EO DATA APPLICATIONS IN CENTRAL AND SOUTH AMERICA

Examples of environmental applications of Earth Observation data, methods and techniques

Ana B. Ruescas
ESA/ESRIN

Overview

- ESA EO missions review
- The Diversity Project
- The Jaguar Project
- EOPI
- International Charter Space and major Disasters
- ESA Initiative on Climate Change
- Remote Sensing Principles
- Eduspace and LEOWorks 3.0

ESA EO missions review

PIONEERS IN EARTH OBSERVATION

Meteosat – ESA has been dedicated to observing Earth from space ever since the launch of its first meteorological mission (1977).

ERS-1 (1991) and **ERS-2** (1995) – providing a wealth of invaluable data about Earth, its climate and changing environment.

Envisat – the largest satellite ever built to monitor the environment, it provides continuous observation of Earth's surface, atmosphere, oceans and ice caps (2002).

EARTH EXPLORERS

Part of ESA's '**Living Planet' Programme**, these missions address critical and specific issues raised by the science community, while demonstrating the latest observing techniques. The first two were launched in 2009:

GOCE – studying Earth's gravity field

SMOS – studying Earth's water cycle

The next missions are:

CryoSat-2 – studying Earth's ice cover

ADM-Aeolus – studying the atmosphere

Swarm – three satellites to study Earth's magnetic field

EarthCARE – an ESA/JAXA mission to study Earth's clouds, aerosols and radiation

METEOROLOGICAL MISSIONS

'Living Planet' also includes the next generation of missions dedicated to weather and climate.

Meteosat Third Generation – taking over from Meteosat 11 in 2015, the last of four Meteosat Second Generation (MSG) satellites. MSG is a joint project between ESA and Eumetsat following the success of the first-generation Meteosat satellites.

MetOp – a series of three satellites to monitor climate and improve weather forecasting, the space segment of Eumetsat's Polar System (EPS).

MetOp-A – Europe's first polar-orbiting satellite dedicated to operational meteorology (2006).

OBSERVING OUR PLANET FOR A SAFER WORLD

A joint ESA/European Commission initiative, **Global Monitoring for the Environment and Security (GMES)** is the response to Europe's need for geo-spatial information services. It will provide autonomous and independent access to information for policy-makers, particularly for environment and security issues.

ESA is implementing the space component: developing the **Sentinel** satellite series, its ground segment and coordinating data access.

ESA is also starting a **Climate Change Initiative**, for storage and production of essential climate data.

Diversity Project


DIVERSITY


CCAD
UNESCO
CBD
MarViva

Diversity project

In 1992, at the "Earth Summit", the Convention on Biological Diversity, the first global agreement on the conservation and sustainable use of biological diversity was signed.

Since then more than 187 countries have ratified the agreement.

The Convention has three main goals:

- *The conservation of biodiversity,*
- *Sustainable use of the components of biodiversity, and*
- *Sharing the benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way*

DIVERSITY addresses the first two targets;

Diversity project

• In 2003, UNESCO and ESA signed "The Open Partnership".

• Under this agreement ESA and UNESCO collaborates to explore the potential of Earth Observation technology to support the implementation of the WHC and to conserve WH sites worldwide.

"Biosphere reserves are sites recognized under UNESCO's Man and the Biosphere Programme which innovate and demonstrate approaches to conservation and sustainable development. There are 482 sites worldwide in 102 countries.

Biosphere reserves have three inter-connected functions:

- *Conservation: landscapes, ecosystems, species and genetic variation*
- *Development: economic and human and culturally adapted*
- *Logistic support: research, monitoring, environmental education and training*

Earth Observation is a key element for the identification, documentation, conservation, and monitoring of these UNESCO sites.

Sustainable use at Biosphere reserves contributes to UNCCBD and the CBD 2010 goal.

Diversity project

Short-term Objectives:

- *Develop and Implement a number of dedicated information services based on EO-technology to support the implementation of the UNCBD in central America:*
  - *Regional monitoring system for the Mesoamerican Biological corridor;*
  - *Monitoring of coral-reef and water quality conditions;*
  - *Inventorying of mangroves;*
  - *Supporting wildlife migration studies: Tropical East Pacific Corridor;*
- *In addition a dedicated global index of dry-lands will be developed for the CBD;*

Long-term objectives:

- *Prepare the basis for a potential larger project on Biodiversity to be launched after 2008.*
- *Contribute to establish a solid basis for the use of EO within the context of the UNCBD;*

Diversity project

Biodiversity in Mesoamerica:

- 7 countries
- 0.51 % of earth surface
- 9 % of world's biological richness

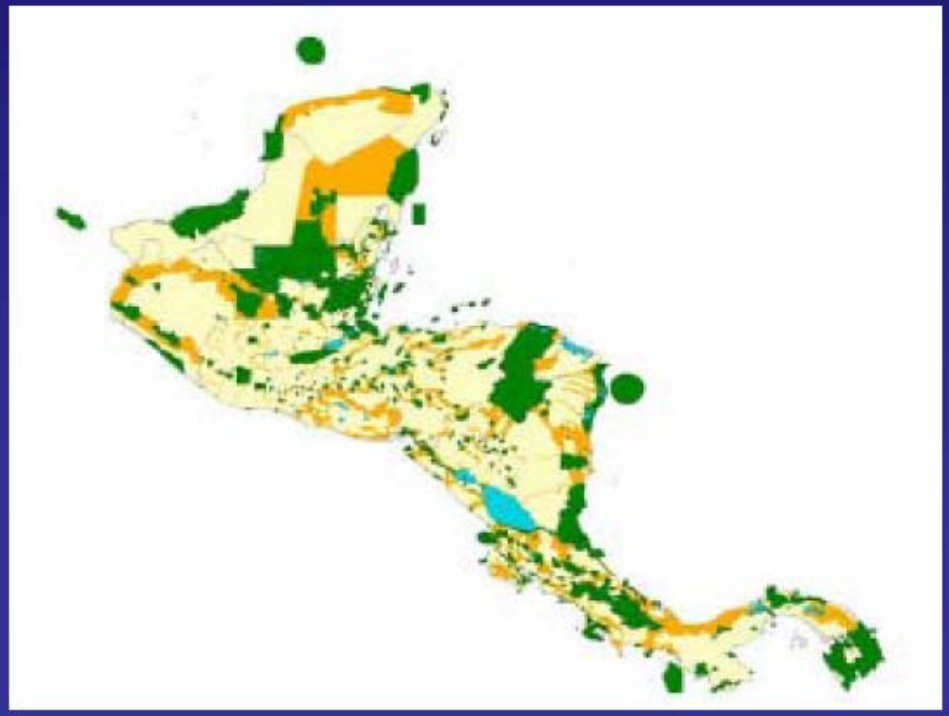
http://www.geoville.com/diversity/products/

Diversity project: Mesoamerican biological corridor

Example: "Mesoamerican Biological Corridor"

- Multitude land cover and land use, ecoregions of different protection status
- Area: approx. 320.000 km²

- Composition in 2000:
  - 48.7% legally declared protected areas
  - 3.9% areas proposed for protection
  - 47.4% corridor zones connecting protected areas.



Threats:
Urban/Industrial development, intensive agriculture

→ Annual loss of 2.1 % of forests is estimated

Diversity project: Mesoamerican biological corridor

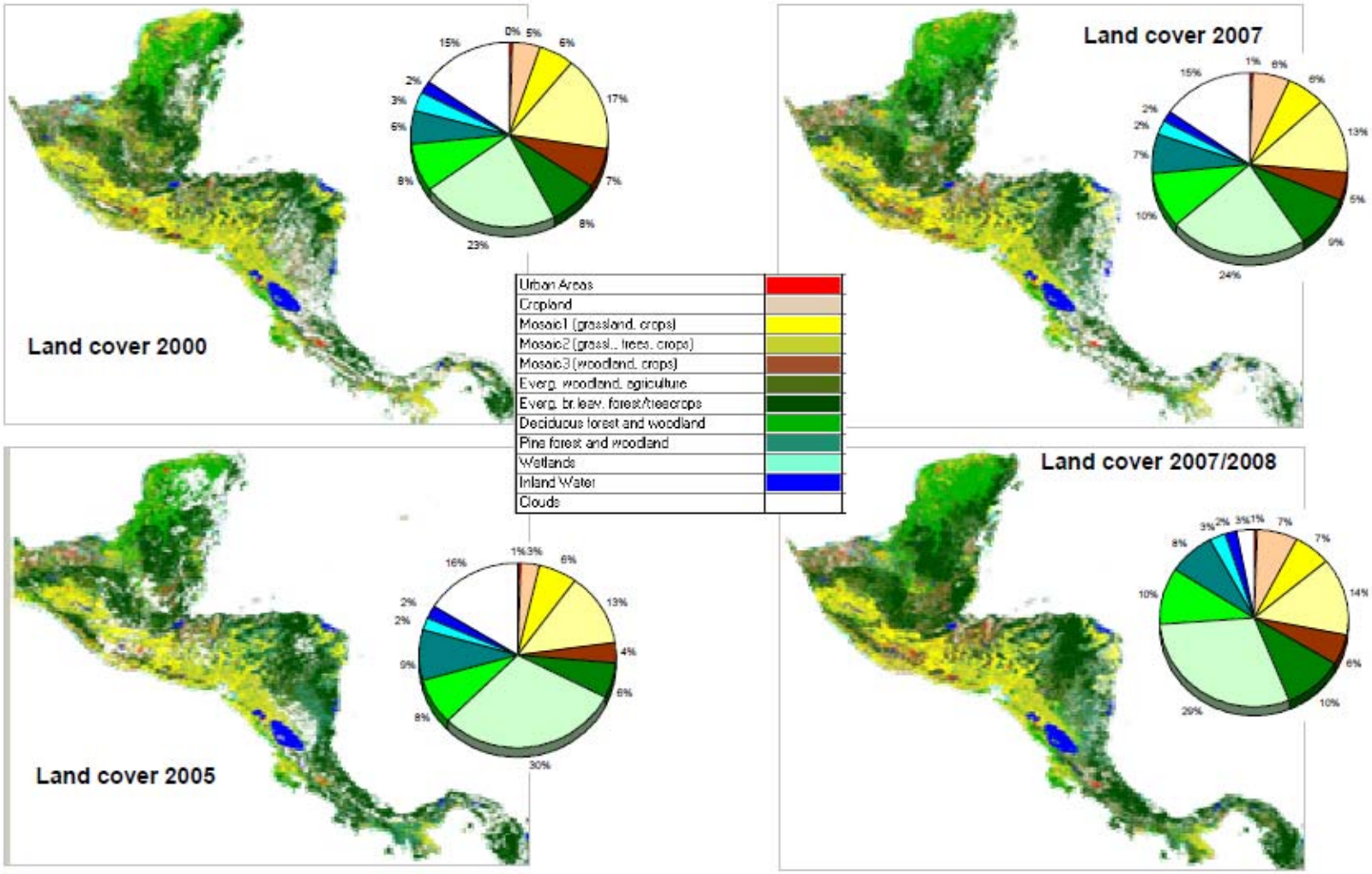
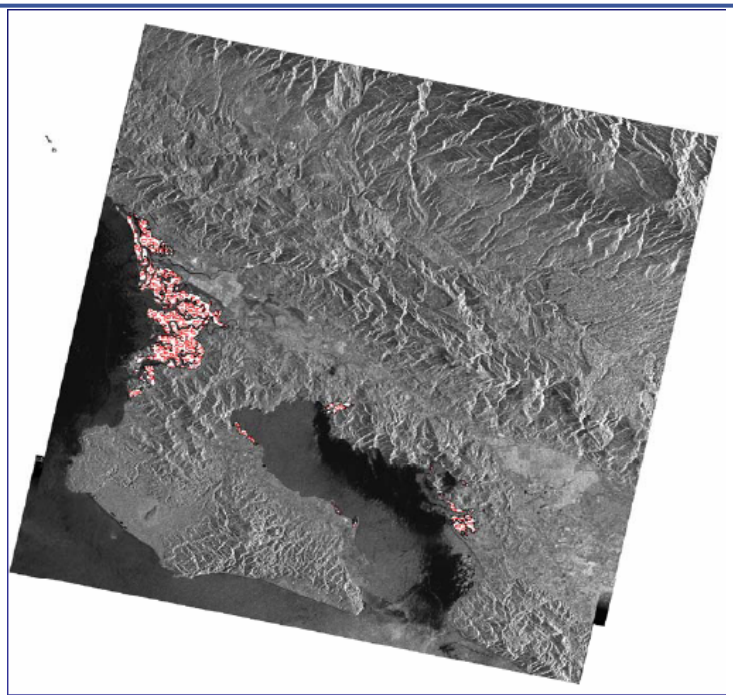
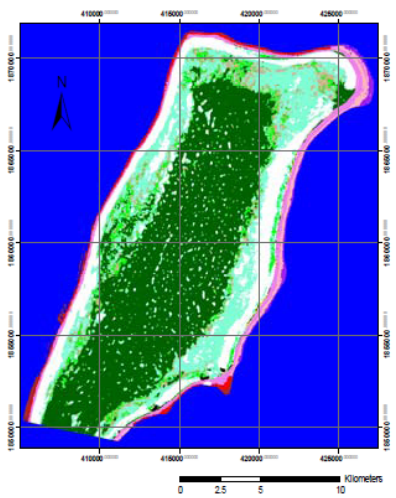


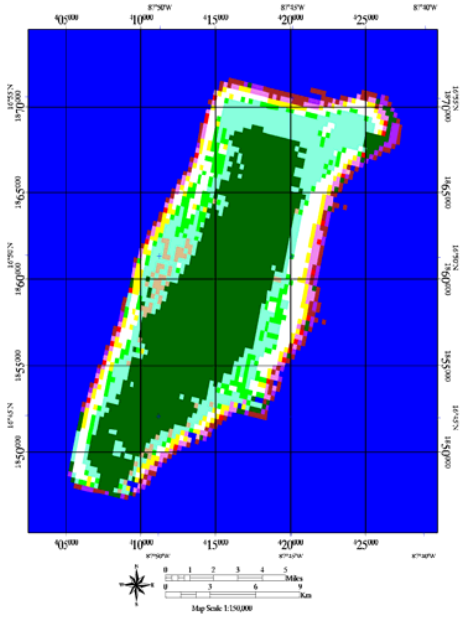
Figure 1: Regional land cover maps for the years between 2000 and 2007/2008 based on MERIS (MODIS)

Diversity project: Coral reef maps



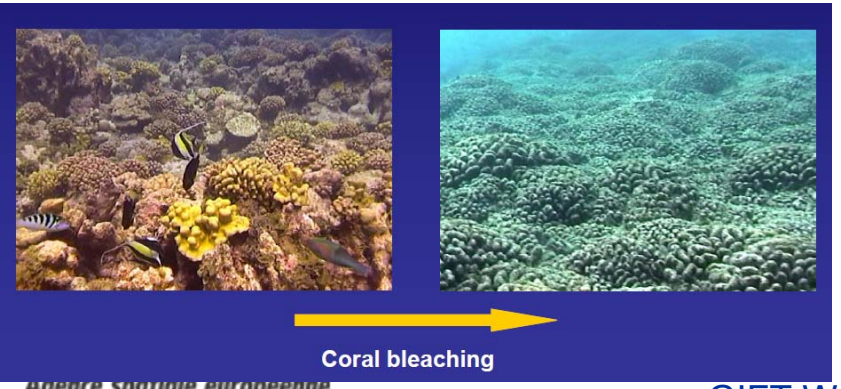


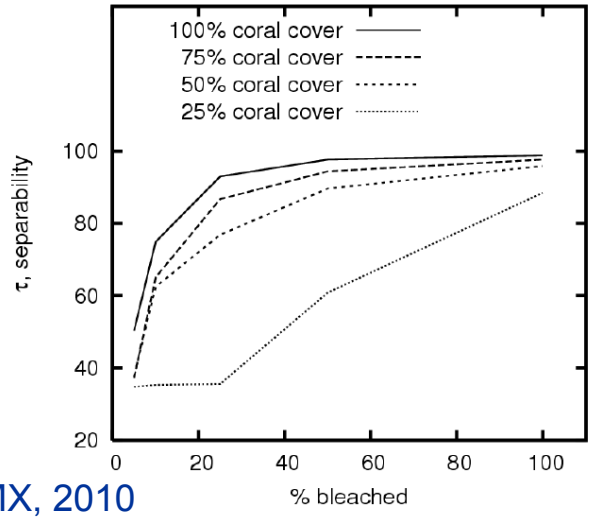
SPOT 20 m x 20



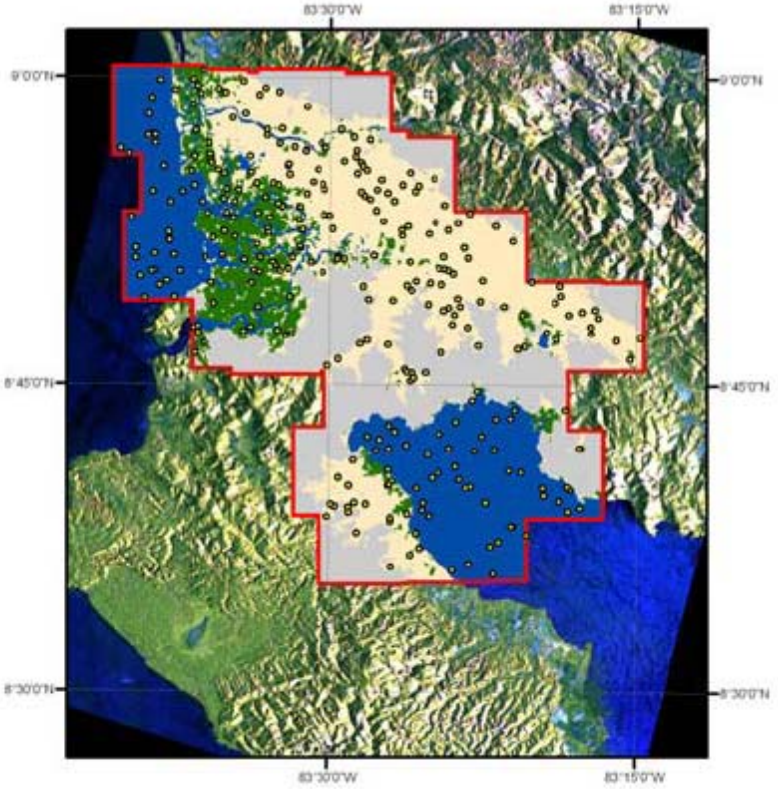
MERIS FR 300 m x 300 m

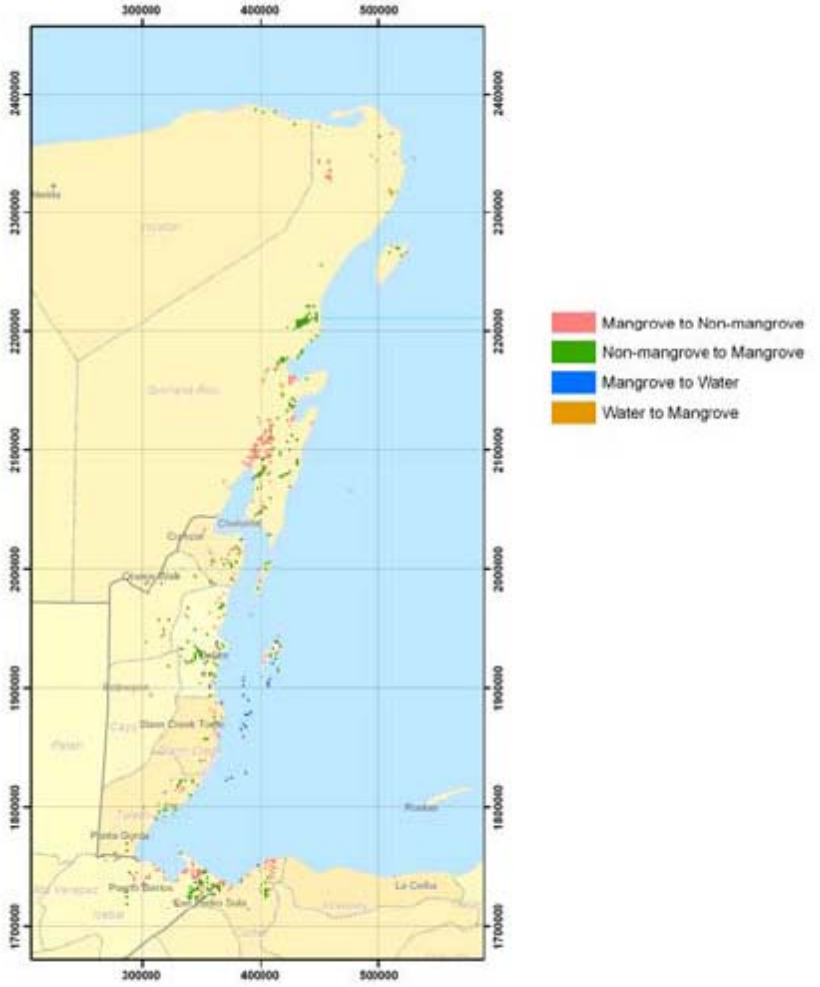
Coral reef maps and surfaces of coral bleaching



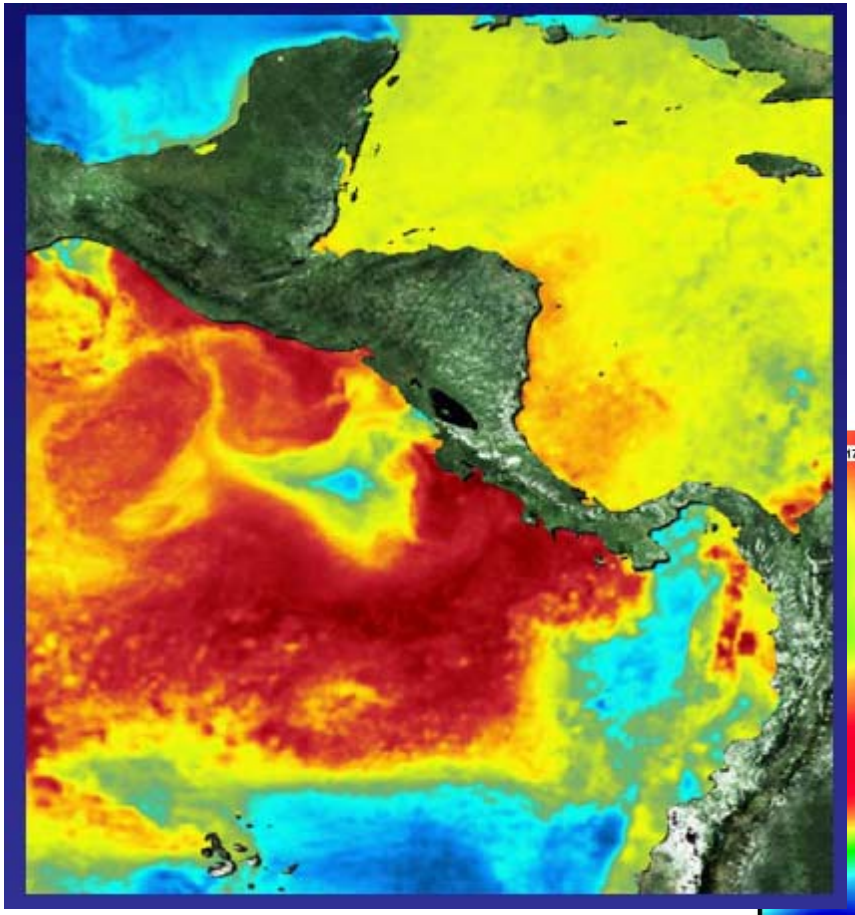


Diversity project: mangrove maps

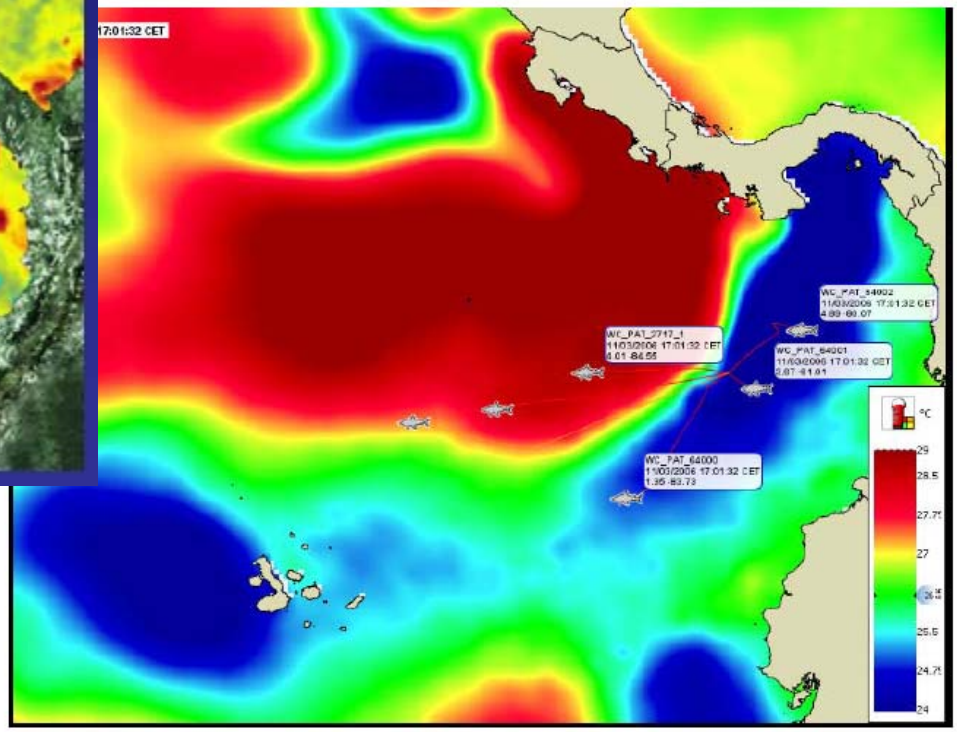




Diversity project: wildlife migrations



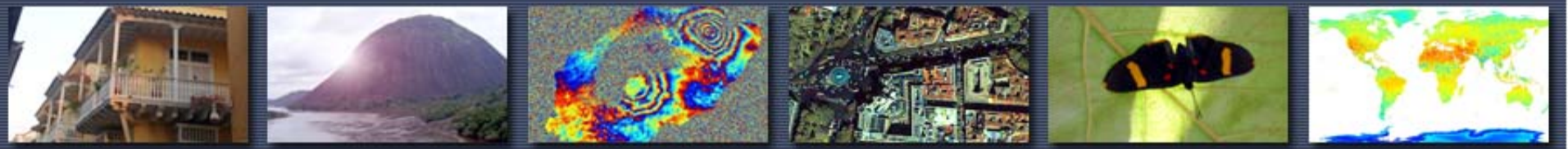
Shark's trajectories in the Tropical East Pacific Corridor (tracking data courtesy of Malpelo Foundation



Jaguar Project

PLAN JAGUAR

Definition of a remote sensing strategy for Latin America & the Caribbean



The goal of the JAGUAR PLAN is to design an action plan for European Space Agency (ESA), in order to promote the international development of the European and Canadian EO market in Latin America and the Caribbean.

Actions:

- **Market characterization**: collected information referred to the situation of the EO market in Latin America and the Caribbean region
- The development of **4 miniprojects.**
- INDRA will provide an **Action Plan** to ESA for the development of a Strategic Plan, focused on the expansion of the usage of European and Canadian EO products in Latin America and the Caribbean region, with an expected duration of five years.

Institutions

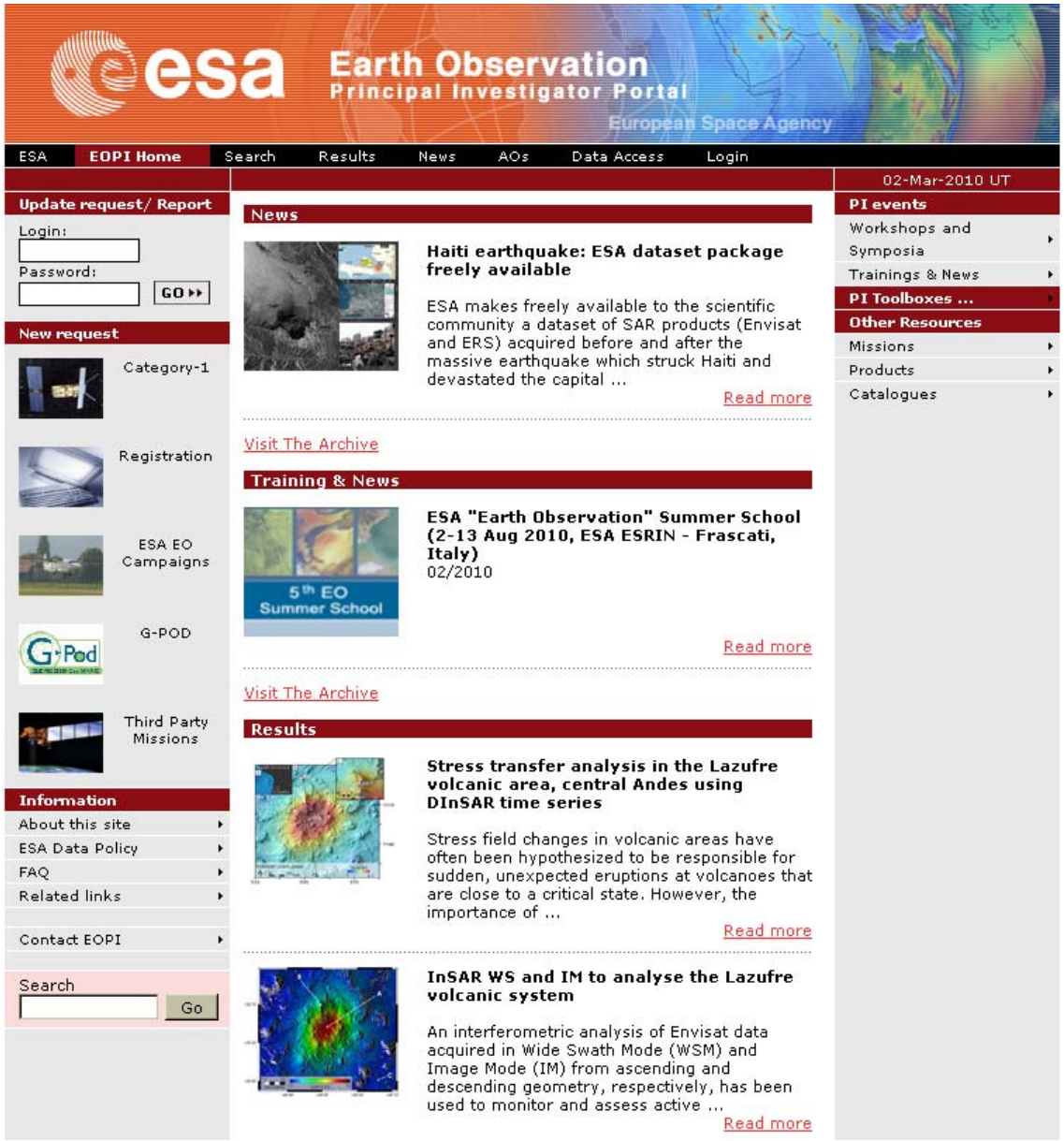
http://www.planjaguar.info

Jaguar Miniprojects

- **Miniproject 1**. "Definition of the Lake Titicaca Territorial Observatory".
- **Miniproject 2**. "Remote Sensing as an Instrument to Manage Risks and to Develop Agrarian Insurances in the Rural Sector".
- **Miniproject 3**. "Cooperación Urban Services (CUbS): Viability analysis of remote sensing products for the urban management in LAC countries".
- **Miniproject 4**. "Methodology for an Enviromental Audit for Oil & Gas Activity in Ecuador Using Earth Observation (EO) Data".

Earth Observation Principal Investigators

Principal Investigator Portal



Principal Investigator Portal

- Users who would like to submit scientific proposals for the use of ESA EO missions data
- PIs of any accepted project willing to present their findings to ESA
- Representatives of the ESA Member States, who can get up-to-date information on the on-going EO projects, their status and their achievements
- Scientists working in connected fields who can find projects with related objectives and establish contact with other PIs
- Students, who can find up to date information and contacts to leading R&D groups all over the world
- Industry who can get a broad overview of state-of-the art projects in many EO application domains
- The Aerospace industry, who can see the results obtained with systems and technologies they develop
- Members of the broader user community who want to understand how EO could help in meeting their information needs
- ESA staff involved in past, present and future Earth Observation missions

Principal Investigator Portal

Search

Use thematic and geographic criteria to search results and published papers reported from PIs

Application Domain

Unselect / Select all

- Atmosphere
- Calibration/Validation
- Coastal Zones

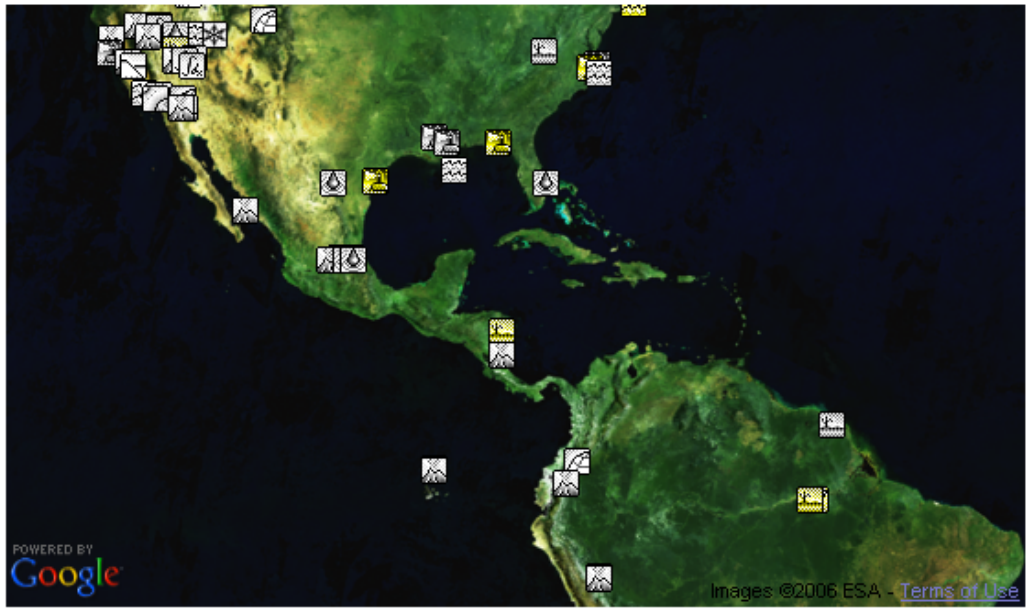
Instruments

- Altimeter
- SAR
- Optical / IR
- Other

Date Selection

From:

To:



... and draw an area on map
Rectangle Zoom

... or search "global" results
Search global

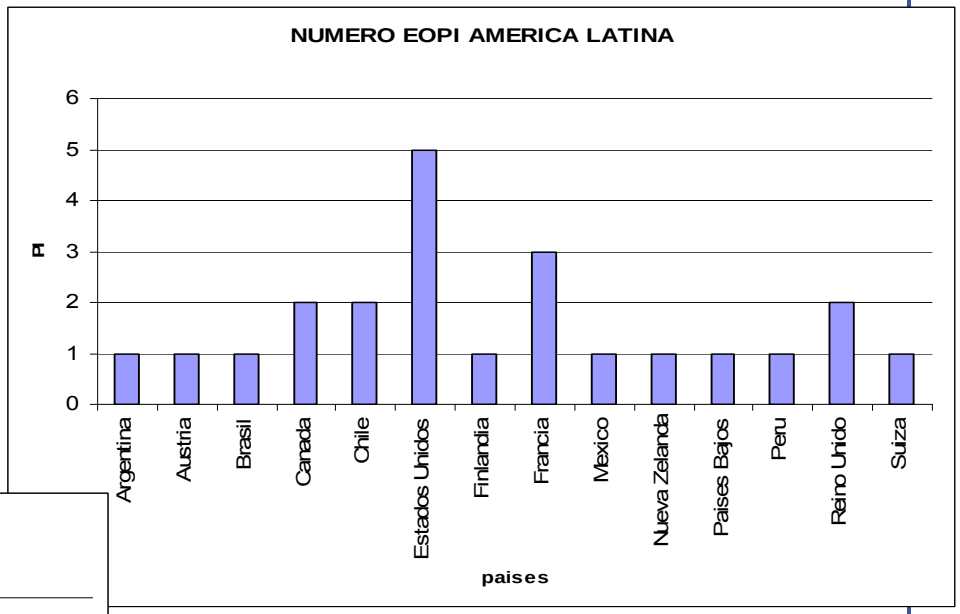
Choose zoom level

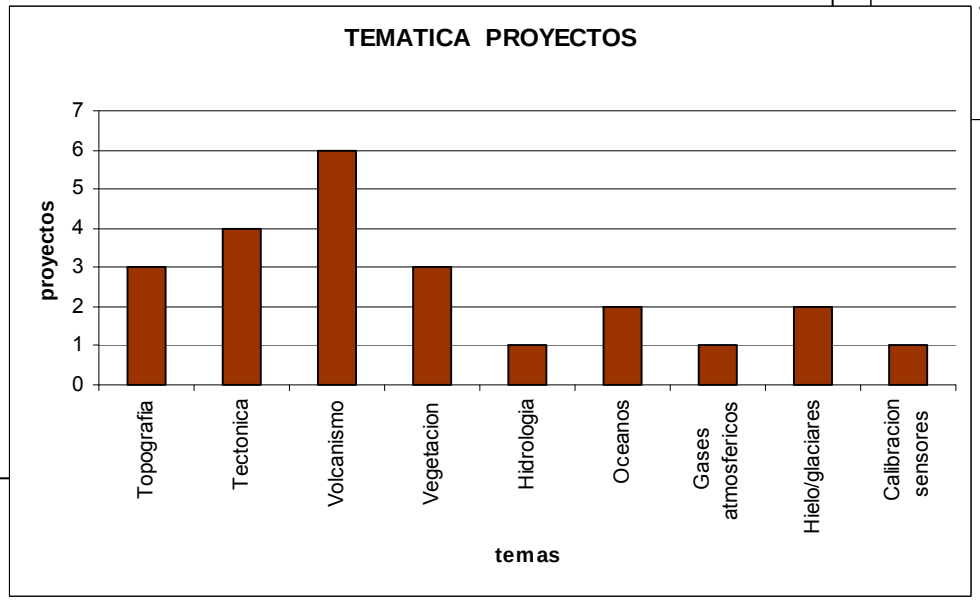
Satellite

ID	Title	Pi	Report Types
215	SUBSIDENCE MAPPING WITH ENVISAT ASAR	Tazio Strozzi	
413	ENVISAT ASAR FOR REGIONAL VOLCANO EARLY WARNING	Nicki Stevens	
431	OPERATIONAL DEMONSTRATION OF COASTWATCH COASTAL OCEANOGRAPHIC AND HYDROLOGIC APPLICATIONS OF ENVISAT	William	

EO Principal Investigator Portal

- 23 proyectos científicos aprobados sobre América Latina, 2 de ellos ya cerrados.
- Investigadores principales de 14 países.
- 9 temáticas diversas.





SÓLO 7 INVESTIGADORES PRINCIPALES DE AMÉRICA LATINA

EOPI: DEFORMACIÓN DE LA TIERRA

Detecting ground deformation in landslides areas in Peru, by means of INSAR (PI: Miguel Vidal Valdiviezo, Perú)

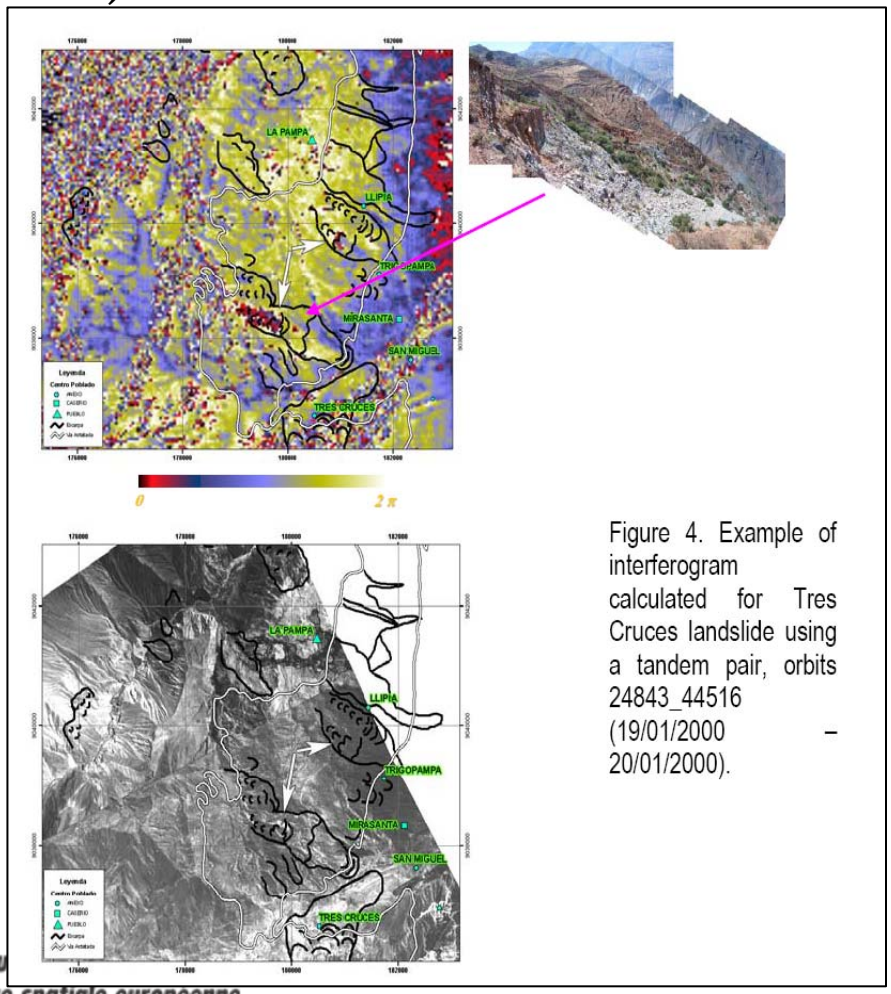
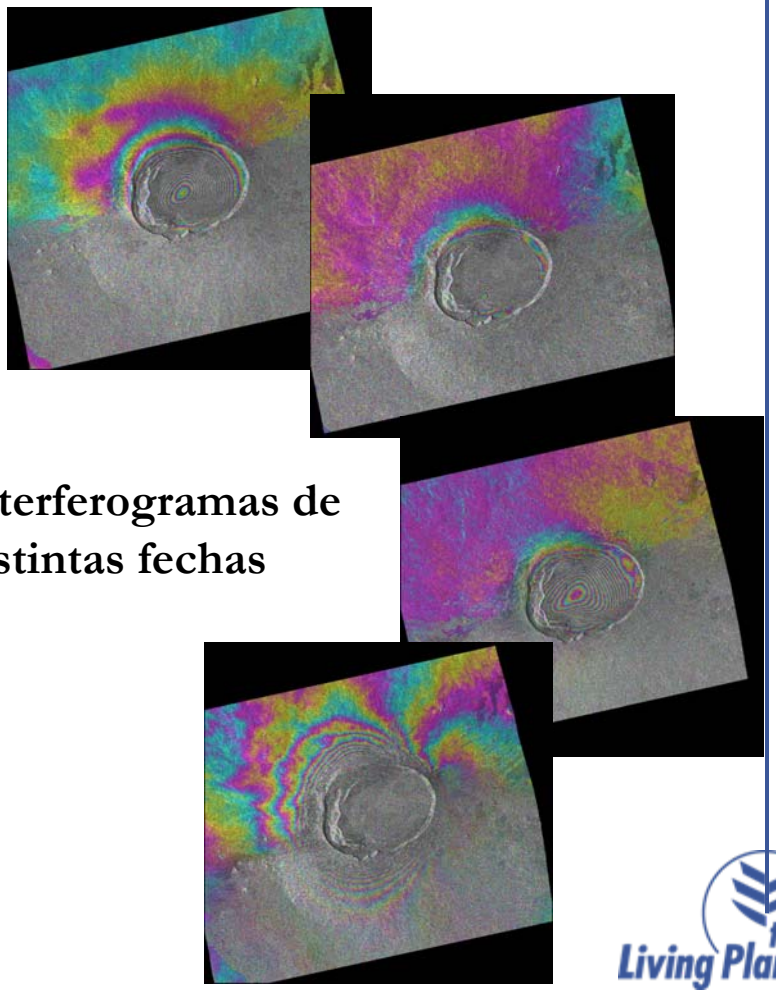


Figure 4. Example of interferogram calculated for Tres Cruces landslide using a tandem pair, orbits 24843_44516 (19/01/2000 – 20/01/2000).

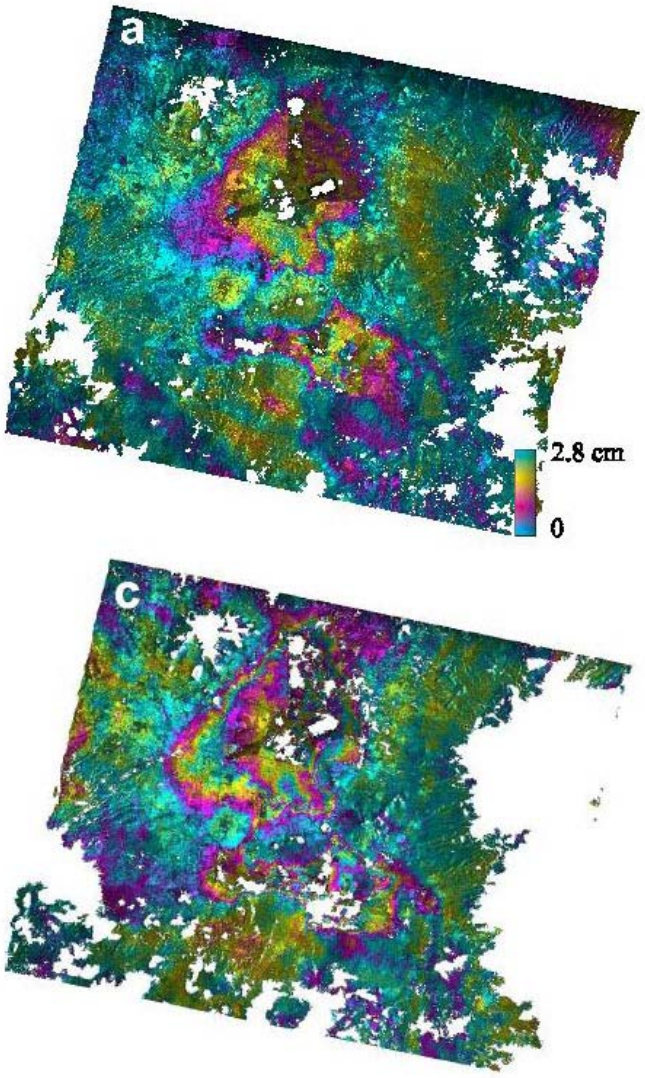
Surface deformation at Sierra Negra and Fernandina volcanoes, Galapagos (PI: William Chadwick, USA)

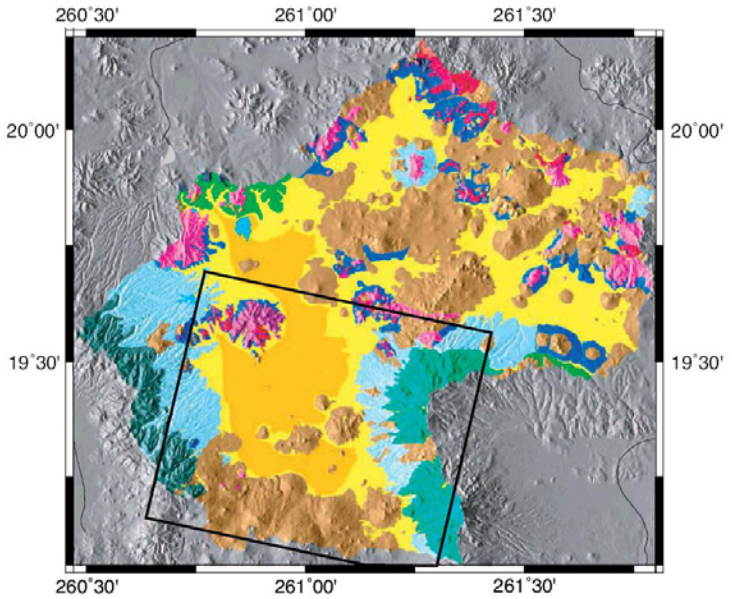


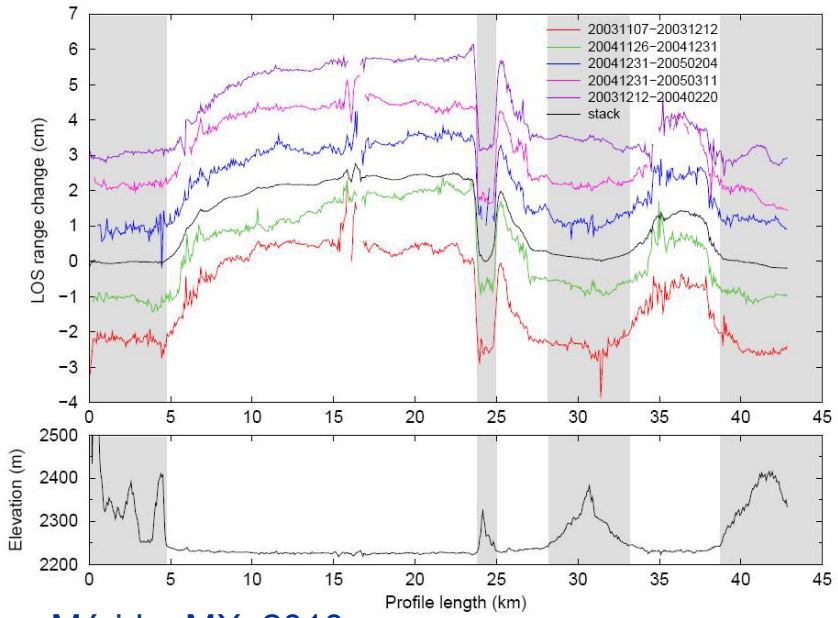
Interferogramas de distintas fechas

EOPI: SUBSIDENCIAS URBANAS

Subsidencia en Mexico City - Lopez-Quiroz et al., 2008



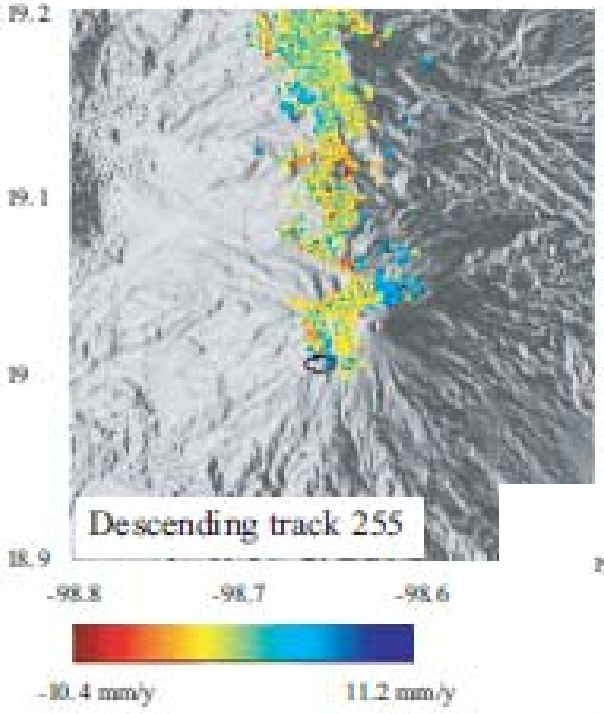


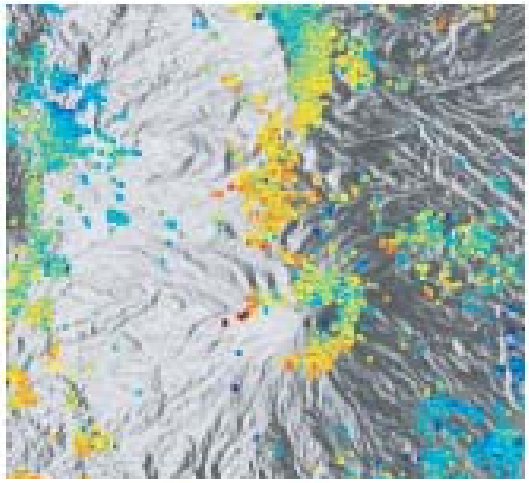


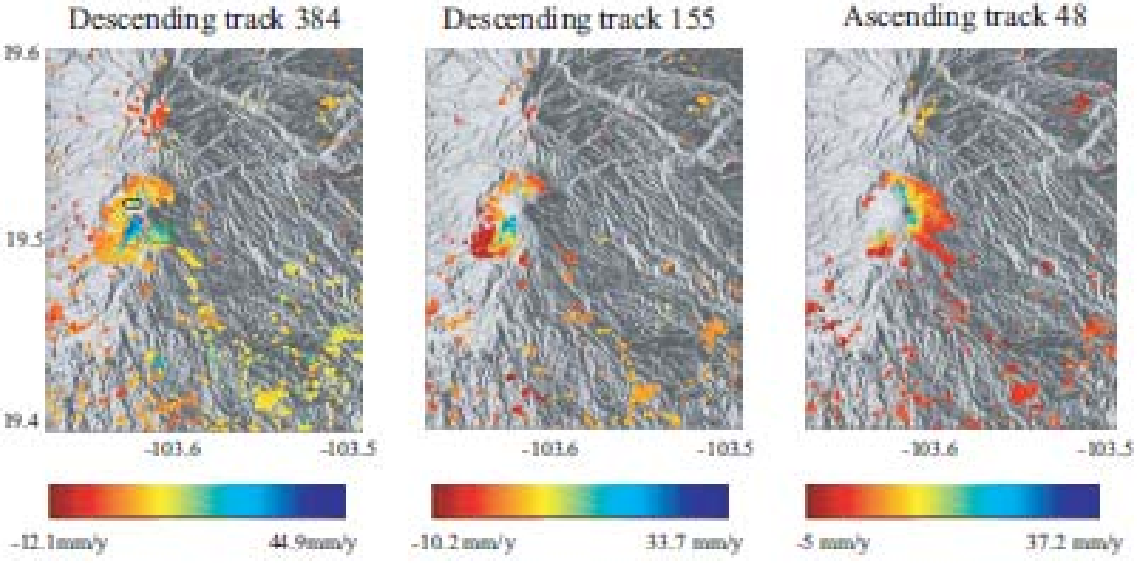
Agence spatiale européenne

EOPI: VOLCANOES

STUDY OF THE DEFORMATION FIELD OF TWO ACTIVE MEXICAN STRATOVOLCANOES (POPOCATEPETL AND COLIMA VOLCANO) BY TIME SERIES OF INSAR DATA (Pinel et al.)





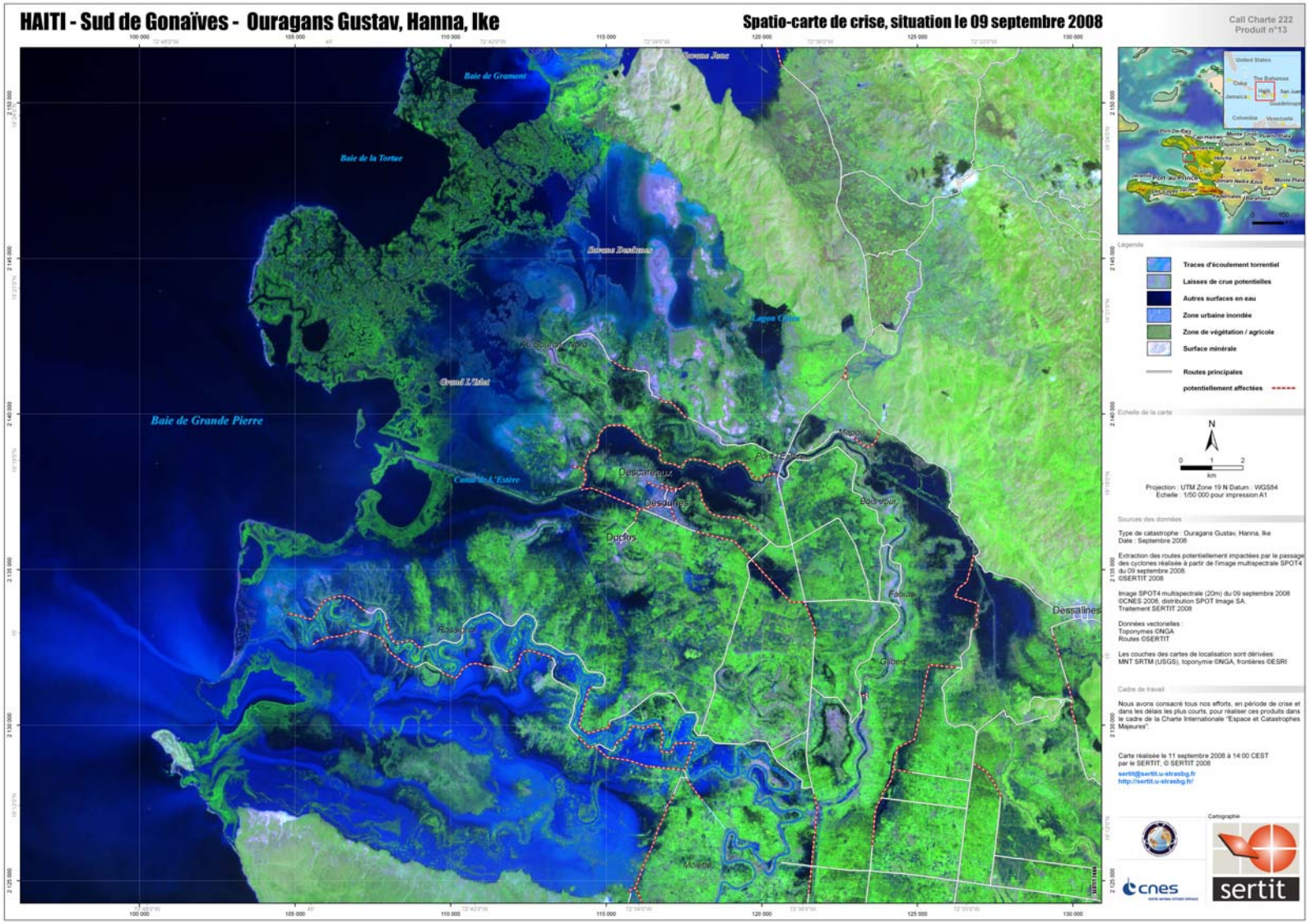


International Charter
Space and Major Disasters

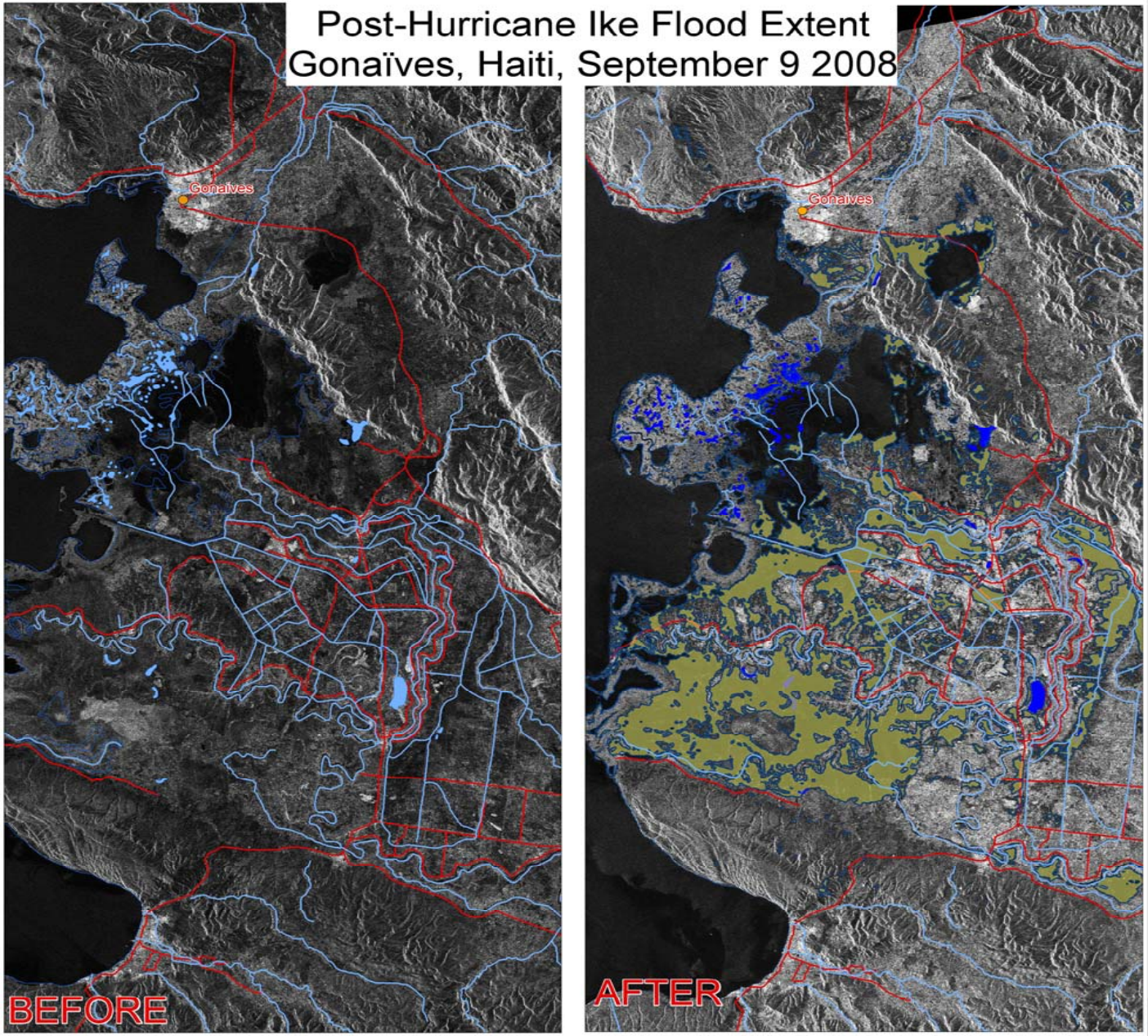
INTERNATIONAL CHARTER SPACE AND MAJOR DISASTERS

http://www.disasterscharter.org/home

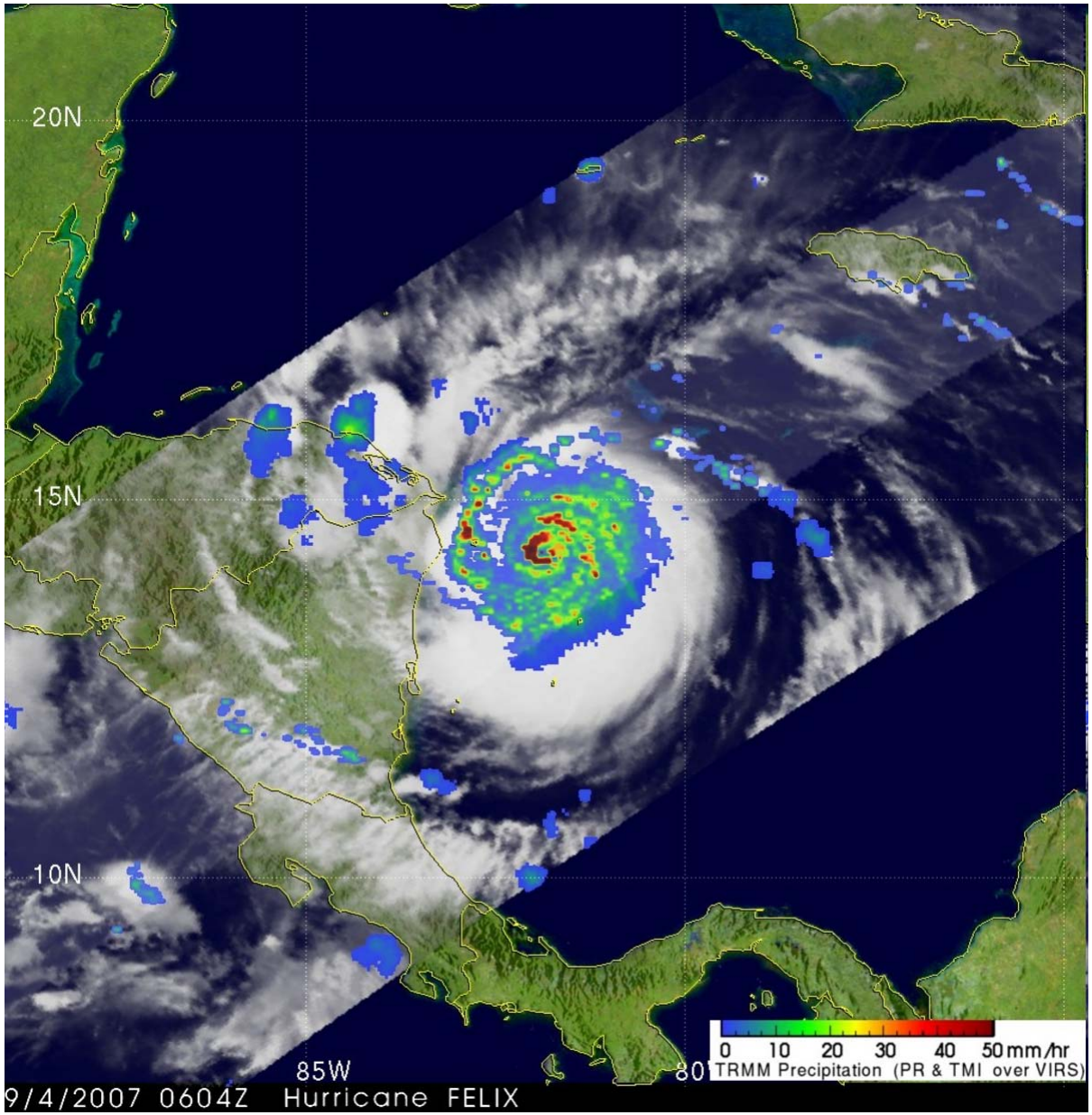
CHARTER: Floods in Haiti, Hurricanes Gustav, Hanna & Ike



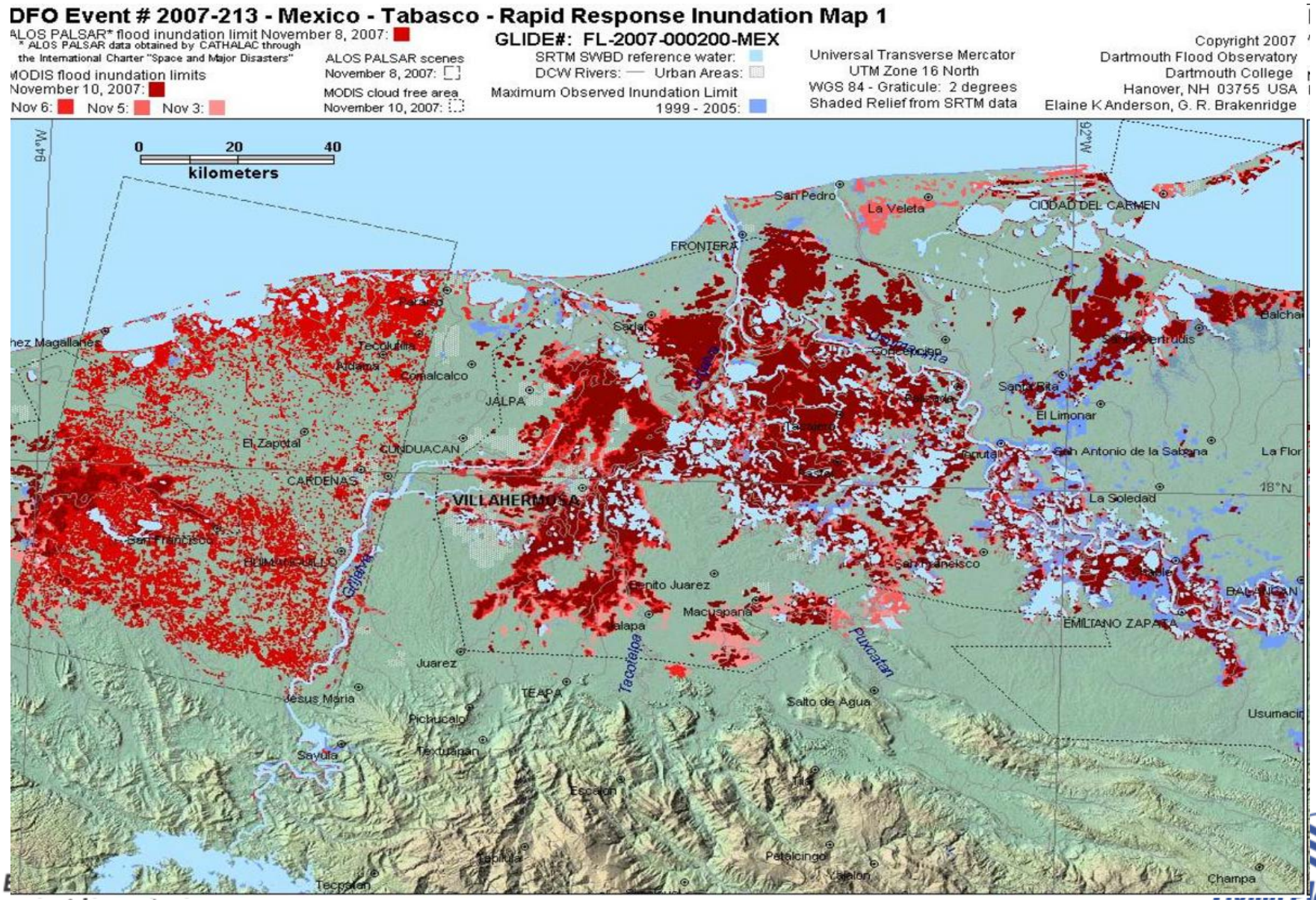
CHARTER: Floods in Haiti, Hurricanes Gustav, Hanna & Ike



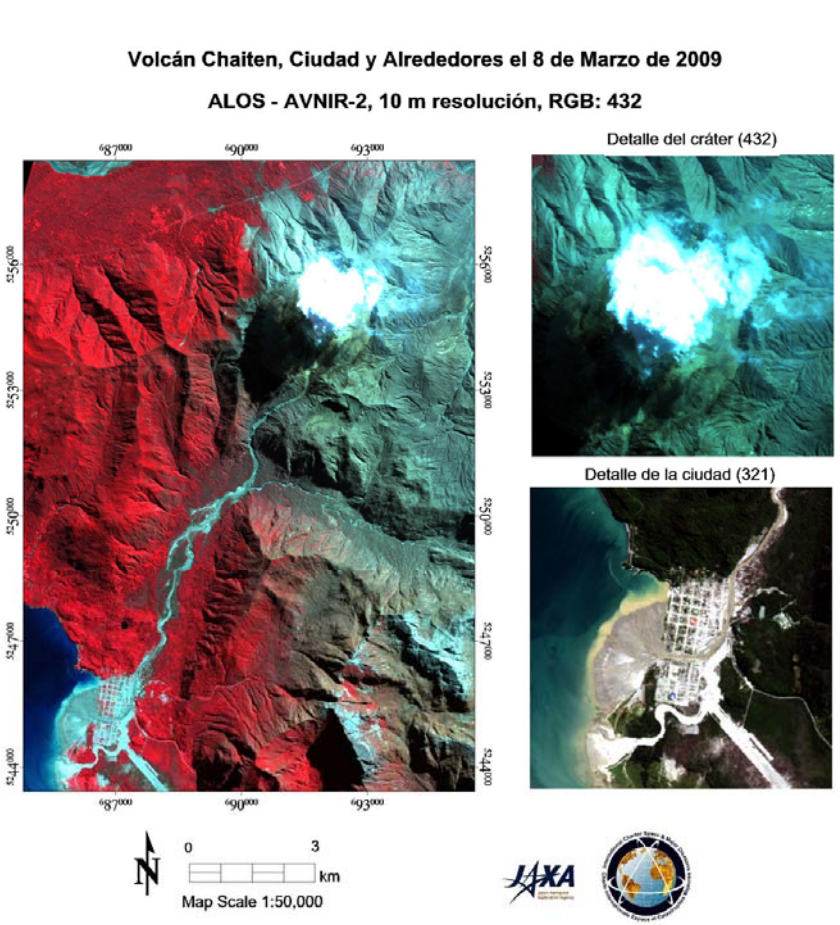
CHARTER: Hurricane Felix, Yucatan

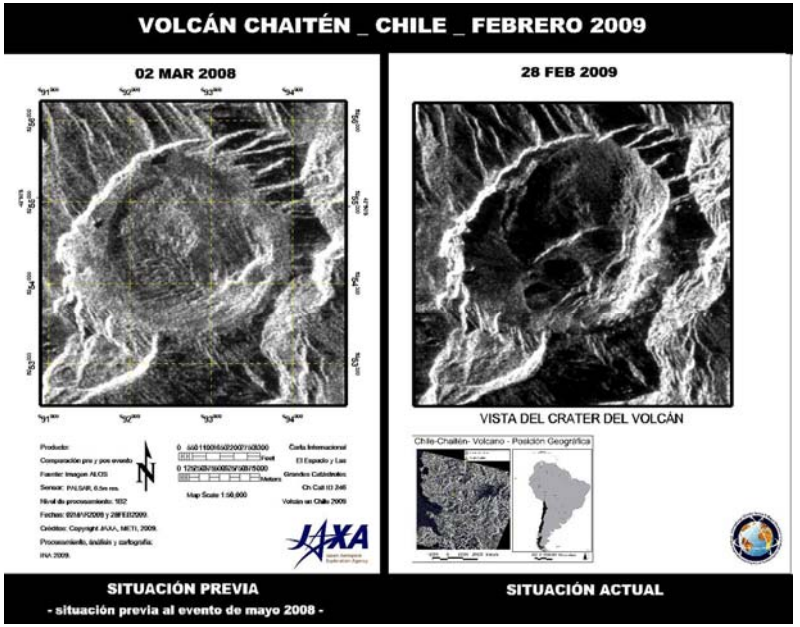


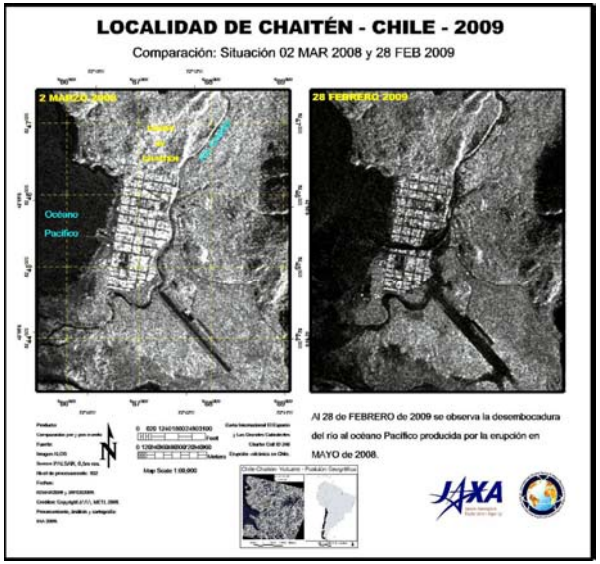
CHARTER: Hurricane Felix, Yucatan



CHARTER : Chaiten (Chile), February 2009



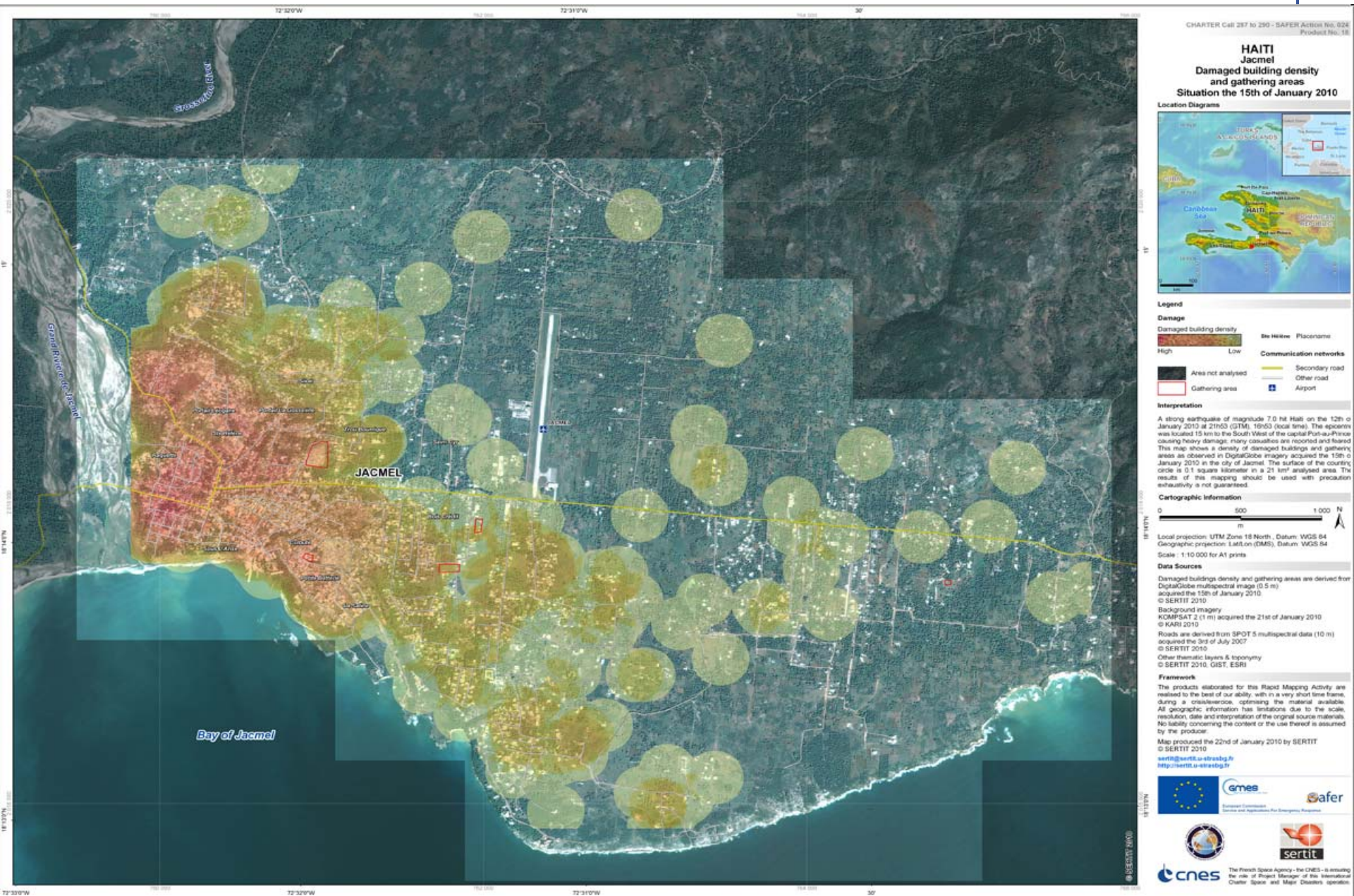


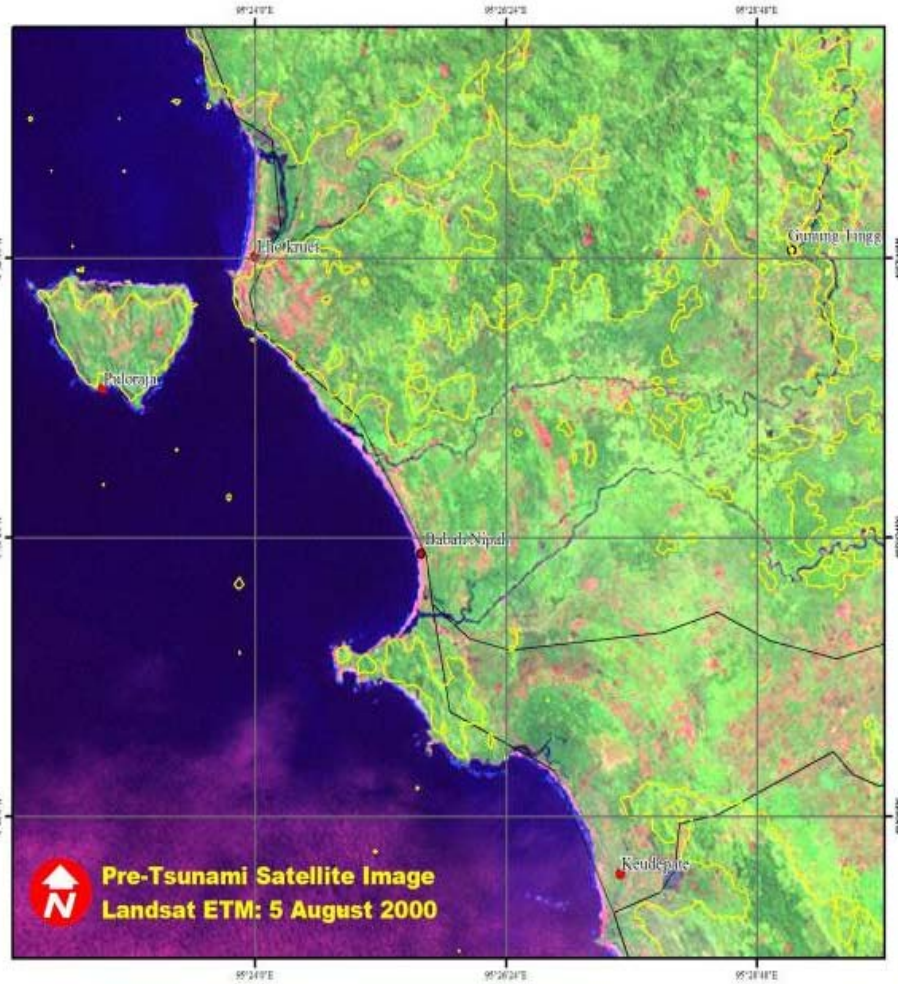


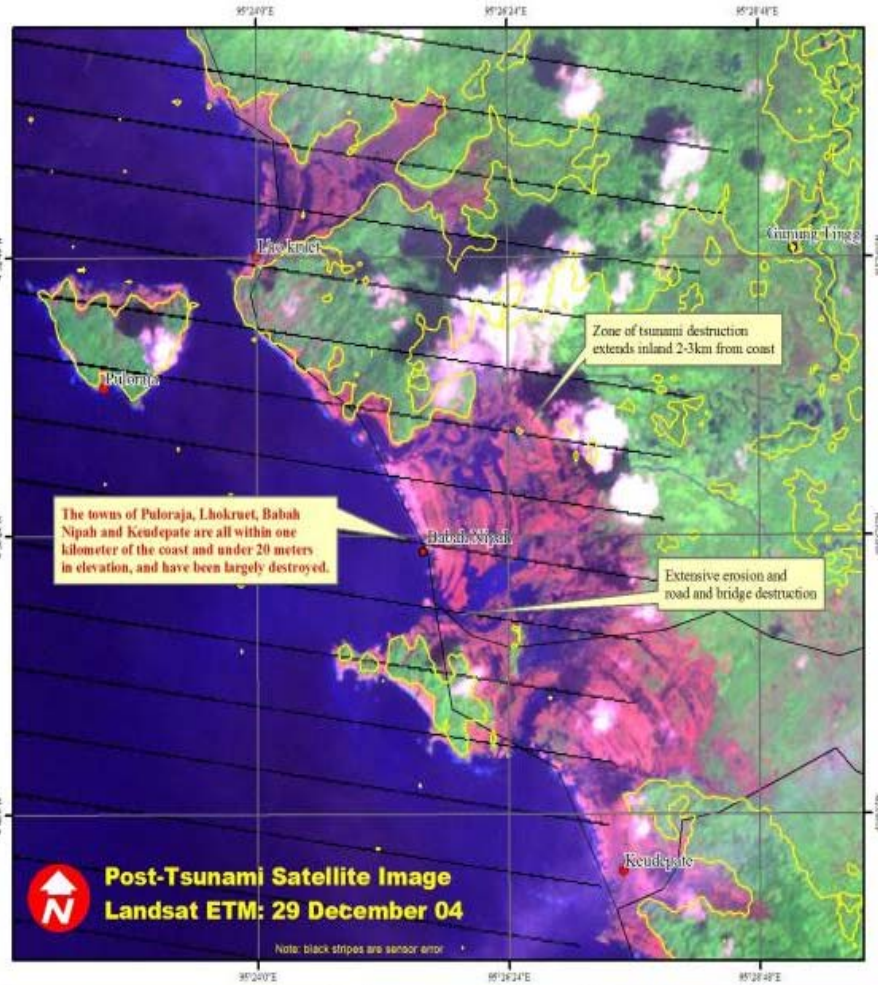
European Space Agency
Agence spatiale européenne

the Living Planet

CHARTER : Earthquake, Haiti 2010







Post-Tsunami Image along West Coast of Aceh Province

The International Charter on Space and Major Disasters aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users. Since 1 July 2003 the Charter is available to support the UN with satellite imagery. Please contact the UN Office for Outer Space Affairs for further information (oosa@unvienna.org).

This map was produced for the UNOSAT project headed by UNITAR and executed by UNOPS. UNOSAT is a UN-private consortium providing satellite imagery and related geographic information to UN humanitarian and development agencies, and their implementing partners. Please see www.unosat.org for additional information.

Disaster Type: Tsunami & Earthquake
Disaster Date: 26 December 2004
Data Source: USGS EROS, JPL, Global Insight
Sensor: Landsat ETM (p131r057) 29 Dec.2004 & 05 August 2000
Resolution: 28m
Bands: 7/4/2
Elevation Data: SRTM (3 arc second)
Resolution: 90m horizontal/16m vertical
Scale: 1:77,000 for A3 Prints
Datum: WGS-84
Projection: UTM Zone 46N
Map Produced: 1 January 2005

The depiction and use of boundaries, geographic names and related data shown here are not warranted to be error-free nor do they necessarily imply official endorsement or acceptance by the United Nations.

This map illustrates the extent of the tsunami destruction along the western coast of Sumatra. The dark red zone in the image from 29 Dec.04 shows the tsunami reached inland up to 4km, inundating most coastal areas under 20 meters in elevation. The roads, bridges and villages in this zone have been devastated.

0 0.5 1 2 3 4 Kilometers

0 0.5 1 2 3 Miles

- Town in 20m zone
- Town above 20m
- Airport
- Road
- Railroad
- 20 Meter Contour

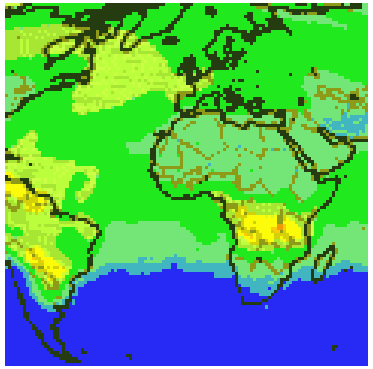
UNOSAT
satellite imagery for all

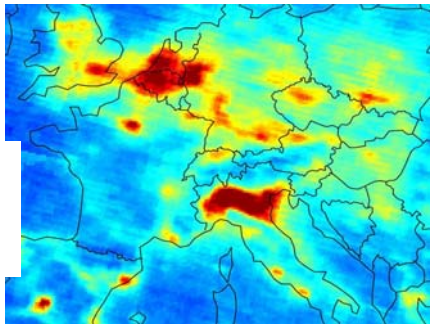
ESA Initiative on Climate Change

ESA Iniciativa sobre el Cambio Climático

- **El fundamento de la iniciativa:**

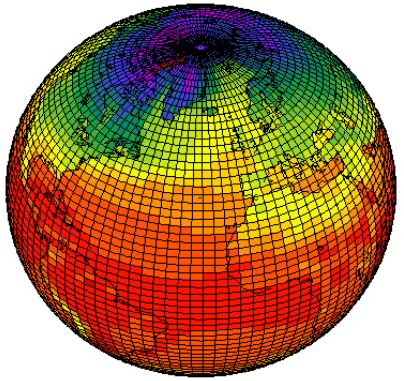
Para generar y distribuir sistemáticamente series a largo plazo de **"Variables climáticas esenciales" (ECV)** para cubrir las necesidades de la UNFCCC y el IPCC, basado en datos de archivo de la ESA





- **Output :**

- **ECV Records:** Cuantificar el estado del sistema climático para (a) avanzar en el conocimiento y (b) respaldar el trabajo de UNFCCC y el IPCC para la migración y adaptación al cambio climático

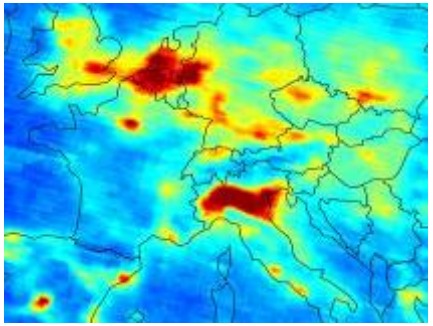


ESA Initiative on Climate Change

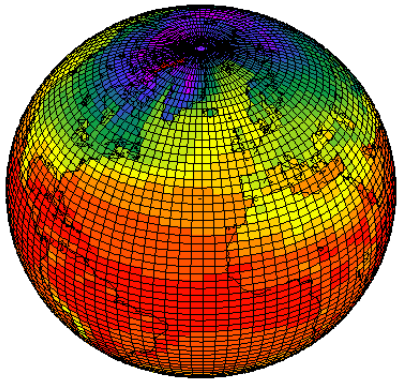
UNFCCC Conference Dec 2007 **Bali Action Plan**

"parties should describe the status of their programmes for contributing observations of the essential climate variables (ECVs) to the international community"

- **EO from space plays a vital role,**
- **ESA to systematically generate and distribute long-term series of "Essential Climate Variables"**



- **Based on ESA archived EO data (30 years),**
- **Internationally agreed requirements**
  - **GCOS definition of ECV**
  - **CEOS response for required space observations**
- **To quantify the state of the Climate system to**
  - **Advance our knowledge of climate change,**
  - **Support work of UNFCCC and IPCC for climate change mitigation and adaptation**

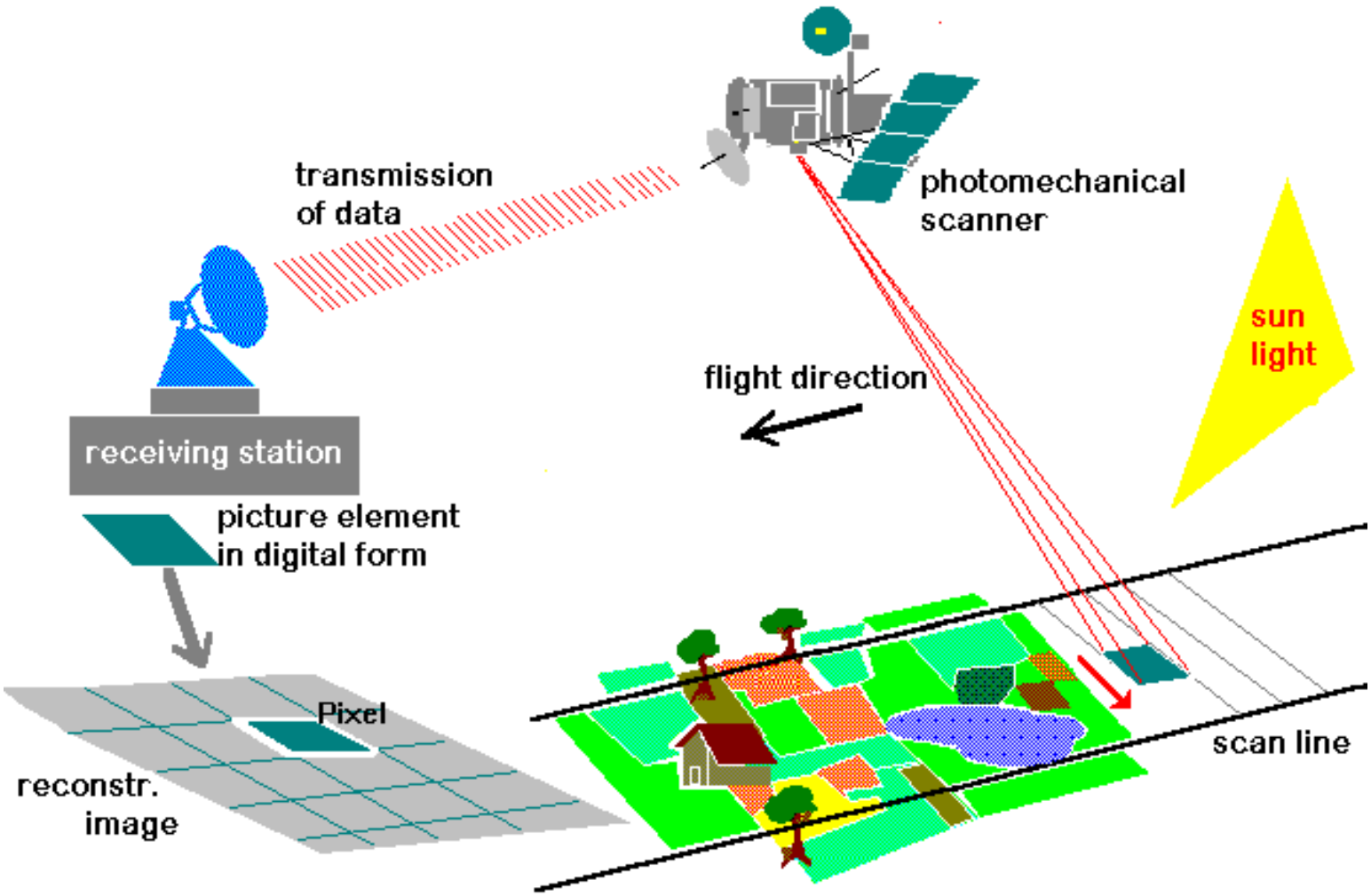


- **5 year program, ~ 300M€, decision C-MIN Nov 2008**

the Living Planet

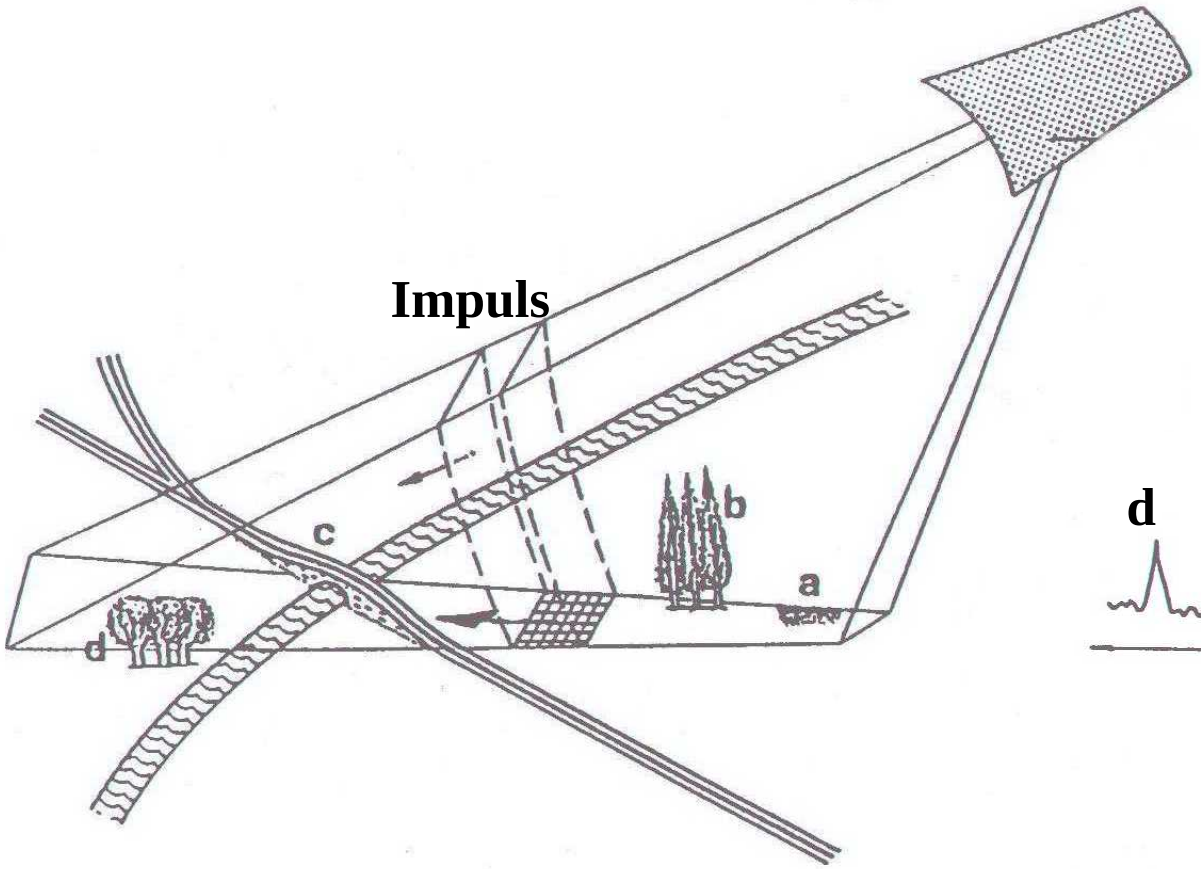
Remote Sensing Principles

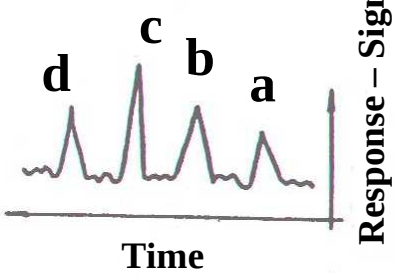
Scanning and Image Reconstruction (visible/IR)



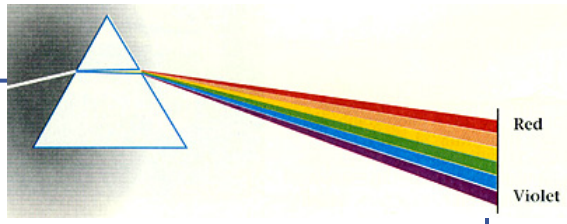
Imaging Radar

Radar Antenne:
Transmitter/Receiver





The Electromagnetic Spectrum



red orange yellow green blue violet

white light

1 near infrared 0,7 visible light 0,4 ultraviolet 0,2 micron

1 micron = 10^{-6} meter

RADIO

long medium short waves

micro-waves

thermal infrared

ultraviolet X-ray Gamma-ray

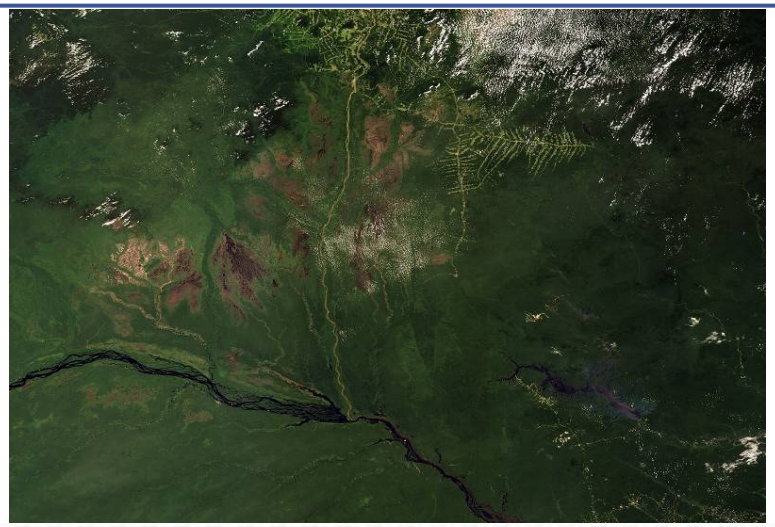
Wave length

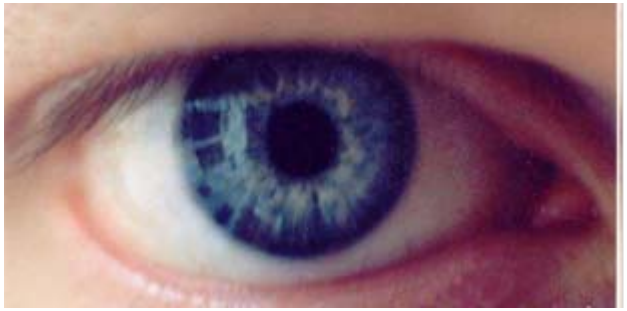
10^{3} 10^{2} 10^{1} 10^{0} 10^{-2} 10^{-4} 10^{-6} 10^{-8} 10^{-10} 10^{-12} 10^{-14} m.

C 6 7 5 4 3 2 1

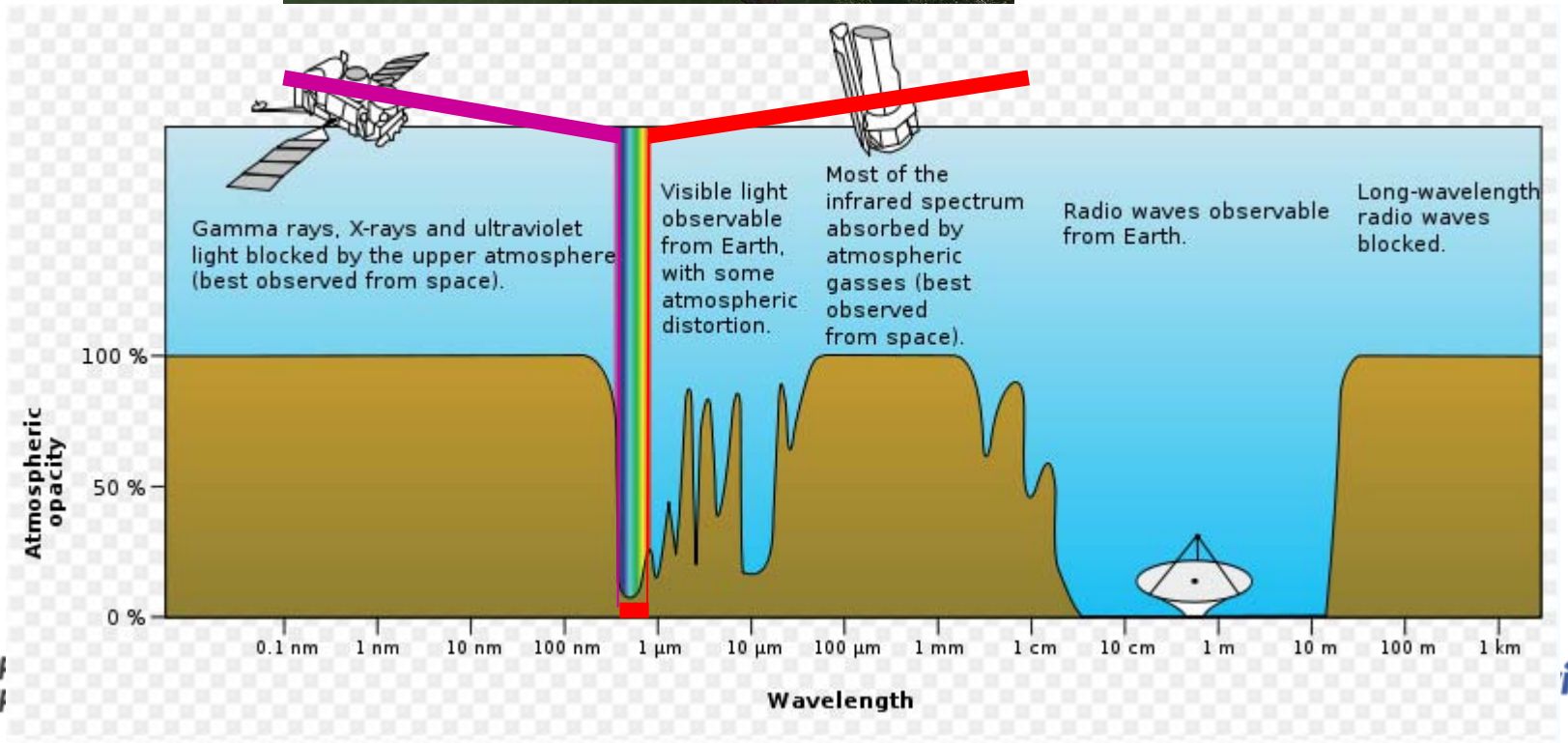
ERS1 LANDSAT TM Bands

El espectro electromagnético

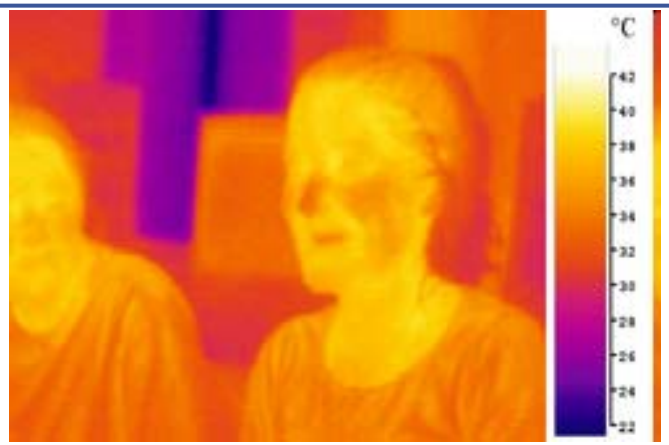


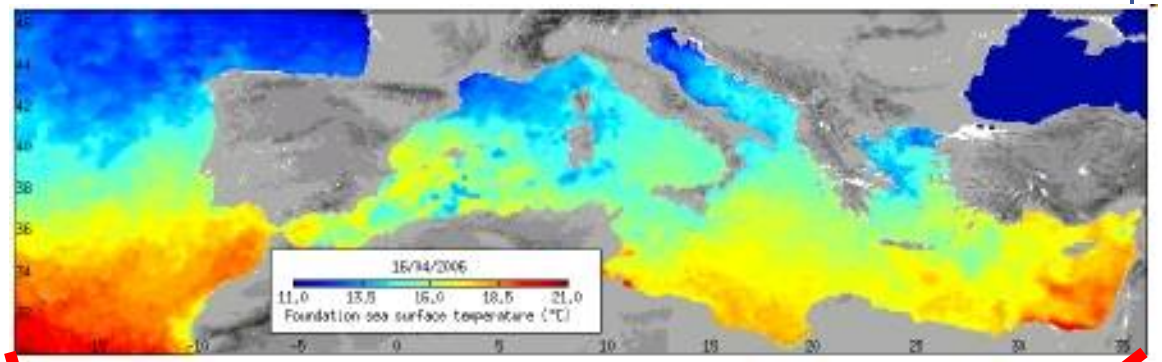


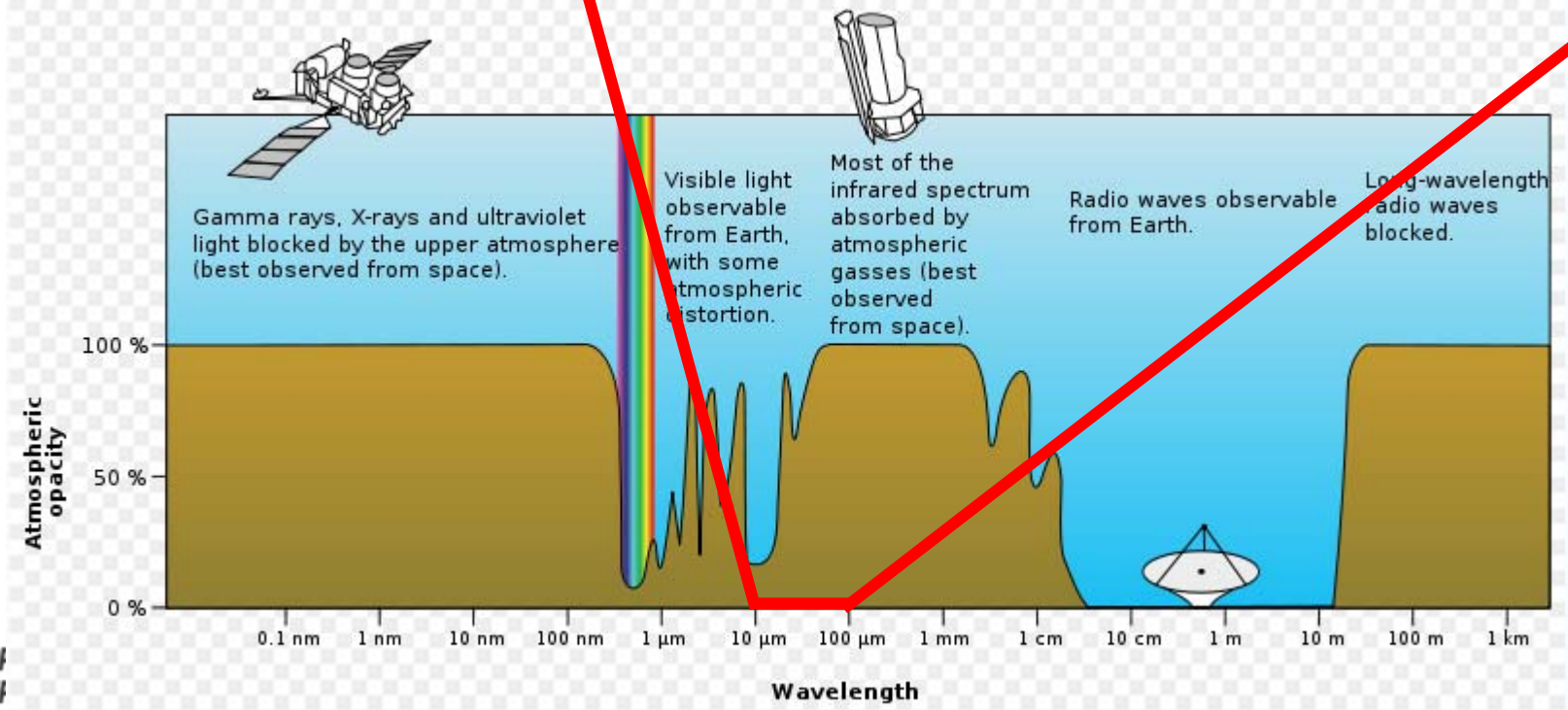
VISIBLE



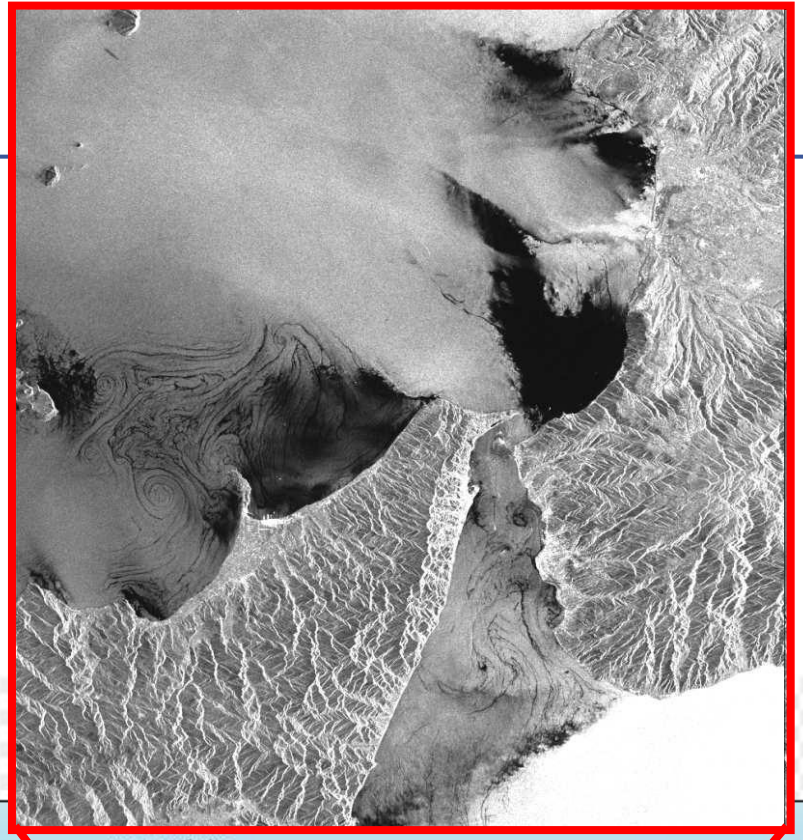
Infrarrojo térmico

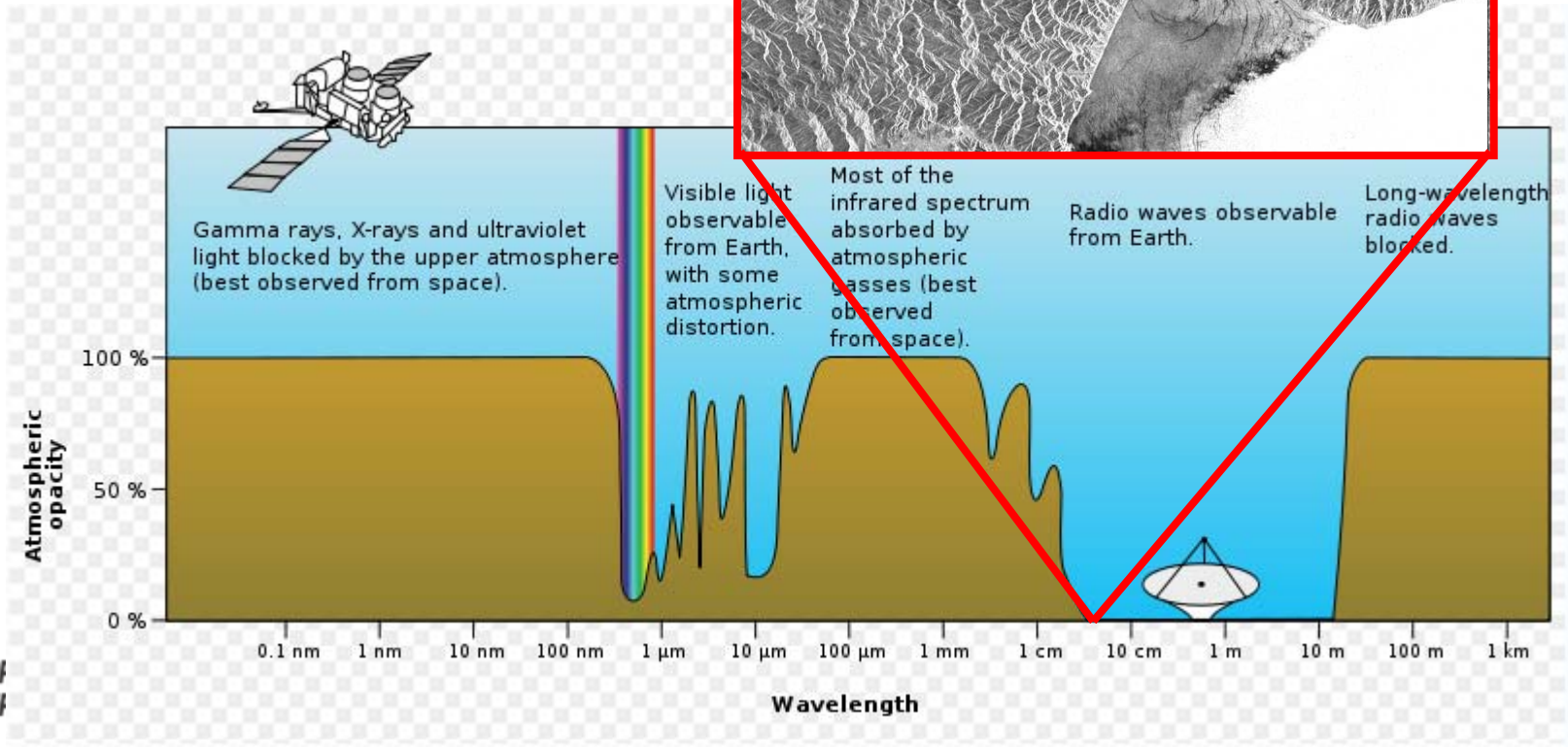


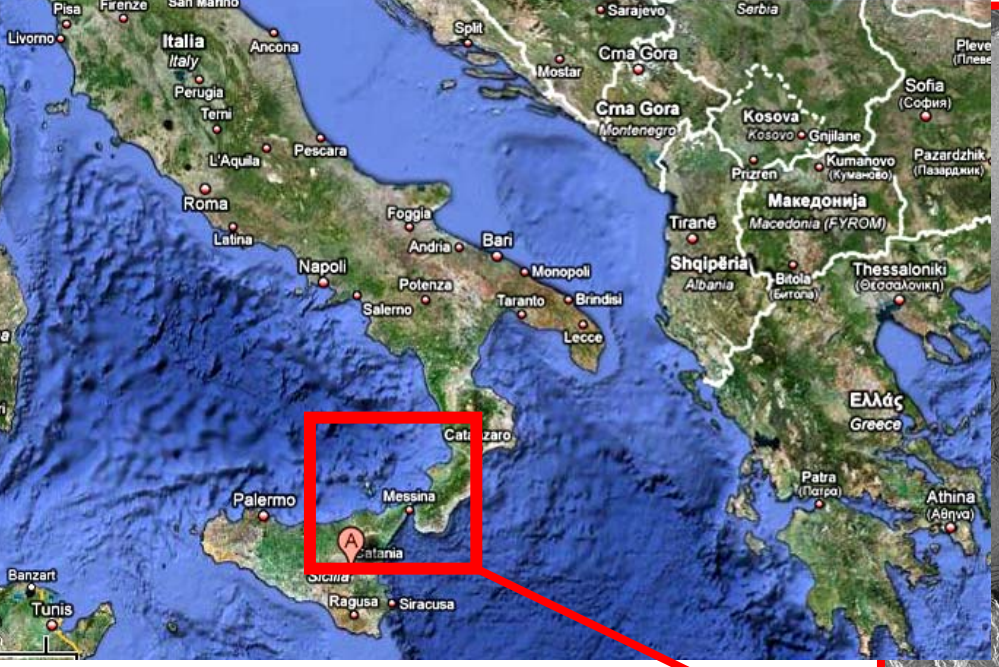


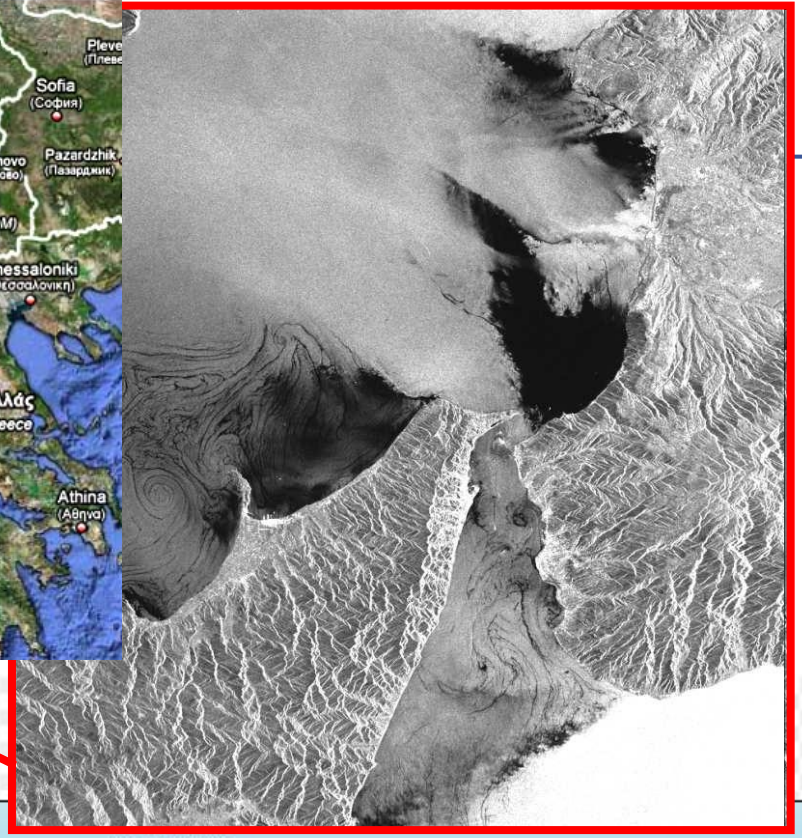


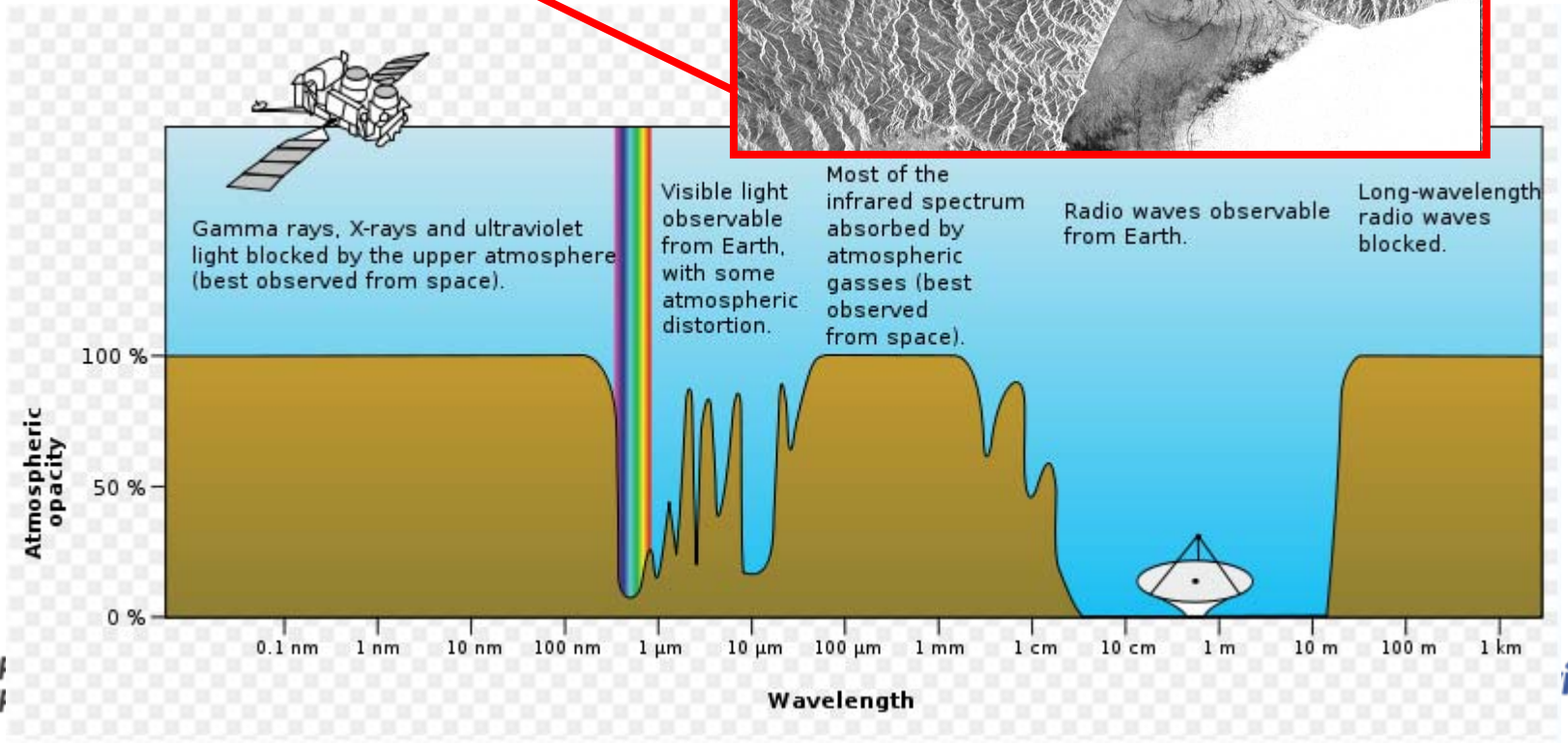
RADAR




Gamma rays, X-rays and ultraviolet light blocked by the upper atmosphere (best observed from space).
Visible light observable from Earth, with some atmospheric distortion.
Most of the infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio waves observable from Earth.
Long-wavelength radio waves blocked.
Atmospheric opacity
100 %
50 %
0 %
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength


Pisa
Firenze
San Marino
Livorno
Italia
Italy
Ancona
Split
Sarajevo
Serbia
Mostar
Crna Gora
Montenegro
Sofia
(София)
Perugia
Terni
Kosovo
Gnjilane
Pescara
L'Aquila
Prizren
Kumanovo
(Куманово)
Pazardzhik
(Пазарджик)
Roma
Foggia
Македонија
Macedonia (FYROM)
Latina
Andria
Bari
Tiranë
Napoli
Shqipëria
Albania
Bitola
(Битола)
Thessaloniki
(Θεσσαλονίκη)
Monopoli
Potenza
Taranto
Brindisi
Salerno
Lecce
Ελλάς
Greece
Palermo
Messina
Patra
(Πατρα)
Athina
(Αθηνα)
Catania
Banzart
Tunis
Ragusa
Siracusa

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1 nm
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1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength

Eduspace and LEOWorks 3.0

History of Eduspace

- **Eduspace initiative based on a 98 EURISY workshop on education**

- **Carried out under umbrella of EURISY by ESA and by some of its national and industrial Partners:**

  - Danish Ministry of Education, representing the final users (professors and teachers)
  - Norwegian Space Centre (NSC), providing also the initial nucleus from the educational SAREPTA Web Site (which was co-sponsored by ESA PR a long time before)
  - British National Space Centre (BNSC), contributing to the initial project proposal and towards funding
  - Eurimage, providing access to Landsat imagery
  - Geospace, Austria, providing access to their "The Alps from Space" high-resolution satellite database.

- **Transferred in 2002 from EURISY to ESA**

OBJECTIVES

- To inspire teachers to incorporate Earth observation into their curricula
- To provide ready-made curricula projects
- To provide tools and Earth observation data for educational purposes
- To enable schools to take part in collaborative work in Earth observation through a network

Target Groups

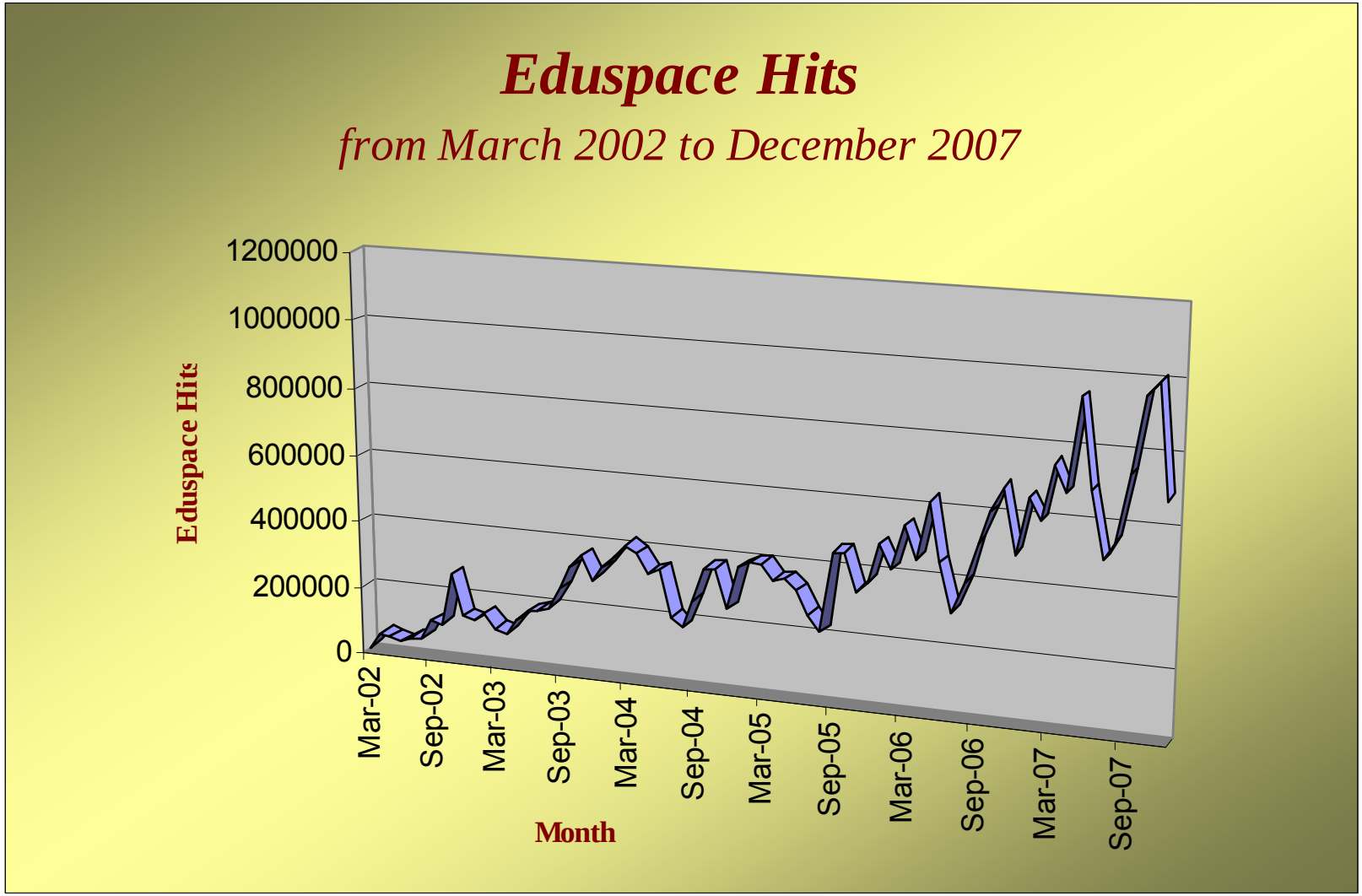
- **Secondary school teachers who want to incorporate EO into their curricula**

- **Secondary school students to extend on what they have learned in class**

- **University students pursuing related academic studies**

- **Access to website www.esa.int/eduspace is free**

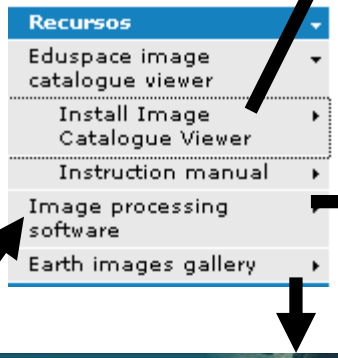
Eduspace Website Hits

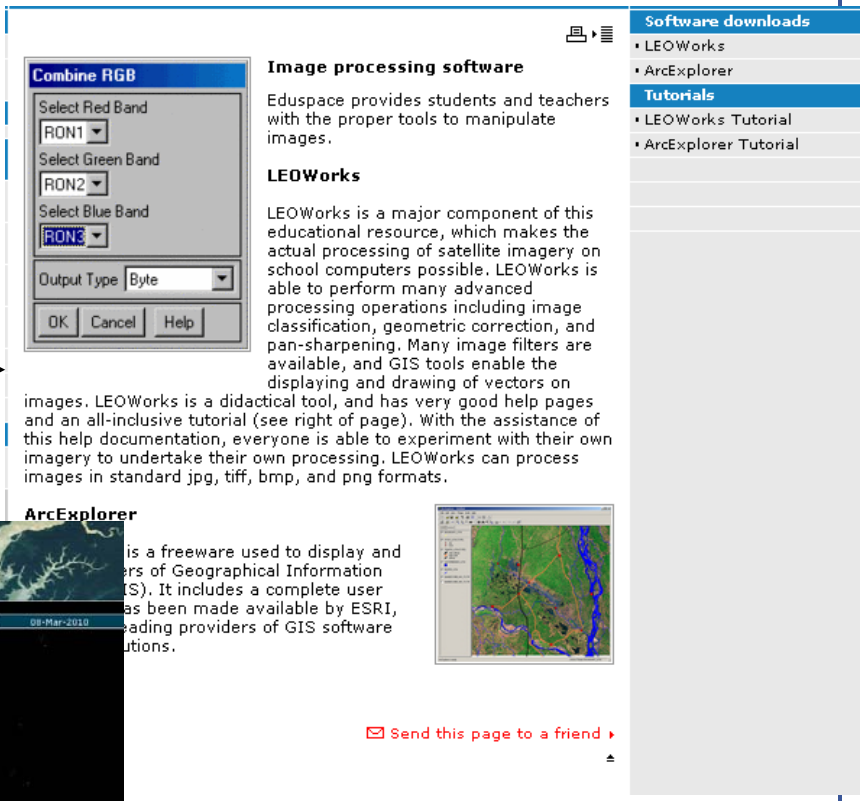


Low values correspond to school holidays

EDUSPACE

http://imagedbk-srv.esrin.esa.int/Eduspace_Installer/install.htm



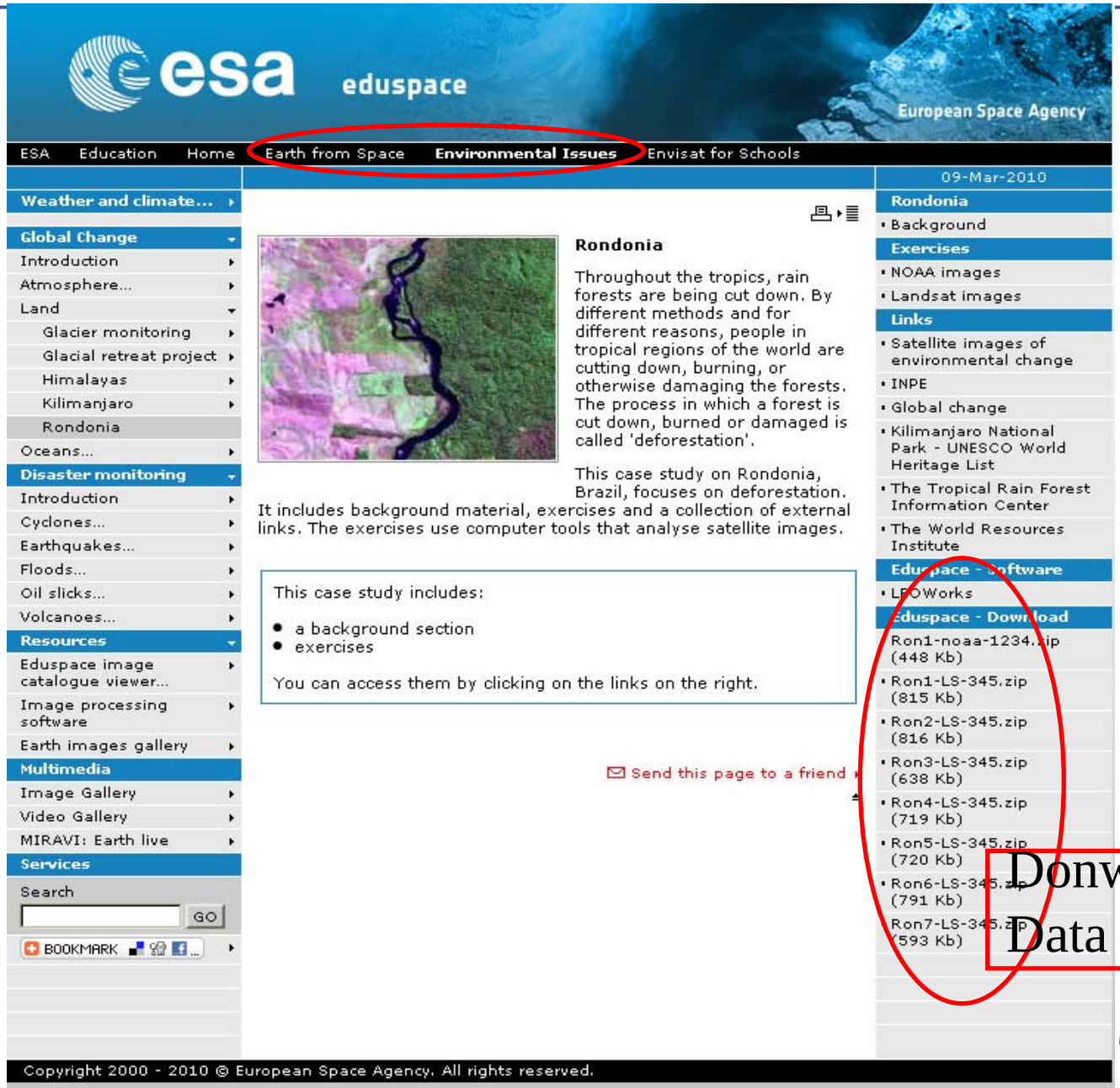


http://earth.eo.esa.int/satelliteimages/

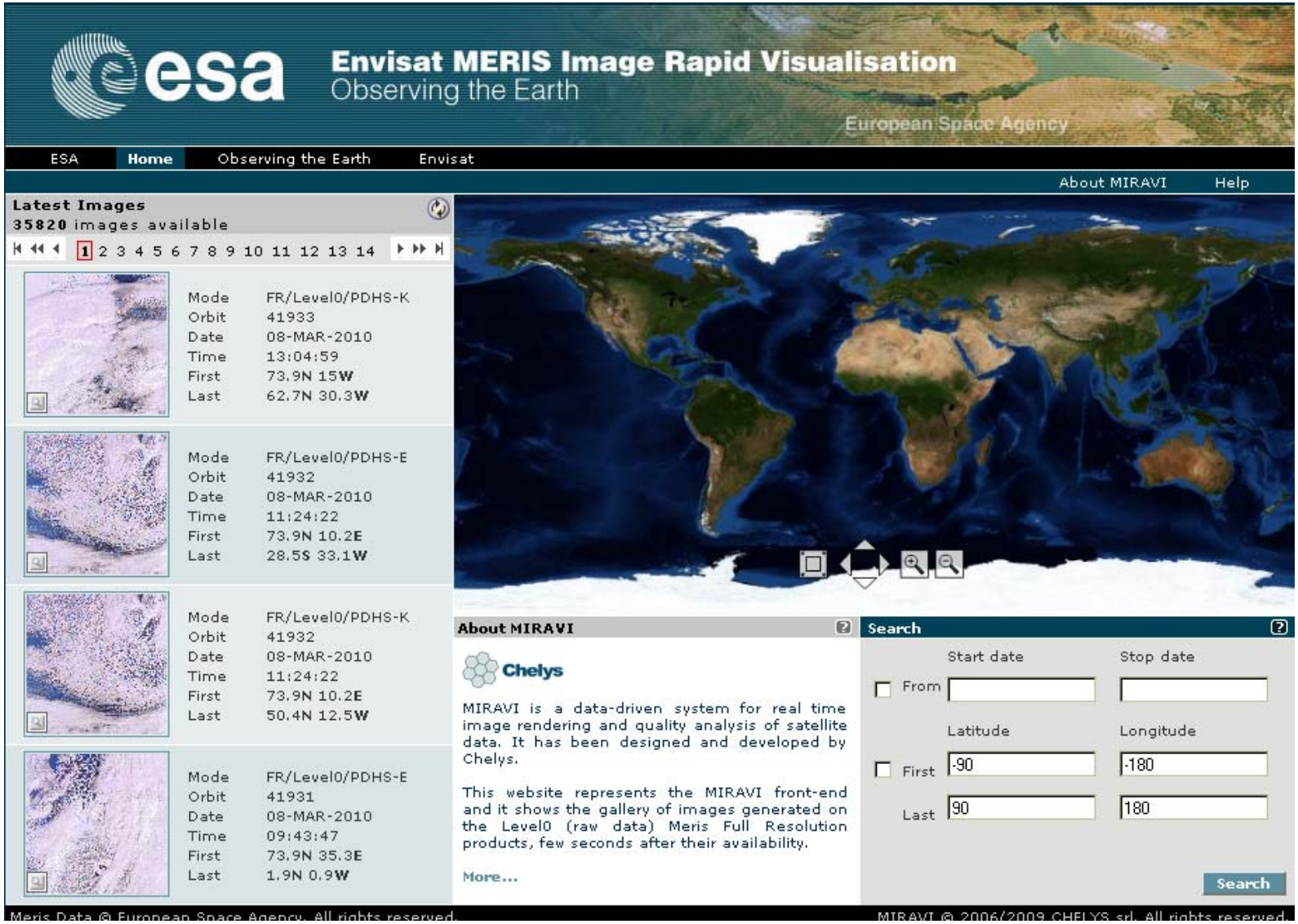
Agence spatiale europeenne

the Living Planet

EDUSPACE: Case studies



http://miravi.eo.esa.int/en/



E-learning

What is remote sensing?

Remote sensing is a way of collecting and analysing data to get information about an object without the instrument used to collect the data being in direct contact with the object.

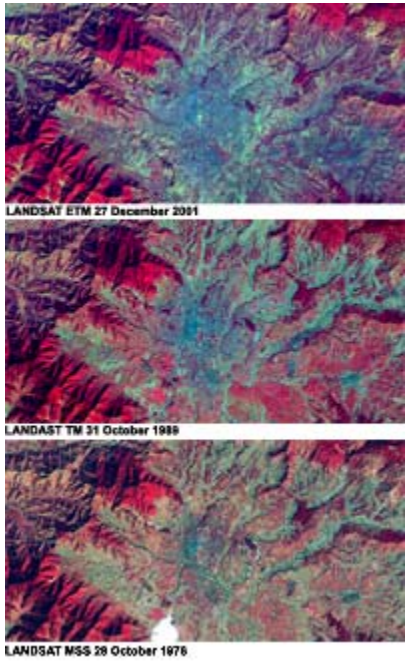
For example, if you take a photograph of your house, and on the picture you see that the house is composed of a roof, walls and windows, all of which appear as different colours, then this is remote sensing.

In remote sensing, three elements are essential. They are:

1 - a platform to hold the instrument
2 - a target object to be observed

Case Study

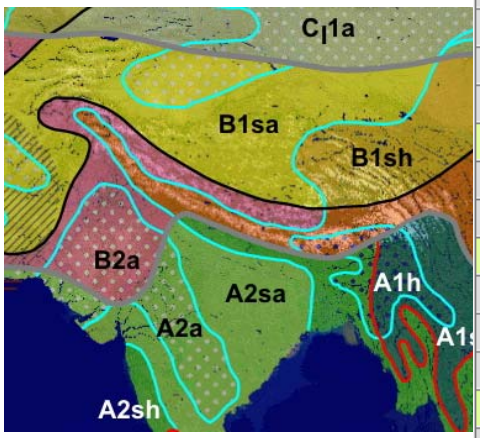
Overview – Himalaya from Space



Case Study: Kathmandu Now and Then optical case study
→ Change detection of Kathmandu

Instrument: LANDSAT ETM, TM, MSS

Resource: Classification of Climate Zones



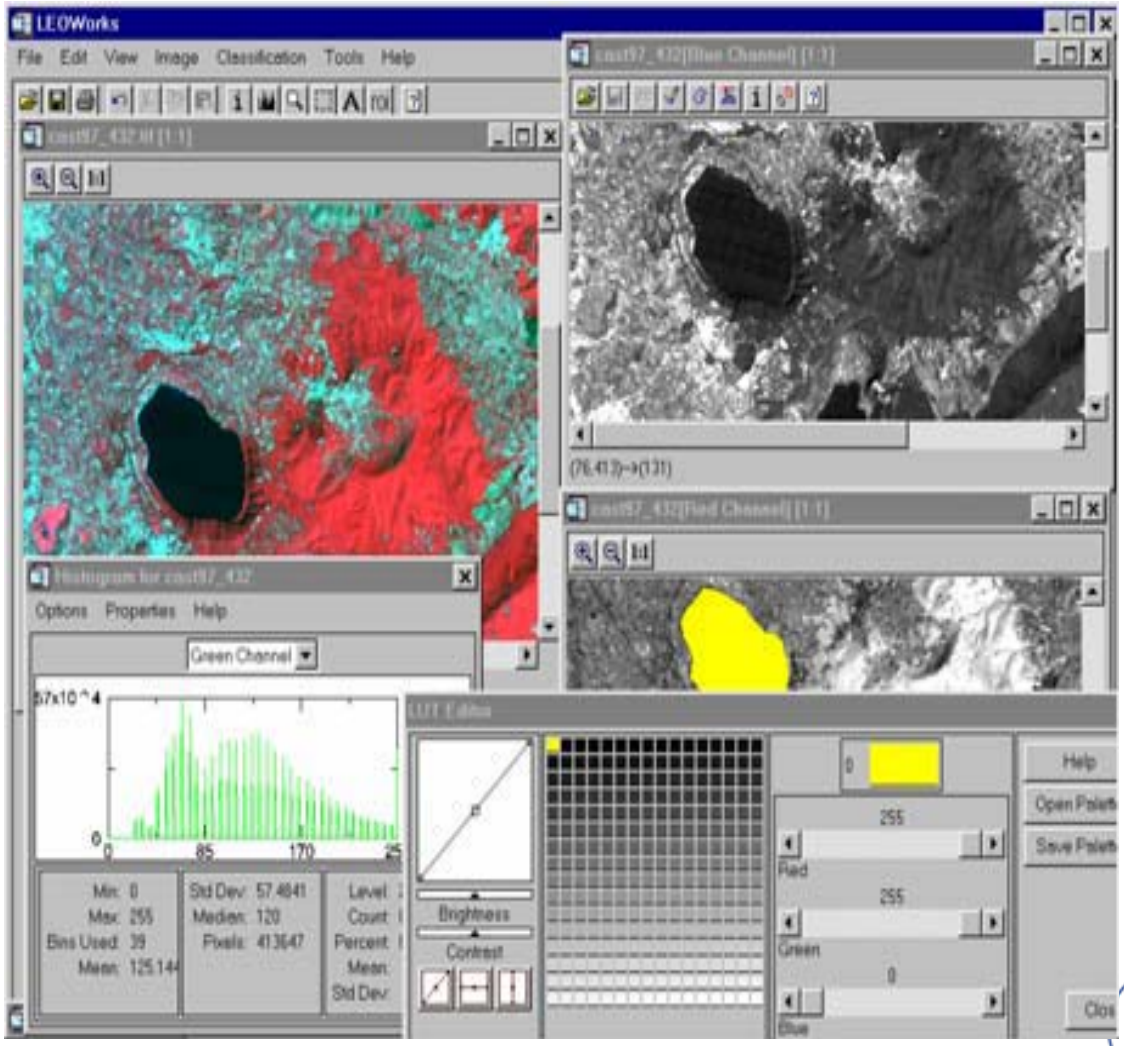
CLIMATE ZONES:	
A	tropical
B	subtropical
C	temperate (moderately warm = I and cold = II)
D	polar regions
SUBCLASSIFICATION OF THE TROPICS:	
1	cold tropical
2	warm tropical
SUBCLASSIFICATION OF OTHER CLASSES	
1	high-continental
2	continental
3	maritime
WATER HOUSEHOLD:	
a	arid (0-2 rainy months)
sa	semi-arid (3-5 rainy months)
sh	semi-humid (6-9 rainy months)
h	humid (10-12 rainy months).

Project: Analysis of Meteosat visible, infrared and water vapour channels

LEOWorks 3.0

Image Processing Software (with GIS functionality)

- View images, histogram, pixel values, header info
- Crop, invert, stretch, layer stack, etc
- Image arithmetic, filters
- Classification, PCA, geometric correction, pan sharpening
- GIS tools



Classification Example

Classification of Hanoi

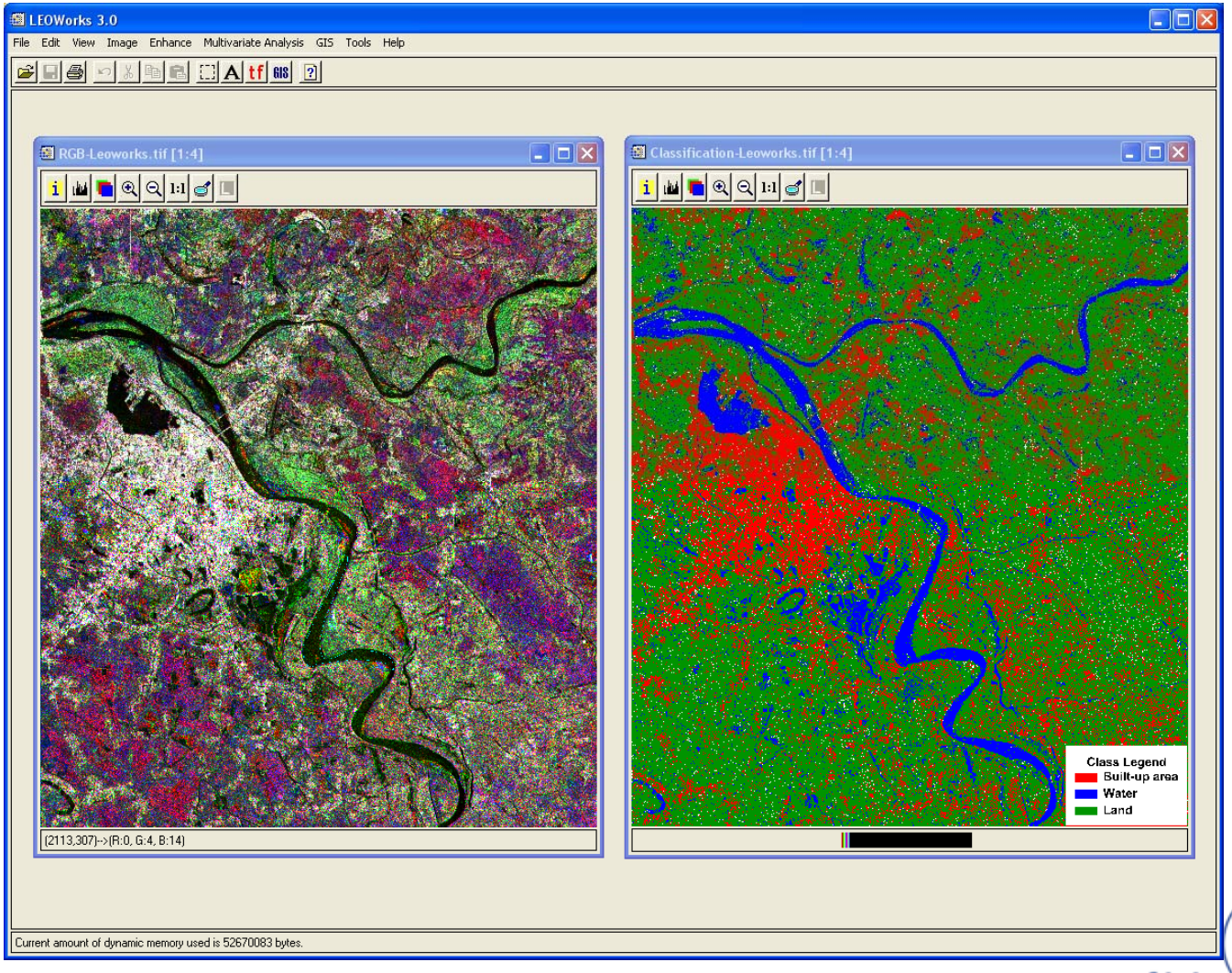


Image Resources

Image Catalogue

- The EduSpace Image Catalogue software is developed by Terranova in collaboration with ESA/ESRIN. It allows the user to perform multi – mission inventory searches on the main ESA – supported missions

- Eduspace Image Catalogue is an application composed principally by two main viewers, positioned in the centre of the application
  - -The first shows satellite images from data-bank
  - -The second shows a map of the area covered by EduSpace project

- Eduspace Image Catalogue application can be downloaded at page **http://imagedbk-srv.esrin.esa.int/Eduspace_Installer/install.htm**

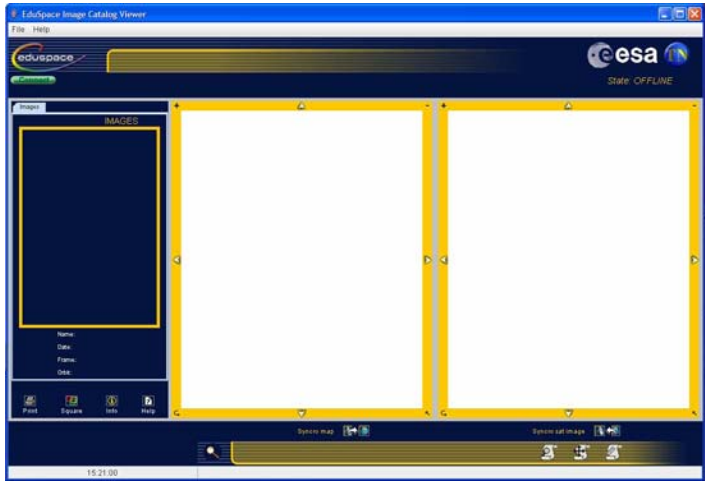
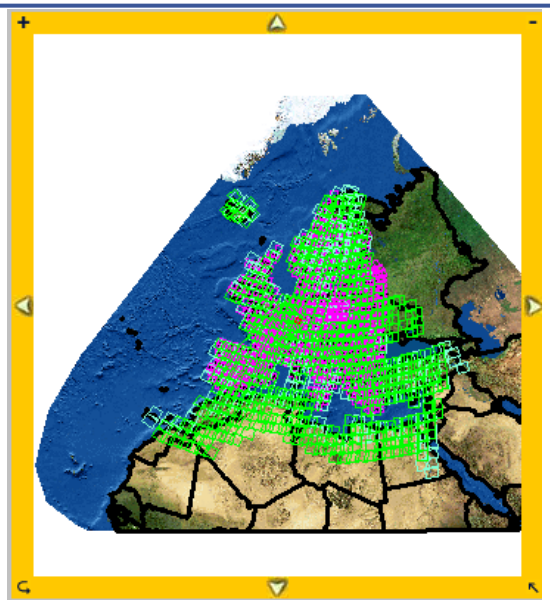
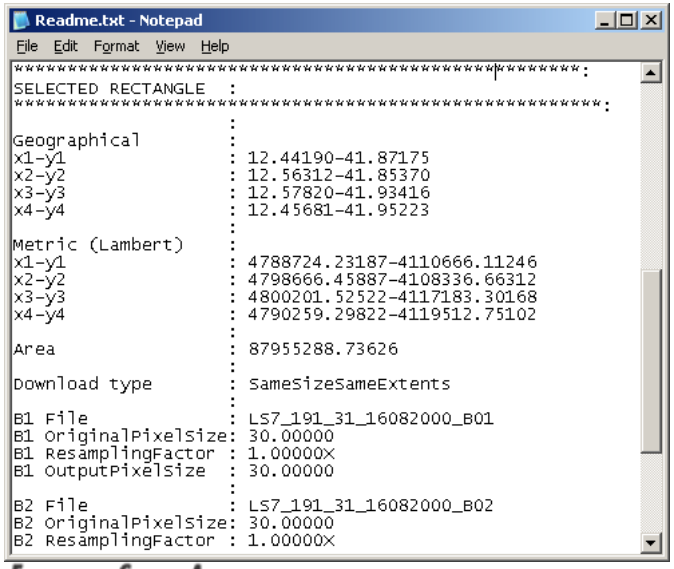
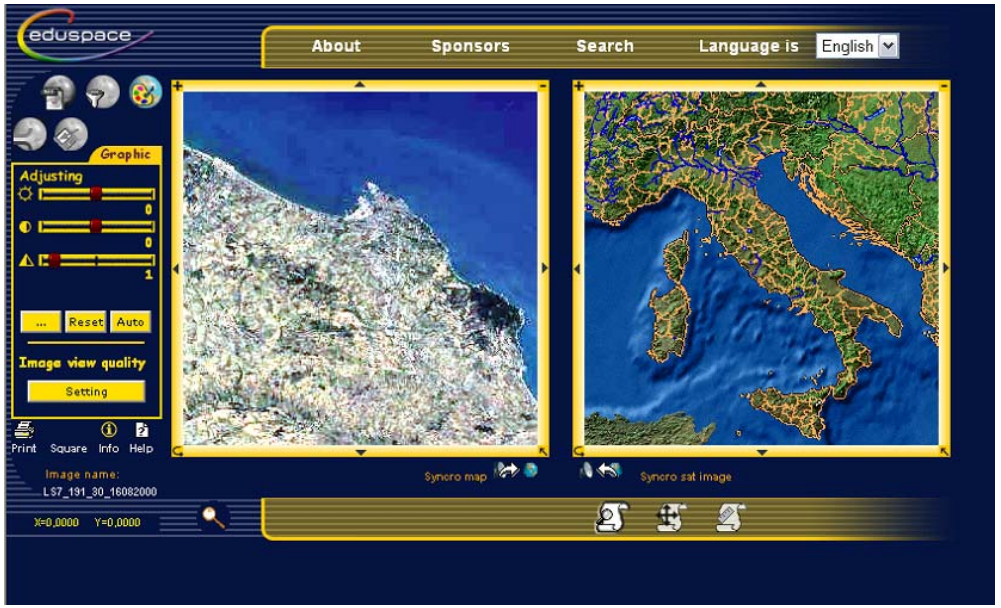


Image Catalogue



Eduspace Image Catalogue allows multi-mission inventory searches of the main ESA supported missions. Registered users can download selected sections of scenes of size 1000 x 1000 pixels





For each downloaded image there is a read-me file containing image information