# *The European Space Agency and the International Environmental Conventions*

Marc Paganini

**European Space Agency**

**Directorate of Earth Observation Programmes**
**Science, Applications and Future Technologies Department**

# *The European Space Agency*

"To provide for and promote, for exclusively peaceful purposes, cooperation among European states in **space research** and **technology** and their **space applications**"

***Article 2 of ESA Convention***

# *ESA, 19 European Member States*

- Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom and… Romania since 20 January 2011.
- Canada takes part in some programmes under a Cooperation Agreement.
- Hungary and Poland are European Cooperating States.
- Cyprus, Slovenia, Estonia and Latvia have recently signed Cooperation Agreements with ESA.

European Space Agency

# THE EUROPEAN SPACE POLICY

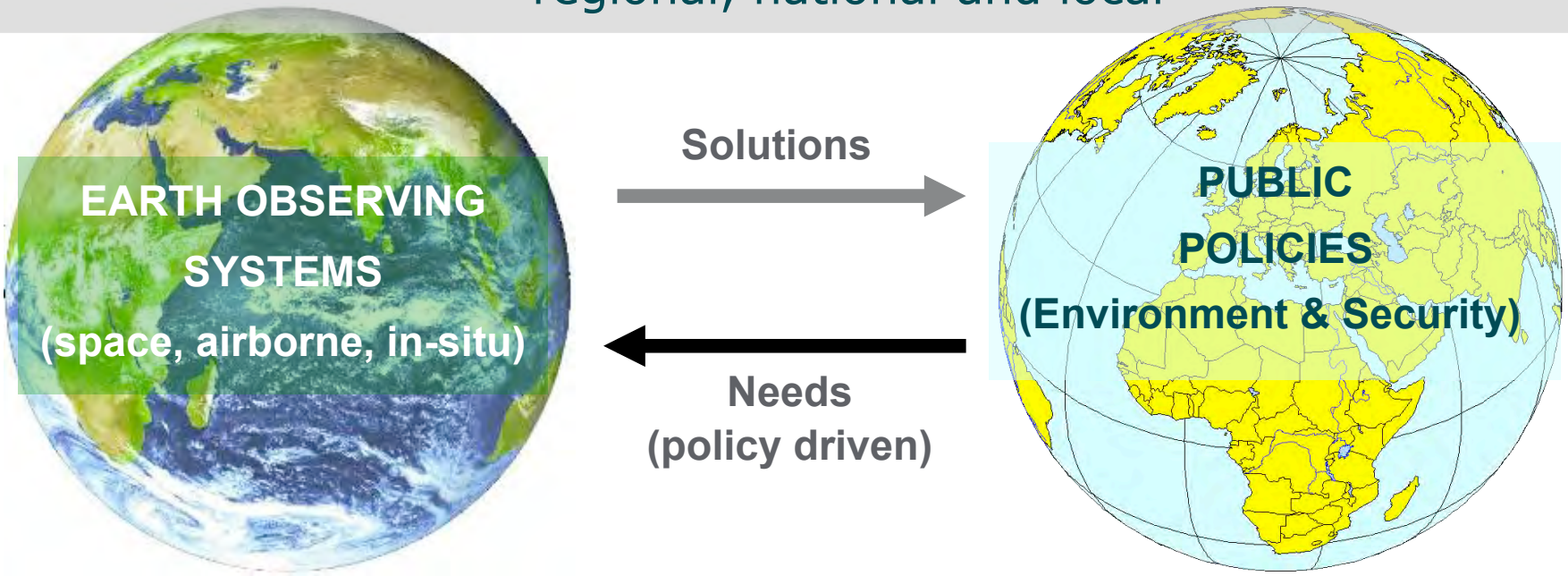
## *Strategic objectives of Space for Europe:*

- develop **space applications** to serve Europe's public policies, enterprises and citizens;
- meet Europe's **security and defense** needs;
- foster **competitive** and **innovative** industries;
- contribute to the **knowledge-based** society;
- secure access to technologies, systems and capabilities for **European independence** and cooperation.

In May 2007, 29 European countries (17 Member States of ESA and 27 Member States of the EU) adopted a Resolution on the **European Space Policy**, adding a new dimension to European space activities.

## *GMES, Global Monitoring for Environment and Security*

for the access to timely and reliable **policy-relevant** information services on the status and the evolution of the Earth **environment** and on the **security** of its citizens at all scales from global to regional, national and local

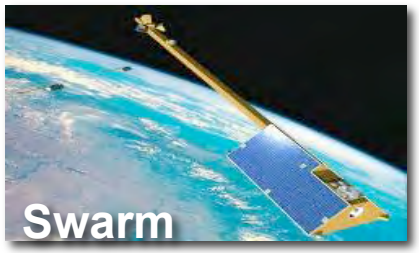



**ESA** with National Space Agencies develops the **GMES Space Component (GSC)**
**EC** with its Member States develops the **GMES Service component**

# ESA Earth Observation programmes
## 40 years comprehensive long-term observations from space

esa

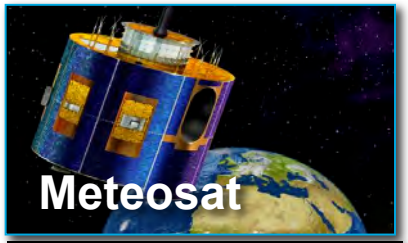
## Earth Science Missions

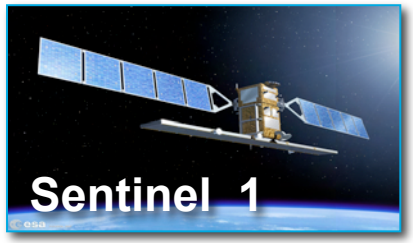





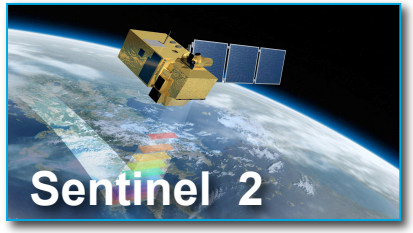


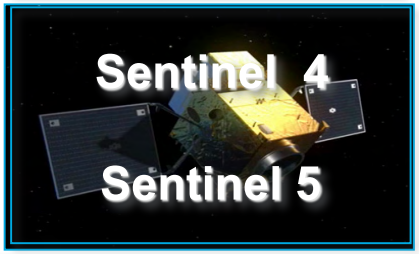

## Operational Missions

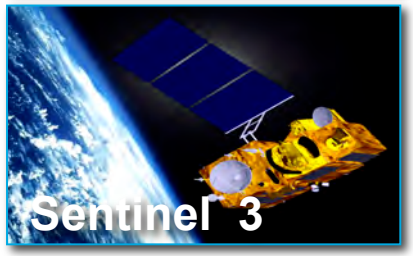


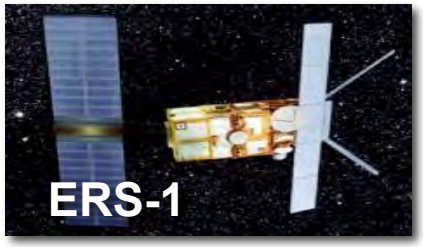





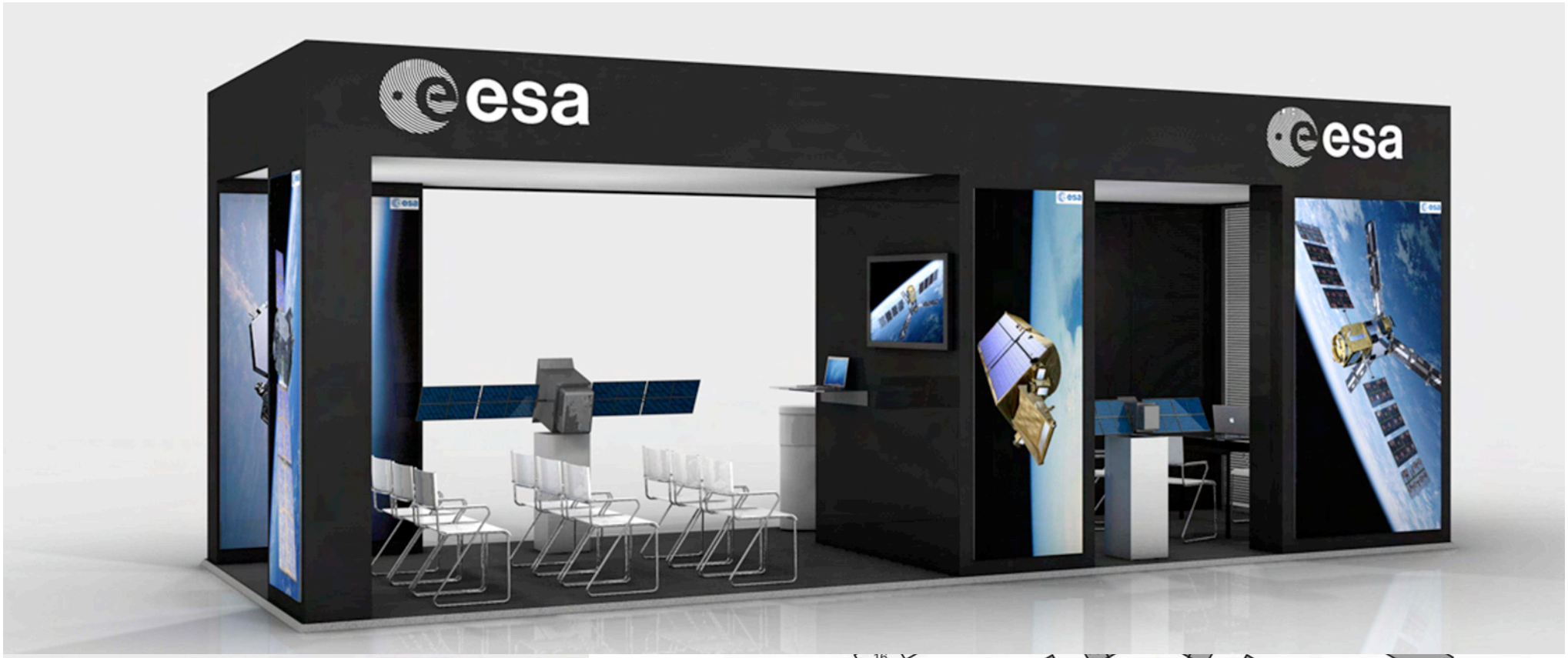


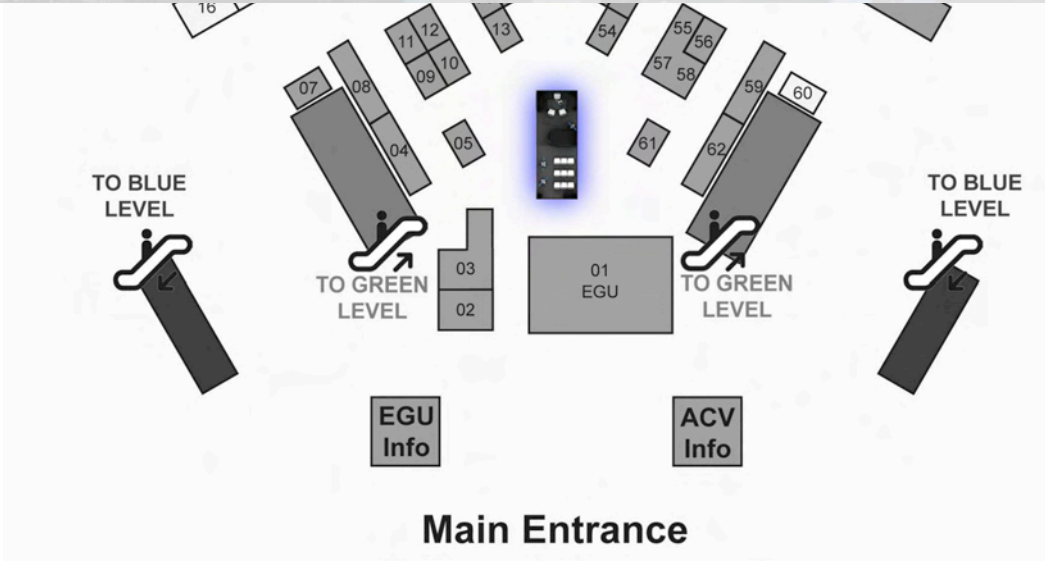






esa
esa


esa


16
11
12
13
54
55
56
57
58
59
60
07
08
09
10
04
05
61
62
TO BLUE LEVEL
TO GREEN LEVEL
03
02
01 EGU
TO GREEN LEVEL
TO BLUE LEVEL
EGU Info
ACV Info
Main Entrance

# *International Environmental Conventions*

- Dramatic environmental problems affecting our planet have mobilised governments, scientists and environmental organisations over the world.
- As a result, several **Multilateral Environmental Agreements (MEAs)** have been signed that aim at reducing environmental degradation.

The United Nations Conference on Environment and Development (UNCED), also known as the 'Earth Summit', held in Rio in 1992.
It resulted in the definition of the 'Agenda 21' plan of actions
and the subsequent signature of different multilateral agreements such as

- the UN Convention to Combat Desertification (**UNCCD**),
- the UN Convention on Biodiversity (**UNCBD**)
- the UN Framework Convention on Climate Change (**UNFCCC**).

# Working with International Environmental Conventions

- ***UNFCCC,***
  *UN Framework Convention on Climate Change*
- ***UNCCD,***
  *UN Convention to Combat Desertification*
- ***UNCBD,***
  *UN Convention on Biodiversity*
- ***Ramsar,***
  *Intergovernmental Convention on Wetlands*
- ***WHC,***
  *World Heritage Convention*


European Space Agency

# ESA participate to UNFCCC, UNCCD, UNCBD and Ramsar COPs

| | UNFCCC | UNCCD | UNCBD | Ramsar |
|---|---|---|---|---|
| **2002** | COP8, New Delhi | | | COP8, Valencia |
| **2003** | COP9, Milan | COP6, La Havana | | |
| **2004** | COP10, Buenos Aires | | | |
| **2005** | COP11, Montreal | COP7, Nairobi | | COP9, Kampala |
| **2006** | COP12, Nairobi | | | |
| **2007** | COP13, Bali | COP8, Madrid | | |
| **2008** | COP14, Poznan | | COP9, Bonn | COP10, Changwon |
| **2009** | COP15, Copenhagen | COP9, Buenos Aires | | |
| **2010** | COP16, Cancun | | COP10, Nagoya | |

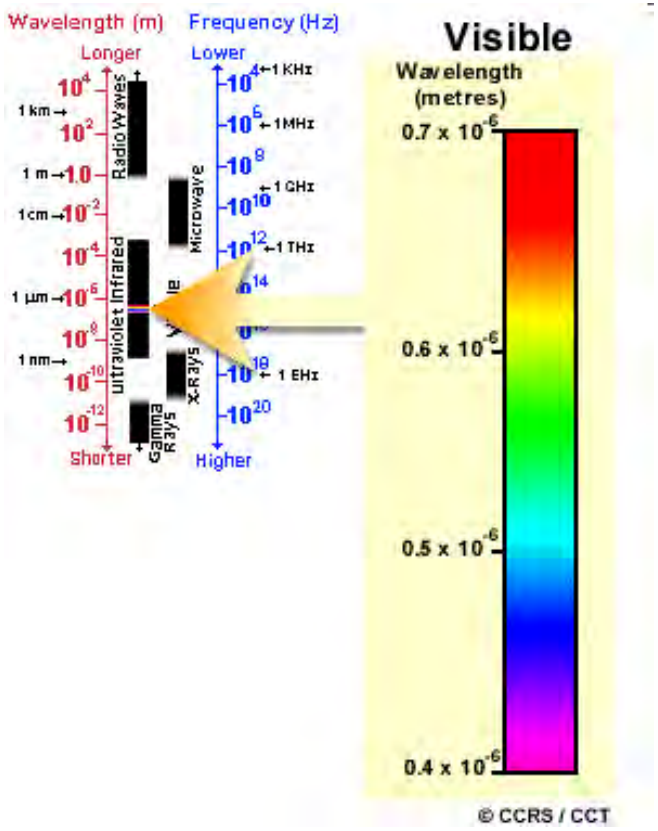
\+ *participation to the World Summit on Sustainable Development, Johannesburg, 2002*

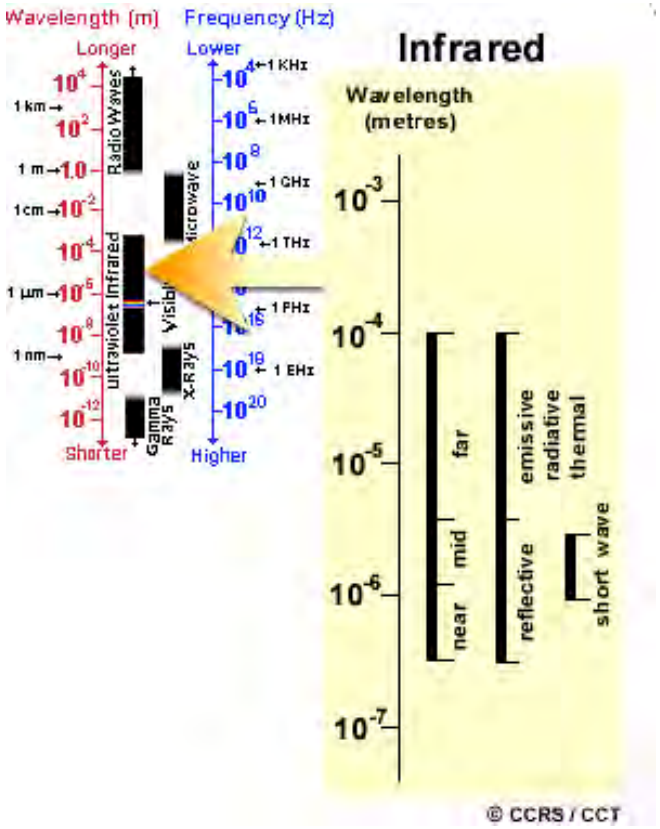
# *Environmental Monitoring from Space*

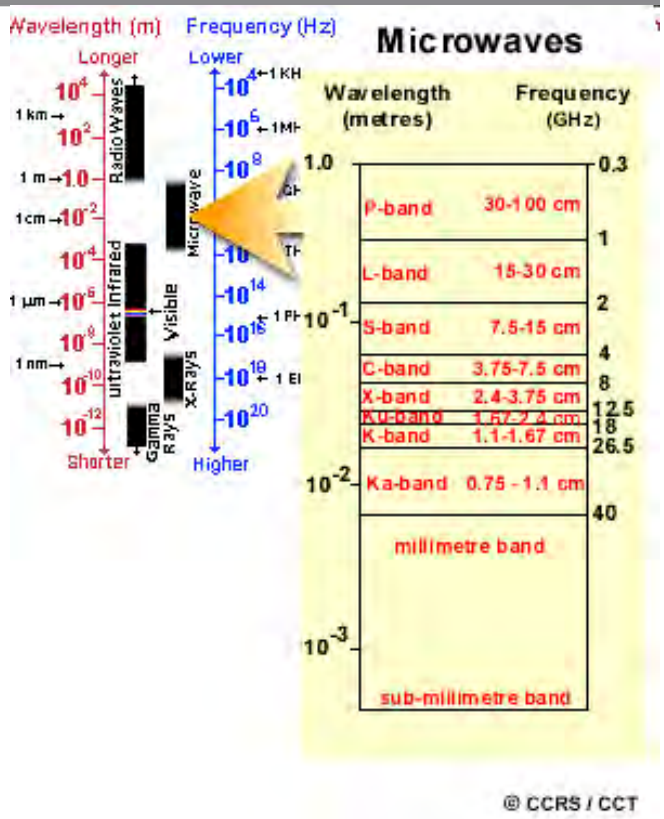
- Continuous data acquisition: Earth Observation satellites allows continuous observation of the Earth surface and its changes on a regular basis.
- Long term archive: The existing archives of Earth Observation data allows an historical view of environmental issues (30+ years).
- Multi-scale capabilities: The different type of Earth Observation systems allows the observation of the Earth at global, regional, national and local scales.
- Multi-sensor information: The synergic use of optical and radar systems allows different types of environmental parameters and processes to be observed and monitored.

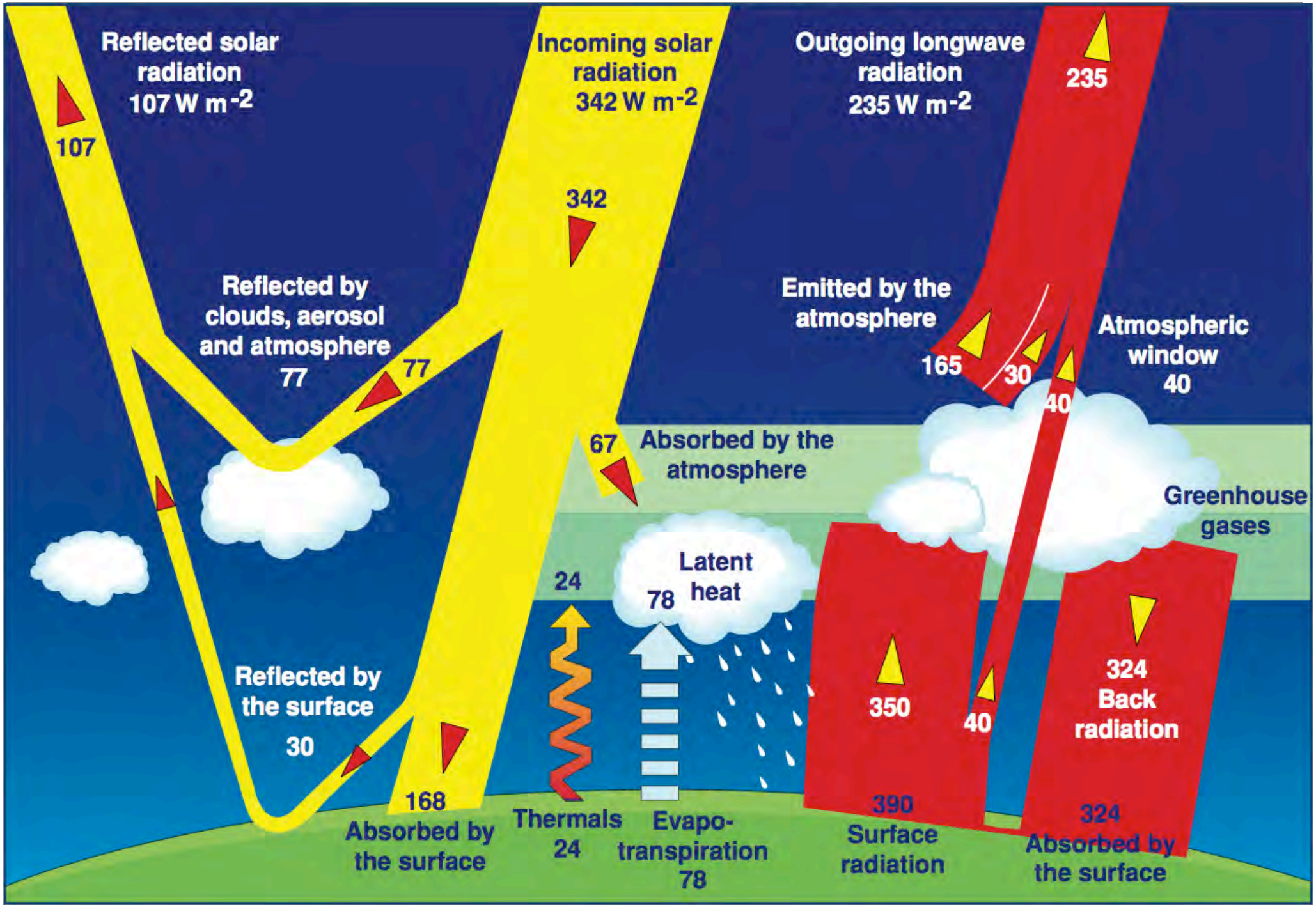
*EO Technology is an **important tool to support the Contracting Parties**, and local, national and international bodies in the **implementation of the Conventions***

# Fundamentals of Remote Sensing: The Electromagnetic Spectrum

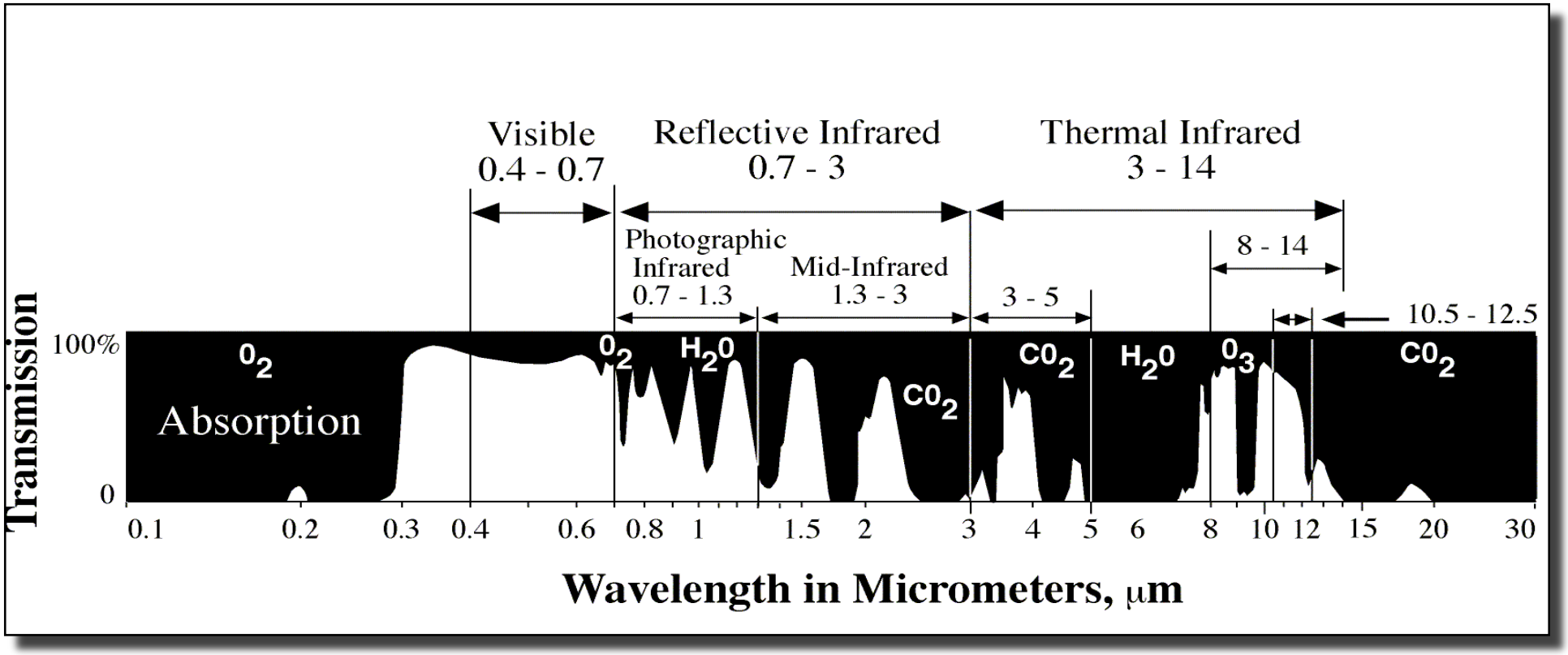


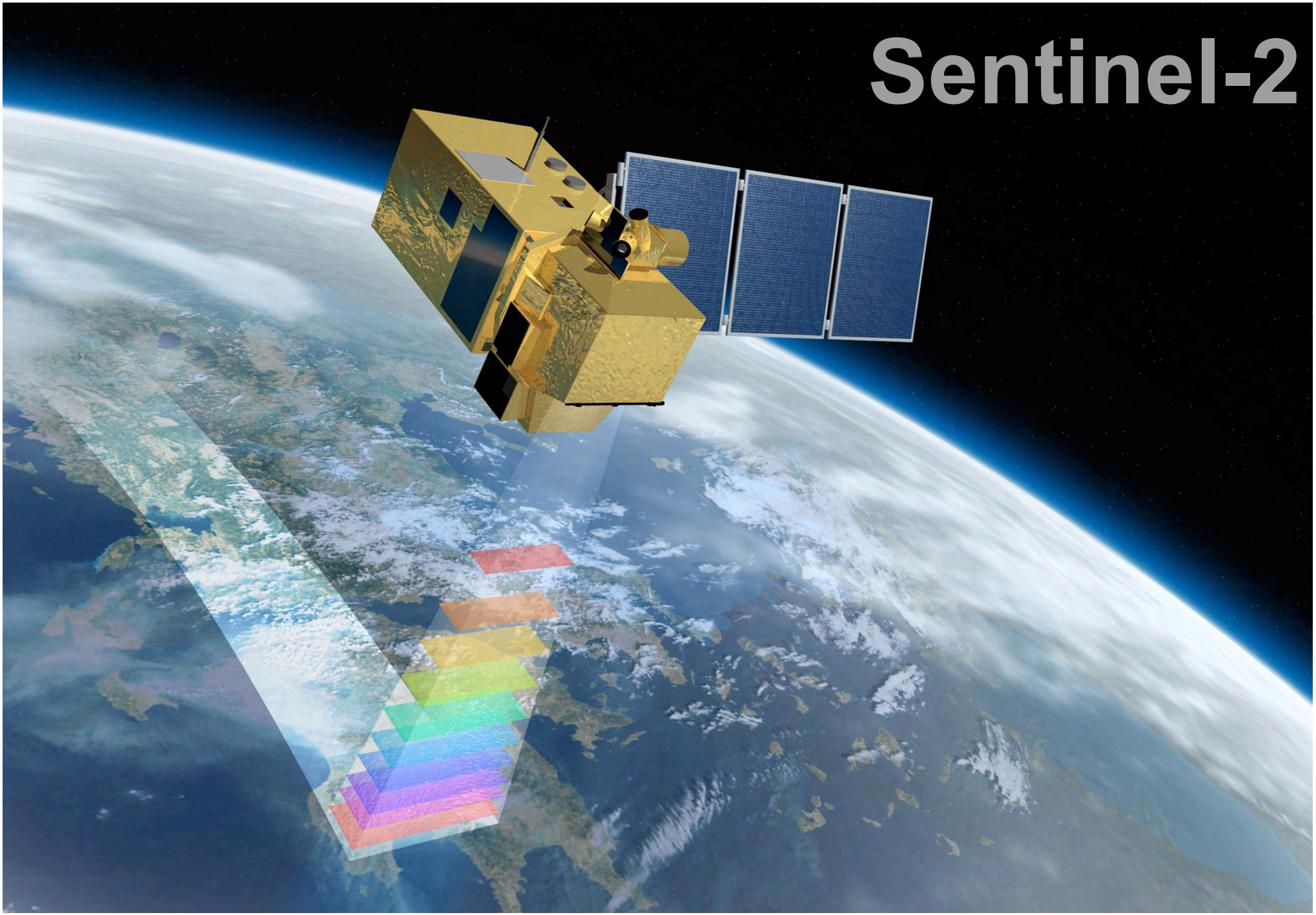



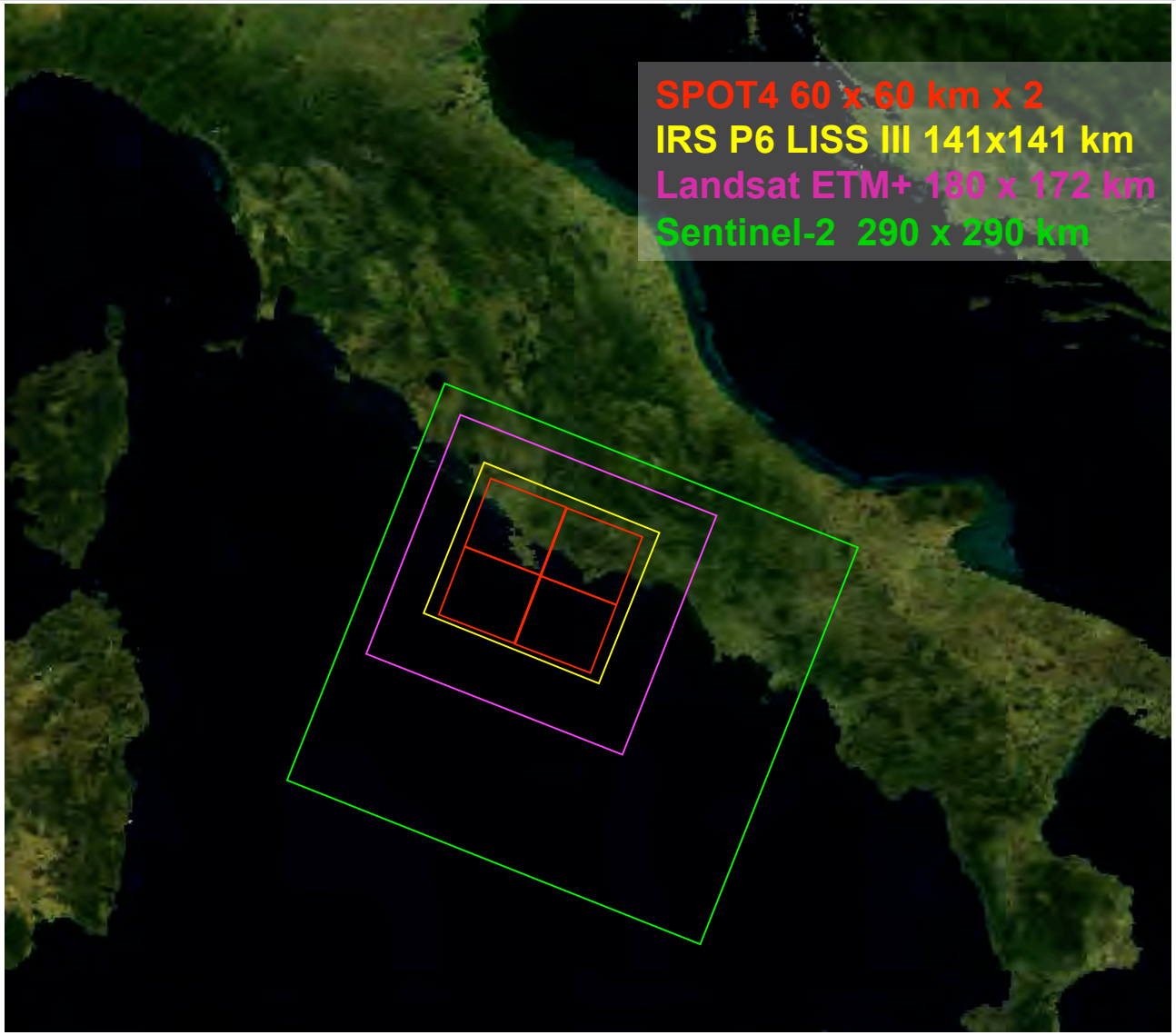

Reflected solar radiation 107 W m-2
107
Incoming solar radiation 342 W m-2
342
Outgoing longwave radiation 235 W m-2
235
Reflected by clouds, aerosol and atmosphere
77
77
Emitted by the atmosphere
165
30
40
Atmospheric window
40
67
Absorbed by the atmosphere
Greenhouse gases
Latent heat
78
24
Reflected by the surface
30
350
40
324
Back radiation
168
Absorbed by the surface
Thermals
24
Evapo-transpiration
78
390
Surface radiation
324
Absorbed by the surface

# Interaction with the Atmosphere



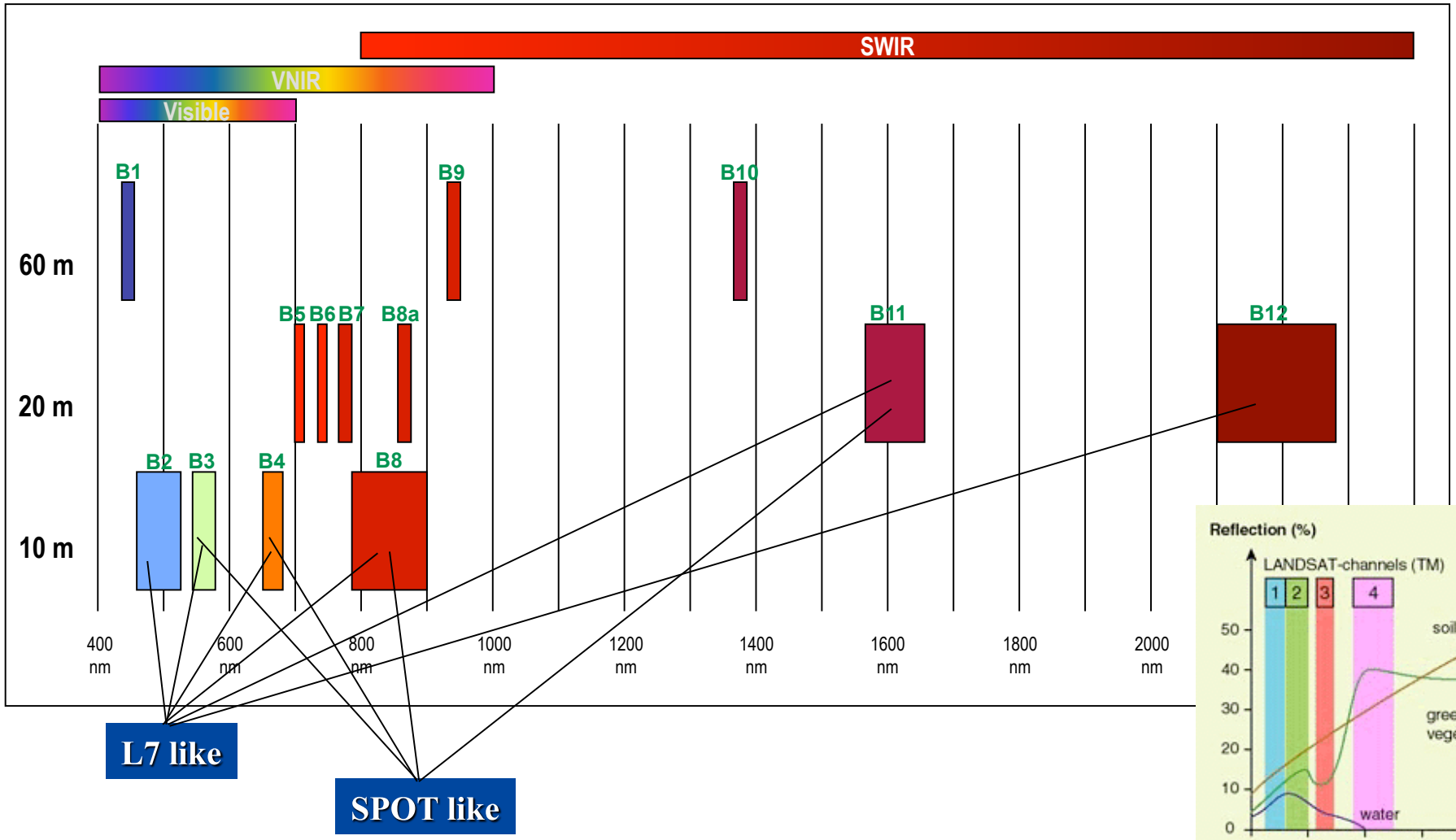

Sentinel-2

# Sentinel-2 Swath




- Frequent revisit time
- High spatial resolution
- Long mission duration (12y)
- Systematic acquisition of land surfaces and coastal waters
- Two satellites flying in sun-synchronous orbit
- Local Time Descending Node ≈ 10:30
- 180° phasing in orbit plane
- 10 days repeat period for the single satellite and 5 days for the twin configuration
- Expected cloud-free revisit of 15-30d on most of the Lands

# Sentinel-2 Spectral Bands



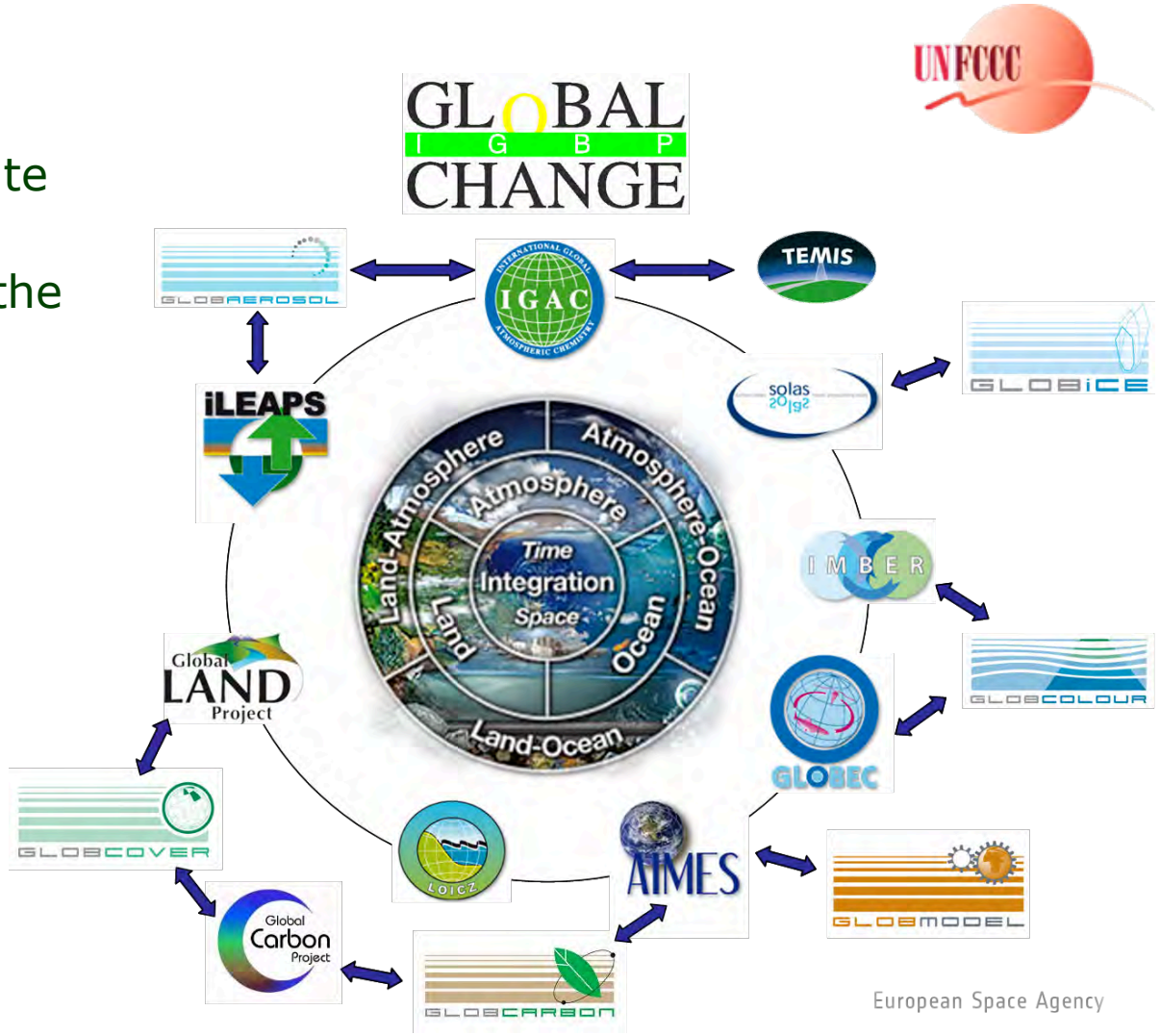
# ***UNFCCC,***
# *UN Framework Convention on Climate Change*

http://www.unfccc.int/

# ESA and the UNFCC Convention

International organizations (e.g. IPCC, GCOS, IGBP, WCRP, GODAE, ECMWF, GOFC) participate in ESA projects addressing the monitoring of Global Change on the different elements of the Earth System

New ESA Programme on Global Monitoring of Essential Climate Variables as a contribution to the CEOS response to the GCOS Implementation plan endorsed by the UNFCCC SBSTA at COP12

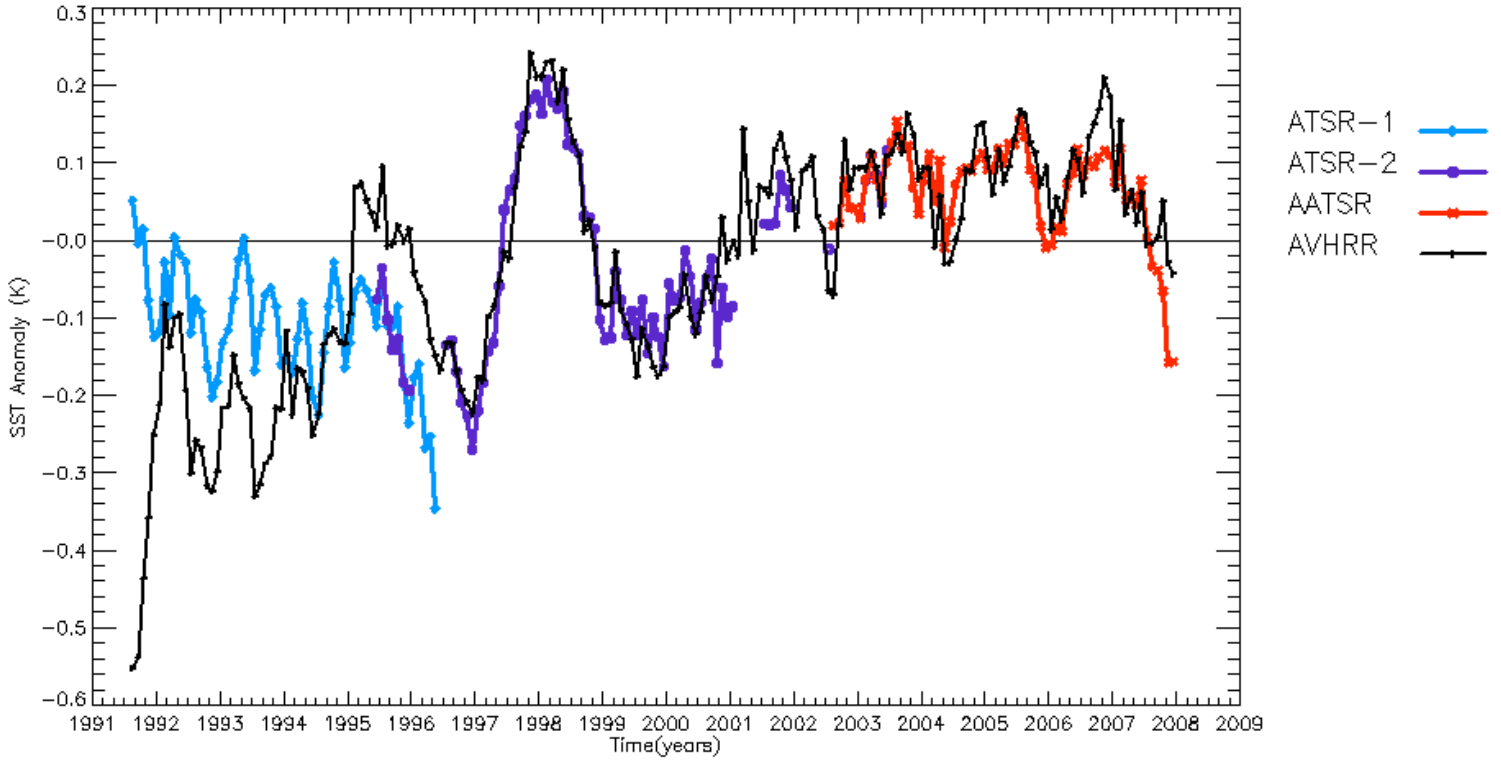


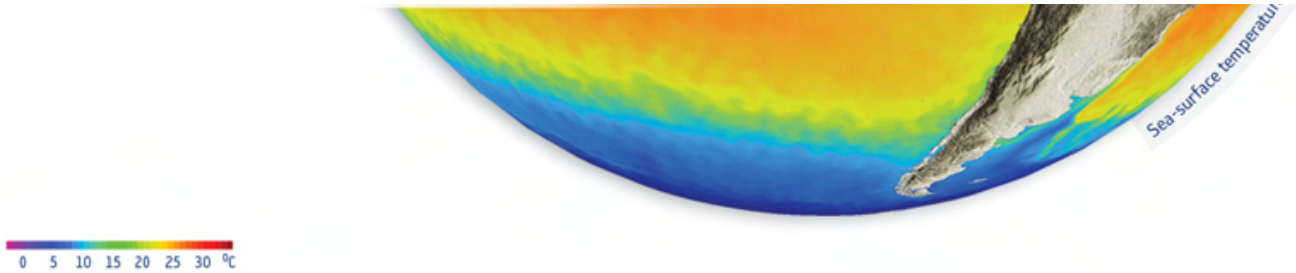
# Satellite Observation of Essential Climate Variables (ECVs)

| | | |
|---|---|---|
| ***Atmosphere*** | **Surface ( 0, 0, 6 )** | *Air Temperature; Precipitation ; Air pressure; Water vapour; Surface radiation budget; Wind Speed & direction;* |
| | **Upper air ( 1, 1, 3 )** | ***Cloud properties, Wind speed & direction*** *Earth radiation budget; Upper-air temperature; Water vapour;* |
| | **Composition ( 3, 0, 0 )** | ***Carbon dioxide; GHGs; Ozone; Aerosol properties*** |
| ***Ocean*** | **Surface ( 4, 2, 1 )** | ***Sea-surface Temperature; Sea-level; Sea-ice; Ocean colour; Sea state; Sea-surface salinity*** *Carbon dioxide partial pressure* |
| | **Sub-surface ( 0, 0 , 7 )** | *Temperature; Salinity; Current; Nutrients; Carbon; Ocean tracers; Phytoplankton* |
| ***Terrestrial*** **( 3, 7, 4 )** | ***Glaciers & ice caps; Land Cover; Fire disturbance*** ***Fraction of absorbed photo-synthetically active radiation; LAI , Albedo*** ***Biomass, Lake levels, Snow cover, Soil moisture*** *Water use, Ground water, River discharge Permafrost and seasonally-frozen ground* | |

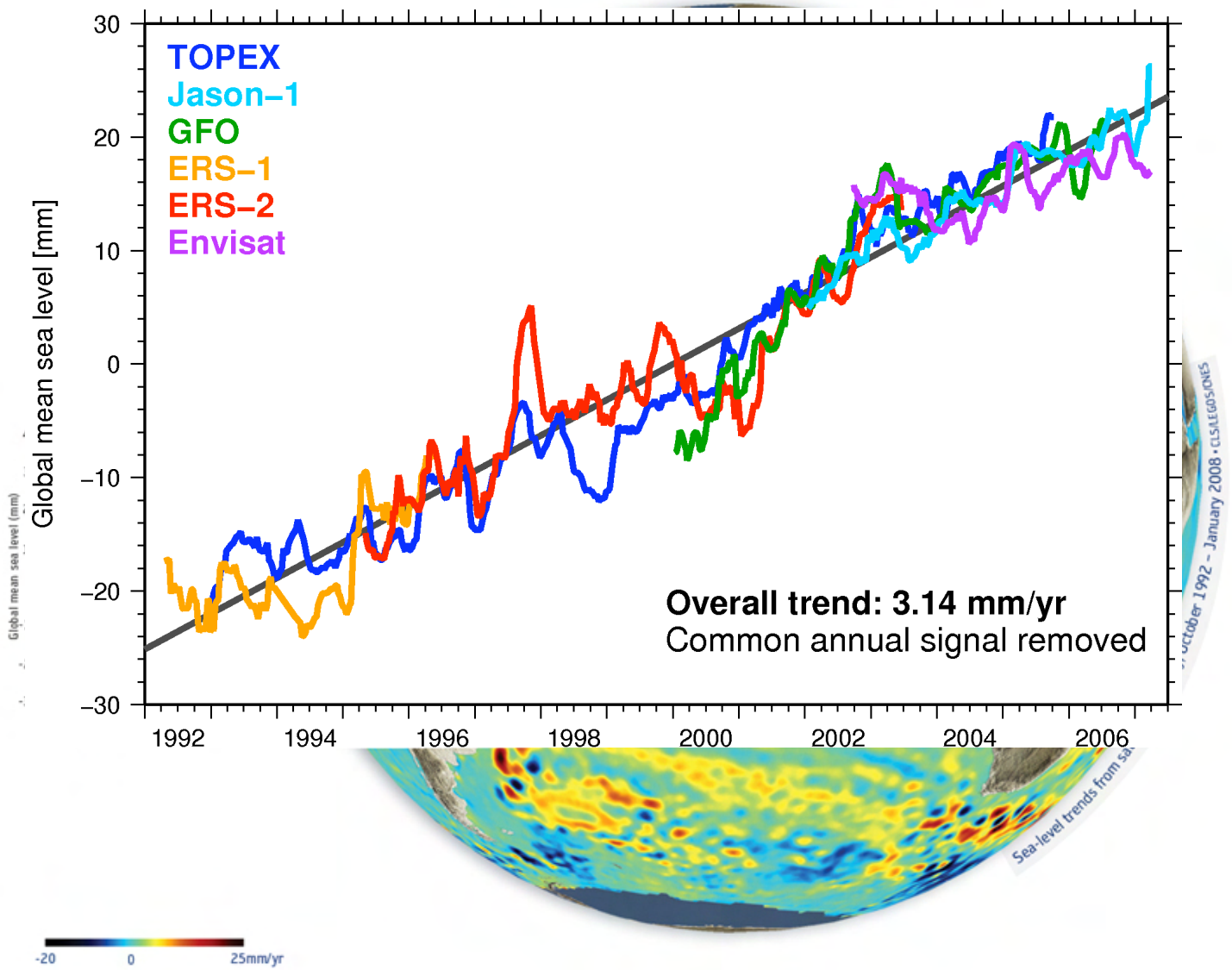
# Global Sea Surface Temperatures

sea surface temperature
increase
since 19



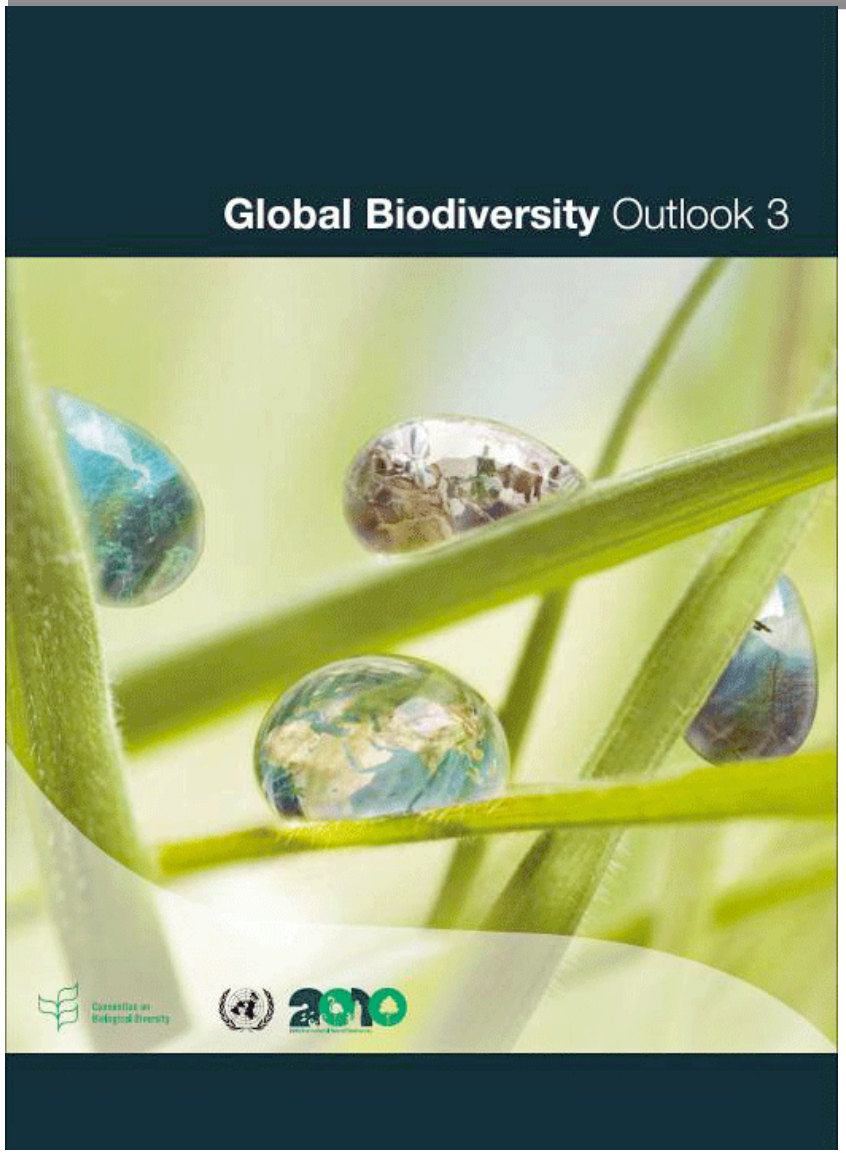
# Global Sea Level Rise



# ***UN-CBD,***
# *UN Convention on Biological Diversity*


http://www.cbd.int/

# The Global Biodiversity Outlook (GBO)




- **Sept 2002**, 2nd Earth Summit, Johannesburg
  "*achieve by 2010 a significant reduction in the rate of Biodiversity loss*"
- **Year 2010**,
  International Year of Biodiversity
- **May 2010**,
  Global Biodiversity Outlook 3
  "*2010 targets have not been met*"
  "*State of Biodiversity: Collective failure*"
- **Sept 2010**, UNGA 65th Session
  "*first high level meeting on Biodiversity*"
- **Oct 2010**, UNCBD COP-10, Nagoya
  "*new strategic plan for the coming decade with a 2020 mission and a 2050 vision*"
- **Feb 2011**, UNGA 66th Session
  "Official approval of the IPBES body"

RIO 2012 United Nations Conference on Sustainable Development

**June 2012**: Rio+20 Earth Summit
United Nations Conference on Sustainable Development (UNCSD)

# GBO-3 key messages

## Natural habitats continue to decline in extent and in integrity

Five main pressures continue to affect biodiversity and are either constant or increasing in intensity:

- Habitat loss
- Unsustainable use and overexploitation of natural resources
- Climate change
- Invasive alien species
- Pollution

**BUT ….**

- Some 170 countries have national biodiversity strategies and actions plans
- Important progress in developing mechanisms for research, monitoring and assessment of biodiversity
- The real benefits of biodiversity, and the costs of its lost, are progressively reflected within economic systems and markets.

# *Space contribution to UN Convention on Biodiversity*

| UN-CBD Focal Areas | Headline Indicators |
|---|---|
| Status and trends of the components of biological diversity | ▪ *Trends in extent of selected biomes, ecosystems & habitats*<br>▪ *Change in status of threatened species*<br>▪ *Coverage of protected areas* |
| Sustainable use | ▪ *Area of forest, agricultural and aquaculture ecosystems under sustainable management* |
| Threats to biodiversity | ▪ *Trends in invasive alien species (IAS)* |
| Ecosystem integrity and ecosystem goods and services | ▪ *Connectivity / fragmentation of ecosystems*<br>▪ *Water Quality of freshwater ecosystems* |

CBD global headline indicators to assess progress towards the 2010 biodiversity target

*UNCBD COP VII, decision VII/30*

# *Examples of Biodiversity indicators from Space*

- Trends in selected biomes, habitats and ecosystems, **Forests**
- **Habitat fragmentation** and connectivity.
- Trends in selected biomes, habitats and ecosystems, **Costal Waters (Mangroves, Coral reefs)**
- Trends in selected biomes, habitats and ecosystems, **Inland Waters (Wetlands)**

***BUT also…***

- *Other ecosystems (dry and sub-humid lands, artic sea ice)*
- *Trends in species population,*
- *Trends in Invasive Aliens Species (IAS),*
- *Protected Areas (terrestrial and marine)*
- *Economics of ecosystems services*
- *… AND also….. New hot topics such as "Biofuels" and "Ocean Acidification"*

# *Trends in selected biomes, habitats and ecosystems, Forest*

Agreement on **Reducing Emissions from Deforestation and forest Degradation,** on conservation, sustainable management of forests, and on enhancement of forest carbon stocks in developing countries (REDD+).

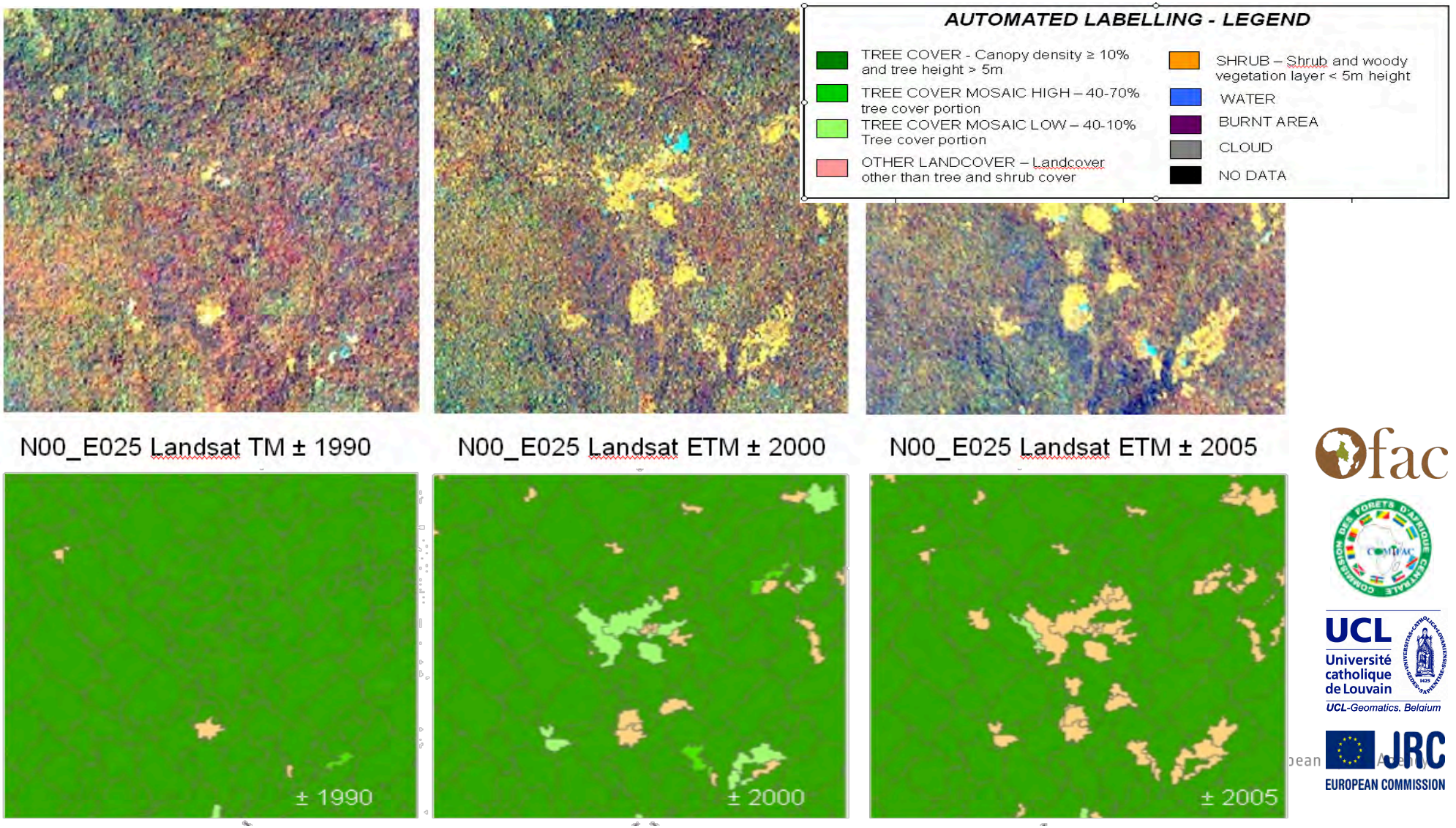
*UNFCCC COP16 decision, Cancun*

- Encourages developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following activities:
  - (a) Reducing emissions from deforestation;
  - (b) Reducing emissions from forest degradation;
  - (c) Conservation of forest carbon stocks;
  - (d) Sustainable management of forest;
  - (e) Enhancement of forest carbon stocks.

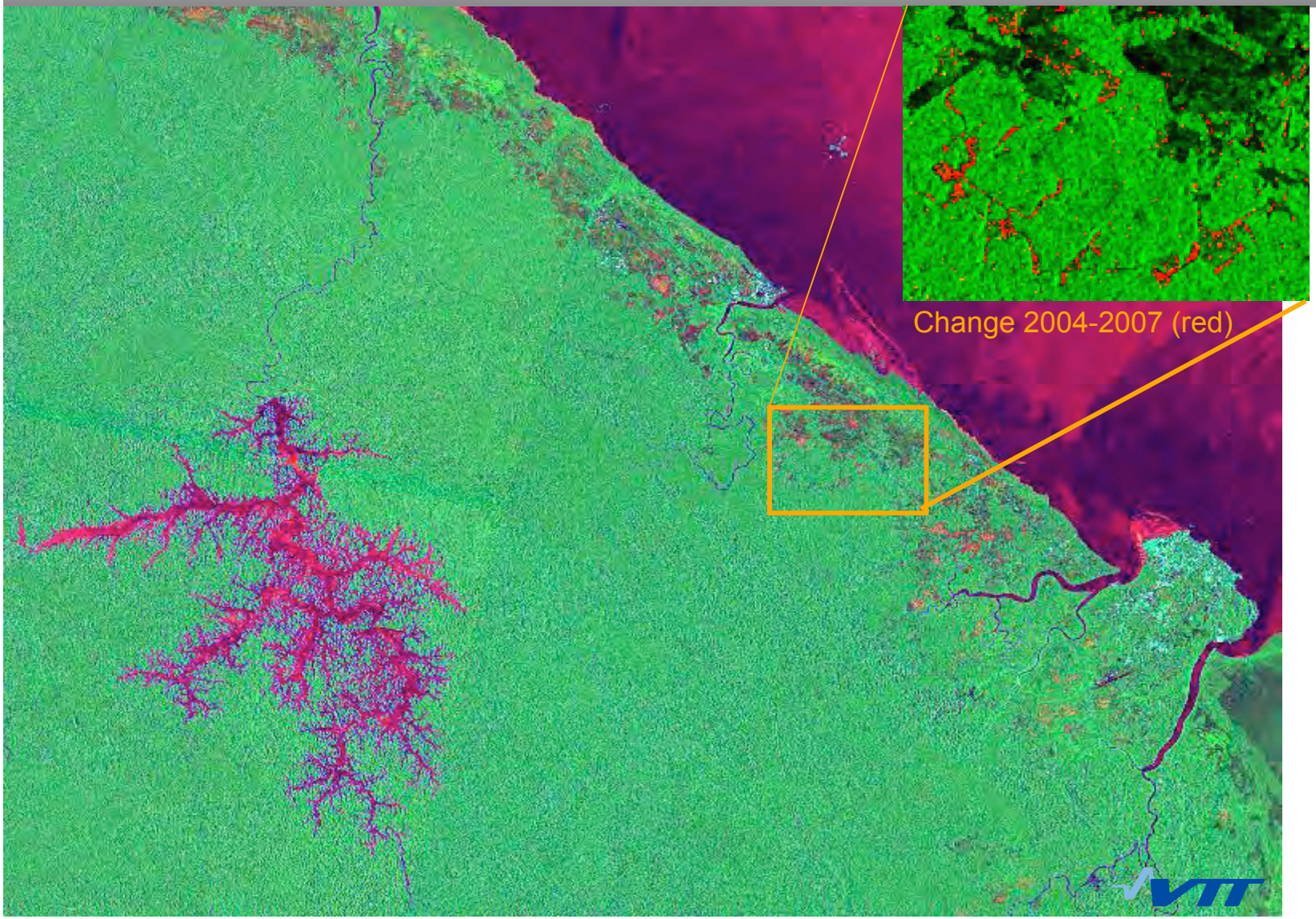
# *REDD+ and biodiversity*

…. If well designed and successfully implemented, REDD+ will also provide unprecedented benefits for biodiversity…

# *Deforestation in the Congo Basin (using passive remote sensing)*



# *Deforestation in French Guyana (using active remote sensing)*




Red: temporal variability

Green: Average amplitude

Blue: Average texture

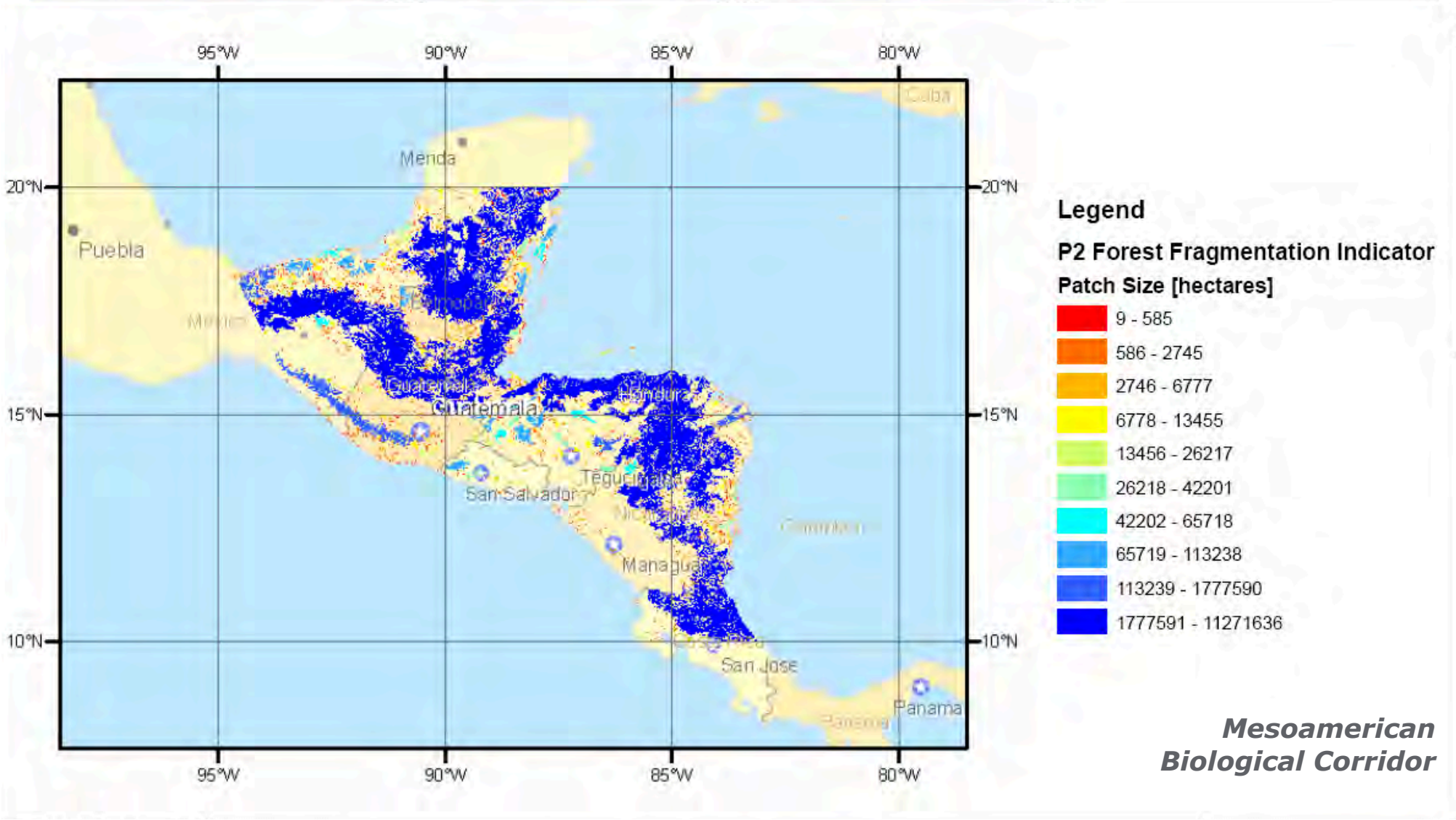
Area size approximately 115 x 90 km$^2$

VTT

GAFAG

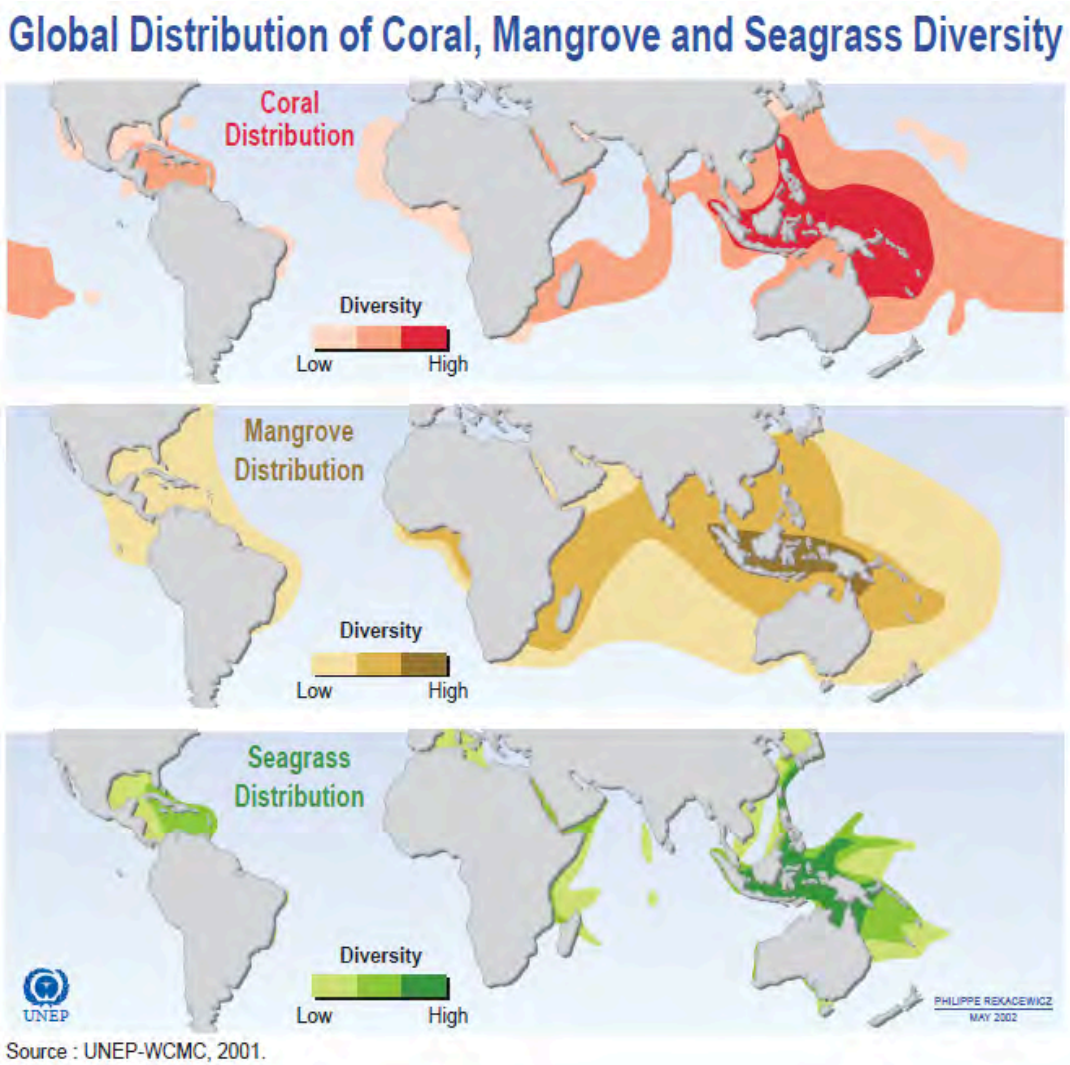
GSE Forest Monitoring

# *Habitat Fragmentation and connectivity*




***Mesoamerican Biological Corridor***

# *Costal Biodiversity: mangroves, coral reefs and seagrass beds*



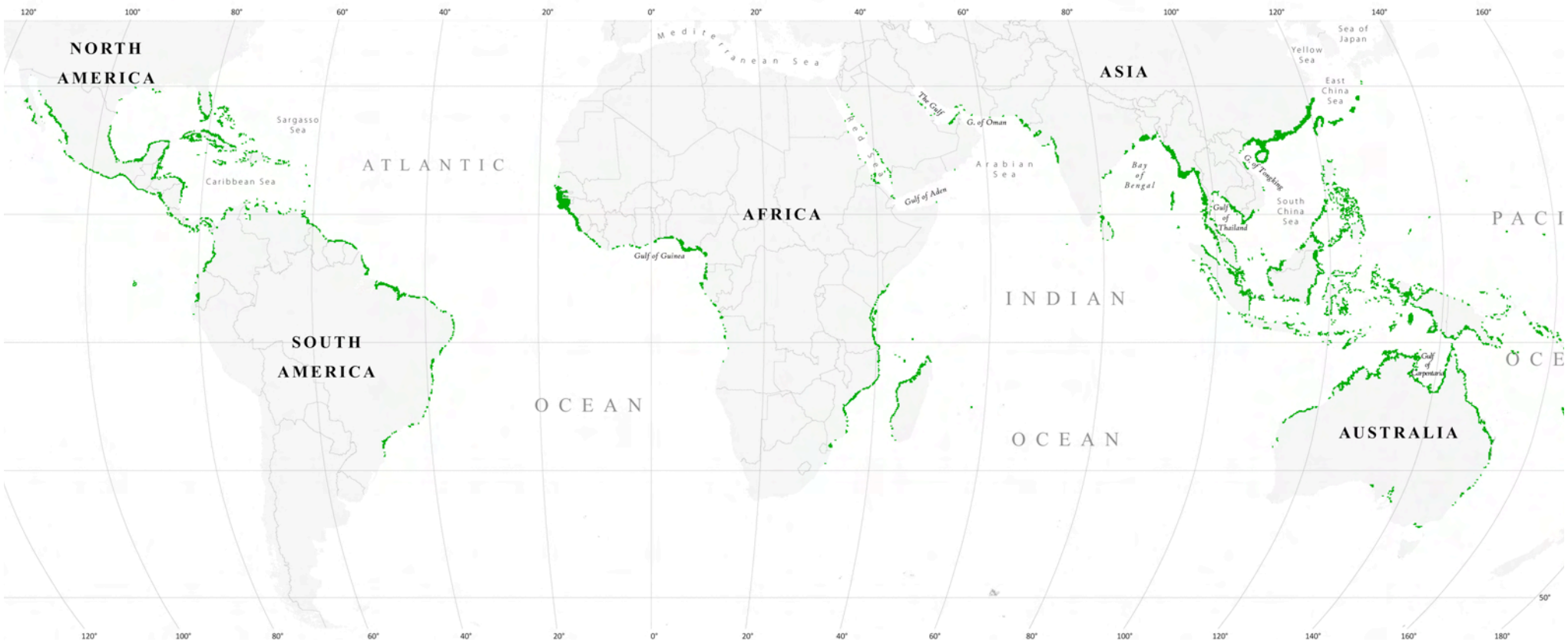
Source : UNEP-WCMC, 2001.

Indo-pacific reefs: living coral cover fell from 47% of the reef areas in 1980 to 26% in 1989 (average loss of 2.3% a year)

El Niño/La Niña events of 1997–1998 resulted in the most extensive coral bleaching (16% of the world's coral reefs being effectively destroyed)

One fifth of the world mangroves (36,000 km2) have been lost between 1980 and 2005

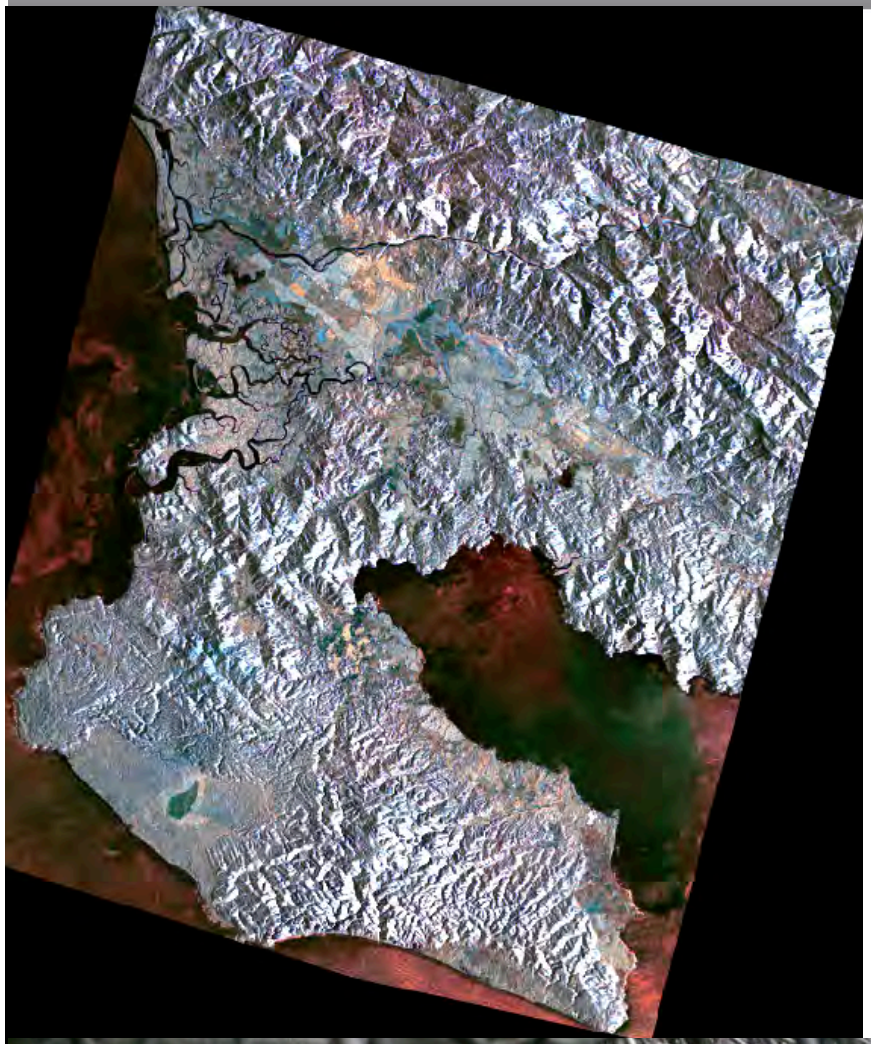
Rate of loss:
1,850 km2 in the 1980s
1,185 km2 in the 1990s
1,020 km2 in the 2000s

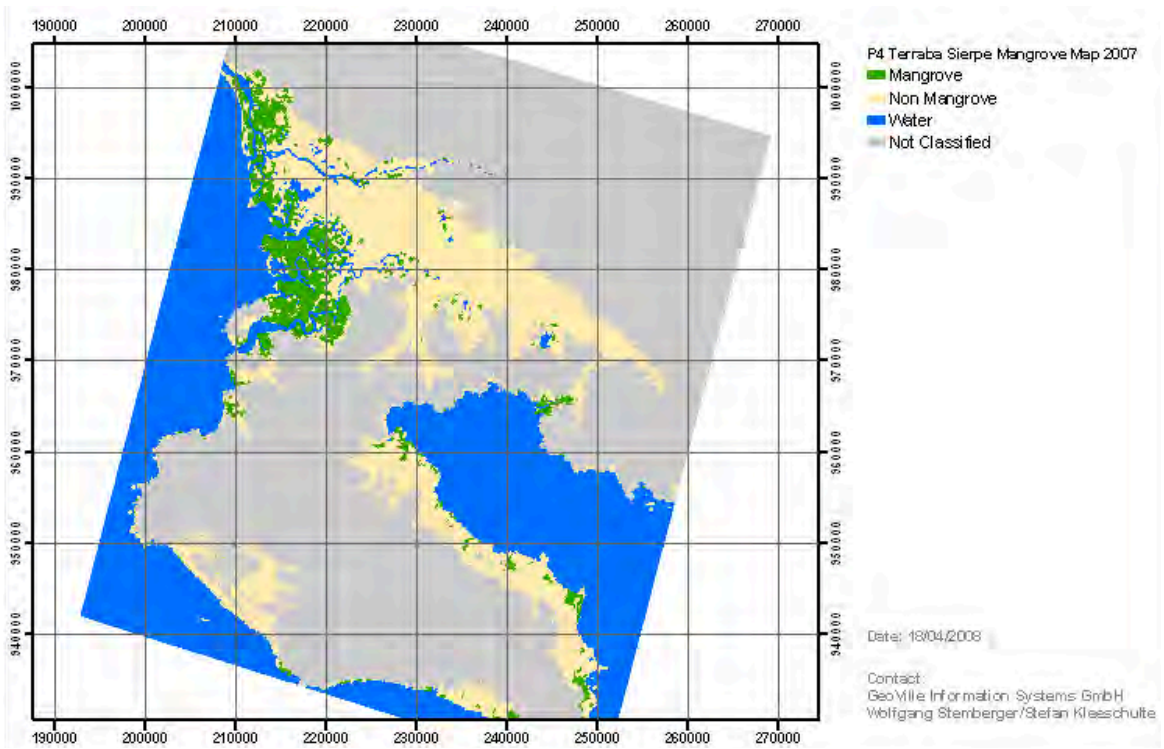



***Mangrove forests distributions of the world – 2000*** (©USGS – UNEP)

- based on the Global Land Survey (GLS) data and the Landsat archive (1,000 scenes).
- total area of mangroves in the year 2000 was 137,760 km2 in 118 countries and territories in the tropical and subtropical regions of the world.
- Approximately 75% of world's mangroves are found in just 15 countries,
- only 6.9% are protected under the existing protected areas network (IUCN)

# *Mangroves mapping*

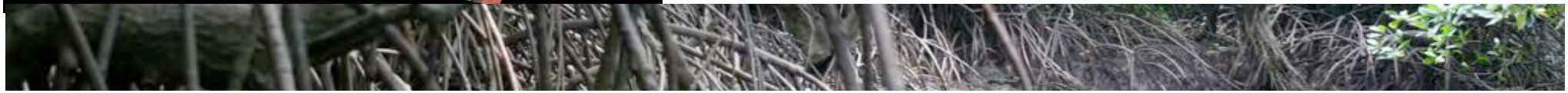




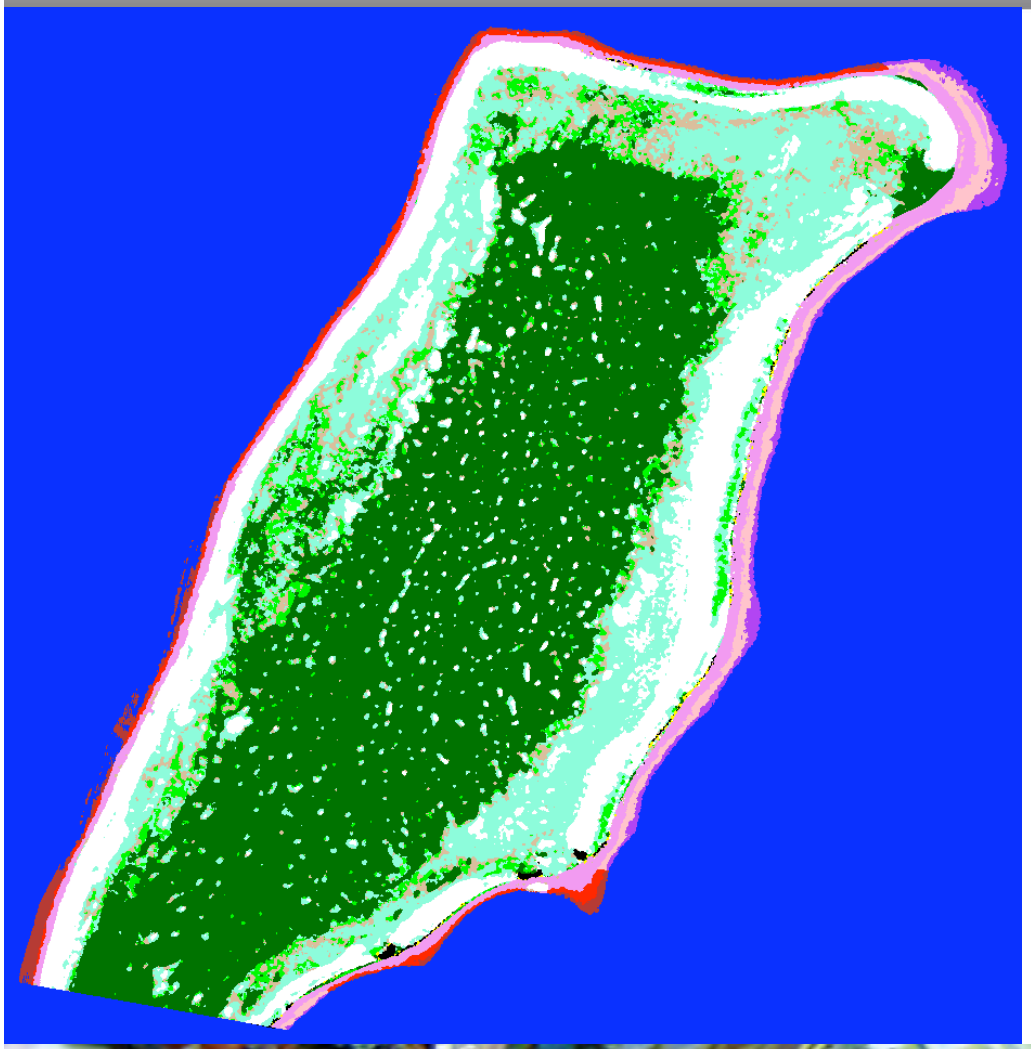

***C-band Radar images, RGB composite***

*B: temporal variability, G: average brightness, R: average texture*

***Terraba-Sierpe Reserve, Costa Rica***



# *Coral Reefs habitat mapping over Hotspots*




***Glovers Atoll, Belize***

# Detection of Coral Bleaching

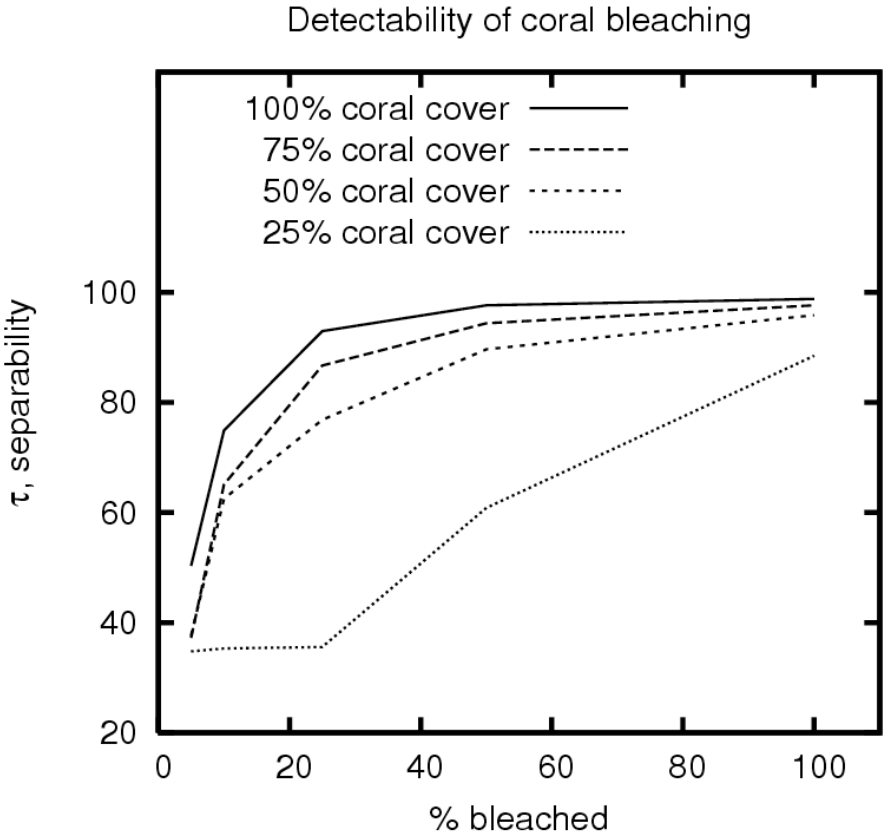
Basic reflectance of corals, bleached corals and sand

↓

Radiative transfer model to predict radiance at sensor level

↓

Assess spectral separability encompassing all sources of environmental variation

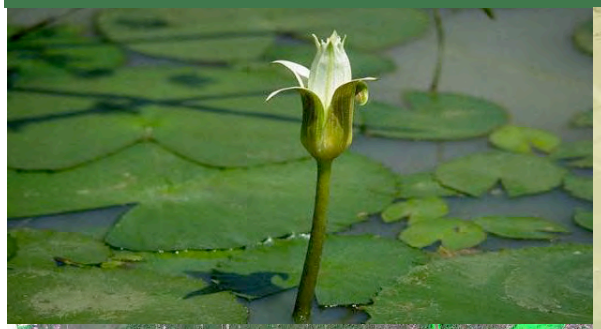


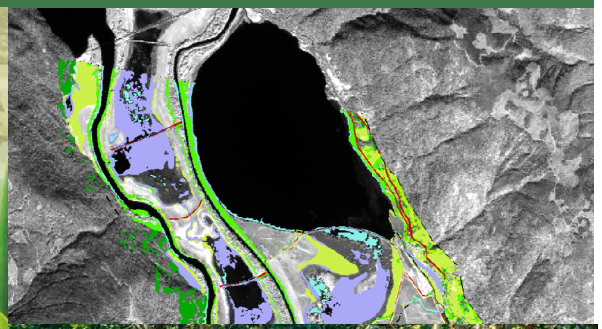

- complete bleaching events detectable for coral covers as low as 25%
- partial bleaching events difficult to detect for low coral covers

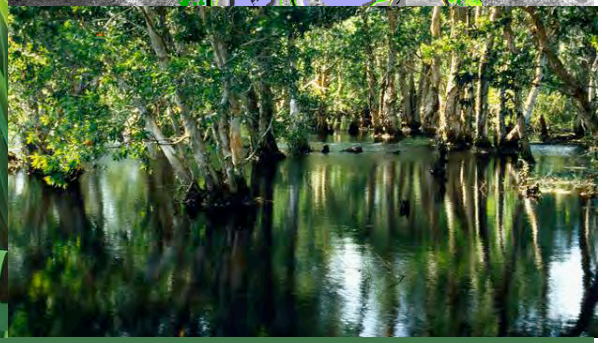
# ***Ramsar,***
# *The Ramsar Convention on Wetlands*


http://www.ramsar.org/

# Space for the Ramsar Convention on Wetlands



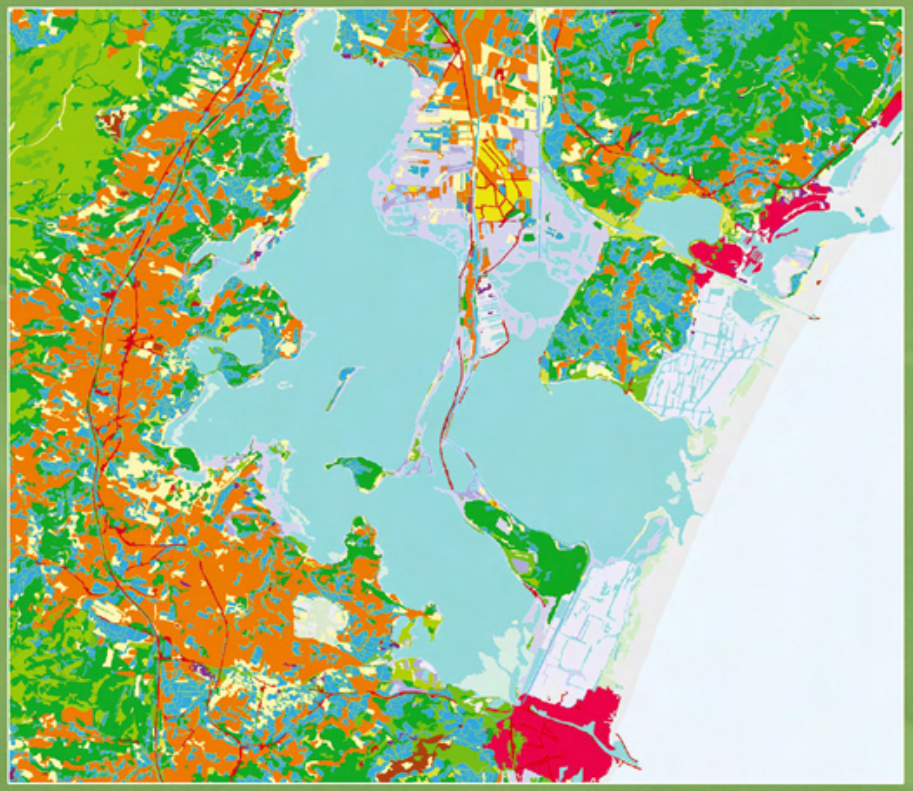





- *Increase scientific knowledge*
- *Support efficient management, conservation and wise use of wetlands*
- *Contribute to improve the performances (reporting obligations) of the Contracting Parties to the Convention*

# Land Use and Land Cover Mapping

The Land Use Land Cover (LULC) maps provide detailed classification of all land parcels within wetland sites at different scales depending on the size (1:25,000 or 1:50,000). The LULC maps use a standardised classification scheme based on the Corine Land Cover system (EC, 1993), which has been adapted to incorporate the Ramsar wetlands classification system. The thematic information provided in the LULC maps follows a 5 level nomenclature where the first level distinguishes between water, natural areas and artificial surfaces and the most detailed levels include the single wetland typologies defined by the Ramsar Convention.



*Parc Naturel Régional de la Narbonnaise, Littoral Audois, France*
*Natural preserved site along the Mediterranean coast, which includes a vast area and large biodiversity. The park's land use is mainly characterized by lagoons and saline exploitation ponds.*

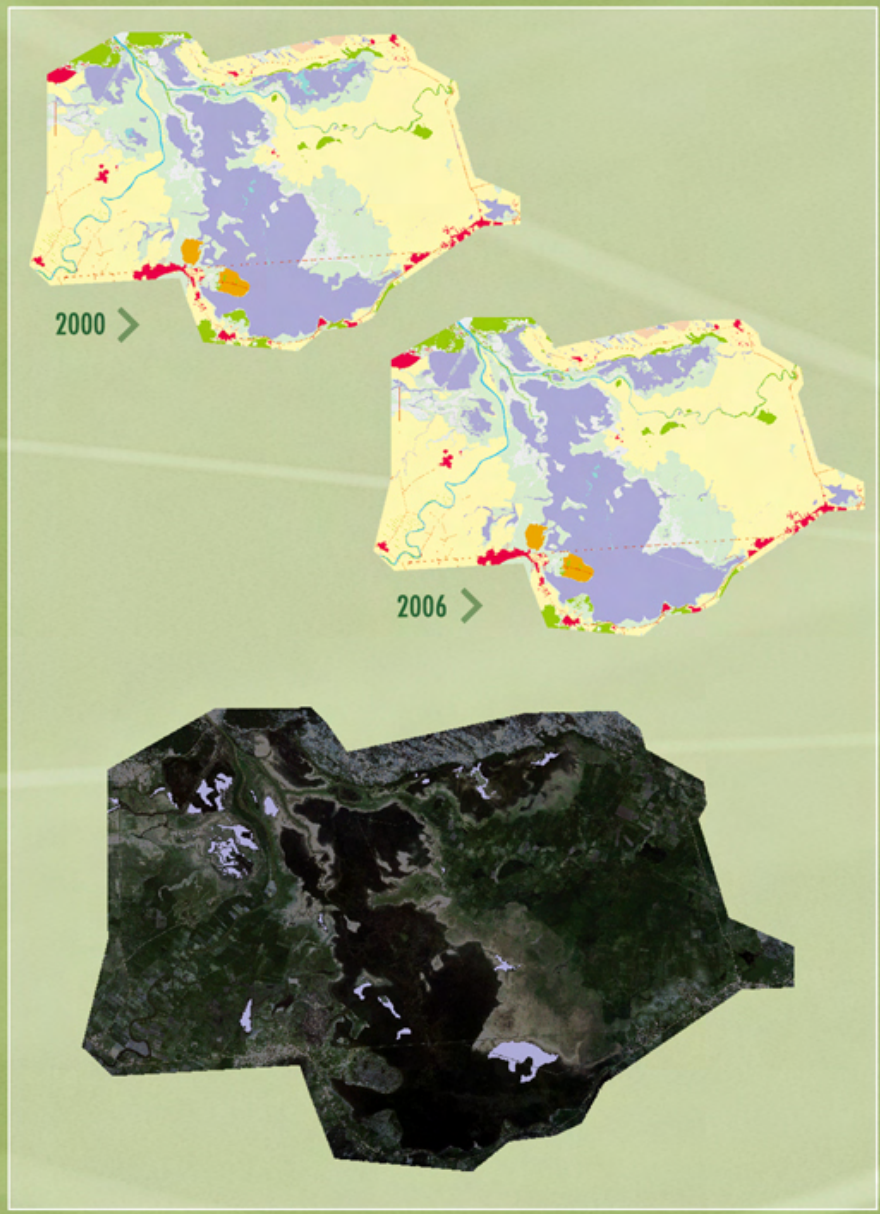
*Source image: SPOT-5*

- 1.1.1 - Continuous urban fabric
- 1.2.2 - Road and rail networks
- 1.3.1 - Mineral extraction sites
- 1.3.2 - Dump sites
- 1.4.2 - Sport and leisure facilities
- 2.1.1 - Non-irrigated arable land
- 2.1.3 - Rice fields
- 2.2.1 - Vineyards
- 3.1.1 - Broad-leaved forest
- 3.1.2 - Coniferous forest
- 3.1.3 - Mixed forest
- 3.2.1 - Natural grassland
- 3.2.2 - Moors and heathland
- 3.2.3 - Sclerophyllous vegetation
- 3.2.4 - Transitionale woodland-shrub
- 3.3.1 - Beaches, dunes, sands
- 3.3.3 - Sparsely vegetated areas
- 4.1.1 - Inland marshes
- 4.2.1 - Salt marshes
- 4.2.12 - petits helophytes: sansuires (F)
- 4.2.2 - Salines
- 5.1.2 - Water bodies
- 5.2.3 - Sea and ocean
- 5.1.1.3 - Seasonal/intemittent/irregular rivers
- 5.2.3.2 - Maine subtidal acquatic beds

*"Precision mapping of wetland catchment areas is critical for practical management and decision-making purposes and for beeing able to objectively and confidently delineate and characterise wetlands' ecosystem"*

# Change Detection Mapping

The Change Detection Maps provide historical comparisons of the land use and the land cover in wetlands and their surrounding areas between now and reference dates in the past. They provide synoptic views of the main changes that occurred in the catchment areas due to natural and anthropogenic factors. EO data archives, which include imagery acquired from the 60s, provide a unique source of information to assess the historical evolution of wetlands worldwide. Change analysis also gives wetland managers the possibility to identify threats affecting their site and to assess the impacts on the ecosystem over time.




*La Réserve Naturelle du Lac des Oiseaux, Algeria*
*Shallow permanent freshwater lake that shrinks to about half its size during the dry season. The change detection map from April 2000 to April 2006 evidences a gain of inland marshes shown in purple.*

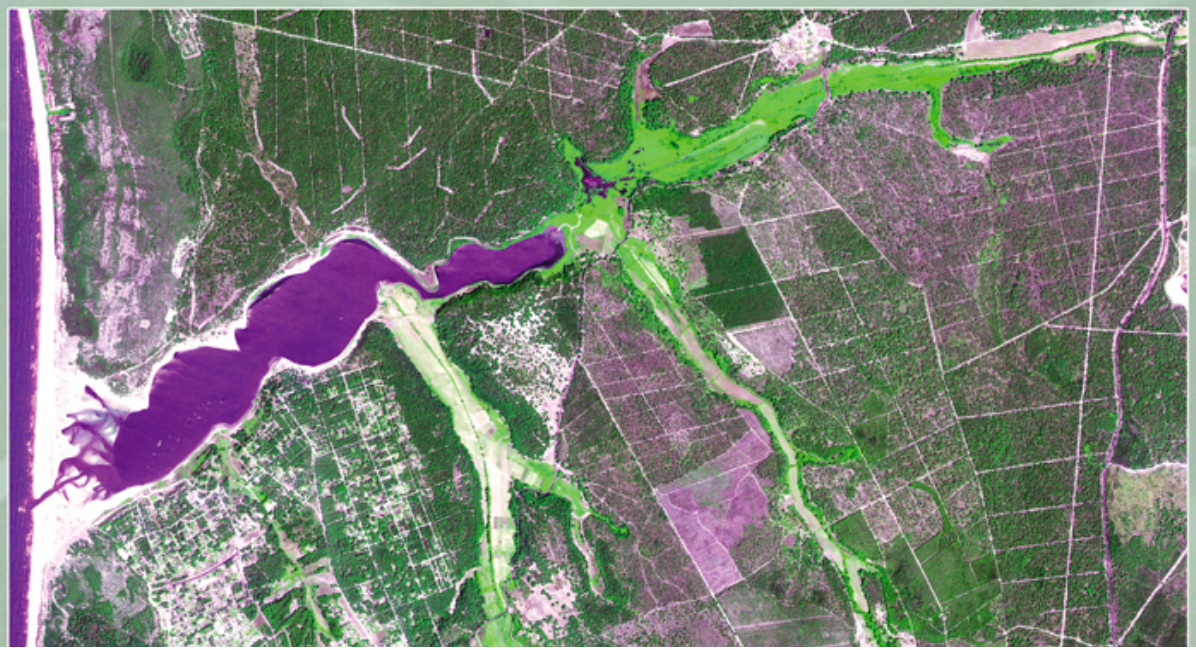
*Source image: Landsat and QuickBird*

*"Trend assessment, based on the analysis of changes with multi-temporal remote sensing datasets, is a well established field, with various techniques successfully applied to the identification and characterisation of changes in different types of wetlands and over varying time periods"*

# Water Cycle Regime Mapping

The Water Cycle Regime (WRC) Mapping provides an overview of the annual variations of the water table over the wetland sites. Available at scales 1:50,000 and higher spatial resolutions, the WCR maps show the minimum and maximum water extent of the water table, including open water bodies and inundated vegetation, during a hydrological year. This product, when generated over several years, provides wetland managers with a unique monitoring capacity to characterise the water cycle of wetlands and identify variations that may affect the overall ecosystem.

*"Monitoring the water table during a full hydrological year in order to characterise the water cycle of wetlands requires the acquisition of satellite images at different seasons ranging from the lowest water availability period to the season with the maximum water level and even during flood events"*



*Lagoa da Albufeira, Portugal*
*The site consists of a brackish water coastal lagoon that has intermittent communication to the ocean across a narrow sand dune system. The water cycle regime was measured during the years 2004-2005.*

*Source image: Radarsat-1*

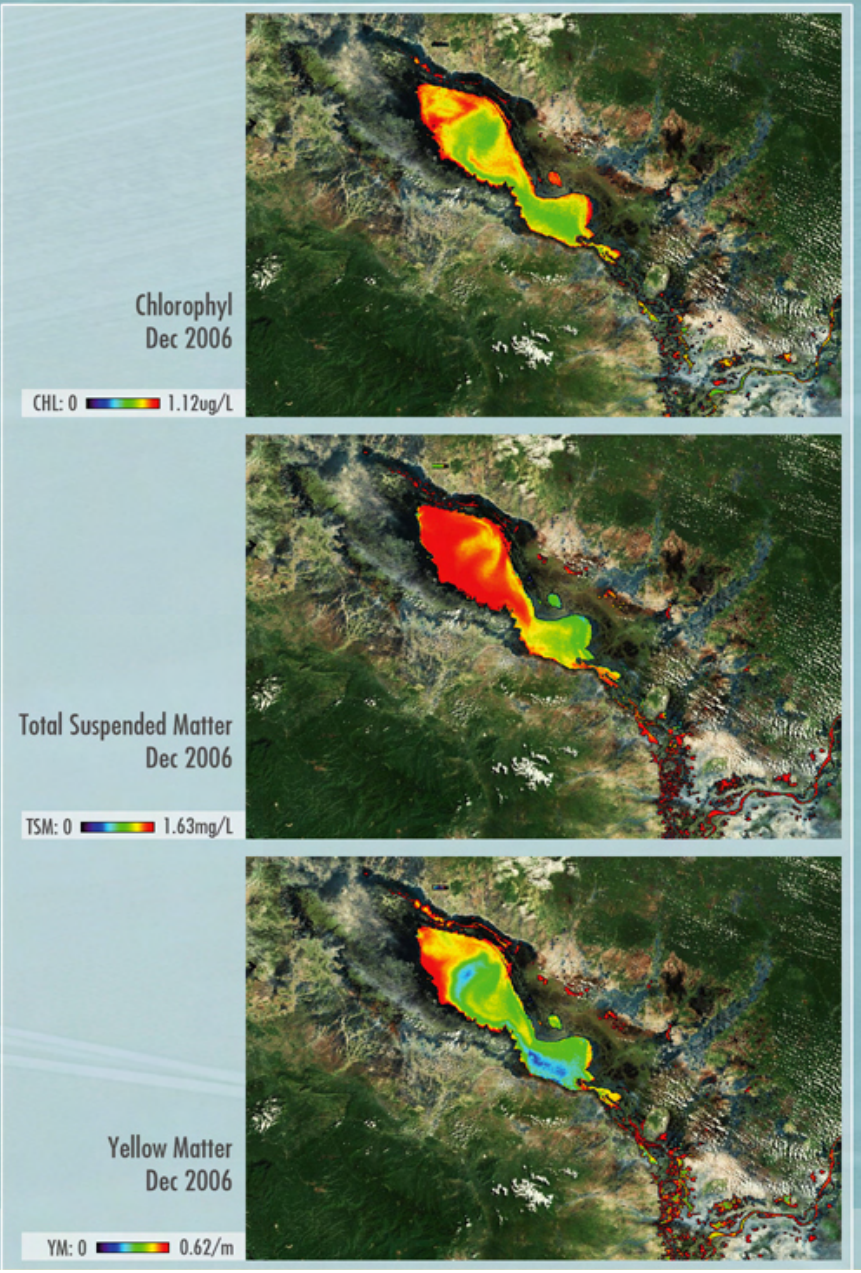
# Water Quality

The retrieval of water quality parameters over large lakes and wetland areas is one of the most interesting applications of EO technology to support wetlands management and conservation. Large water bodies and wetlands represent a main economic driver (e.g., fisheries industry) and source of fresh water for many populations in the surrounding areas. The continuous monitoring of water quality represents not only a key aspect in wetlands conservation but a fundamental input for water management. Parameters such as turbidity, suspended solids and algae or chlorophyll concentration can be monitored from Space with different spatial resolutions.

*Mekong River Basin, Lao PDR, Vietnam, Cambodia, Thailand.*
*The Mekong River Basin is defined by the land area surrounding all the streams and rivers that flow into the Mekong River. The most abundant resources in the Mekong Basin are water and biodiversity. Water quality on the Mekong River has been accessed measuring three parameters: chlorophyll concentration, yellow matters and suspended sediments.*

*Source image: ENVISAT MERIS*

*"Wetland managers must rely on efficient means for identifying pollution sources, and assessing water quality.*
*Remote sensing provides ways for obtaining spatial and temporal observations about surface water conditions for large water bodies like the Mekong River Basin"*



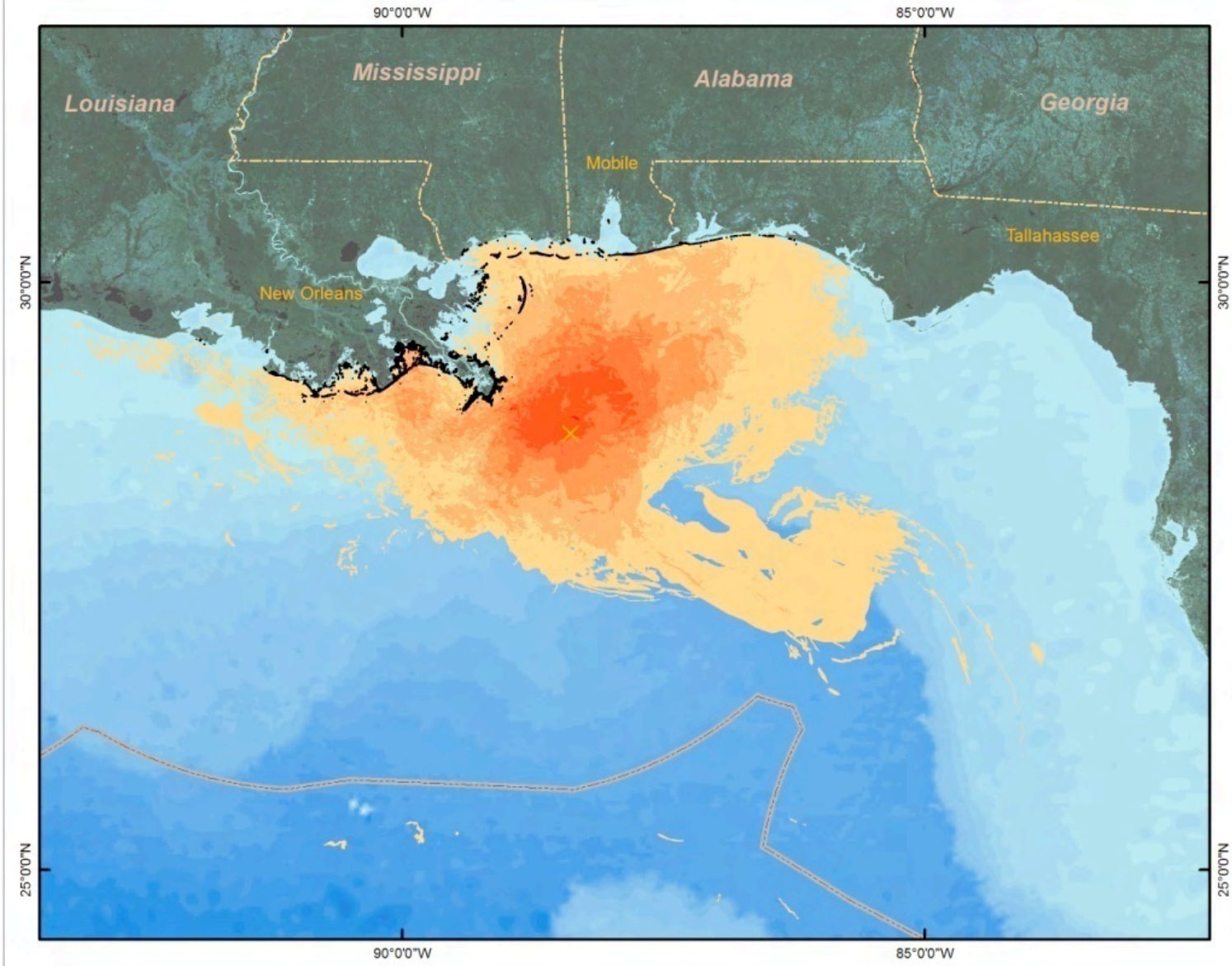
# *Practical case study*

# *Habitat impact assessment of the Deepwater Horizon Oil Spill*

- ***April 20**, catastrophe struck the Gulf of Mexico with the explosion and sinking of the **Deepwater Horizon** oil rig*
- *The **Ocean Foundation** requested a **spatial chronology of the oil spill** and a mapping of its interaction with natural maritime and coastal habitats*
- ***Cumulative weekly maps** (overall area impacted during one week) **and statistics** documenting the extent of the oil spill and identifying site impacts of terrestrial and marine habitats of critical natural value*

# Deepwater Horizon Oil Spill Delineation

20.04. - 29.08.2010




**Legend**

- Location of Deepwater Horizon
- GOM EEZ
- Oil spill land fall
- 1 - 3 weeks oil coverage
- 4 - 6 weeks oil coverage
- 7 - 9 weeks oil coverage
- 10 - 12 weeks oil coverage
- 13 - 15 weeks oil coverage
- 16 - 18 weeks oil coverage
- Administrative boundary

1 : 6 000 000

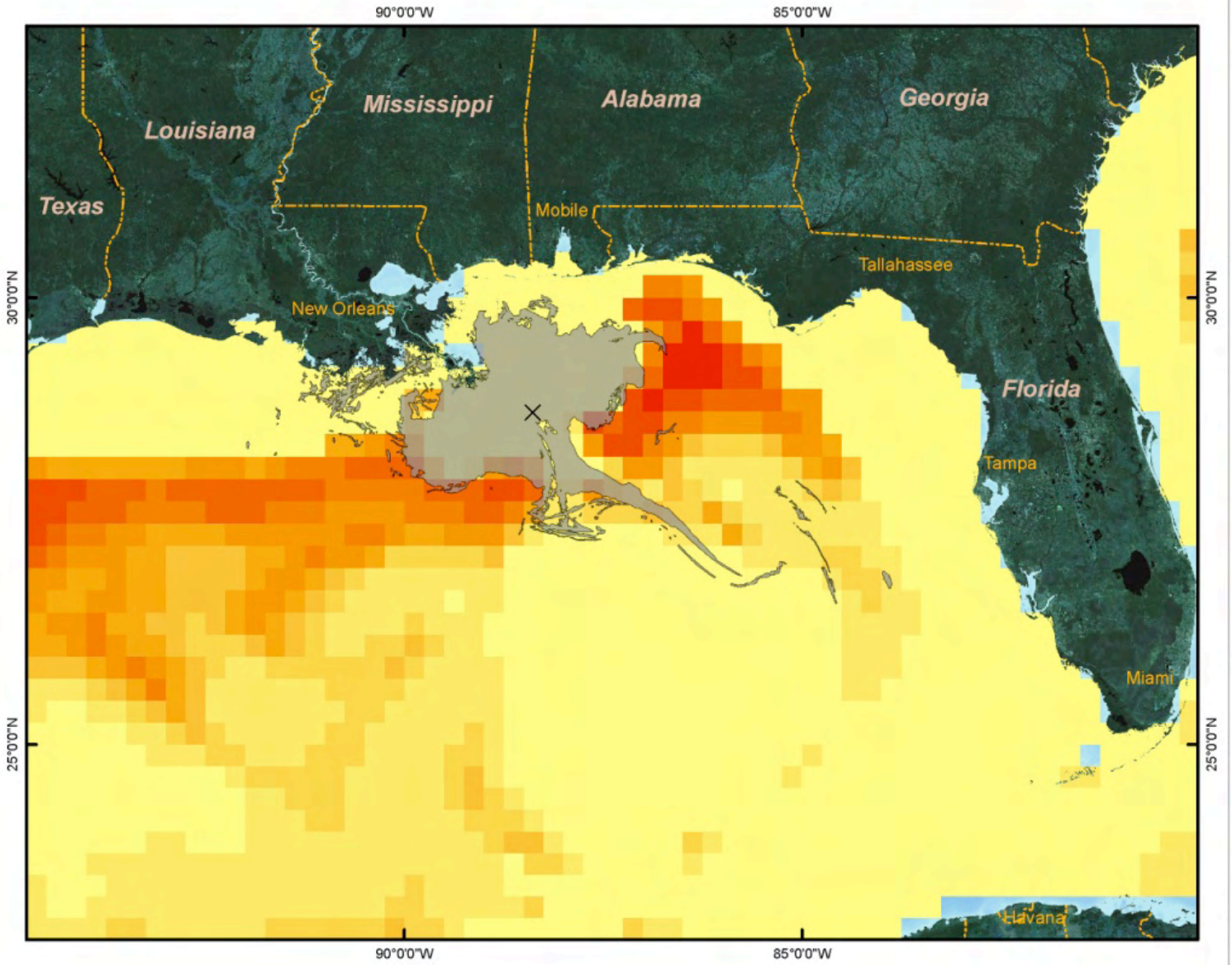
0 25 50 100 150 200 250 km

Data sources:
ESA, NESDIS, NOAA, NOS-CSC-DOC, SWOT

The project "Deepwater Horizon Oil Spill - Spatial Chronology and Habitat Impact Mapping" was financed by ESA under Contract No. 20009/06/I-EC.

# Cumulative Daily Oil Spill Delineation with ABFT Spawning Habitat

Time frame
24.05. - 30.05.2010




**Legend**

- Administrative boundary
- Location of Deepwater Horizon
- Oil spill delineation

ABFT Spawning Habitat Index

| | |
|---|---|
| 0 - 0,1 | 0,5 - 0,6 |
| 0,1 - 0,2 | 0,6 - 0,7 |
| 0,2 - 0,3 | 0,7 - 0,8 |
| 0,3 - 0,4 | 0,8 - 0,9 |
| 0,4 - 0,5 | 0,9 - 1 |

1 : 7 900 000

0 50 100 200 300 400 500 km

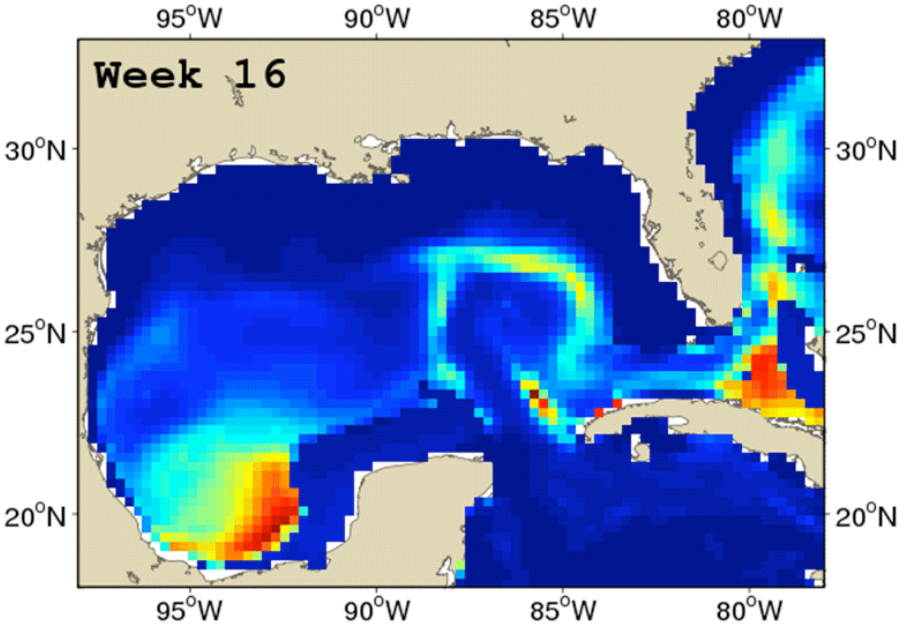
Data sources:
ESA, NESDIS, NOAA, NOS-CSC-DOC, SWOT

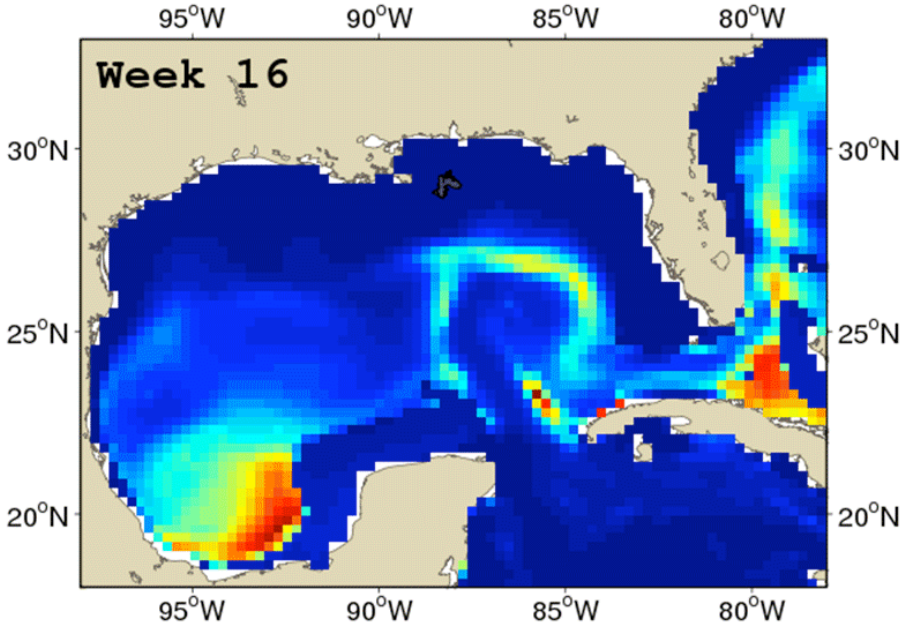
The project "Deepwater Horizon Oil Spill - Spatial Chronology and Habitat Impact Mapping" was financed by ESA under Contract No. 20009/06/I-EC.

# Spawning habitat of Atlantic bluefin in the Gulf of Mexico with and without oil Spill

CLS
COLLECTE LOCALISATION SATELLITES

19 Apr – 25 Apr

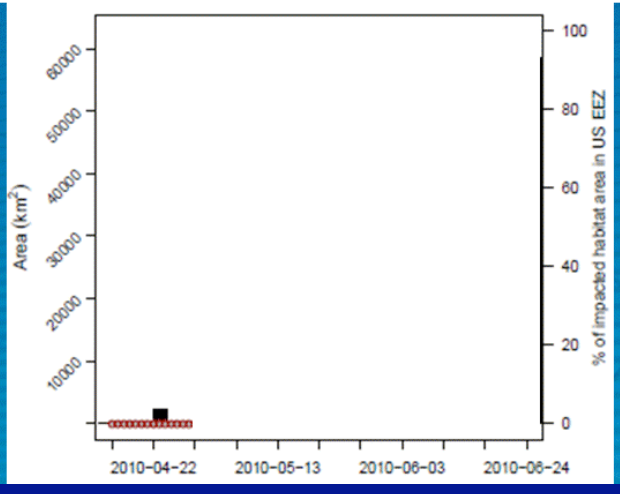



Total oil spill area

Habitat impacted by oill spill

% high quality habitat (>0.5) impacted in US EEZ



# *Conclusions*

*"….Technological advances, refined methodologies and growing databases make our systems for monitoring biodiversity increasingly effective…. Remote sensing is without a doubt one of the indispensable tools for detecting changes in multiple facets of biodiversity over time…"*

**UN-CBD Secretariat Technical Series No. 32,**

"Sourcebook on Remote Sensing and Biodiversity Indicators"

***THANK YOU for your attention***

Contact:

**Marc Paganini**
Phone +39 06 94180 563
Fax +39 06 94180 552
marc.paganini@esa.int