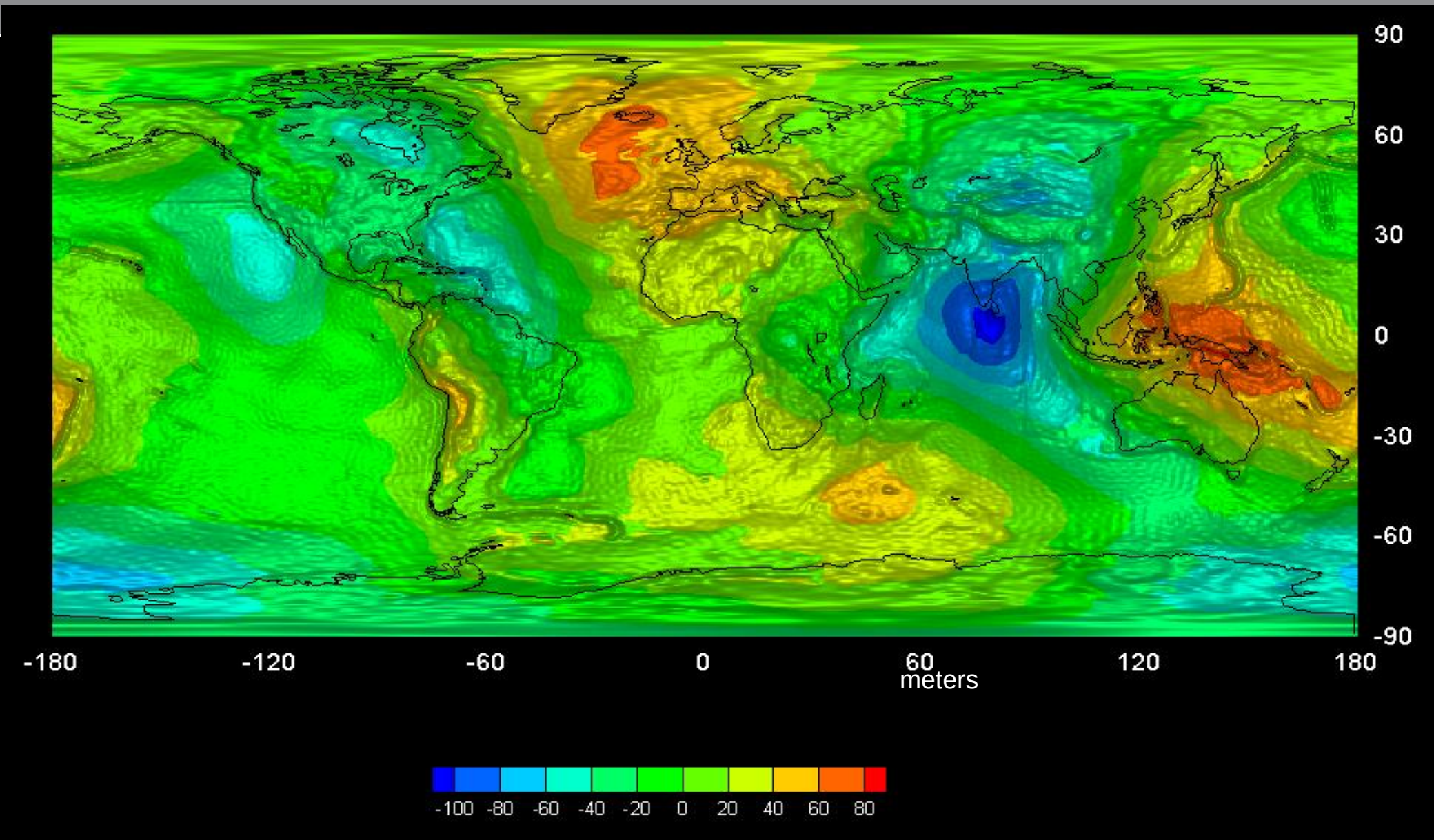
- First gradiometer in space
- Very low orbit (255 km)
- Active air drag control (ion engine)
- Perfectly quiet environment

ESA's GOCE mission has delivered the most accurate model of the 'geoid' ever produced

- GOCE is a technology marvel: the first gradiometer in space at one of the lowest satellite orbits ever
- GOCE's **geoid** has been created using more than 50 million measurements of variations in gravitational attraction



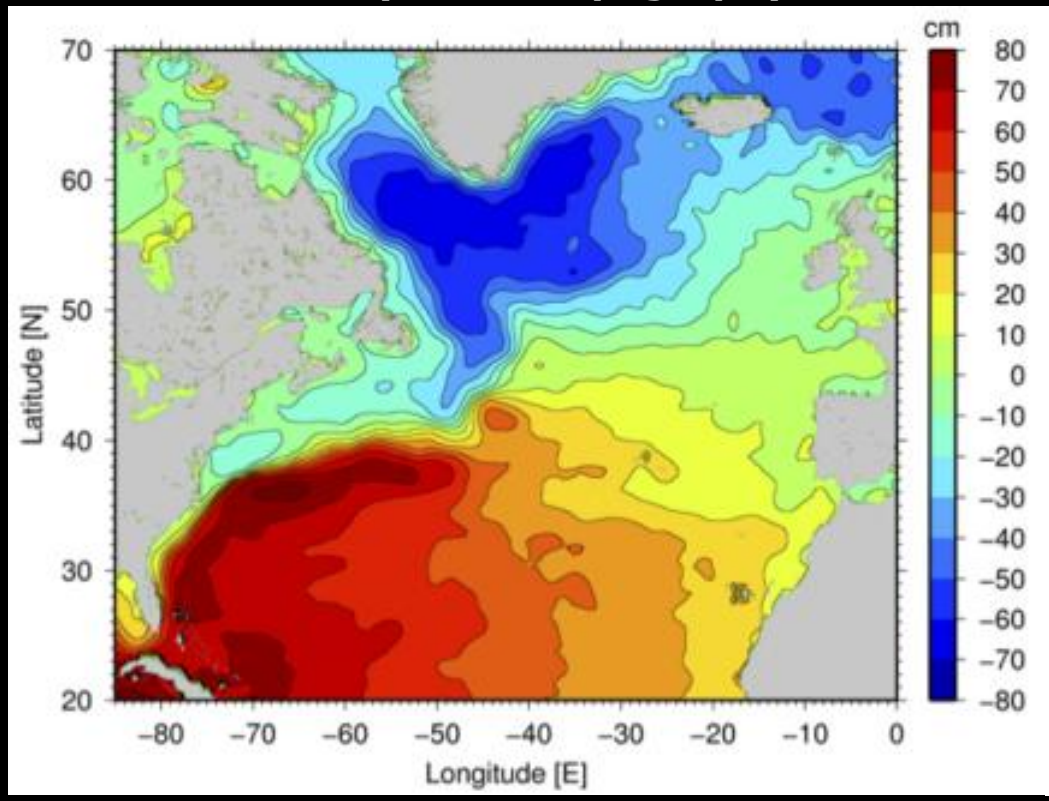
GOCE gravity field



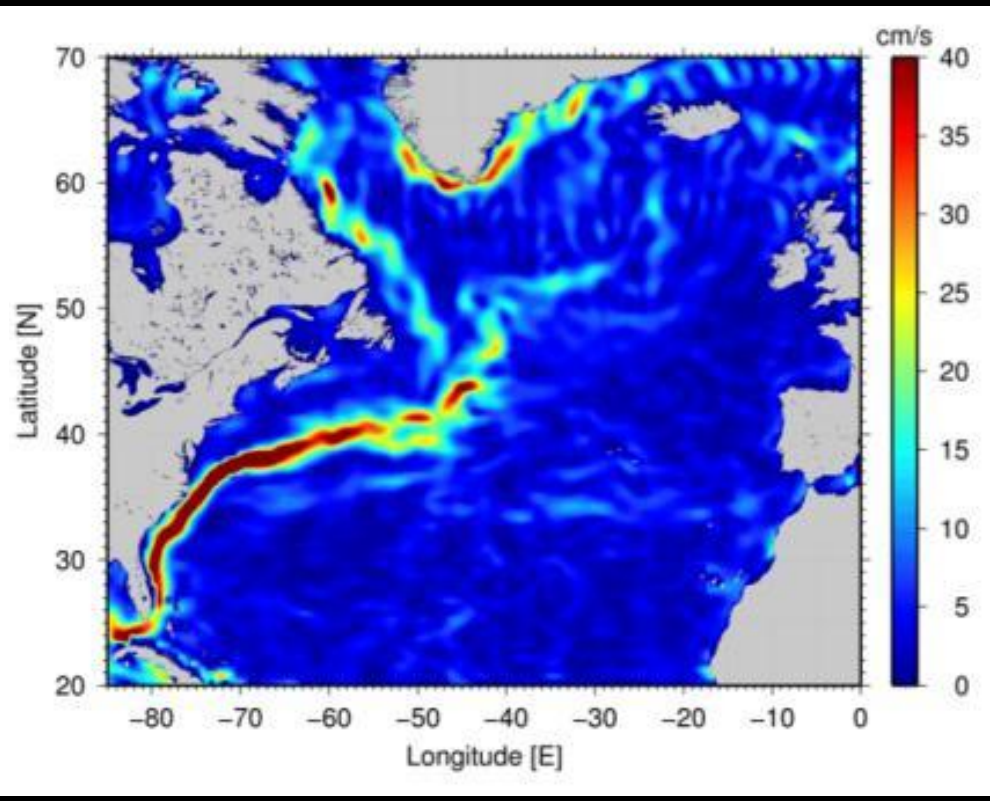
GOCE: accurate ocean currents map

- With GOCE geoid, for the first time, global currents can be extracted directly from satellite altimetry data.

Ocean Dynamic Topography



Water Surface Velocity



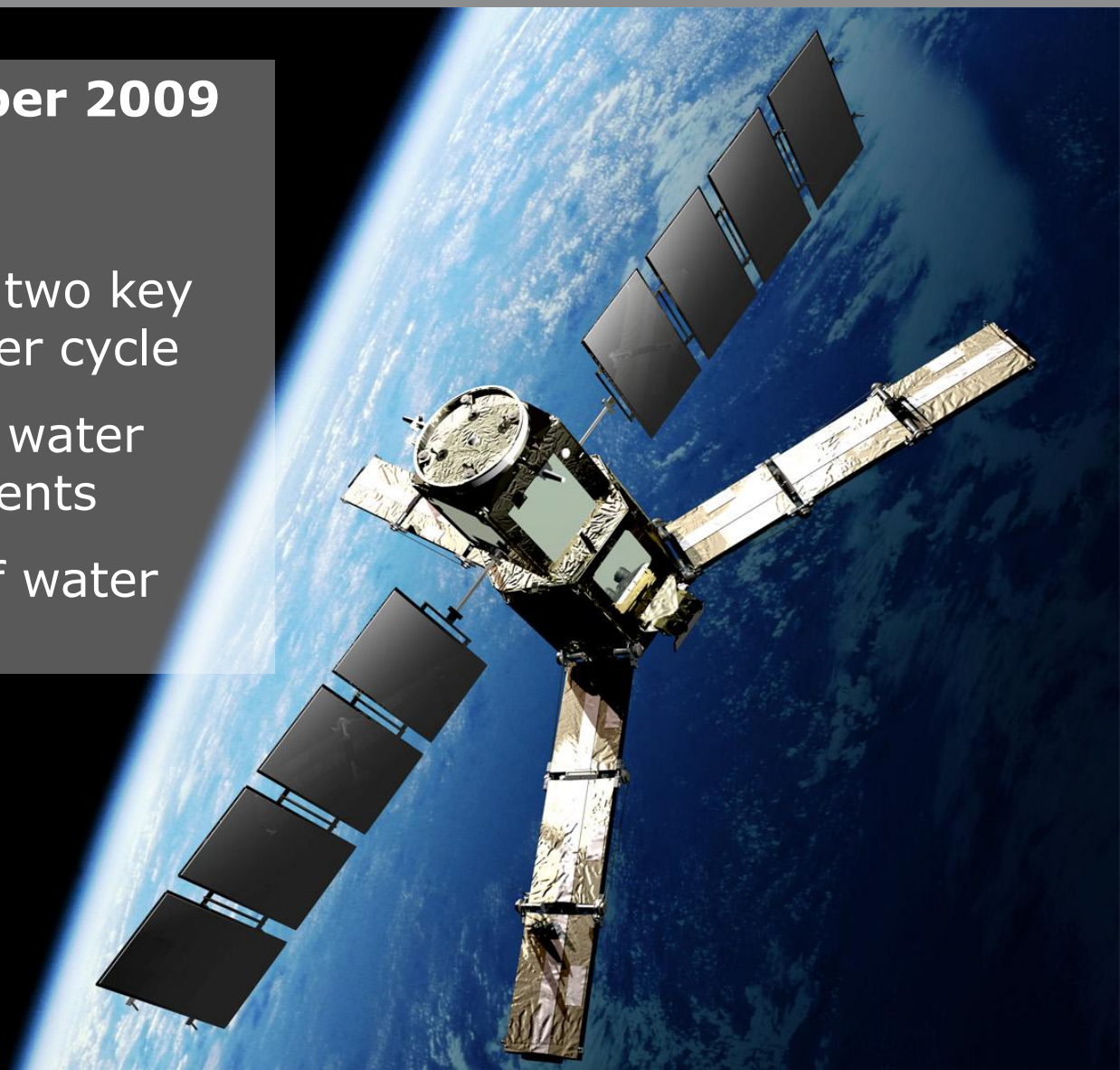
SMOS – *The ESA water mission*

In space since 2 November 2009

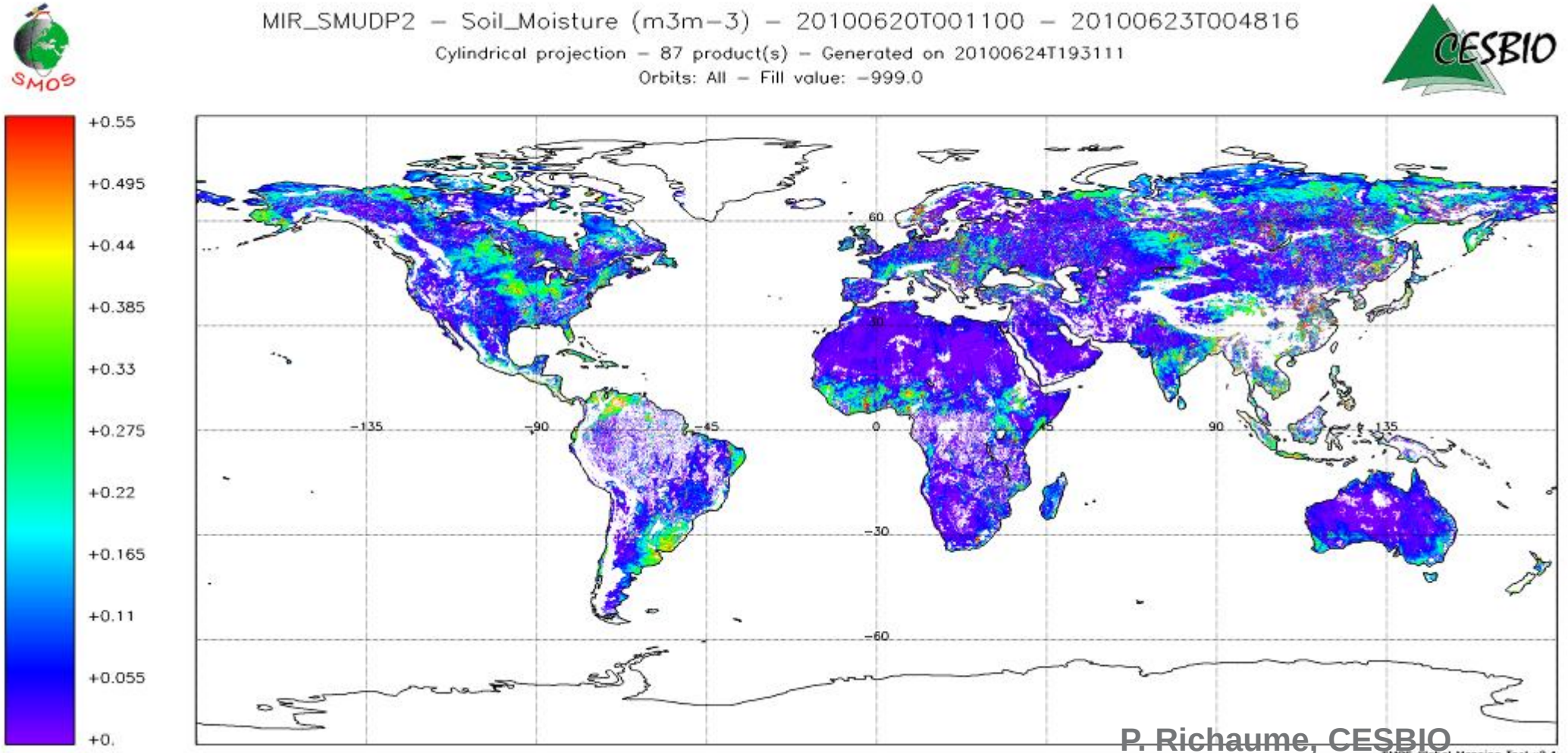
Applications:

First global observations of two key variables of the Earth's water cycle

- Improve *models* of global water cycle and global ocean currents
- Improved management of water resources



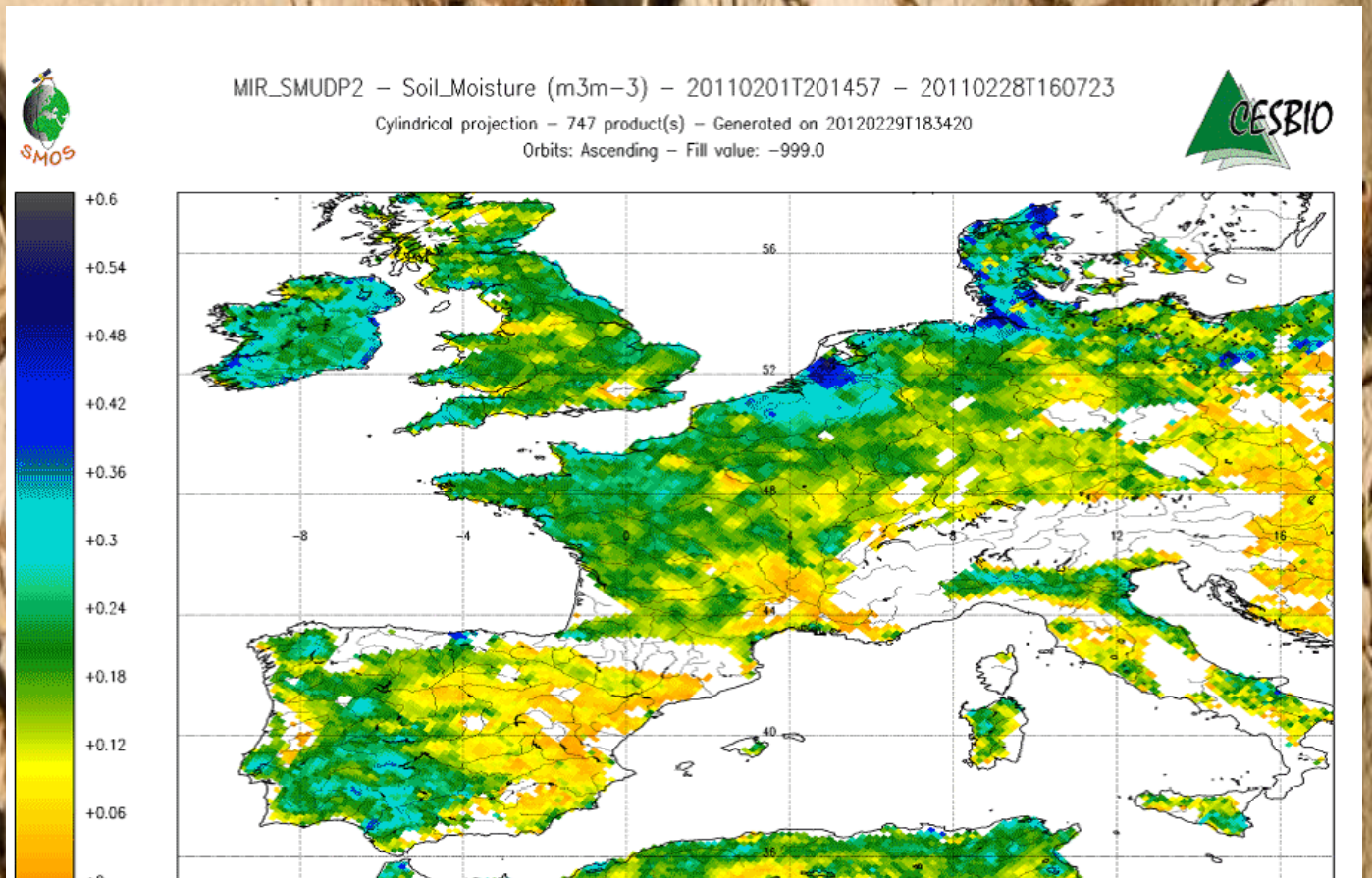
The first SMOS Global Soil Moisture Map (20-23 June 2010)



P. Richaume, CESBIO

SMOS: 2012 Drought in Europe

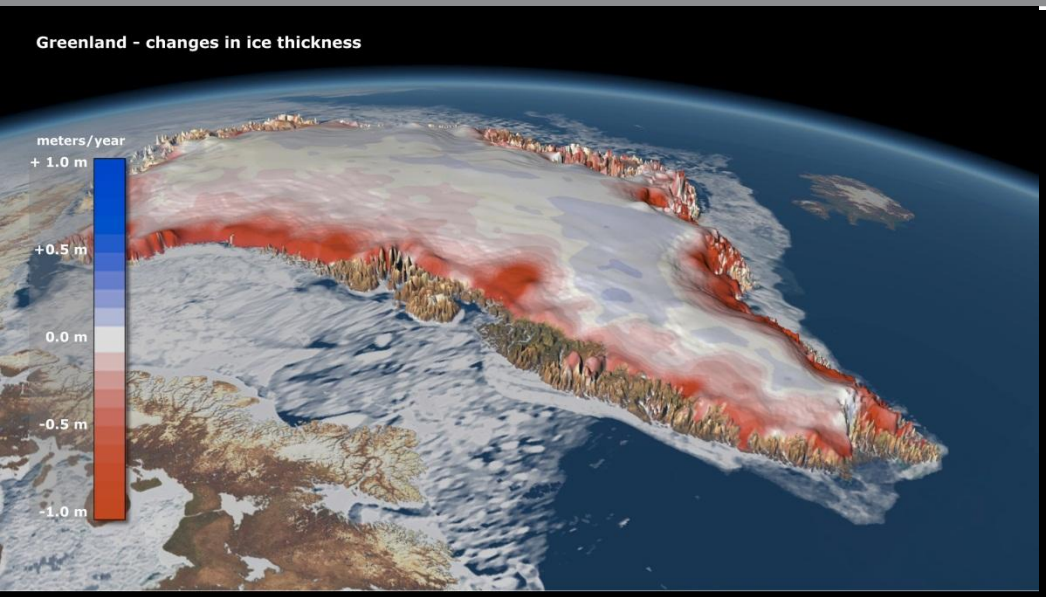
- Western Europe: severe lack of water due to less than average rainfall
- Absence of sufficient water resources: diminishing food supply, shortage of water for households and industry, shipping routes can fall dry

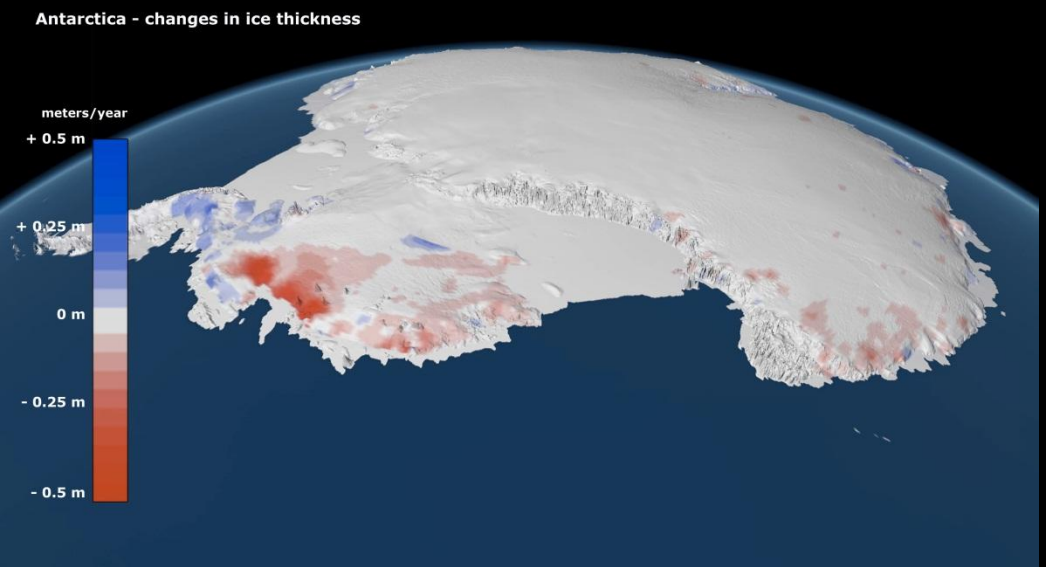


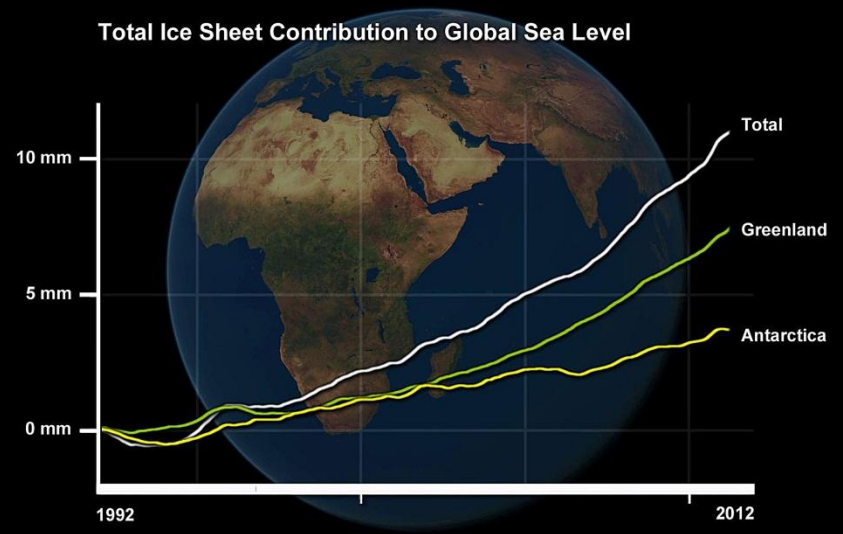
CryoSat-2 – *ESA's ice mission*

- monitoring precise changes in the thickness of the polar ice sheets and floating sea ice, reaching latitudes of 88°
- Launched 8 April 2010

Ice thickness contribution



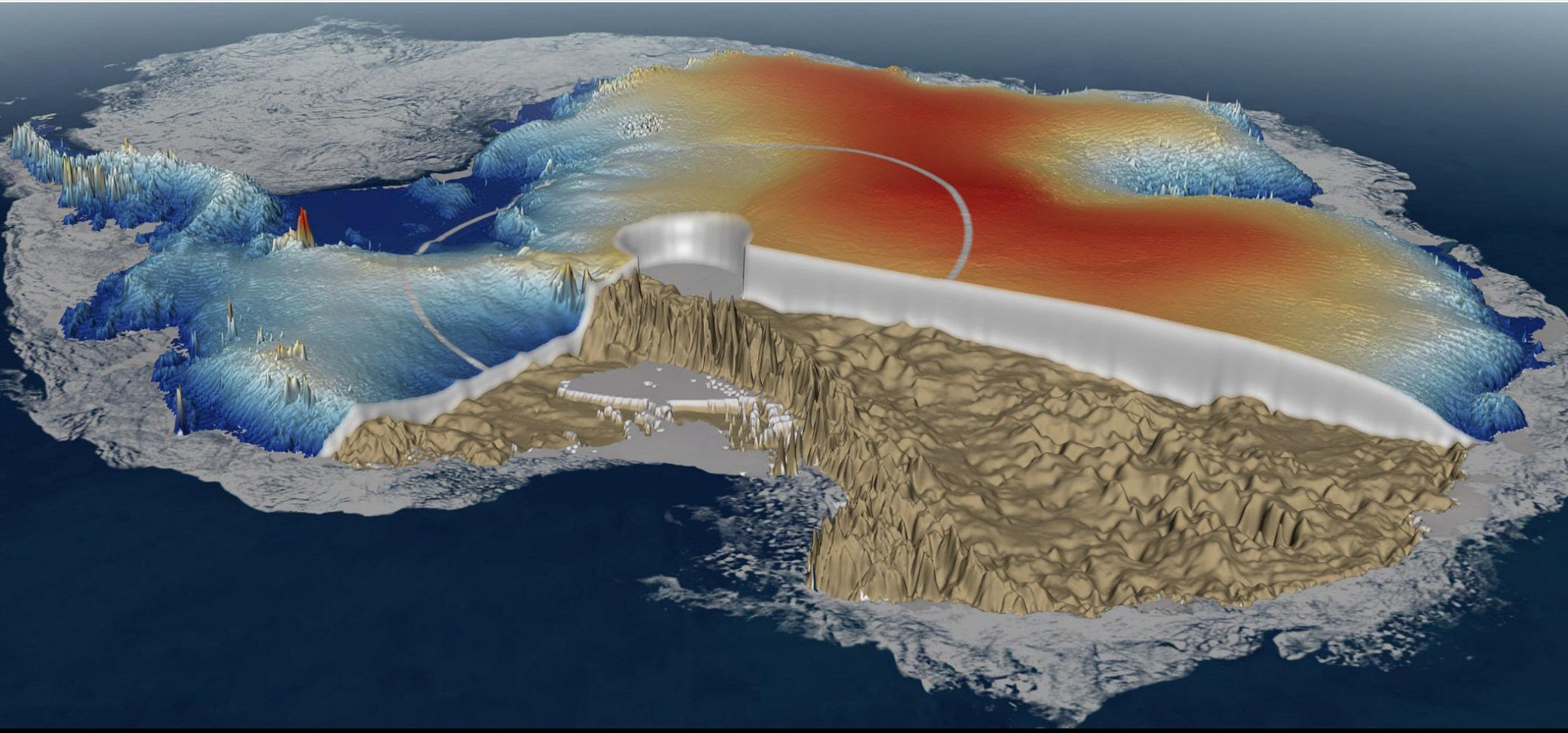




European Space Agency

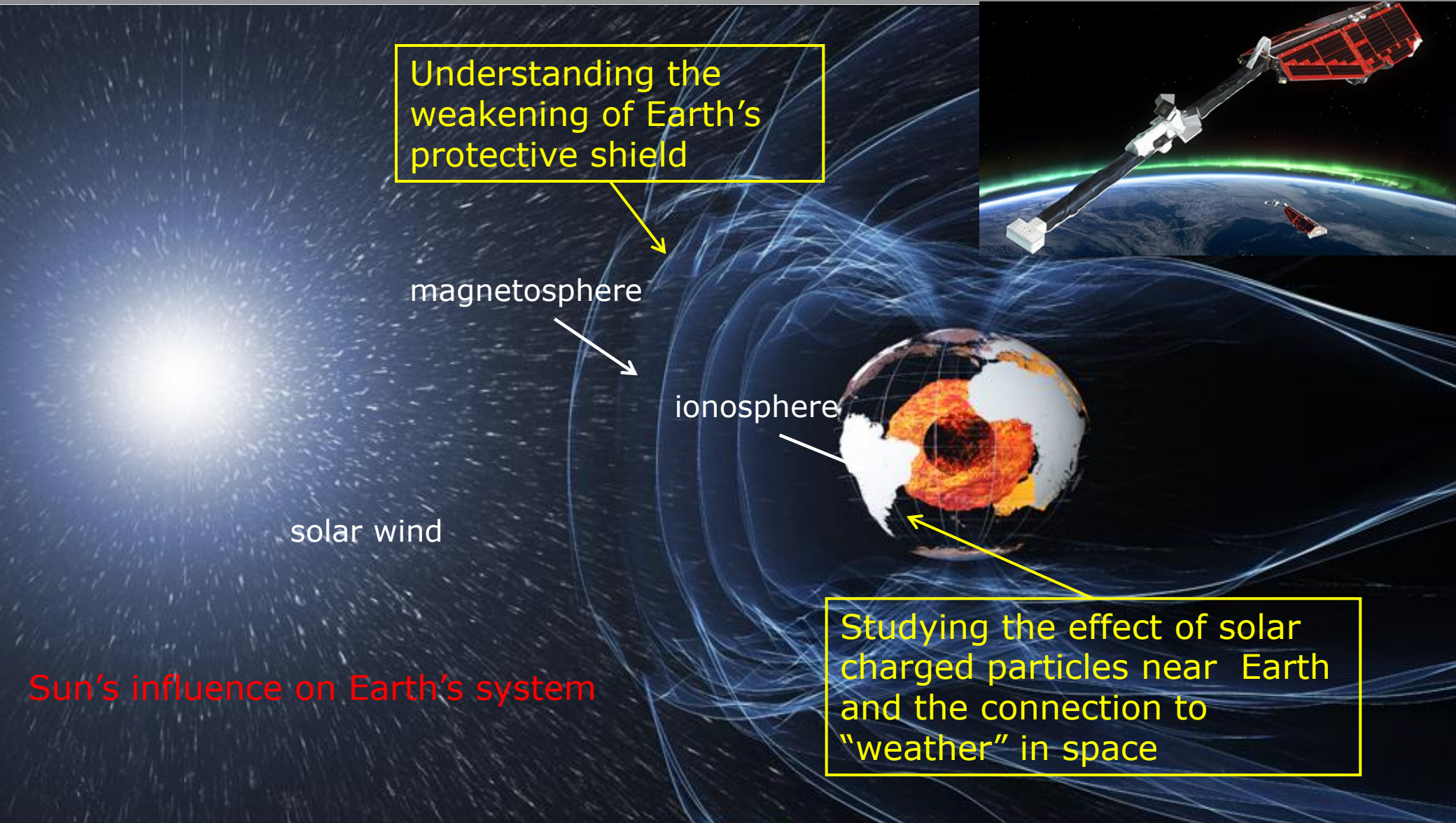
Changes in ice thickness in Greenland and Antarctica

CryoSat allowed to map the height of the ice sheet in Antarctica (data from February and March 2011).



Orbiting closer to the poles than other Earth observation missions, CryoSat offers additional coverage: the outer white circle represents the limits of earlier missions and the inner circle shows that CryoSat is collecting data up to 88° latitude.

Looking into the force that protects Earth

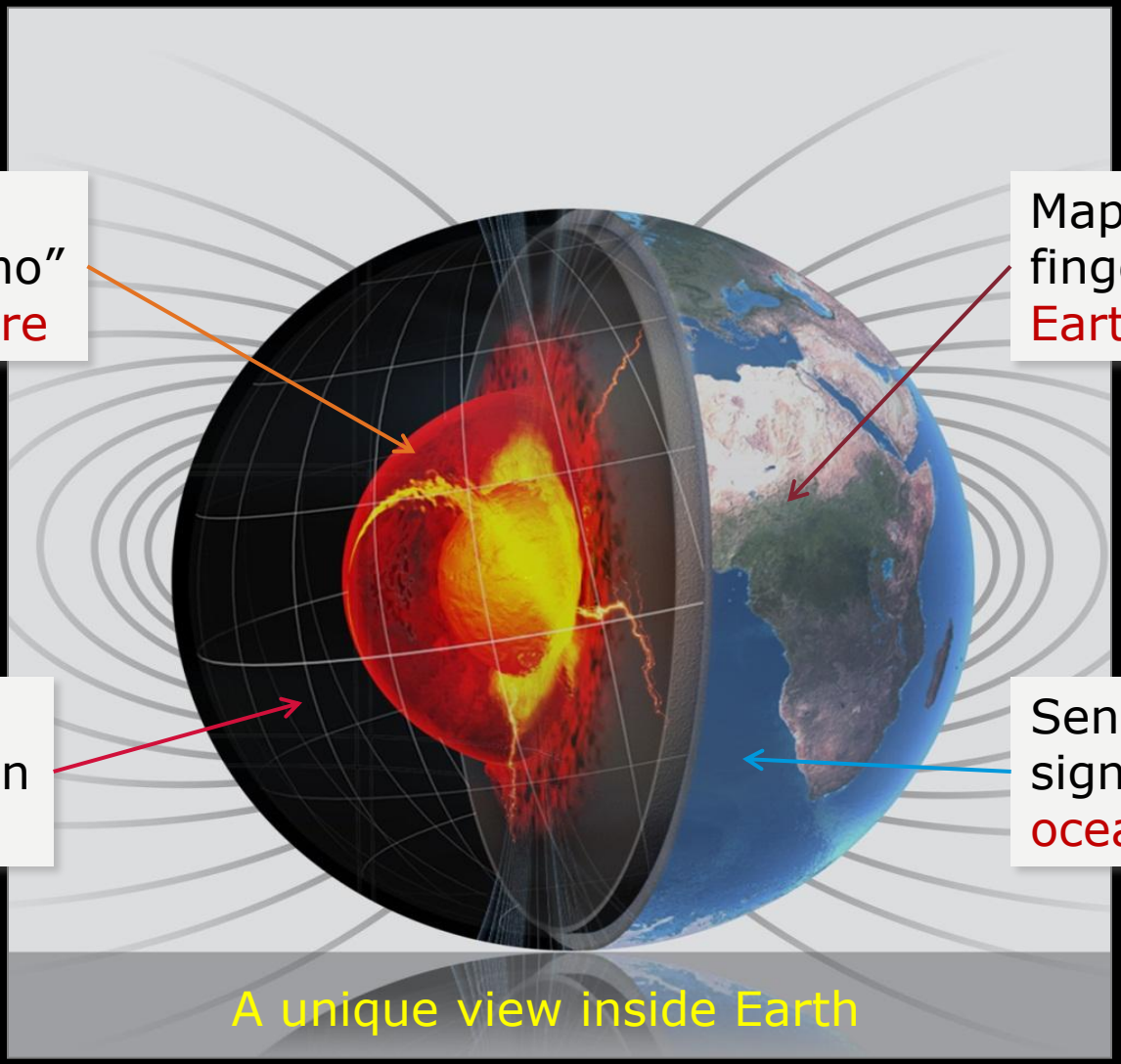


Swarm: revealing Earth's inner secrets

***A journey to the centre of the Earth* (Jules Verne)**

Understanding "Earth's dynamo" in the outer core

Mapping "magnetic fingerprints" in Earth's crust

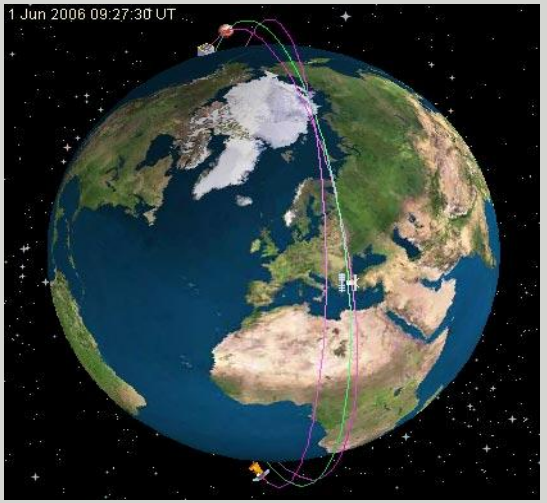


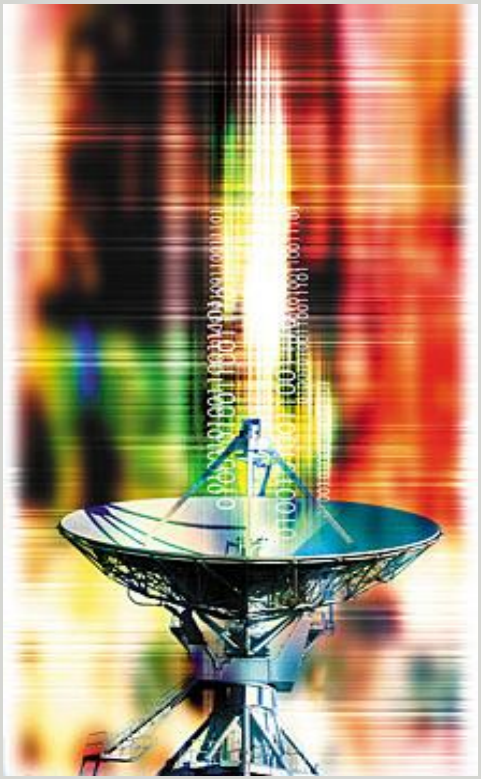
Looking into the composition of the mantle

Sensing the weak signature of the ocean currents

A unique view inside Earth

Global Monitoring for Environment and Security



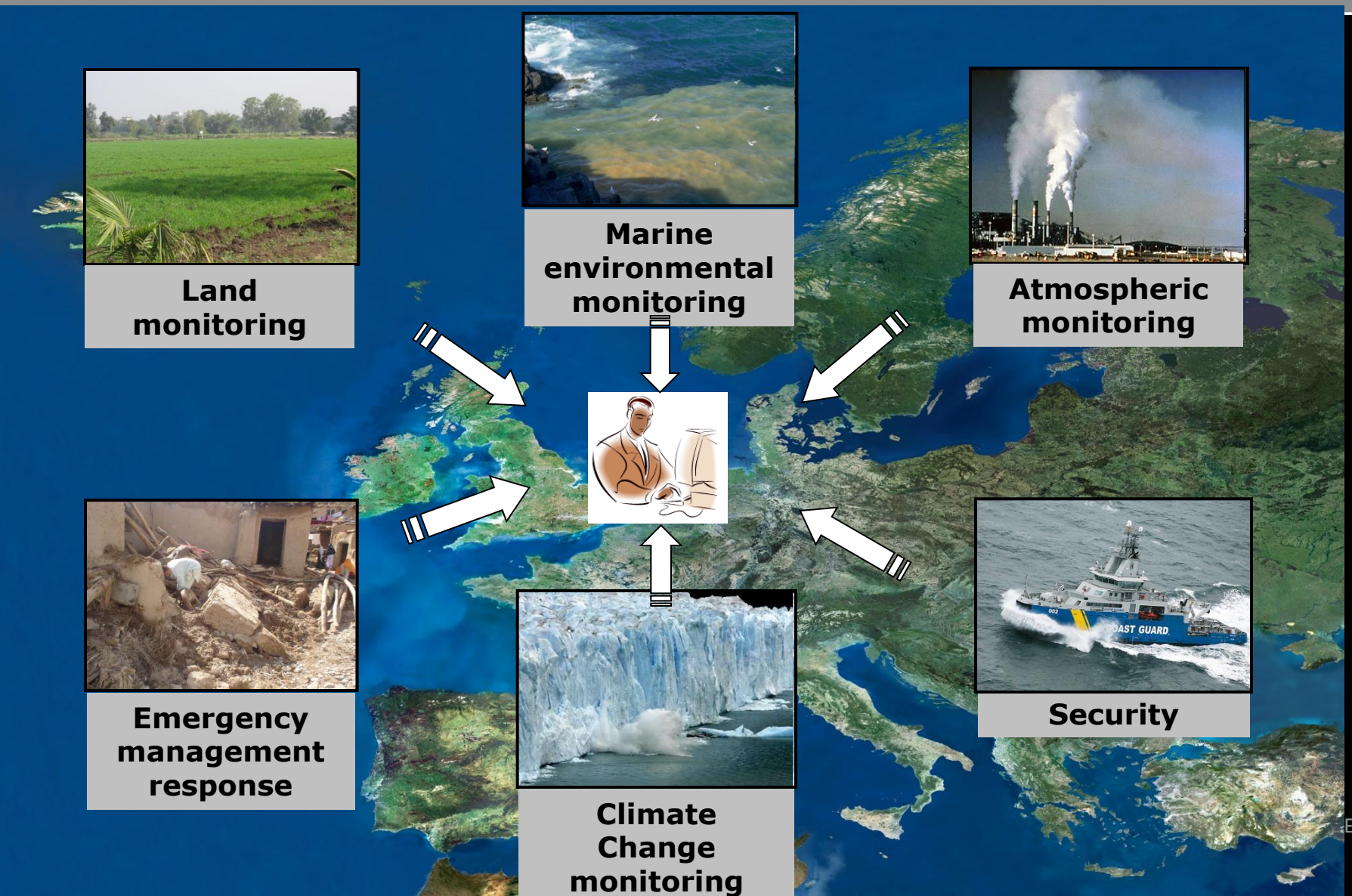


European independence in data sources for environment and security monitoring

and

The European contribution to the Global Earth Observation System of Systems (GEOSS)

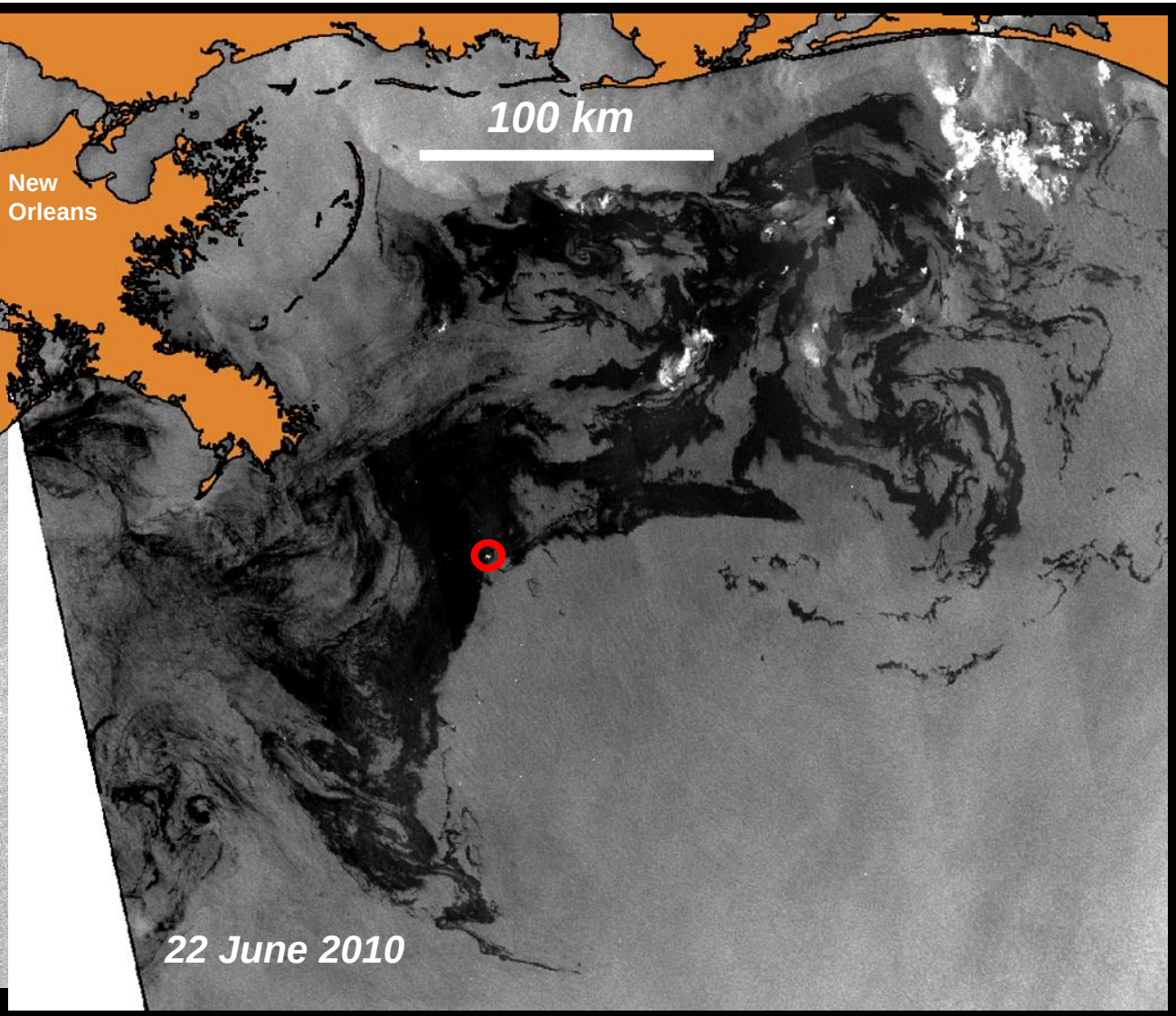
GMES Services domains



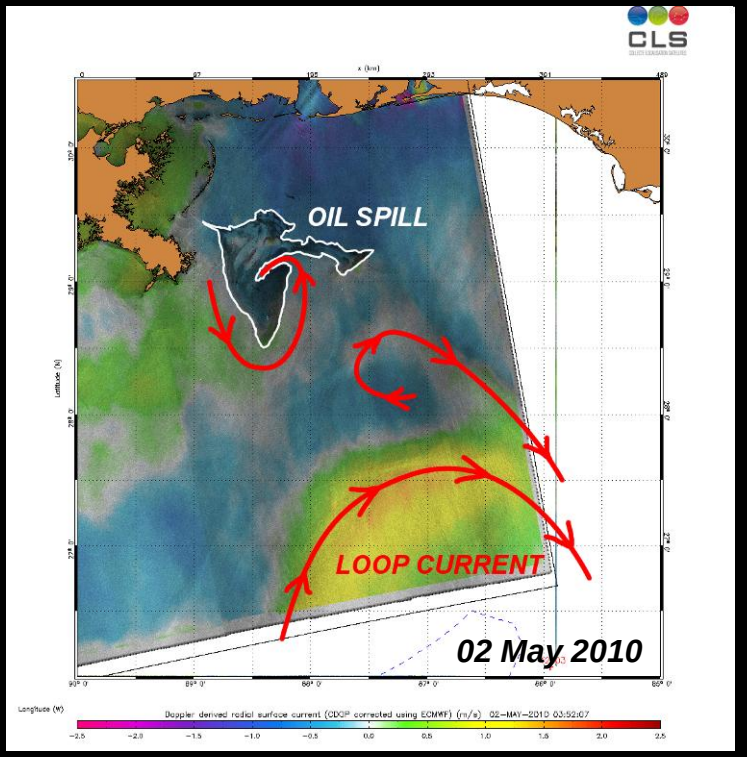
Emergency management: Rapid Mapping during Flood Crisis Romania, July 2010

- Heavy rainfall causing severe flooding in central and eastern Romania
- 3 July flood extent of Galati/Braila district based on RADARSAT-2, produced on 4 July
  - Pre-flood water extent based on Landsat-7
- 13 July flood extent of Tulcea based on RADARSAT-2, produced on 14 July
  - Pre-flood water extent based on SPOT

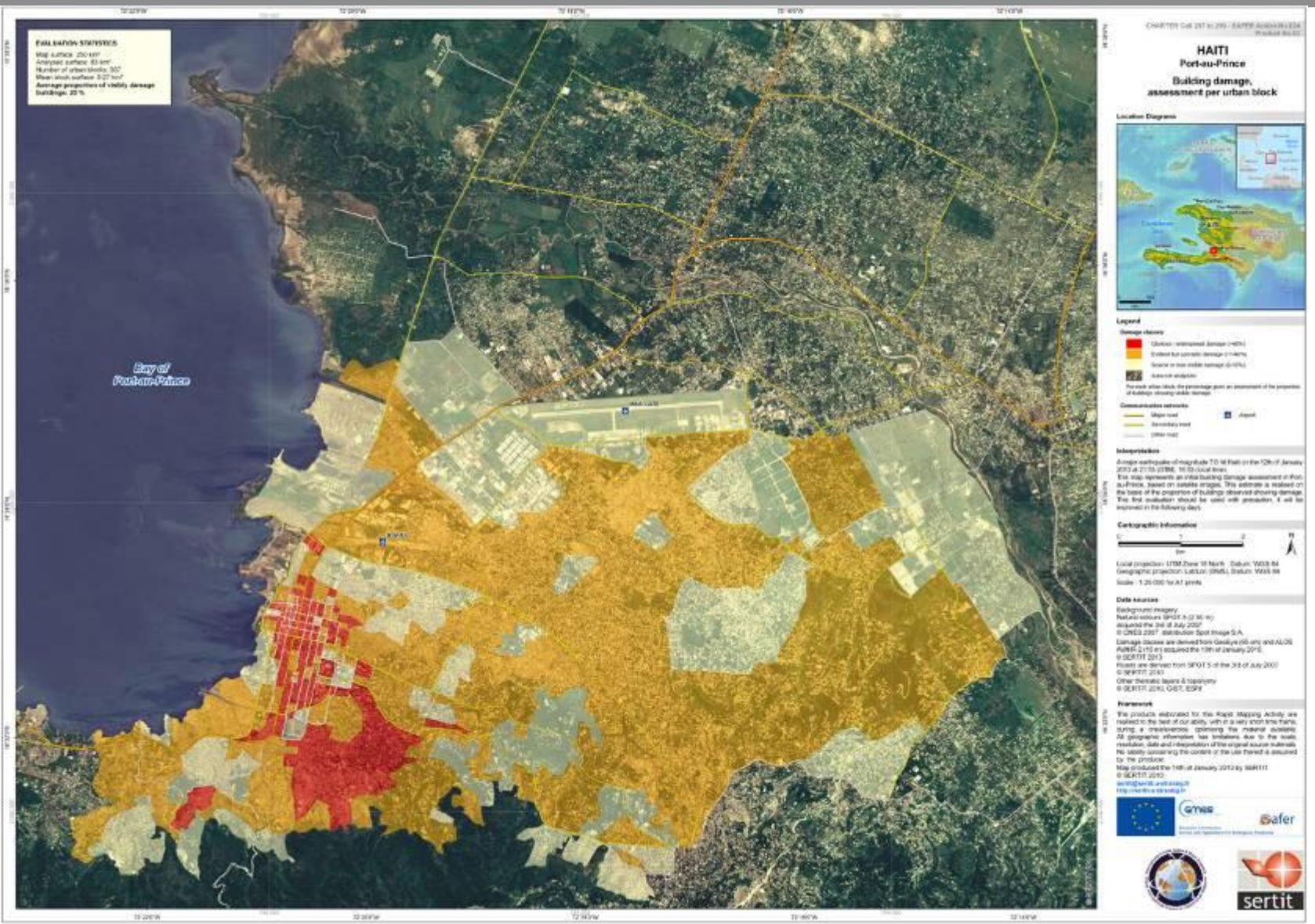
Emergency management: Oil Spills



The Louisiana Oil Spill disaster from space
(Envisat ASAR)



Emergency management: Earthquake

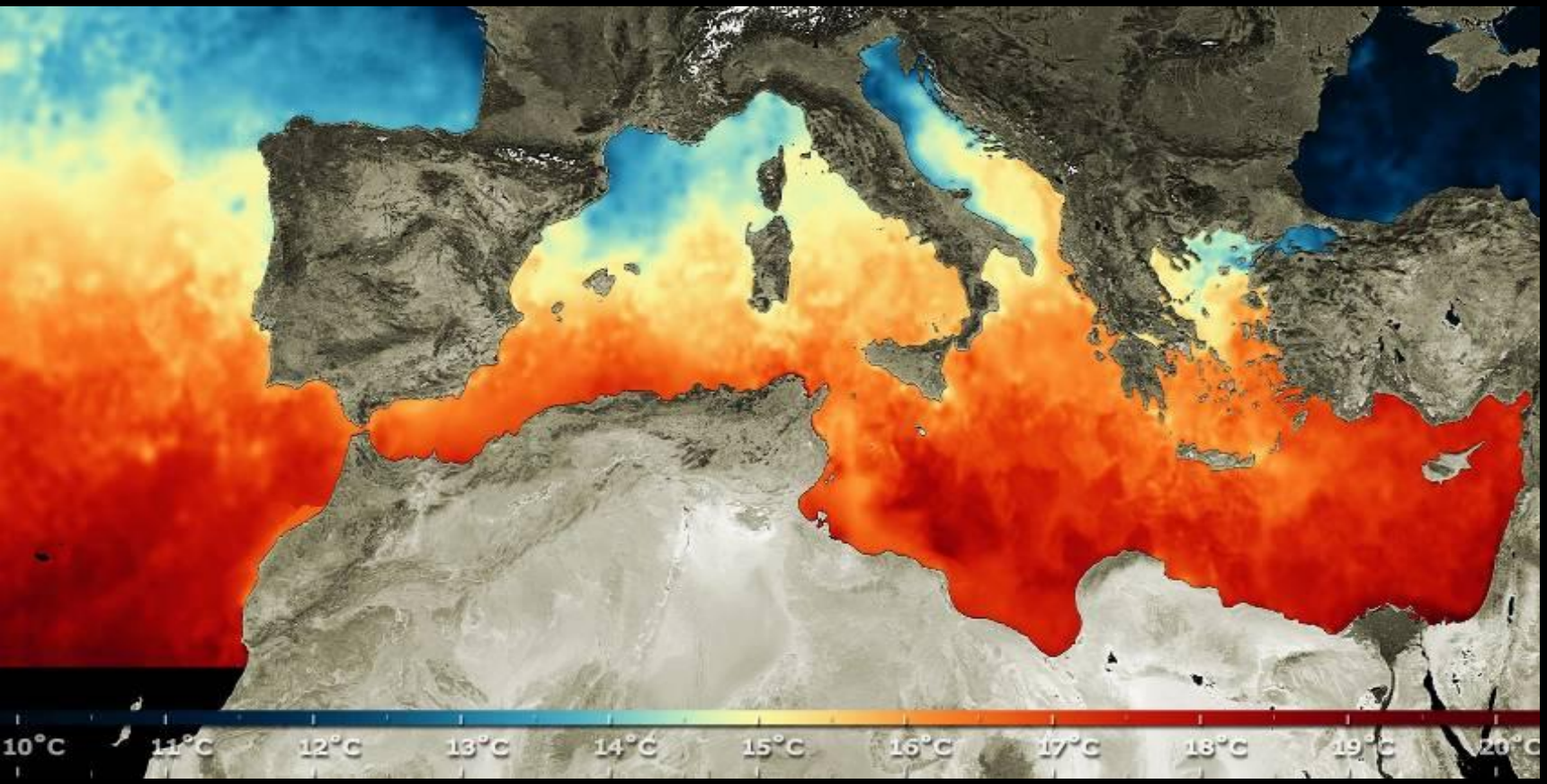


Earthquake management at Port-au-Prince, Haiti – 13 January 2010

Dati: ALOS, SPOT-5, GeoEye

Credits: SERTIT/SAFER

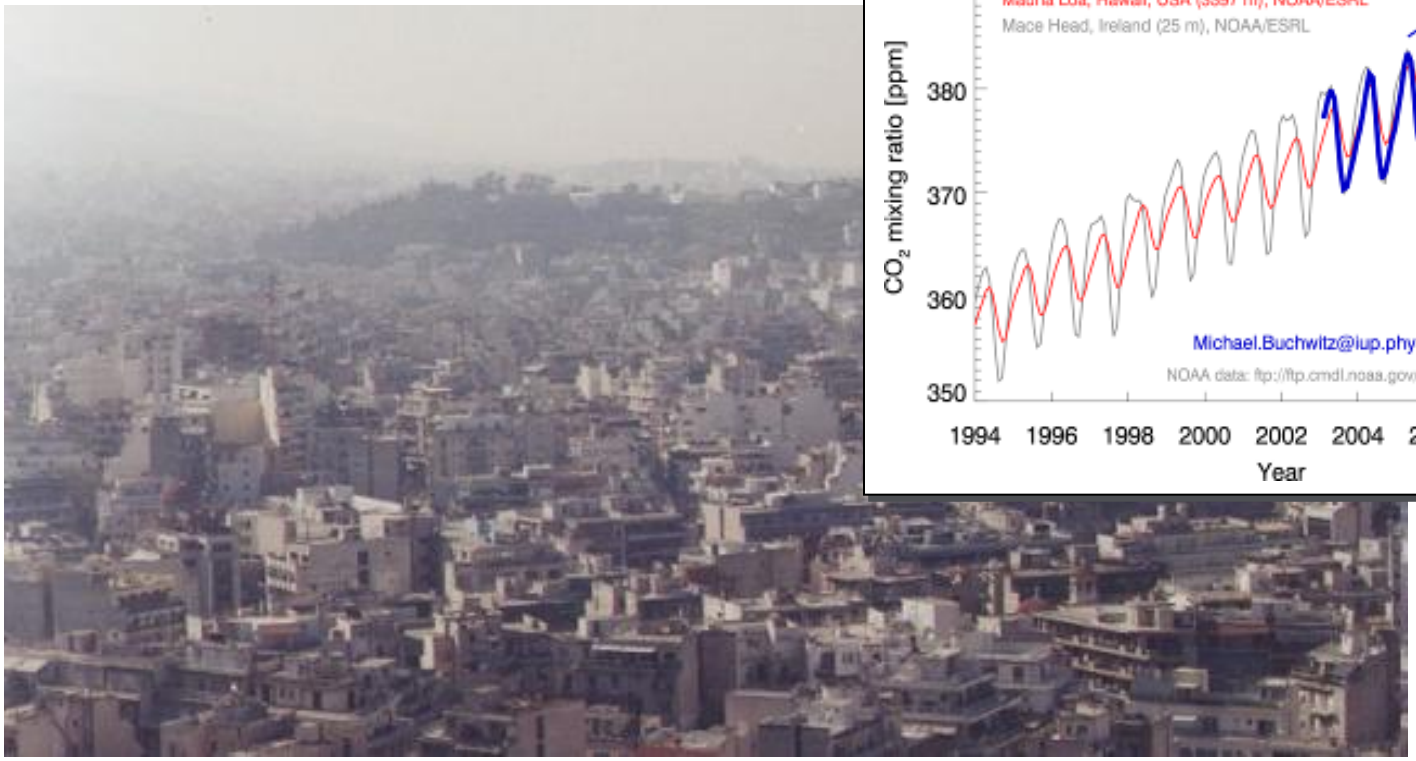
Example of marine service: Marine Monitoring

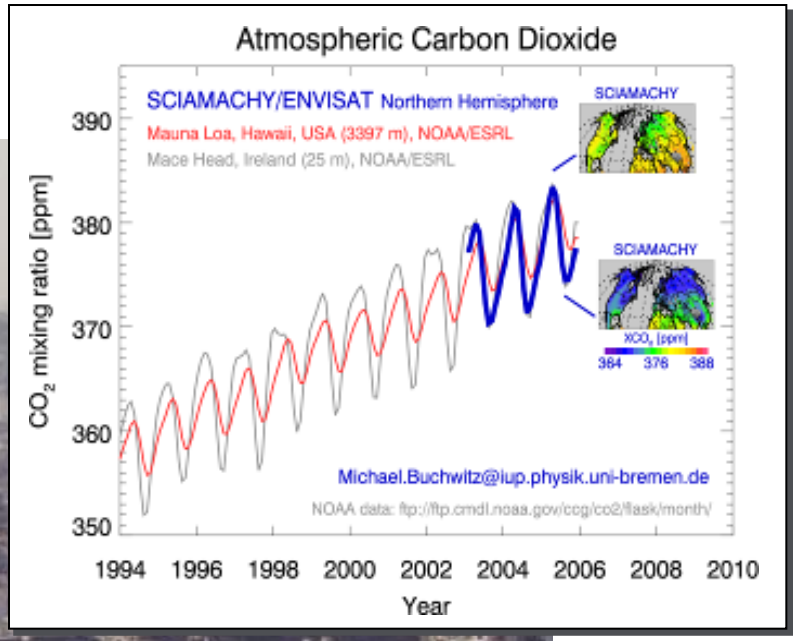


Sea Surface Temperature over the Mediterranean

Credits: Medspiration

Example of atmospheric service: Sciamachy CO_2 Columns

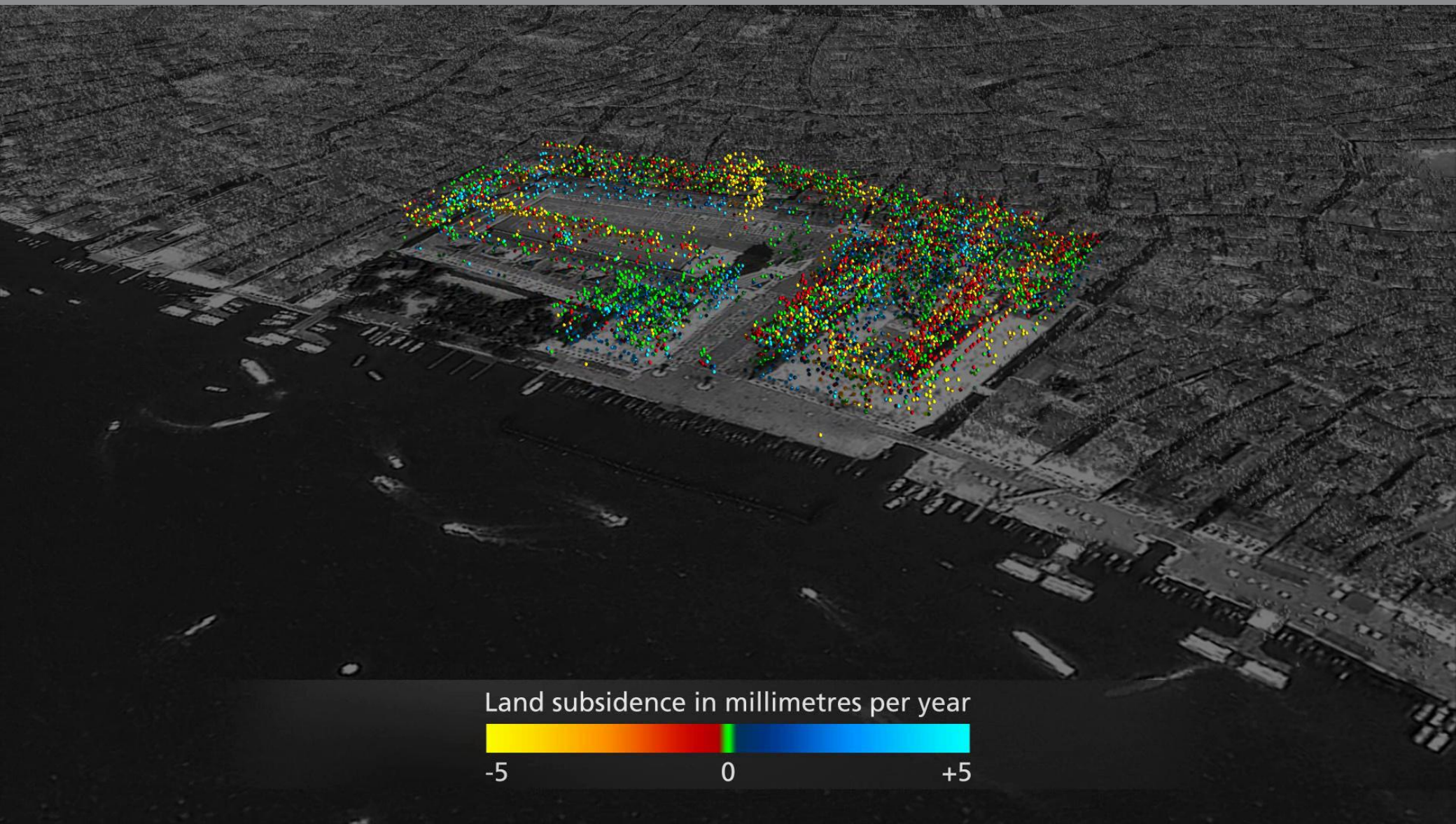




Annual variability of carbon dioxide mixing ratio in parts per million

Smog over Athens city centre

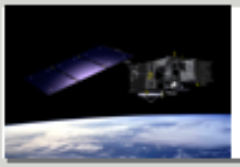
Example of Land Service: Land subsidence (Venezia, Italy)



The GMES Space Component (GSC)

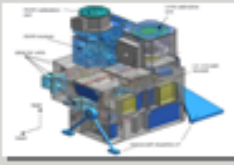
Sentinel 1 – SAR imaging
All weather, day/night applications, interferometry
2012, 2014+

Sentinel 2 – Multispectral imaging
Land applications: urban, forest, agriculture,..
Continuity of Landsat, SPOT
2013, 2014+



Sentinel 3 – Ocean and global land monitoring
Wide-swath ocean colour, vegetation, sea/land surface temperature, altimetry
2013, 2014+

Sentinel 4 – Geostationary atmospheric
Atmospheric composition monitoring, trans-boundary pollution
2018+



Sentinel 5 and Precursor – Low-orbit atmospheric
Atmospheric composition monitoring
2015, 2020

+ Ground Segment and Coordination

GMES: Upcoming satellite launches

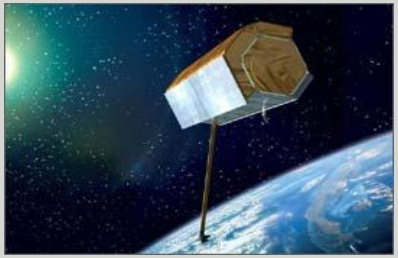
Sentinel-1A

Sentinel-2A

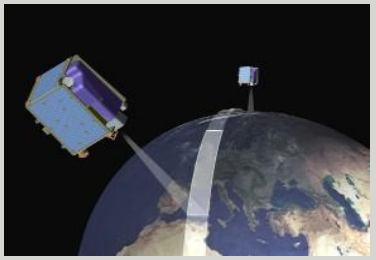
Sentinel-3A

- GMES is a European space flagship programme.
- GMES provides the necessary data for operational monitoring of the environment and for civil security.
- GMES is currently being re-named to Copernicus.

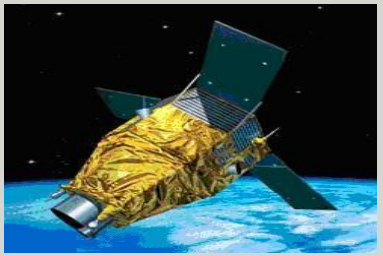
Contributing missions



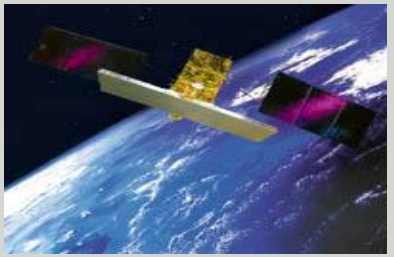
Terrasar–X



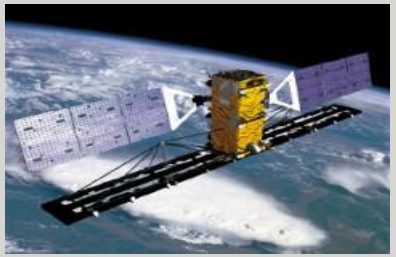
RapidEye



Pléiades

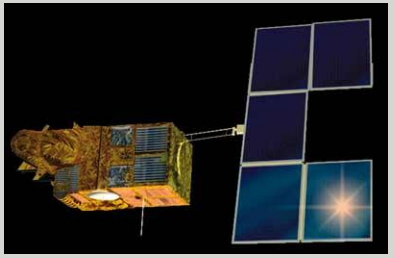


Cosmo-Skymed

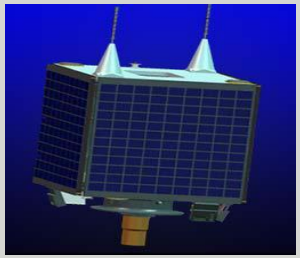


Radarsat

Jason

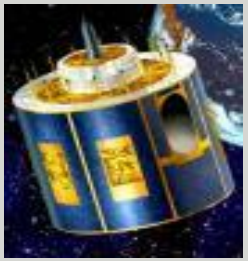


SPOT



DMCs

METOP



MSG

Sentinel Data Policy Principles

FREE and OPEN

- ✓ **Anybody can access Sentinel data; no difference is made between public, commercial and scientific use → open access**
- ✓ **Sentinel data will be made available to the users via a 'generic' online access mode → free of charge**

DUE GlobBiomass

Objective:

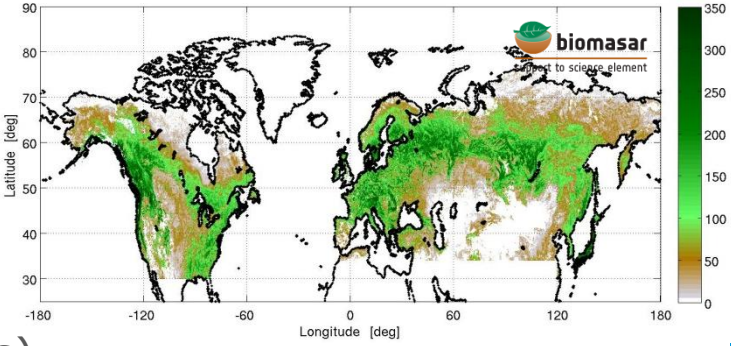
Provide the user communities with a better characteristic of the distribution and changes, and an improved quantification of regional and global biomass

ITT issue:	Summer 2013
KO:	Autumn 2013
Budget:	€1,500,000
Duration:	3 years

User Consultation in Jena, October 2012:

User Requirements from:

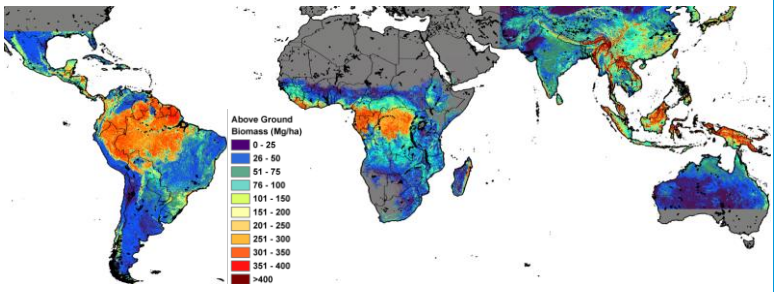
1. Science: Carbon Cycle Science Community
2. Policy: National Forest Inventory and REDD
3. Forest Industry: timber production and certification



Pan Boreal AGB map Santoro et al.

Project Activities:

1. Improve above ground biomass maps (stock and changes)
    - Better geometric resolution
    - Improved accuracy
    - Validation (discrepancy map and error statistics)
2. Platform for data sharing and validation
3. Better stratification of landscape (forest types/species)
4. Standardization of maps



Pan Tropical map AGB – Saatchi et al.

ESA Earth Observation Programme - Educational activities & tools for schools and universities

- Series of Remote Sensing courses at university and PhD level (most course material available on line): PECS courses in SAR, advanced RS courses, TAT training etc.

- Free Image Processing SW toolboxes (SAR, Optical, etc.)

- Web based multilingual Earth Observation educational material (EDUSPACE)

Eduspace

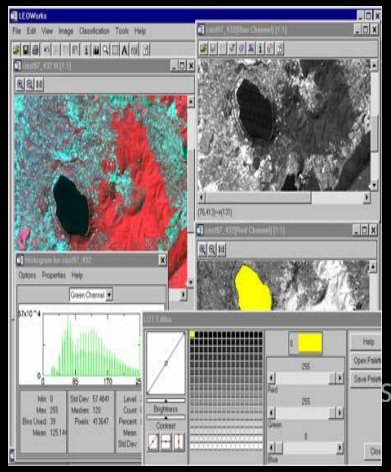
ESA web-based EO Educational tool

LEOWorks 4.0

Image Processing Software (with GIS functionality)

Optical + Radar Image processing SW and GIS

Leoworks an open-source, free and platform-independent Image Processing optical-radar SW and extended GIS for High Schools.



Space Agency

USEFUL ADDRESSES

- ESA education portal: www.esa.int/education
- to order EO material: education@esa.int or eohelp@esa.int
- Eduspace: www.esa.int/eduspace
- ESA EO Education web page: http://eo-edu.eo.esa.int