Ciências ULisboa

Deteção Remota Multiespetral

SATÉLITES E SENSORES

A pair of CubeSat satellites will probe a little-studied portion of the radiant energy emitted by the complex Arctic environment for clues to why the region is warming faster than the rest of the planet. This 2011 composite satellite image shows the expanse of Arctic sea ice (center) and the Greenland Ice Sheet (lower right).
Credits: NASA

Why is the Arctic warming faster than the rest of the planet? Does mineral dust warm or cool the atmosphere? NASA has selected two new, creative research proposals to develop small, space-based instruments that will tackle these fundamental questions about our home planet and its environment.

The Polar Radiant Energy in the Far Infrared Experiment (PREFIRE) will fly a pair of small CubeSat satellites to probe a little-studied portion of the radiant energy emitted by Earth for clues about Arctic warming, sea ice loss, and ice-sheet melting. Tristan L'Ecuyer of the University of Wisconsin, Madison, is the principal investigator.

The Earth Surface Mineral Dust Source Investigation (EMIT) will use a sensor mounted to the exterior of the International Space Station to determine the mineral composition of natural sources that produce dust aerosols around the world. By measuring in detail which minerals make up the dust, EMIT will help to answer the essential question of whether this type of aerosol warms or cools the atmosphere. Robert Green of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, is the principal investigator.

These two instruments were competitively selected from 14 proposals considered under NASA's fourth Earth Venture Instrument opportunity. Earth Venture investigations are small, targeted science investigations that complement NASA's larger missions. The National Research Council recommended in 2007 that NASA undertake this type of regularly solicited, science-based, quick-turnaround project. The council's recently released decadal survey recommended the continuance of the program.

Will ThinSats inspire the next generation of engineers and scientists?

by Debra Werner — February 21, 2018

Dale Nash, executive director of Virginia Space and the Mid-Atlantic Regional Spaceport (center) and Alta Devices, Twiggs Space Lab and Near Space Launch colleagues hold three interlinked ThinSats. Credit: Alta Devices

When Orbital ATK's Antares rocket blasts off from Wallops Island, Virginia, this fall on its way to the International Space Station, the rocket's second stage will carry an unusual payload: one cubesat and 63 ThinSats, miniature satellites shaped like a slice of bread.

For a year, the Virginia Commercial Space Flight Authority, Twiggs Space Lab, Orbital ATK and NASA's Wallops Flight Facility have been collaborating on a campaign to encourage Virginia students to design, build and test Thinsats, which are a seventh the size of cubesats.

Small Satellite Conference, we were at Orbital ATK in Dulles, Virginia, and they had PocketQubes on the manifest," Twiggs said. "That's a record."

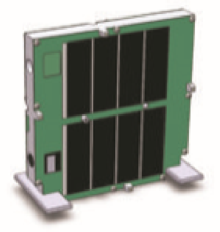
To figure out how to launch PocketQubes, Twiggs turned to his friend Voss, a retired engineering and physics professor at Indiana's Taylor University and NearSpace Launch (NSL) president, chief executive and chief scientist.

After wrestling with the problem for more than a month, Voss proposed a new solution. "What if you think of a three-unit cubesat like a loaf of bread and slice it up like a loaf of bread," he told Twiggs. "Instead of making little boxes, let's make 4.5-inch by 4.5-inch by 3/4-inch satellites and call them ThinSats."

To be precise, ThinSats measure 111 by 114 by 12.5 millimeters. Pins used to separate them bring the total width of each ThinSat to 17.4 millimeters.

It was "one super idea," Twiggs said.

ThinSats are built in a single layer, meaning one printed circuit board that is easy to design, assemble and test. Atmospheric drag in extremely low Earth orbit where the Antares second stage drops them off will orient them with the thin side forward. Best of all, 21 ThinSats fit in Planetary Systems Corp.'s Canisterized Satellite Dispenser without any extra packaging, Holemans said.



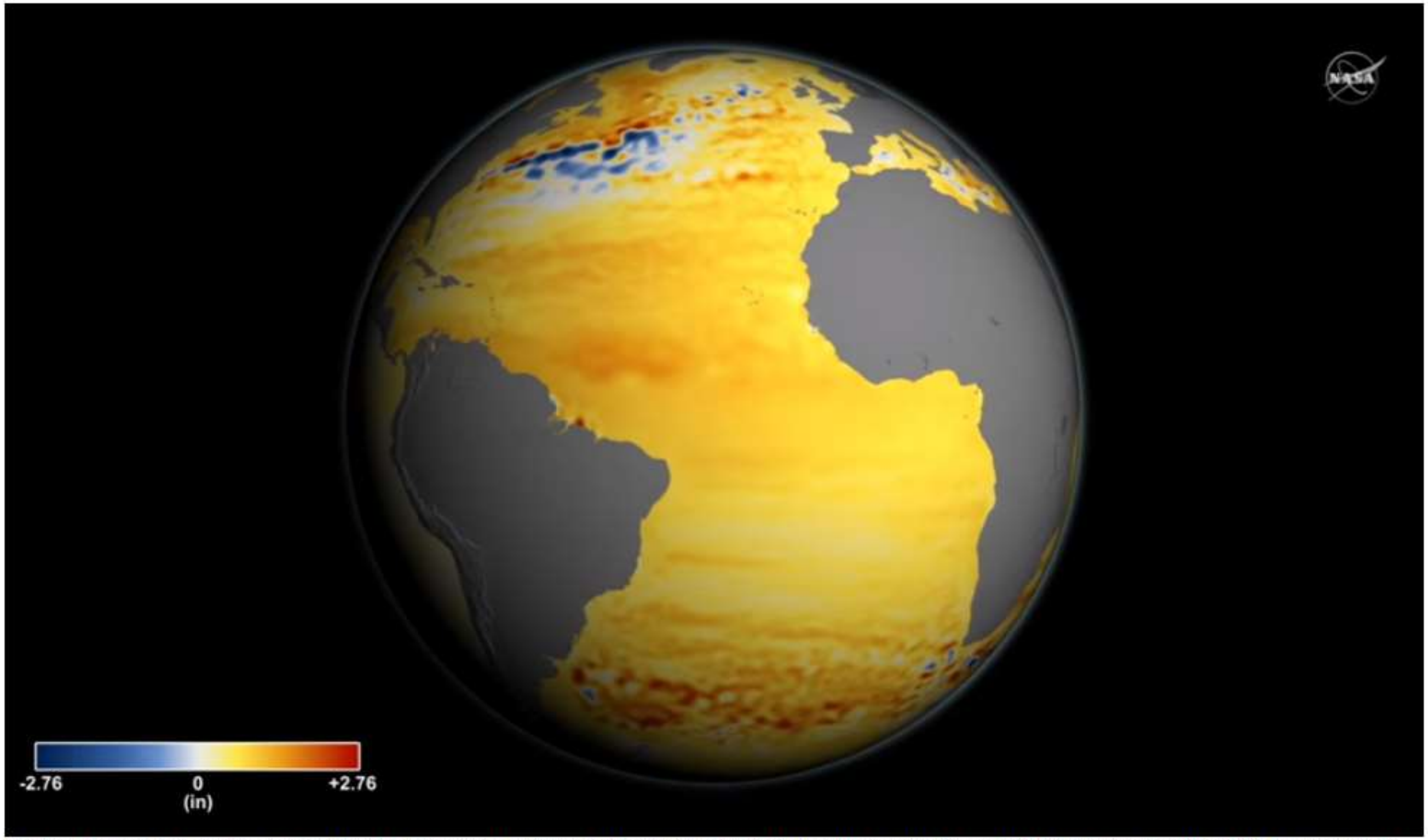
A Twiggs Space Lab rendering of the ThinSat concept.

"Besides, a satellite that looks like a piece of bread is cool," Twiggs said.

ThinSats in the Classroom

Twiggs Space Lab has developed a three-phase curriculum to lead students through the process of designing, developing, testing and operating ThinSats in addition to collecting, analyzing and presenting data they acquire with onboard sensors.

https://www.nasa.gov/feature/goddard/2018/new-study-finds-sea-level-rise-accelerating



Global sea level rise is accelerating incrementally over time rather than increasing at a steady rate, as previously thought, according to a new study based on 25 years of NASA and European satellite data.

Credits: NASA's Goddard Space Flight Center/Kathryn Mersmann

Download more visualizations at NASA's Scientific Visualization Studio.

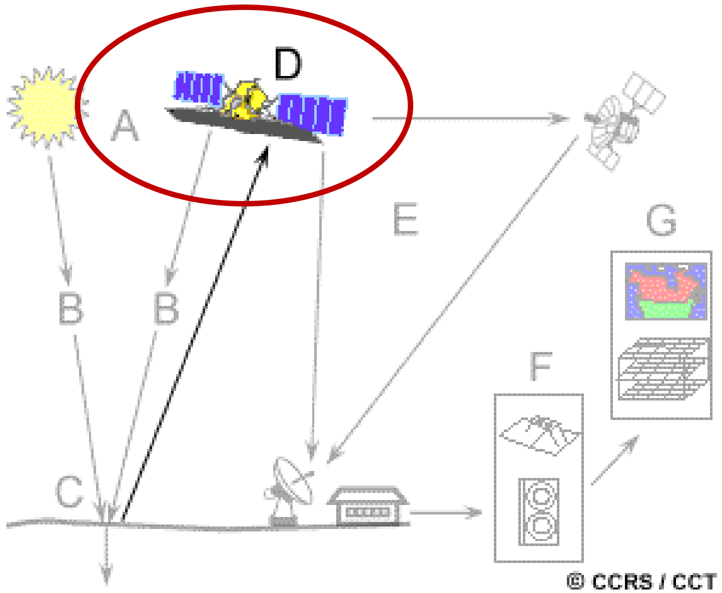
This acceleration, driven mainly by increased melting in Greenland and Antarctica, has the potential to double the total sea level rise projected by 2100 when compared to projections that assume a constant rate of sea level rise, according to lead author Steve Nerem. Nerem is a professor of Aerospace Engineering Sciences at the University of Colorado Boulder, a fellow at Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES), and a member of NASA's Sea Level Change team.

Sumário

Capitulo 2 – Satélites e Sensores

- Satélites Meteorológicos
  - GOES, NOAA AVHRR, Outros satélites
- Altimetria Espacial
- Missões Geopotenciais Espaciais
- Missões SAR
- Missões na banda do visível
  - LANSAT, SPOT, IRS, IKONOS, QuickBird, GeoEye-1

Missões de Observação da Terra



- Meteorológicas
- Geopotenciais
- Altimetria de Satélite
- Observação da Terra

+ About Observing the Earth

EO programmes
- The Living Planet
- Copernicus

ESA's Earth Observing missions
- Envisat
- ERS overview
- Earth Explorers
- Sentinels overview
- Proba-V
- Proba-1 overview
- Third Party Missions overview
- Meteosat Second Generation
- MetOp overview

Multimedia
- Image Gallery
- Video Gallery
- Online resources

ESA > Our Activities > Observing the Earth

→ SENTINEL'S LAST STOP

The Sentinel-2A satellite shows us where its twin, Sentinel-2B, will be launched from tonight – its last stop before space

Archive

LATEST NEWS

Sentinel-2B poised for liftoff

02 March 2017

SnapPlanet app wins top prize at Space App Camp

28 February 2017

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4/5

Stitching together multiple images from #Sentinel2, Austrian company @eox_a gives us an unobstructed view of Europ... t.co/IooiHVET8f

06 Mar 2017 12:54:09

Image of the week archive

Earth from Space on ESA Web-TV

Satélites / Sensores Meteorológicos

A monitorização e previsão do tempo foi uma das primeiras aplicações civis da detecção remota com satélites.

TIROS-1 : 1960, EUA.
(Television and Infrared Observation Satellite-1)

ATS-1, 1966, NASA. Satélite geoestacionário que fornecia imagens hemisféricas da superfície da Terra e cobertura de nuvens a cada meia hora.

A resolução temporal dos satélites meteorológicos é bastante elevada e a sua resolução espacial bastante grosseira (comparada com os satélites de Observação da Terra)

GOES (Geostationary Operational Environmental Satellite)

Imagem de um furacão EUA, Setembro de 1996

O sistema GOES é o seguidor da série ATS.

Fornece imagens frequentes de pequena escala da superfície da Terra e da cobertura de nuvens.

Estes satélites fazem parte de uma rede de satélites separados 70º em longitude que fornecem uma cobertura permanente da Terra.

GOES

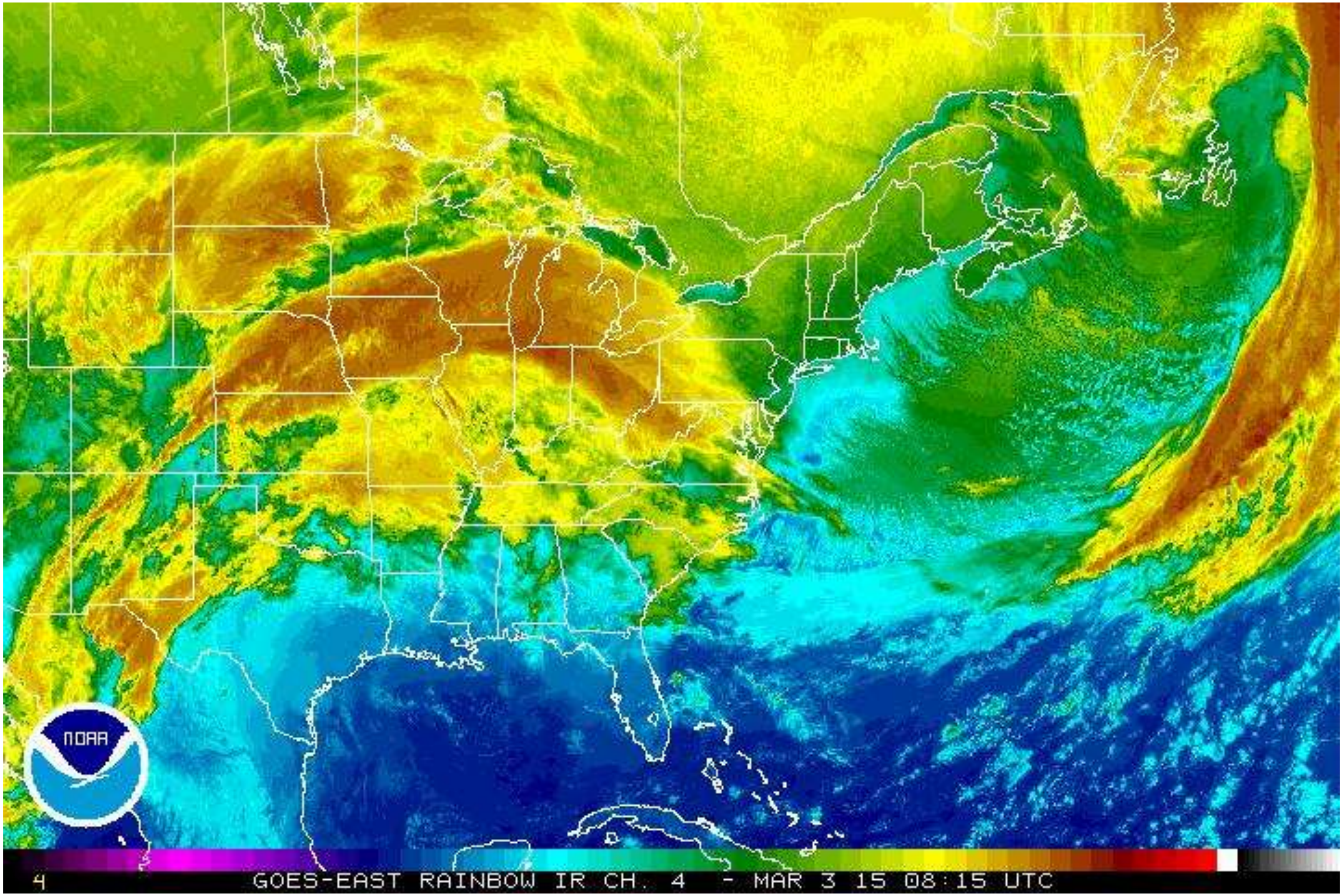
Os dois satélites GOES colocados em órbitas geoestacionárias a 36000 km sobre o equador cobrem um terço da Terra.

Um está situado a 75º W e monitoriza o norte e sul da América e parte do Oceano Atlântico. O outro está situado a 135º W e monitoriza o norte da América e o Oceano Pacifico. Em conjunto cobrem a área de 20ºW a 165 E.

Foram lançadas duas gerações dos satélites GOES ambas medindo a radiação emitida e reflectida a partir da qual se pode determinar:

- a temperatura da atmosfera,
- ventos e
- cobertura de nuvens.

GOES



GOES - Bandas

Band	Wavelength Range (>µm)	Spatial Resolution	Application
1	0.52 - 0.72 (visible)	1 km	cloud, pollution, and haze detection; severe storm identification
2	3.78 - 4.03 (shortwave IR)	4 km	identification of fog at night; discriminating water clouds and snow or ice clouds during daytime; detecting fires and volcanoes; night time determination of sea surface temperatures
3	6.47 - 7.02 (upper level water vapour)	4 km	estimating regions of mid-level moisture content and advection; tracking mid-level atmospheric motion
4	10.2 - 11.2 (longwave IR)	4 km	identifying cloud-drift winds, severe storms, and heavy rainfall
5	11.5 - 12.5 (IR window sensitive to water vapour)	4 km	identification of low-level moisture; determination of sea surface temperature; detection of airborne dust and volcanic ash

NOAA AVHRR

A NOAA é também responsável por outra série de satélites usados em aplicações meteorológicas.

Estes satélites têm órbitas heliosincronas, quase polares a cerca de 830-870 km sobre a superfície e são a continuação da série TIROS e fornecem informação complementar ao sistema GOES.

Dois satélites cada um com cobertura global garantem que qualquer região da Terra é observada no máximo cada 6 horas. Um satélite cruza o equador no final da manhã de norte para sul e o outro cruza o equador no final da tarde.

O sensor a bordo deste satélite é o:

AVHRR (Advanced Very High Resolution Radiometer)

NOAA AVHRR

BANDAS

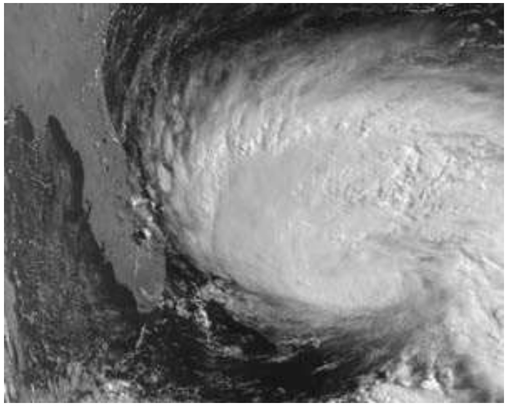
Table 3.1.2.1-1. Summary of AVHRR/3

Parameter	Ch. 1	Ch. 2
Spectral Range (µm)	0.58-0.68	.725-1.0
Detector type	Silicon	Silicon
Resolution (km)	1.09	1.09
IFOV (see Note 1) (milliradian)	1.3 sq.	1.3 sq.
S/N @ 0.5% albedo	≥9:1	≥9:1
NEdT @ 300K	-	-
MTF @ 1.09 km	>.30	>.30
Temperature Range (K)	-	-

Note:
1. Tolerance on IFOV values are ±0.2 mr with a ±0.1 mr design goal.

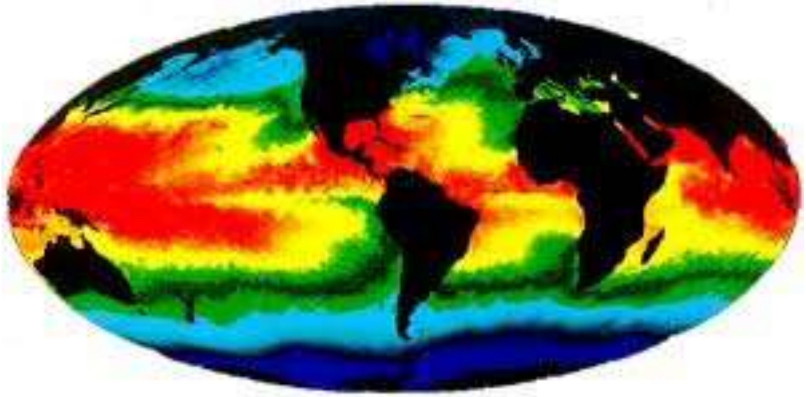
GIFOV = 2* H * tan (IFOV/2)

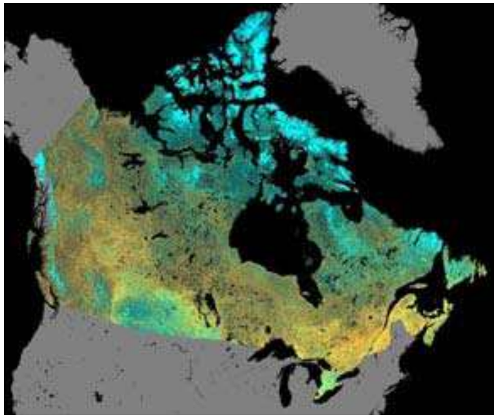
NOAA AVHRR



O AVHRR é também usado para monitorização do uso do solo embora com uma resolução muito grosseira comparada com os satélites de observação da Terra.

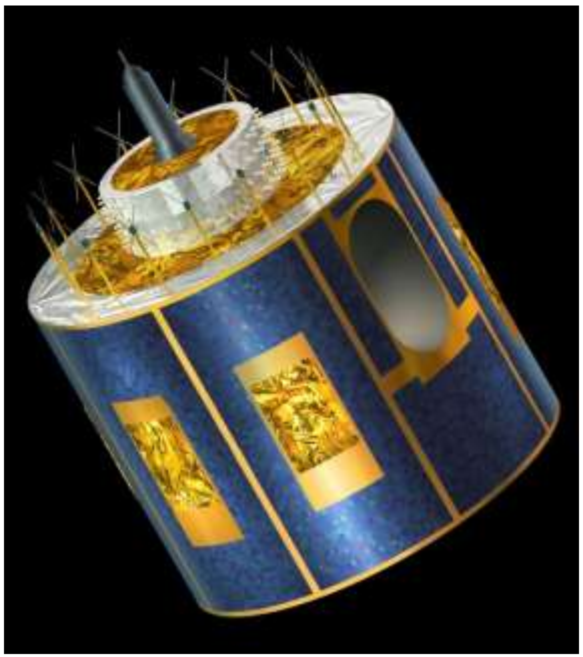
É usado no mapeamento da temperatura da superfície do mar e da vegetação natural ou das condições de gestação dos cereais.





Meteosat Second Generation (MSG)

O MSG é um projecto conjunto entre a ESA e o EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) consiste numa série de 4 satélites meteorológicos geoestacionários que estará operacional até 2020.



Estes satélites têm dois instrumentos:

SERIVI (Spinning Enhanced Visible and InfraRed Imager) com 12 canais espectrais. Tem como objectivo a previsão meteorológica.

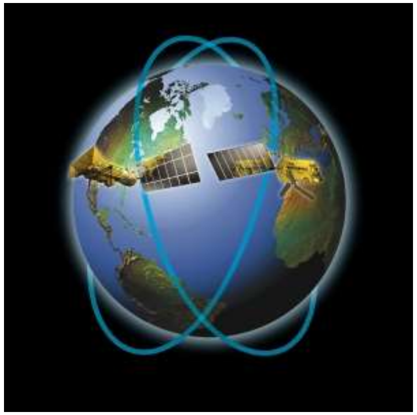
GERB (Geostationary Earth Radiation Budget) que suporta estudos climáticos

MetOp

MetOp é o primeiro satélite europeu de órbita polar dedicado à meteorologia.

MetOp é uma série de 3 satélites a ser lançado sequencialmente em 14 anos consistindo no segmento do espaço do EUMETSAT's Polar System (EPS).

O primeiro foi lançado em 2006 (A) e o segundo em 2012 (B) e o C será lançado em 2018.



Sun-synchronous orbit, 09.30 mean local solar time
Inclination, 98.7 degrees to the Equator
Time for one orbit, 101 minutes
Repeat cycle, 29 days
Mean altitude Approximately 817 km

MetOp

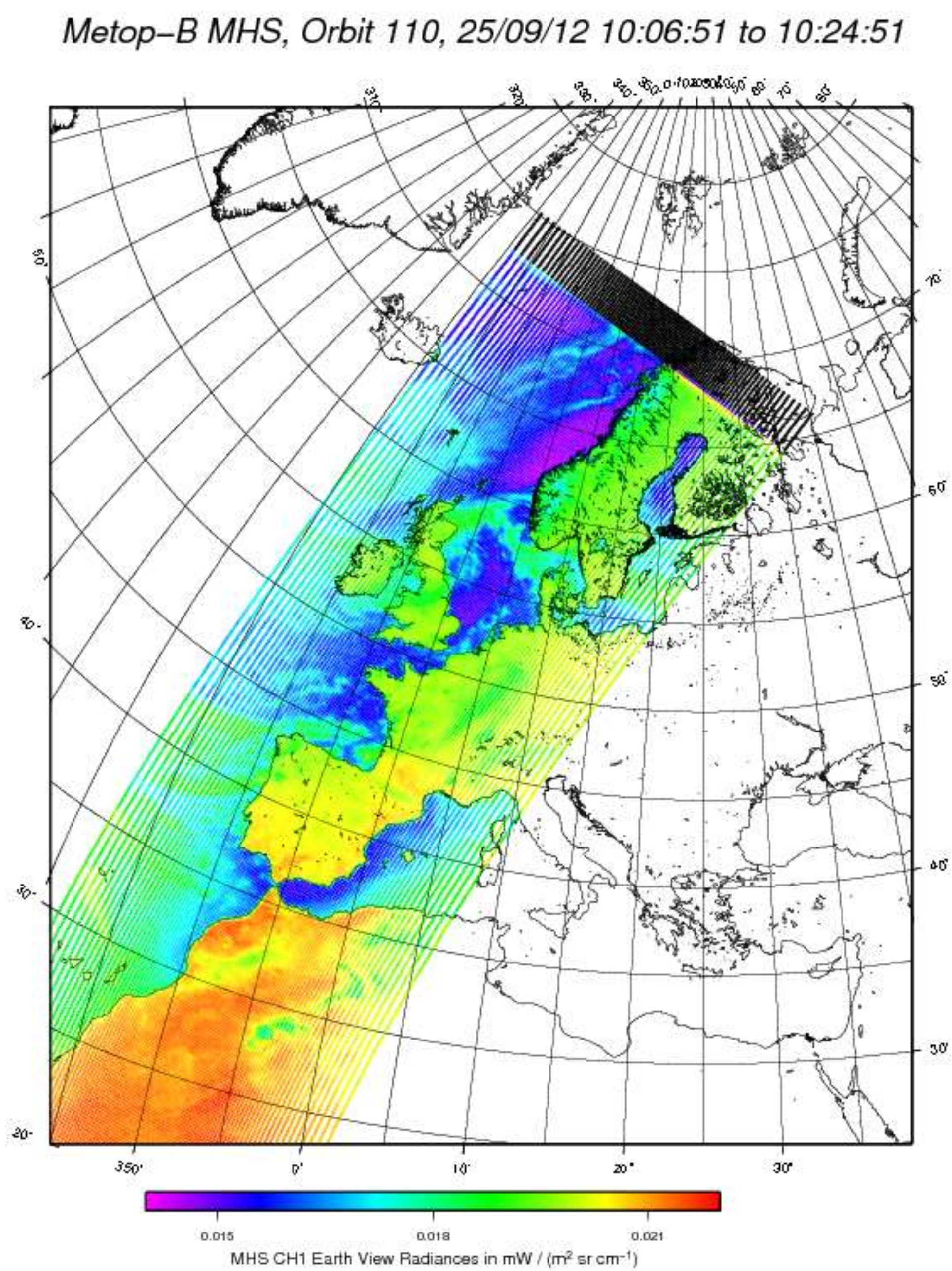
28 September 2012

Four of the instruments on the Metop-B weather satellite (AMSU-A, ASCAT, MHS, GRAS) have been activated this week and are delivering data.

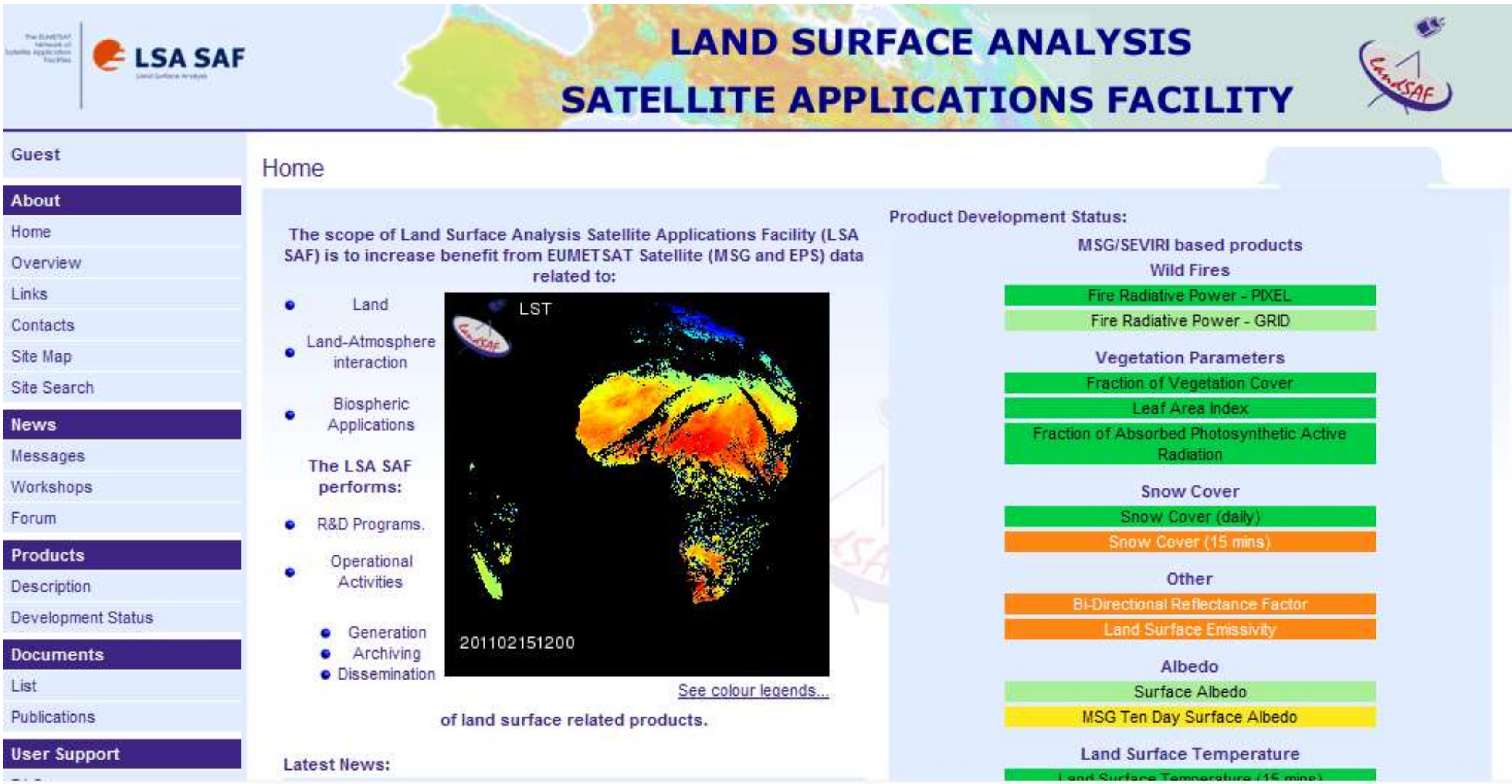
The Microwave Humidity Sounder (MHS) delivers information on atmospheric humidity in all weather conditions.

Funciona em tandem com o Metop-A

2112 km swath width and a resolution of 12 km at nadir

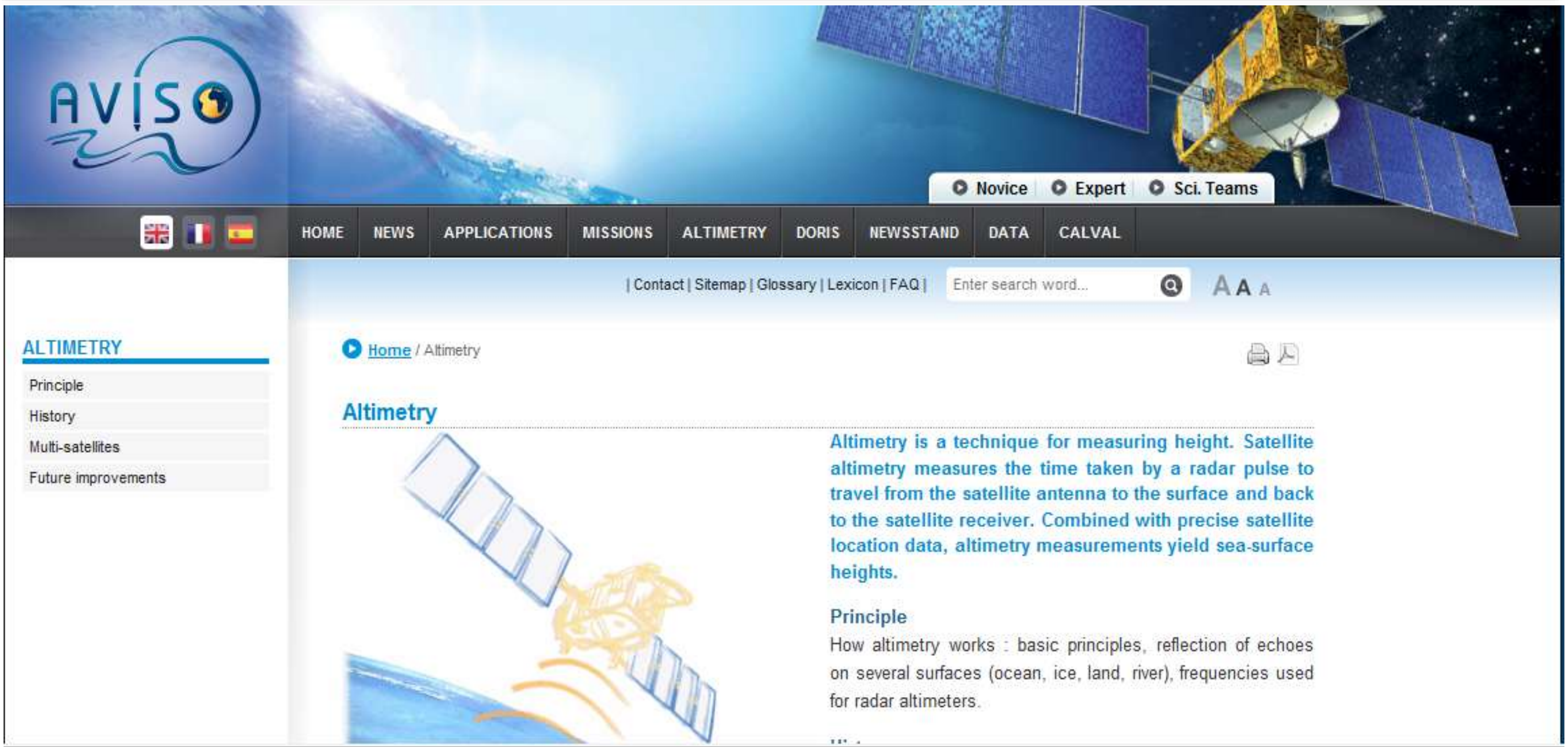


LANDSAF (http.//landsaf.meteo.pt)



Altimetria Espacial

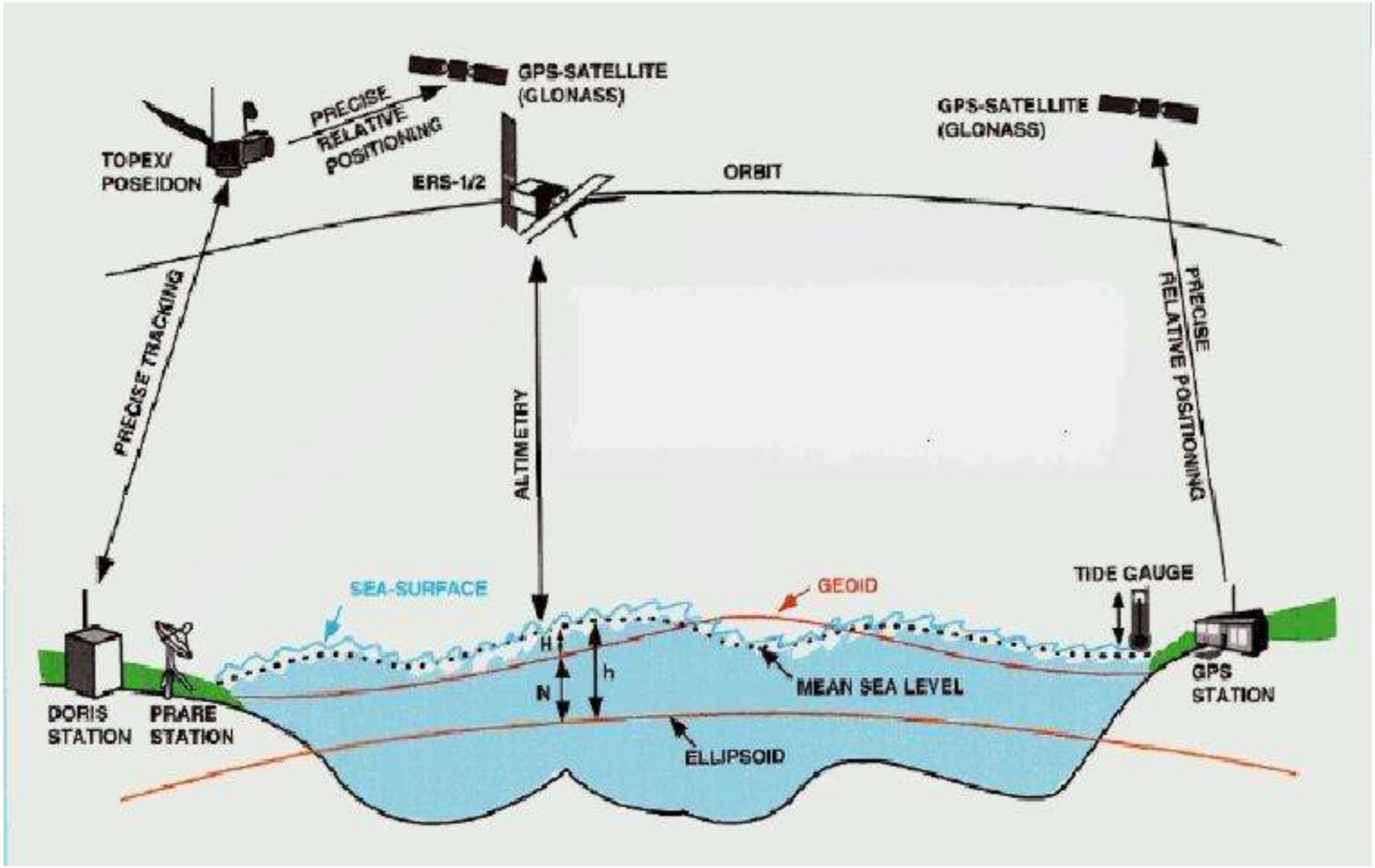
Altimetria Espacial é a técnica de medir altitudes. É medido o tempo que leva um pulso radar a viajar do satélite à superfície e regressar ao satélite.



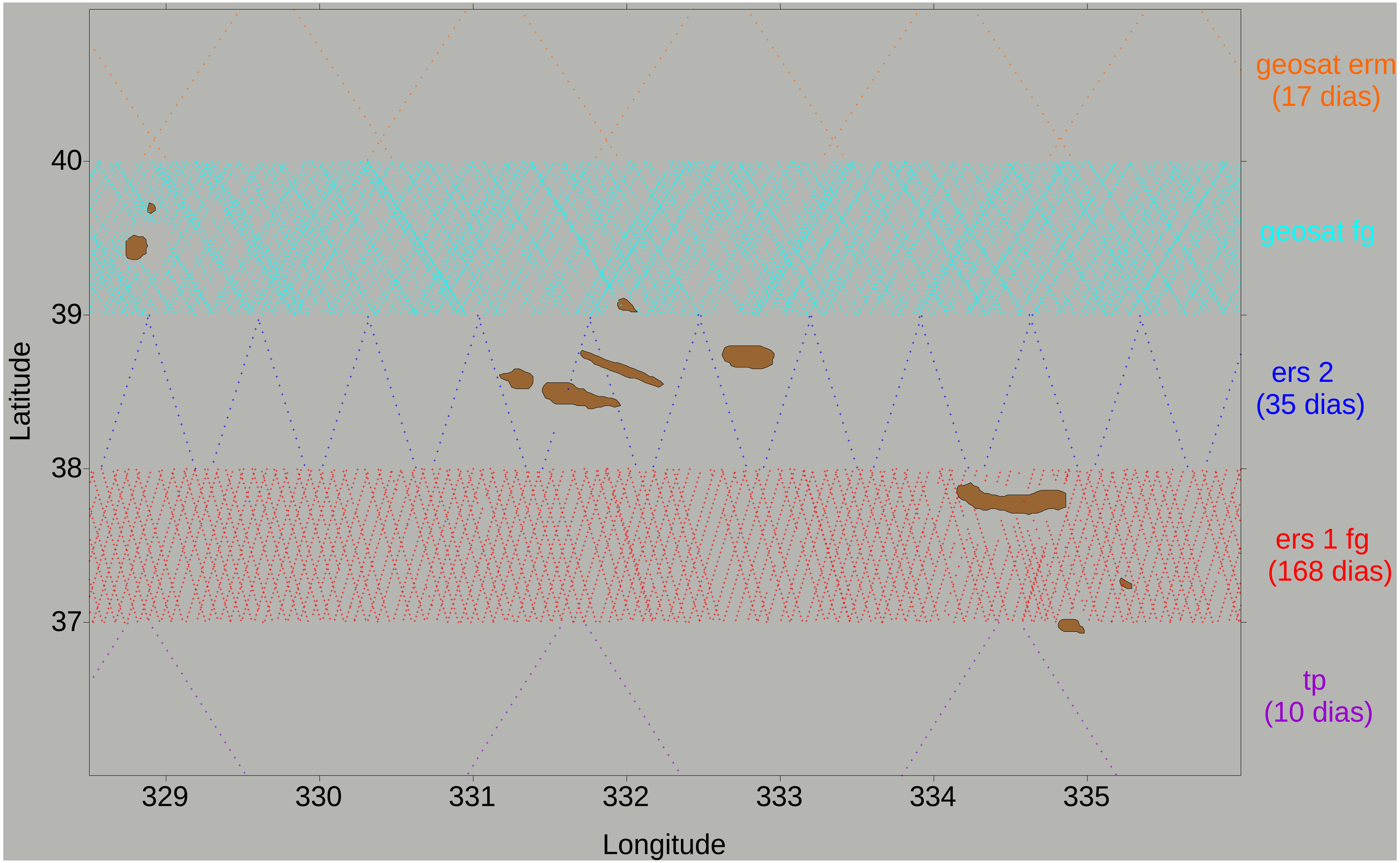
Altimetria Espacial

O resultado da Altimetria Espacial são as altitudes da superfície do mar, ou topografia do mar (Sea Surface Heights)

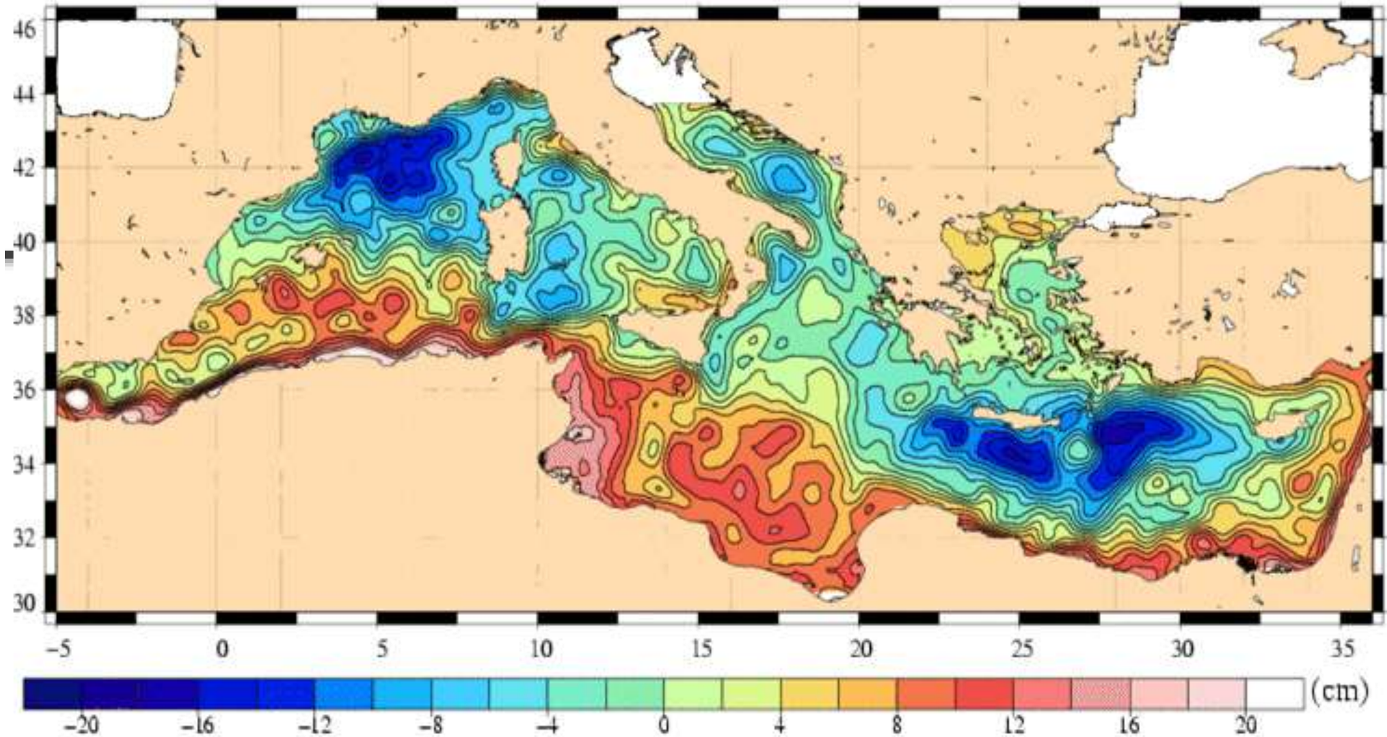
Altimetria Espacial

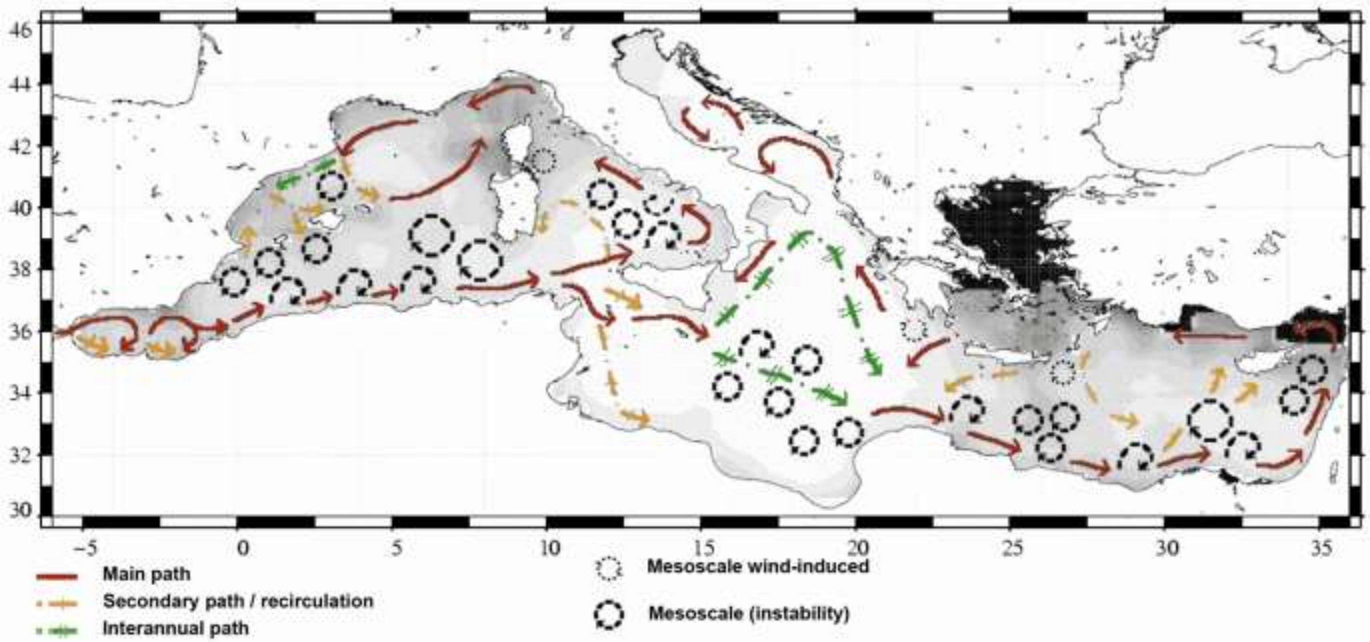


Altimetria Espacial



Topografia Dinâmica Média (1993-1999). Calculada a partir de dados altimétricos, dados Grace e gravimetria de satélite.

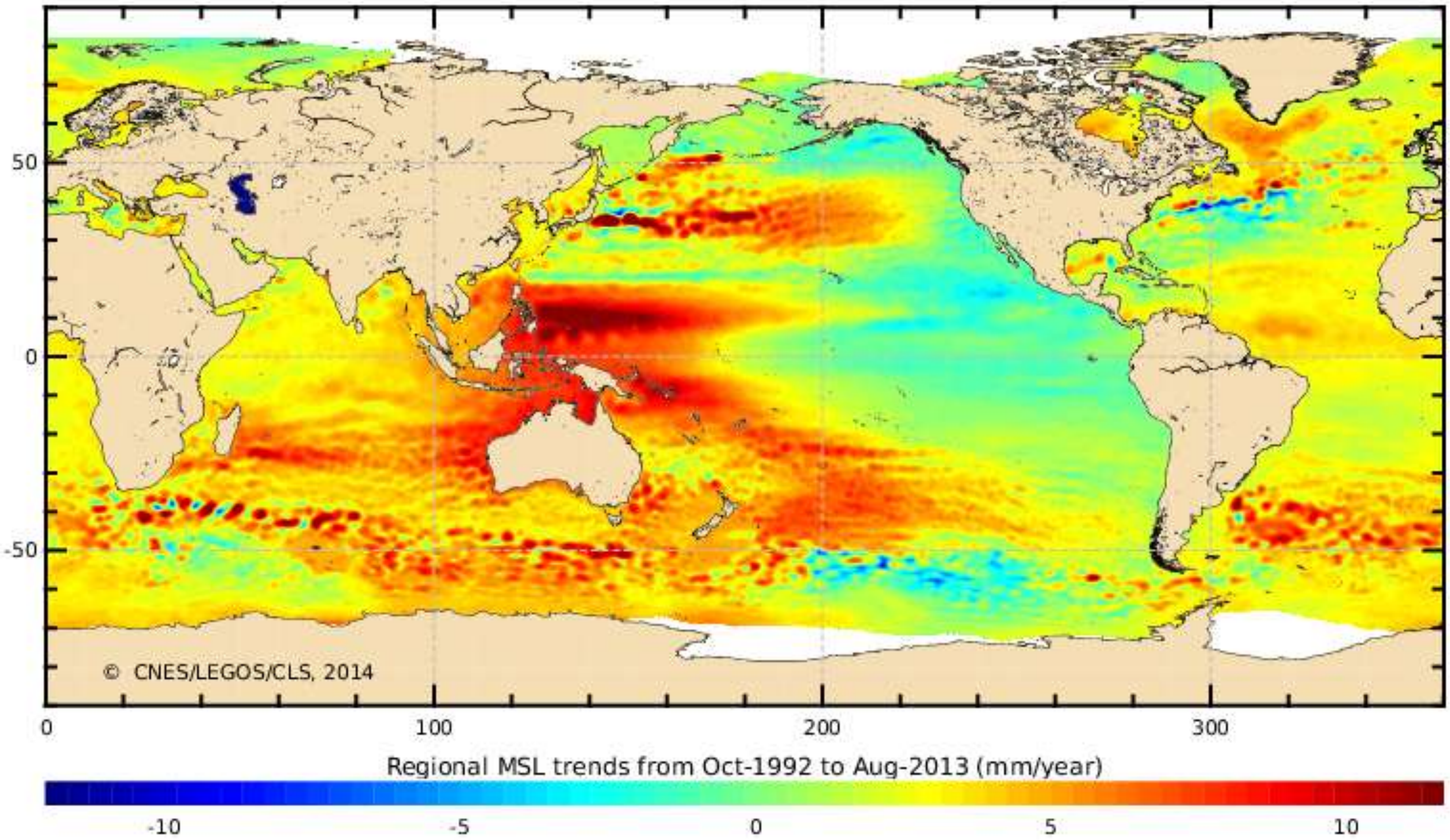




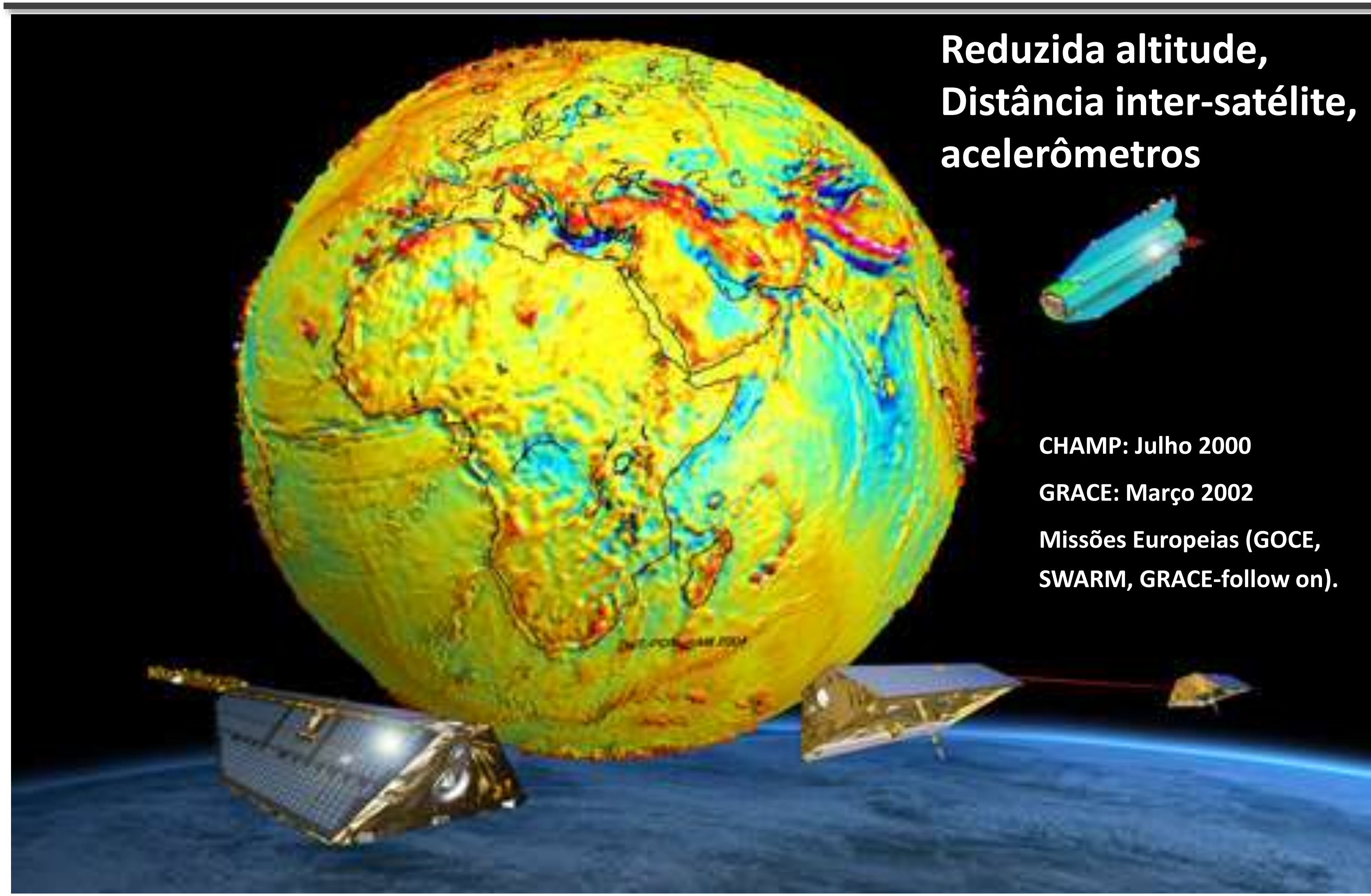
Circulação deduzida da topografia dinâmica e da altimetria de 1993-2004

Altimetria Espacial

Altimetria Espacial



Missões Geopotenciais Espaciais



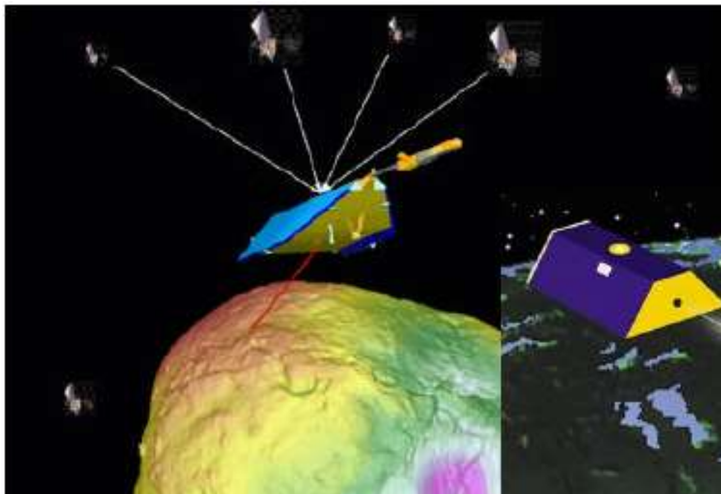
Reduzida altitude, Distância inter-satélite, acelerômetros

CHAMP: Julho 2000

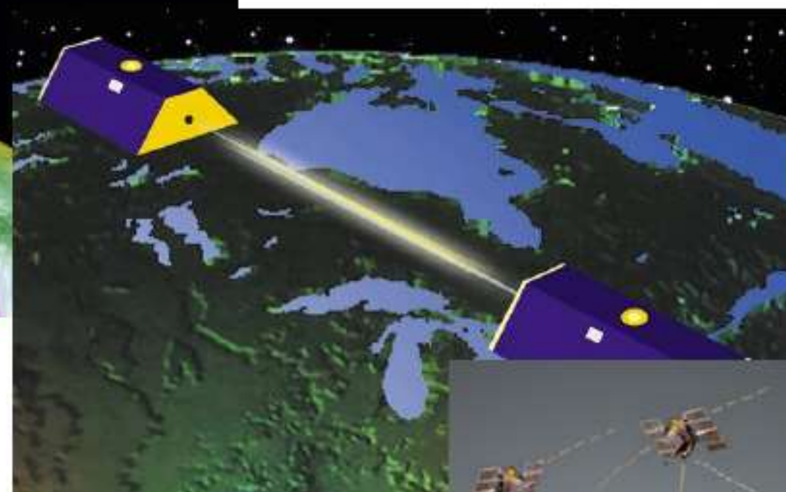
GRACE: Março 2002

Missões Europeias (GOCE, SWARM, GRACE-follow on).

Missões Geopotenciais Espaciais

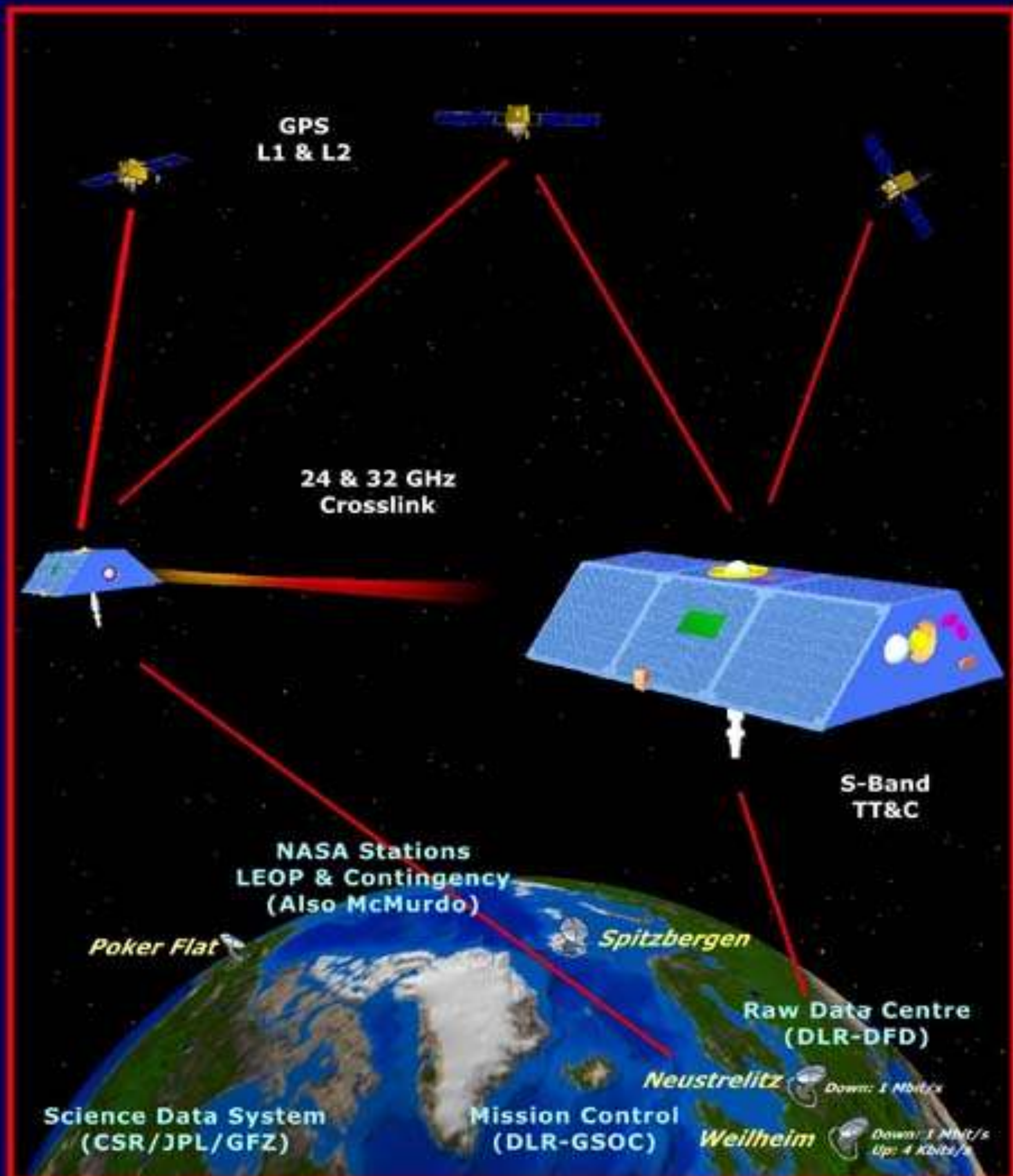


CHAMP



GRACE

GOCE



GRACE Mission

Science Goals

High resolution, mean & time variable gravity field mapping for Earth System Science applications.

Mission Systems

Instruments

- KBR (JPL/SSL)
- ACC (ONERA)
- SCA (DTU)
- GPS (JPL)

Satellite (JPL/DSS)
Launcher (DLR/Eurockot)
Operations (DLR/GSOC)
Science (CSR/JPL/GFZ)

Orbit

Launch: March 2002
Altitude: 485 km
Inclination : 89 deg
Eccentricity: ~0.001
Lifetime: 5 years
Non-Repeat Ground Track
Earth Pointed, 3-Axis Stable

GRACE

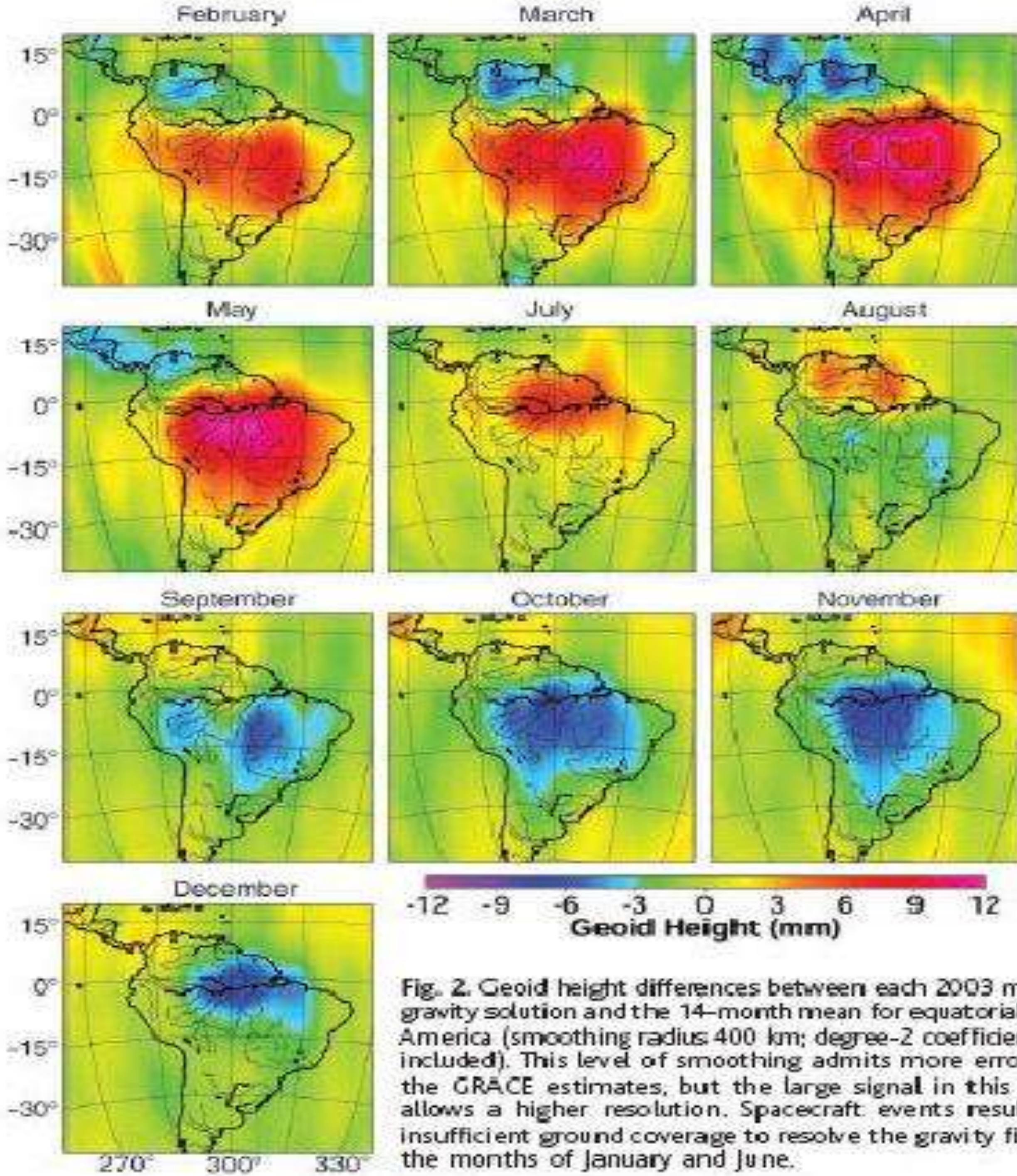
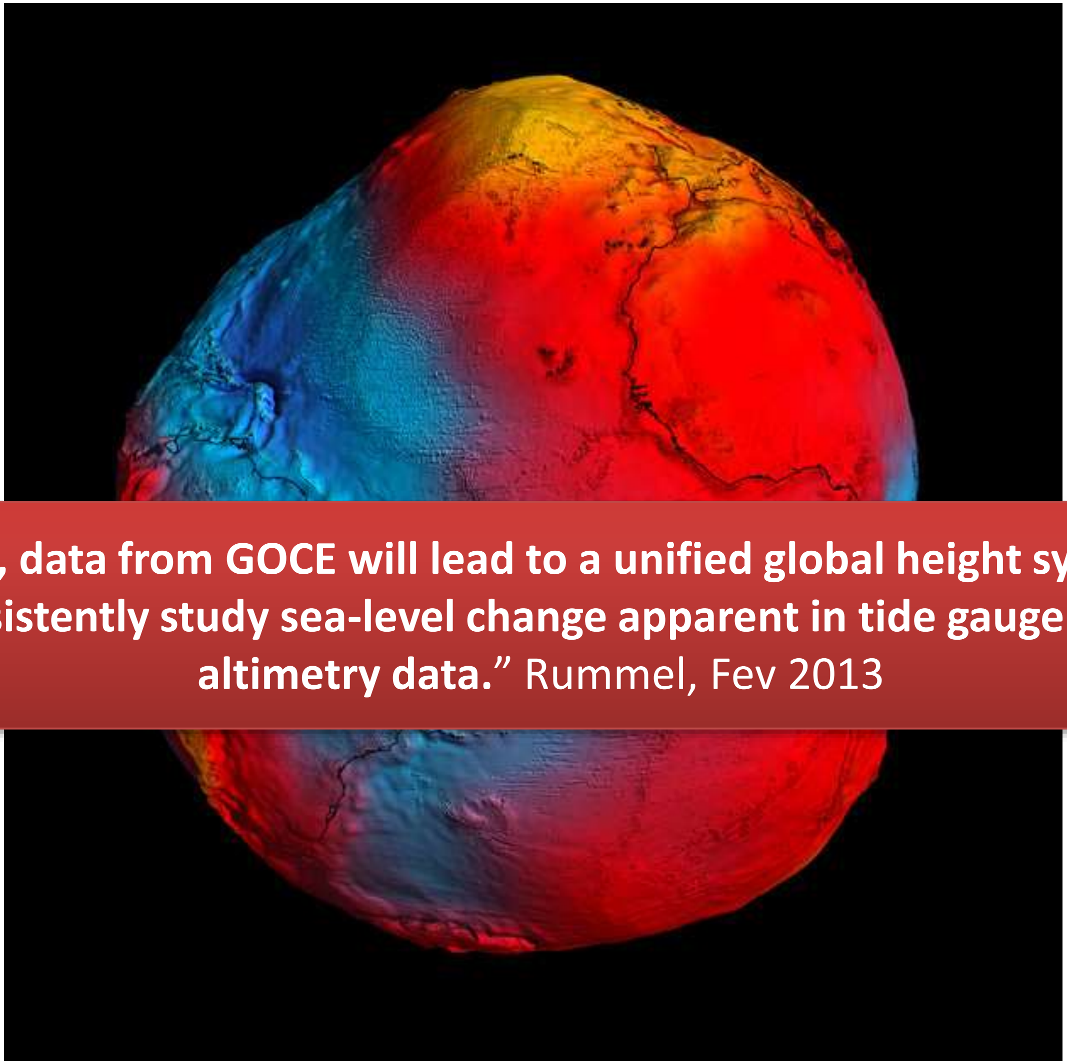


Fig. 2. Geoid height differences between each 2003 monthly gravity solution and the 14-month mean for equatorial South America (smoothing radius 400 km; degree-2 coefficients not included). This level of smoothing admits more error from the GRACE estimates, but the large signal in this region allows a higher resolution. Spacecraft events resulted in insufficient ground coverage to resolve the gravity field for the months of January and June.

Tapley et al.
23 JULY 2004
SCIENCE
Vol 305, pp 305-307

GOCE

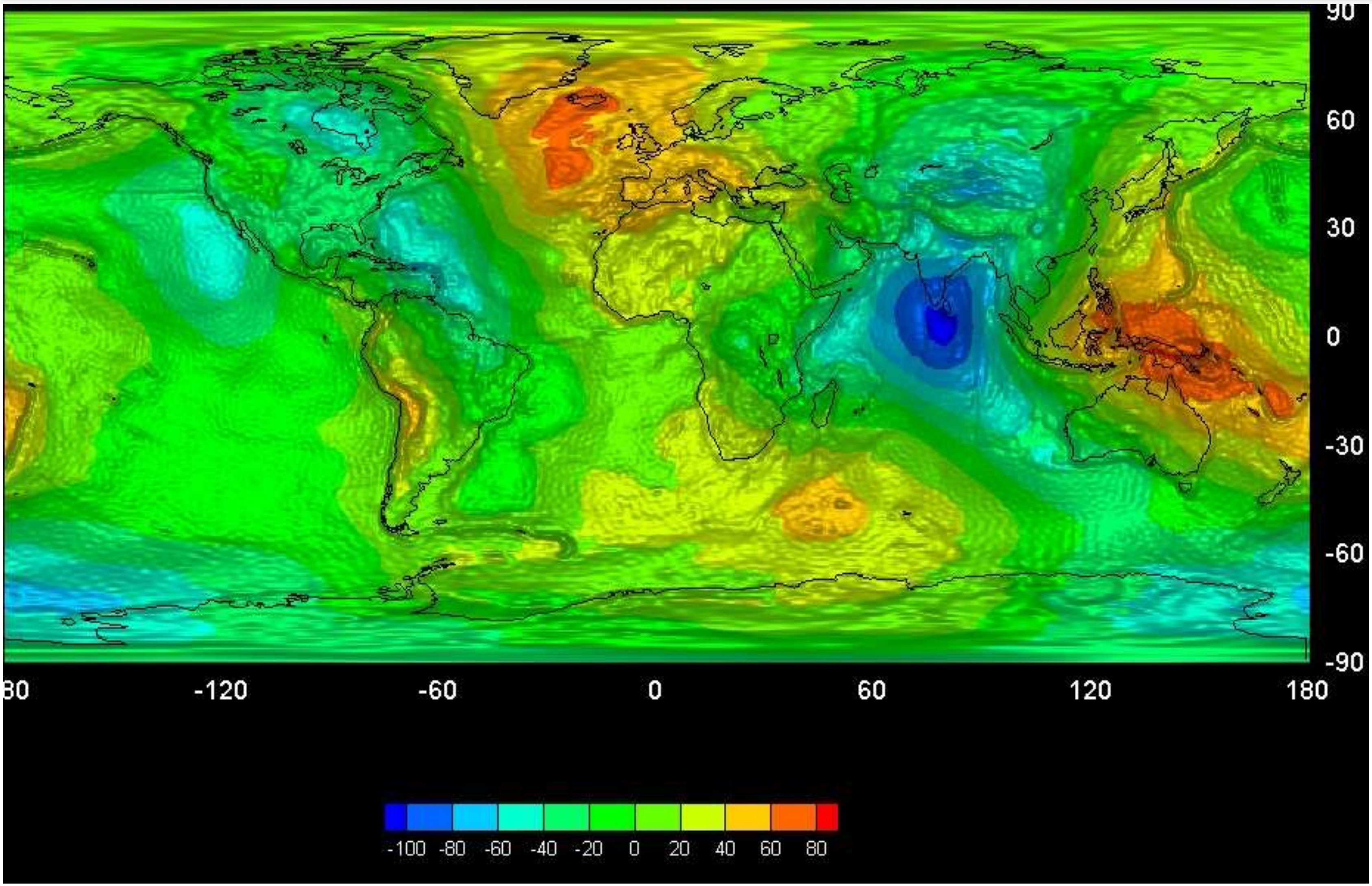
GOCE - Geoid Model



Importantly, data from GOCE will lead to a unified global height system so that we can consistently study sea-level change apparent in tide gauge and satellite altimetry data." Rummel, Fev 2013

2013

GOCE - Geoid Model



DOWNLOAD HI-RES | JPG (672.98 kB)

DETAILS ▼

Title Wall of the Maxwell Test Chamber

Released 07/03/2018 7:42 am

Copyright Edgar Martins

Description

The photographer who took this enigmatic picture inside ESA's Maxwell Test Chamber – used for assessing the electromagnetic compatibility of entire satellites – has been shortlisted by the Sony World Photography Awards for architecture and still-life photography.

Once the chamber's main door is sealed, Maxwell's 9 m-high metal walls form a 'Faraday Cage', blocking electromagnetic signals from outside. The 'anechoic' foam pyramids covering its interior absorb internal signals – as well as sound – to prevent any reflection, mimicking the infinite void of space. Then a satellite can be switched on to detect any harmful interference as its various elements operate together.

05 February 2015
Maxwell Test Chamber
8033
★★★★★ Votes: 55

30 March 2016
Anechoic foam covering
6224
★★★★★ Votes: 83

Technology Image of the Week Archive

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VOYAGING FOR THE SENTINELS

Arriving in South Georgia

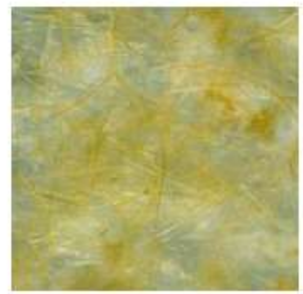
9 March 2018 Two recent expeditions that took scientists 26 000 km across the Atlantic Ocean have returned critical information to make sure that the Copernicus Sentinel satellites are delivering accurate data about the state of our oceans.

Information from the Sentinels is used in a myriad of ways to make lives easier and businesses more efficient.

For example, ocean forecasting is important for maritime safety and off-shore operations, and biological productivity helps sectors such as the fishing industry.

It is therefore imperative to monitor data quality throughout a satellite's life – and this means venturing out to make *in situ* measurements that can be compared with measurements taken from space.

In 2016 and 2017, a team of scientists did just this and braved the seas for months on voyages that took them all the way from the UK to the South Atlantic to collect reference measurements of chlorophyll, sea temperature and more.



Mat of phytoplankton

ESA ocean scientist Craig Donlon explained, "We rely on these measurements, which are fully traceable, independent and collected according to strict protocols.

"They are an essential part of making sure that the satellite data can be used with confidence for practical applications and scientific research."

Gavin Tilstone from the Plymouth Marine Laboratory said, "Each expedition took around seven weeks.

En route to South Georgia and the Falkland Islands we took around a million measurements each time, including readings of ocean colour, surface temperature and wave motion.

"We voyaged through many different ocean regimes so that these measurements were as varied as possible, from productive coastal regions to desert-like gyres in the centre of the ocean that are rarely accessed by research ships."

Importantly, where possible, measurements were taken at the same time as the Sentinels passed overhead.

Sentinel-1

Sentinel-2

Sentinel-3

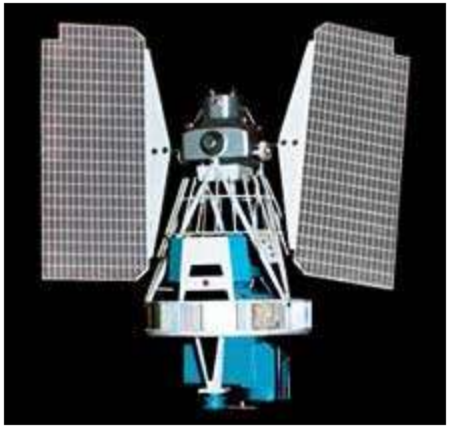
Campaigns blog

Sentinel data access

Related links

- AMT4SentinelFRM
- Plymouth Marine Laboratory
- University of Southampton
- Ifremer

Satélites de Observação da Terra (EOS)



O LANDSAT foi o primeiro sistema de satélites de observação da Terra desenhado para obter uma cobertura global da superfície da Terra numa base regular.

O primeiro LANDSAT foi lançado em 1972.

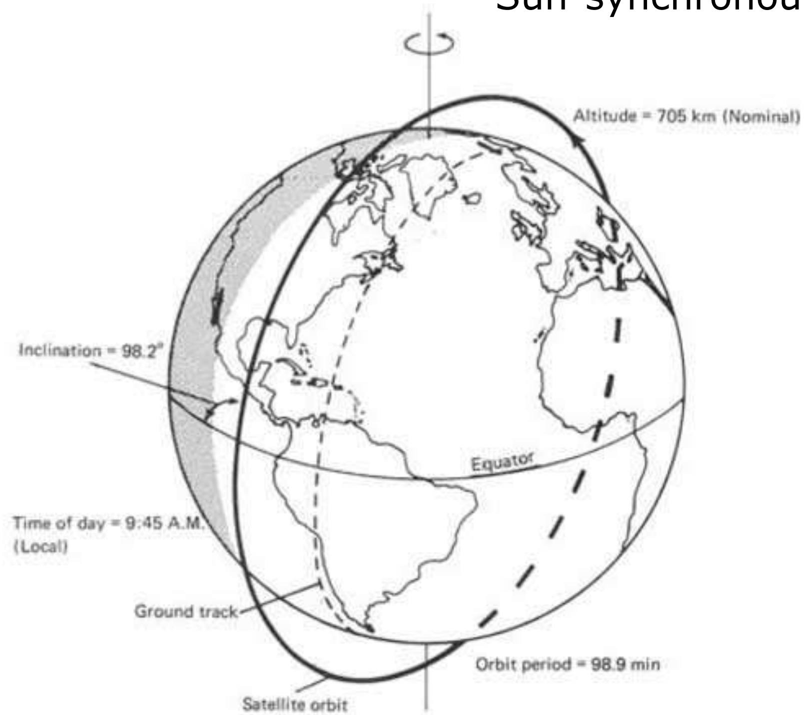
O primeiro nome deste programa foi ERTS (Earth Resources Technology Satellite).

Foram lançados os satélites Landat-2 (1975), Landsat-3 (1978), Landat-4 (1982) e Landsat-5 (1984). Landsat-6 (1993, não chegou a funcionar), Landsat-7 (1999) e Landsat-8 (Fev 2013).

LANDSAT - Órbita

Sun-synchronous

A órbita do **Landsat 7** é circular, heliosíncrona e quase polar com uma altitude de 705 km no equador.



A hora local do nodo descendente é entre as 10:00 e as 10:15h.

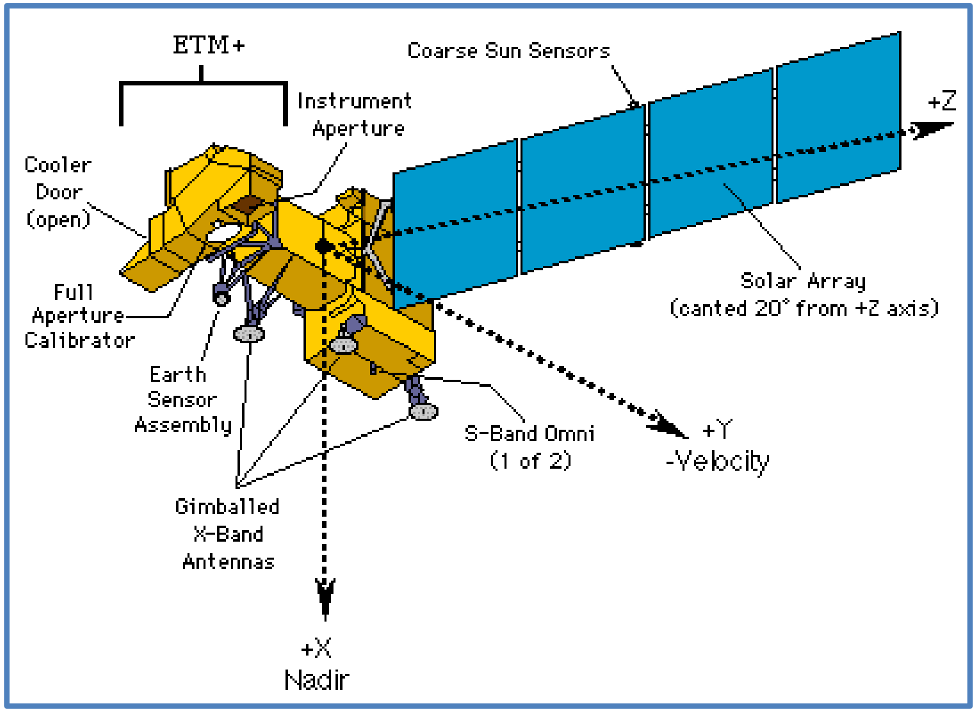
A uma velocidade de 7.5km/s cada órbita são 99 minutos.

Completa 14 órbitas por dia, e tem um ciclo de cobertura de 16 dias. Tem uma resolução espacial de 30m e um swath de 185km.

LANDSAT - Satélite

O principal instrumento é o ETM+ (Enhanced Thematic Mapper Plus) apontando para o nadir.

A banda S é usada para operações de comando e a banda X para transmissão de dados.

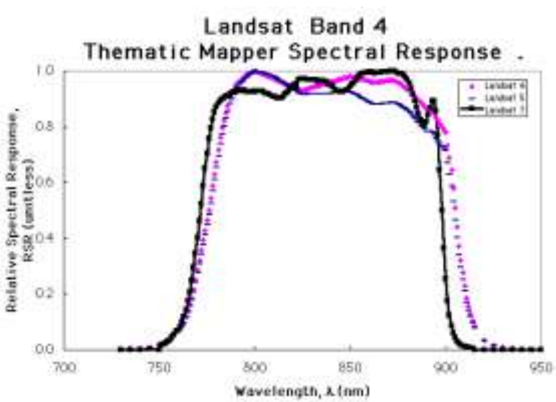


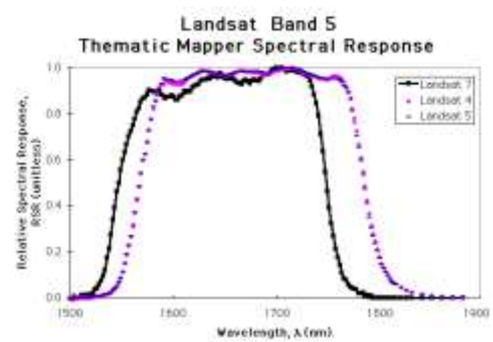
Tem um disco de 378Gb que armazenam 42 minutos de imagens.

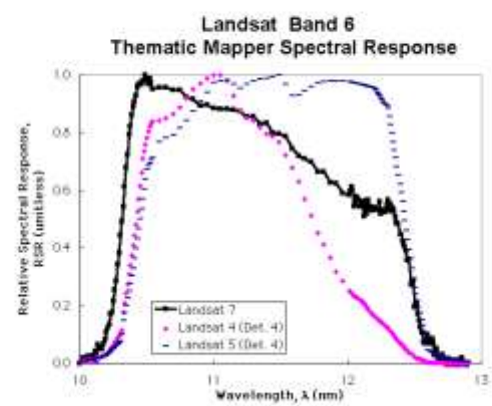
A energia é fornecida por um painel solar e duas baterias de Niquel-Hidrogénio.

LANDSAT – Bandas Espectrais

Bandwidth (µm) Full Width - Half Maximum								
Sensor	Banda 1	Banda 2	Banda 3	Banda 4	Banda 5	Banda 6	Banda 7	Banda 8
TM	0.45 - 0.52	0.52 - 0.60	0.63 - 0.69	0.76 - 0.90	1.55 - 1.75	10.4 - 12.5	2.08 - 2.35	N/A
ETM+	0.45 - 0.52	0.53 - 0.61	0.63 - 0.69	0.78 - 0.90	1.55 - 1.75	10.4 - 12.5	2.09 - 2.35	.52 - .90



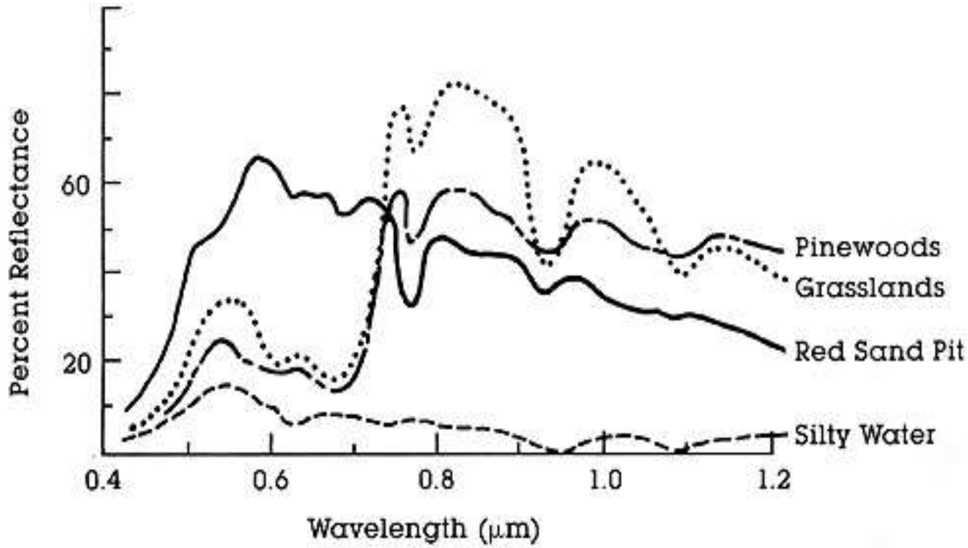


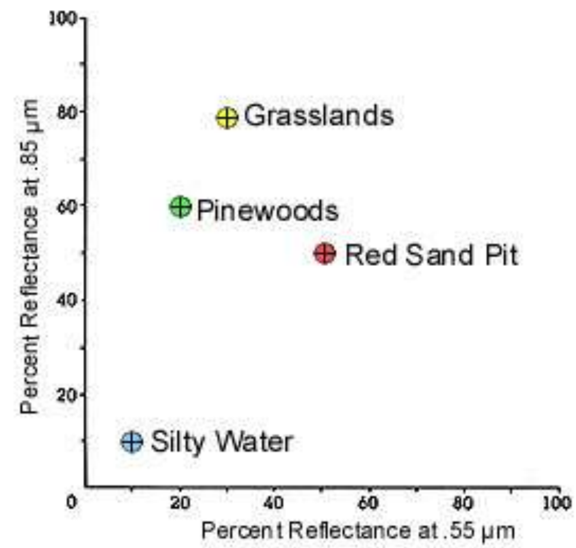


LANDSAT – Bandas Espectrais

Channel	Wavelength Range (μm)	Application
TM 1	0.45 - 0.52 (blue)	soil/vegetation discrimination; bathymetry/coastal mapping; cultural/urban feature identification
TM 2	0.52 - 0.60 (green)	green vegetation mapping (measures reflectance peak); cultural/urban feature identification
TM 3	0.63 - 0.69 (red)	vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
TM 4	0.76 - 0.90 (near IR)	identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
TM 5	1.55 - 1.75 (short wave IR)	sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas
TM 6	10.4 - 12.5 (thermal IR)	vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
TM 7	2.08 - 2.35 (short wave IR)	discrimination of mineral and rock types; sensitive to vegetation moisture content

LANDSAT – Bandas Espectrais



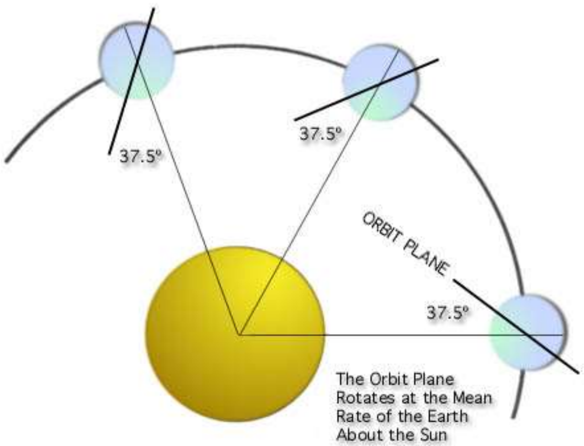


For any given material, the amount of emitted and reflected radiation varies by wavelength. These variations are used to establish the signature reflectance fingerprint for that material.

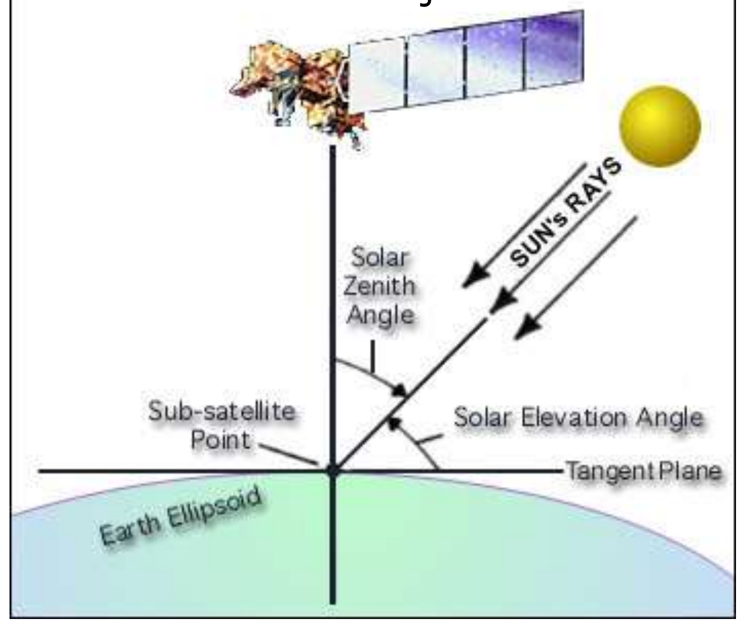
Similar objects or classes of objects will have similar interactive properties with electromagnetic radiation at any given wavelength. . Conversely, different objects will have different interactive properties

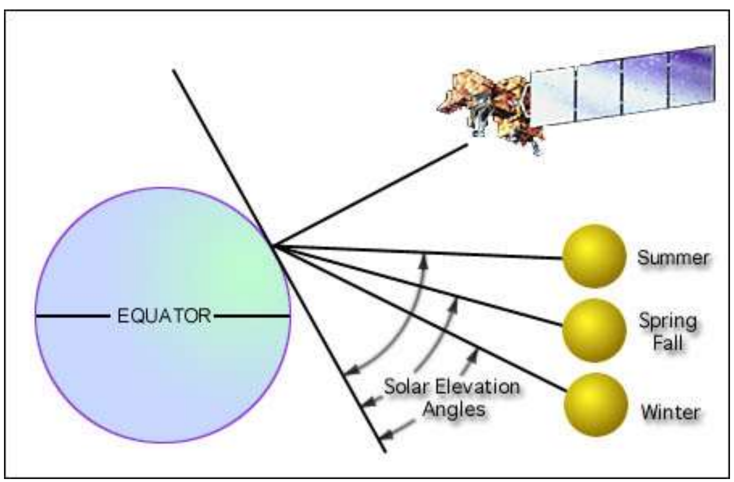
LANDSAT – efeitos sazonais

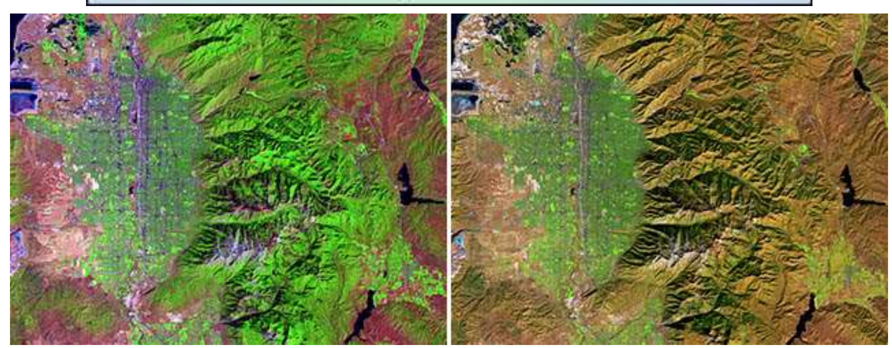
Nodo ascendente Às 10:00



Efeitos da elevação do Sol







Effects of Seasonal Changes on Solar Elevation Angle

LANDSAT 8

Foi lançado a 11 de Fevereiro de 2013.

O Landsat 8 tem a bordo dois sensores:

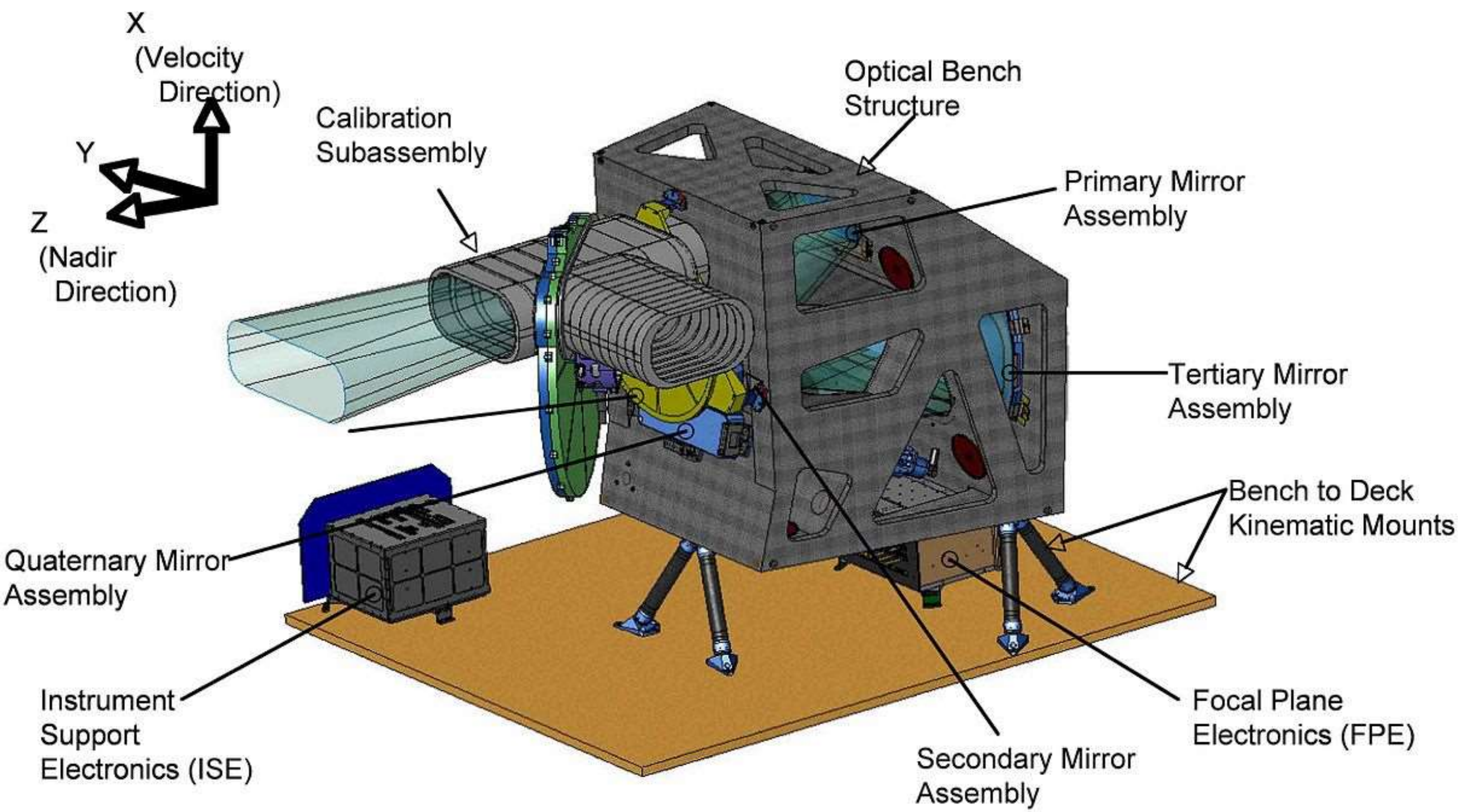
Operational Land Imager (OLI)	Thermal InfraRed Sensor (TIRS).

The Landsat 8 scene size is 185-km-cross-track-by-180-km-along-track.

The nominal spacecraft altitude will be 705 km.

Cartographic accuracy of 12 m or better (including compensation for terrain effects) is required of Landsat 8 data products.

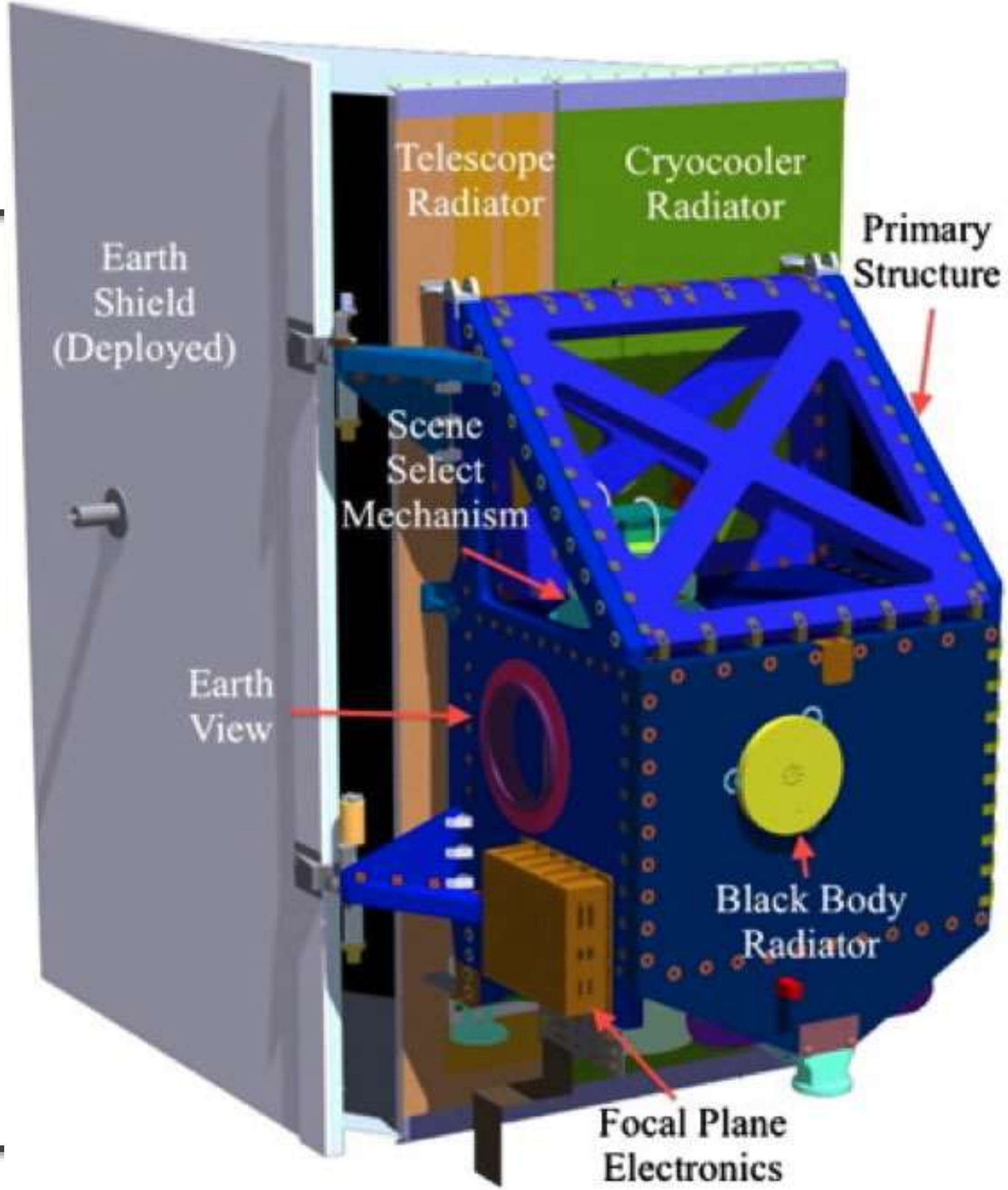
OLI Instrument Overview



15-degree field-of-view, 7000 pixels per spectral band, exception of the 15 m panchromatic band that requires over 13,000 detectors (http://landsat.gsfc.nasa.gov/?p=5775)

1

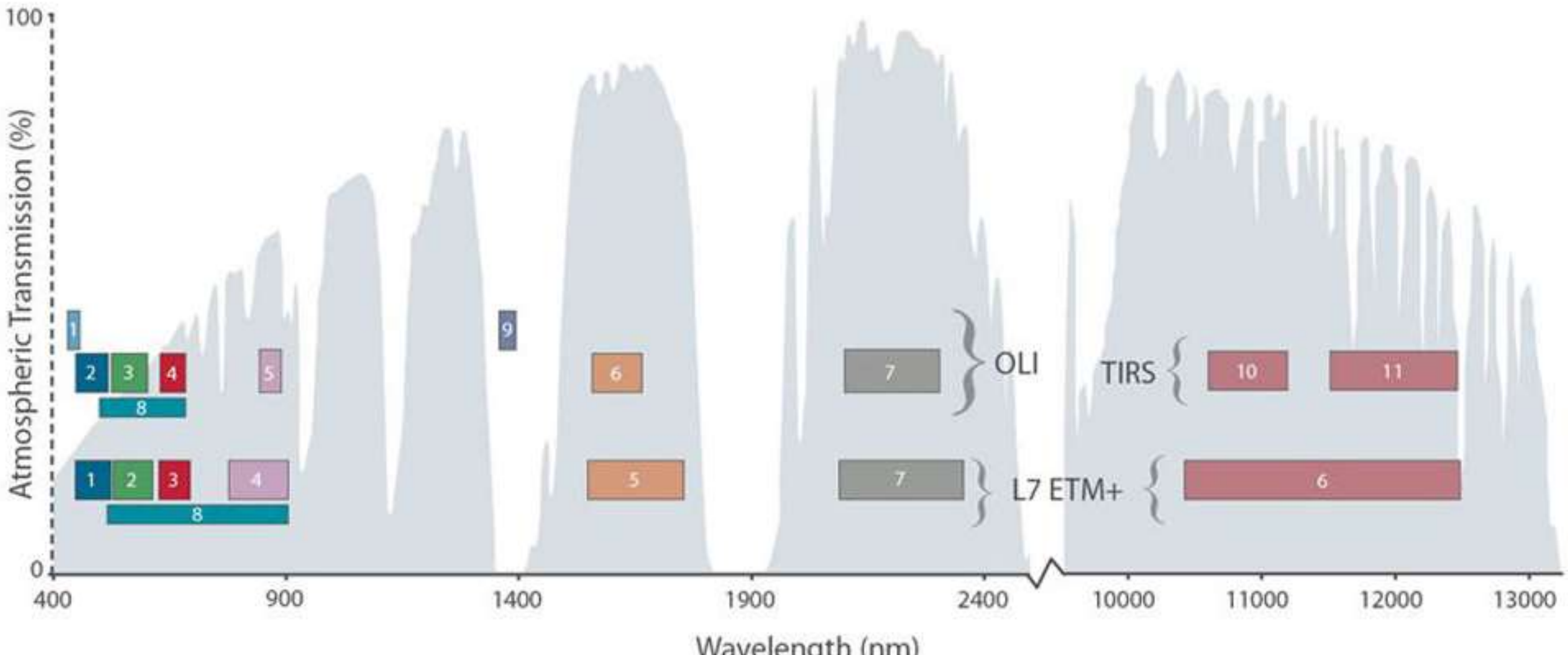
Thermal InfraRed Sensor (TIRS)



LANDSAT 8 – Bandpass wavelenght

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Bands	Wavelength (micrometers)	Resolution (meters)
	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1 Short wave IR	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

LANDSAT 8 – Bandpass wavelenght



Bandpass wavelengths for Landsat 8 OLI and TIRS sensor, compared to Landsat 7 ETM+ sensor

Note: atmospheric transmission values for this graphic were calculated using MODTRAN for a summertime mid-latitude hazy atmosphere (circa 5 km visibility).

New infrared channel (band 9) for the detection of cirrus clouds.

Radiometric quantization (12-bits)

MODIS Moderate Resolution Imaging Spectroradiometer

The MODIS instrument provides high radiometric sensitivity (12 bit) in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm.

Two bands are imaged at a nominal resolution of 250 m at nadir, with five bands at 500 m, and the remaining 29 bands at 1 km. A ±55-degree scanning pattern at the EOS orbit of 705 km achieves a 2,330-km swath and provides global coverage every one to two days.

Level 1

- Raw Radiances
- Calibrated Radiances
- Geolocation Fields

Atmosphere Products

- Aerosol Product
- Total Precipitable Water
- Cloud Product
- Atmospheric Profiles
- Atmosphere Joint Product
- Atmosphere Gridded Product
- Cloud Mask

Land Products

- Surface Reflectance
- Land Surface Temperature
- Land Cover Products
- Vegetation Indices(NDVI & EVI)
- Thermal Anomalies/Fires
- FPAR / (LAI)
- Evapotranspiration
- Gross Primary Productivity
- BRDF / Albedo
- Vegetation Continuous Fields
- Water Mask
- Burned Area Product

Cryosphere Products

- Snow Cover
- Sea Ice & Ice Surface Temperature

Ocean Products

- Sea Surface Temperature
- Remote Sensing Reflectance
- Sub-surface Chlorophyll-a Concentration
- Diffuse Attenuation at 490 nm
- Particulate Organic Carbon
- Particulate Inorganic Carbon
- Fluorescence Line Height (FLH)
- Instantaneous Photosynthetically Available Radiation
- Daily Mean Photosynthetically Available Radiation

Landsat's Unique Niche Leads to a High Resolution Global Seasonal Archive Capability

AVHRR, MODIS — 2048 km swath

- spatial resolution, 250m, 500m, 1000m
- spectral coverage, VIS, NIR, SWIR, MWIR, TIR
- calibrated @ ≤ 5% absolute
- global coverage, 2 days
- nadir only

Landsat — 185 km

- spatial resolution, 15m, 30m
- spectral coverage, VIS, NIR, SWIR, TIR
- calibrated @ ≤ 10% absolute
- 16 day orbital repeat
- seasonal global coverage capability
- nadir only

IRS — 146 km

- spatial resolution 36m, 72m
- spectral coverage, VIS, NIR
- relative calibration
- 22 day orbital repeat
- nadir only

SPOT — 117 km via 2 @ 60 km

- spatial resolution 10m, 20m
- spectral coverage, VIS, NIR
- relative calibration
- 26 day orbital repeat
- pointable, stereo capability

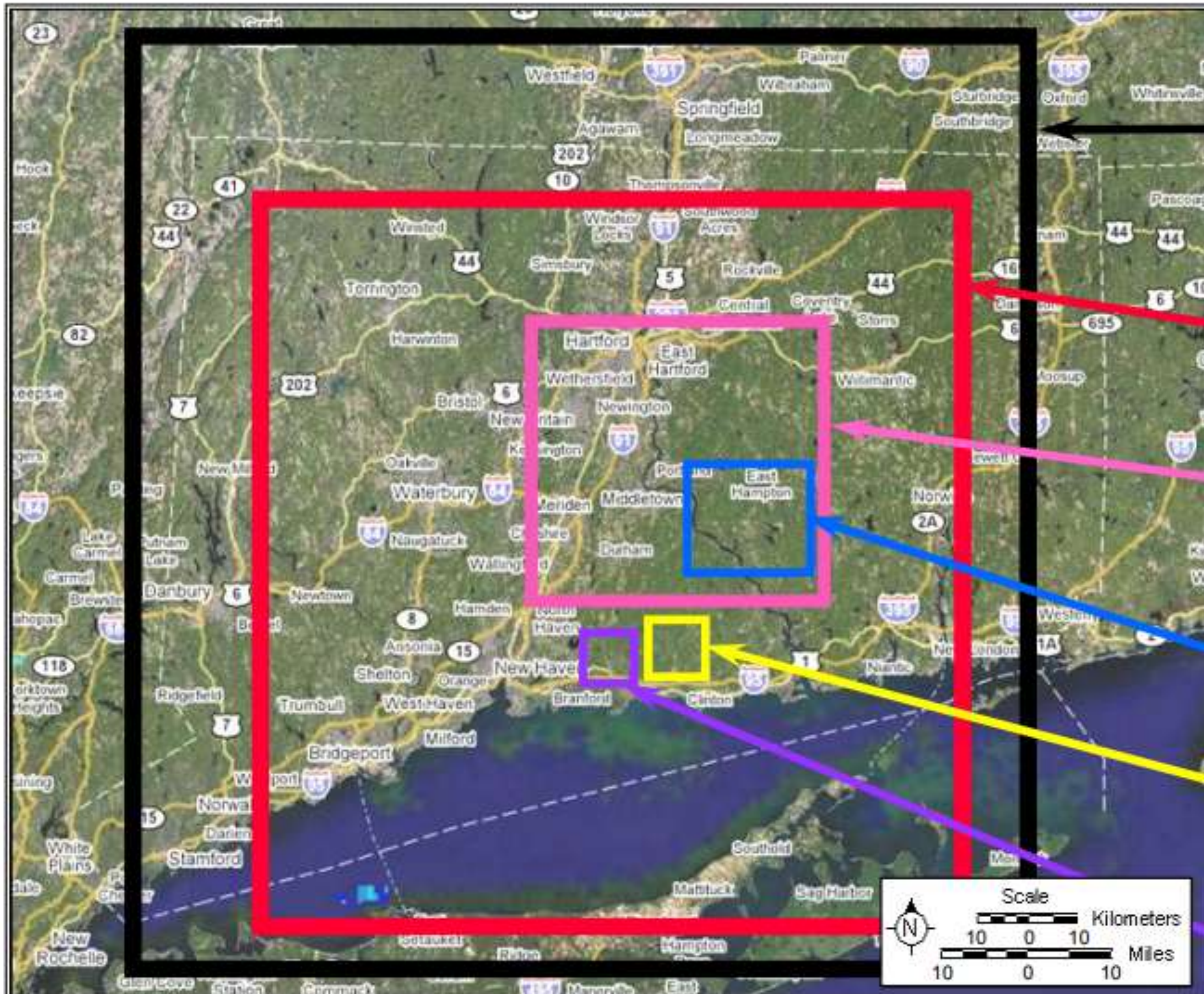
IKONOS — 11 km

- spatial resolution 1m
- spectral coverage, panchromatic
- calibrated @ ≤ 10% absolute
- global coverage, years to ∞
- pointable, stereo capability

Looking More Closely at Resolution

Looking More Closely at Resolution

Selected Satellite Footprints



Landsat 7

185 by 170 km
30-m multispectral

Indian Remote Sensing

145 by 145 km
25-m multispectral

SPOT

60 by 60 km
20-m multispectral

QuickBird 2

16 by 16 km
2.5-m multispectral

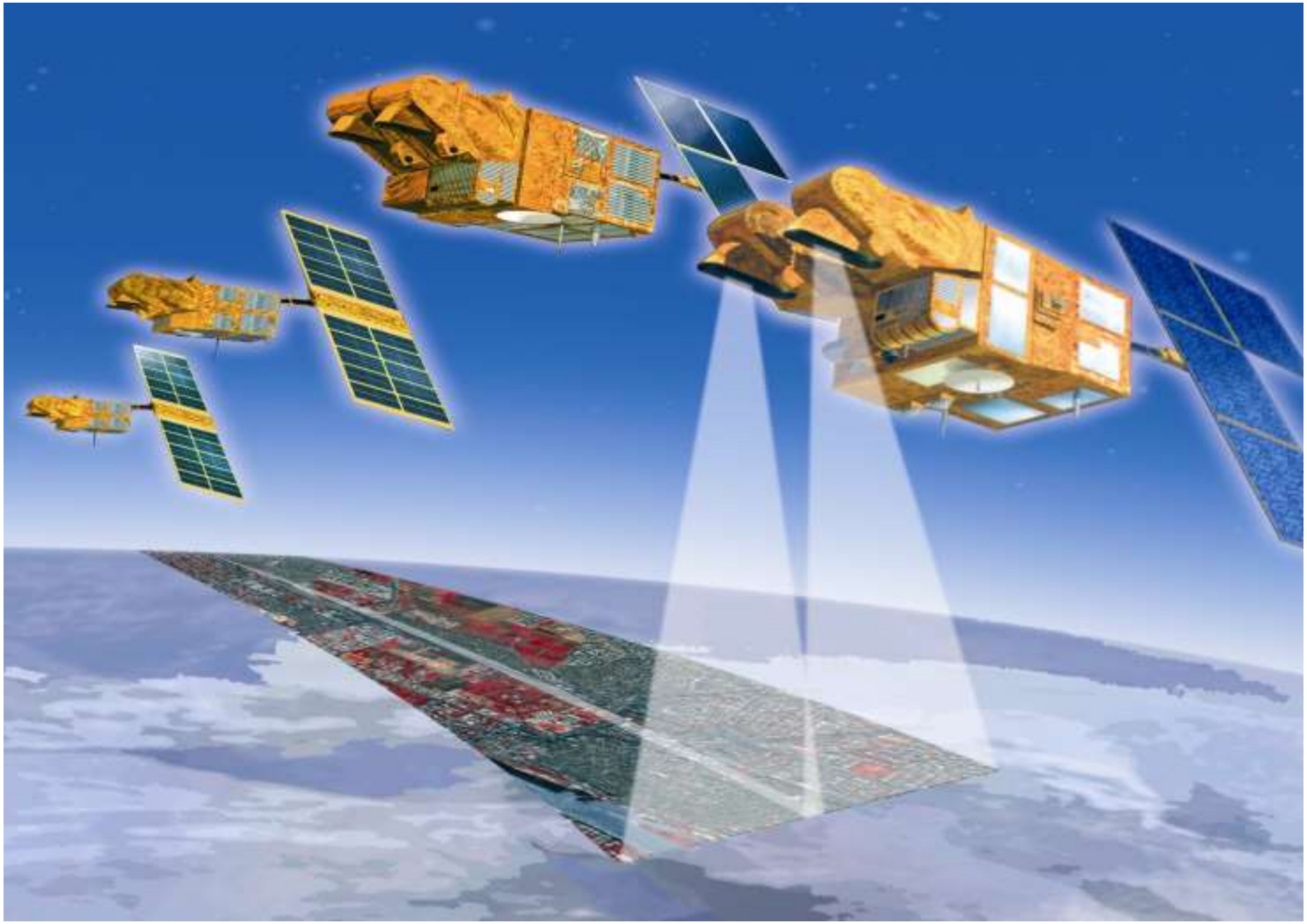
IKONOS

11 by 11 km
4-m multispectral

OrbView 3

8 by 8 km
4-m multispectral
1-m panchromatic

SPOT (Système Pour l'Observation de la Terre)



SPOT – Órbita

	General features		
	SPOT 5	SPOT 4	SPOT 1, 2 & 3
Launch date	May 4, 2002	March 24, 1998	**SPOT 1** – February 22, 1986 **SPOT 2** – January 22, 1990 **SPOT 3** – September 26, 1993
Launch vehicle	Ariane 4		Ariane 2/3
Nominal lifetime	5 years		3 years
Deorbitation	In orbit	In orbit	**SPOT 1** – November 17, 2003 **SPOT 2** – July 30, 2009 **SPOT 3** – November 1996 (end of life)
Orbit	Sun-synchronous		
Local Equator crossing time (descending)	10:30 a.m.		
Altitude at Equator	822 km		
Inclination	98,7°		
Velocity	7.4 km/s		
Orbital period	101.4 minutes		revolutions per day: 14 + 5/26
Orbital cycle	26 days		

SPOT – Características do Sensor

	High-Resolution Instruments		
	SPOT 5	SPOT 4	SPOT 1, 2 & 3
Instruments	2 HRGs	2 HRVIRs	2 HRVs
Spectral bands and resolution	2 panchromatic (5 m), combined to generate a 2.5-metre product 3 multispectral (10 m) 1 short-wave infrared (20 m)	1 panchromatic (10 m) 3 multispectral (20 m) 1 short-wave infrared (20 m)	1 panchromatic (10 m) 3 multispectral (20 m)
Spectral range	P: 0,48 – 0.71 µm B1 (green): 0.50 – 0.59 µm B2 (red) : 0.61 – 0.68 µm B3 (NIR): 0.78 – 0.89 µm B4 (SWIR): 1.58 – 1.75 µm	M: 0.61 – 0.68 µm B1 (green): 0.50 – 0.59 µm B2 (red): 0.61 – 0.68 µm B3 (NIR): 0.78 – 0.89 µm B4 (SWIR): 1.58 – 1.75 µm	P: 0.51 – 0.73 µm B1 (green): 0.50 – 0.59 µm B2 (red): 0.61 – 0.68 µm B3 (NIR): 0.78 – 0.89 µm
Imaging swath	60 km x 60 km to 80 km		
Image dynamics	8 bits		
Angle of incidence	± -31.06°		
Average revisit interval over a 26-day orbital cycle, depending on latitude	2 to 3 days		–

SPOT – Espectro Electromagnético

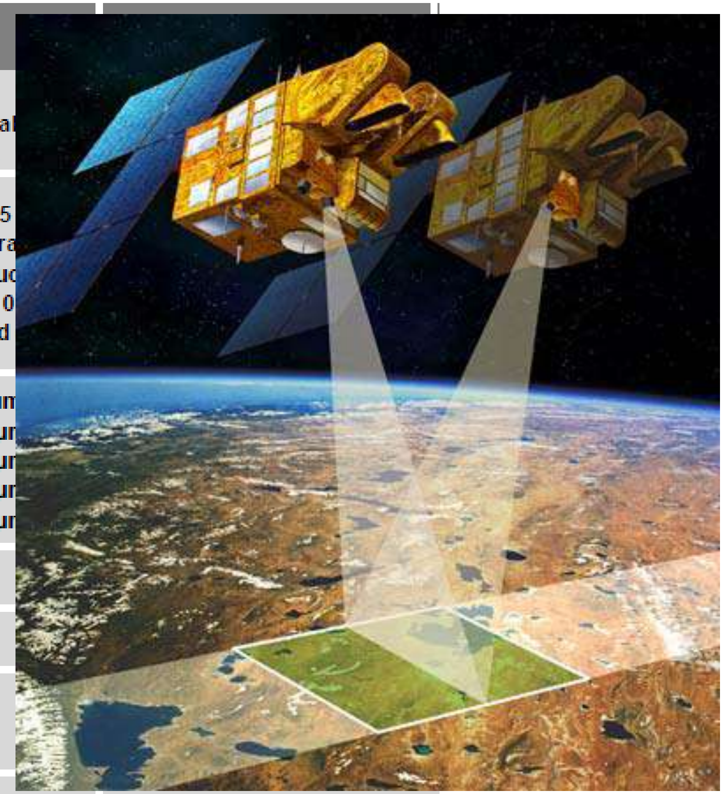
Sensors	Electromagnetic Spectrum	Pixels Size	Spectral bands
SPOT 5	Panchromatic B1 : green B2 : red B3 : near-infra-red B4 : short-wawe infrared (SWIR)	2.5 m or 5 m 10 m 10 m 10 m 20 m	0.48 - 0.71 µm 0.50 - 0.59 µm 0.61 - 0.68 µm 0.78 - 0.89 µm 1.58 - 1.75 µm
SPOT 4	Monospectral B1 : green B2 : red B3 : near-infra-red B4 : short-wawe infrared (SWIR)	10 m 20 m 20 m 20 m 20 m	0.61 - 0.68 µm 0.50 - 0.59 µm 0.61 - 0.68 µm 0.78 - 0.89 µm 1.58 - 1.75 µm
SPOT 1 SPOT 2 SPOT 3	Panchromatic B1 : green B2 : red B3 : near-infra-red	10 m 20 m 20 m 20 m	0.50 - 0.73 µm 0.50 - 0.59 µm 0.61 - 0.68 µm 0.78 - 0.89 µm

SPOT – Características do Sensor

	VEGETATION Instrument	
	SPOT 5	SPOT 4
Passenger instrument	VEGETATION 2	VEGETATION 1
Spectral bands	4	
Electromagnetic spectrum	B0: 0.45 – 0.52 µm B2: 0.61 – 0.68 µm B3: 0.78 – 0.89 µm B4: 1.58 – 1.75 µm	
Resolution	1,000 m	
Imaging swath	2.250 km	
Image dynamics	10 bits	
Revisit interval	1 day	

SPOT – Estereoscopia

	Stereoscopic Instruments		
	SPOT 5		
Instrument	HRS along-track stereoviewing	HRG stereoviewing capa across track	
Spectral bands and resolution	1 panchromatic (10 m) (resampled every 5 m along track) → 10 m across track, 5 m along track	2 panchromatic (5 combined to genera 2.5-metre produc 3 multispectral (10 1 short-wave infrared	
Spectral range	P: 0.49 – 0.69 µm	P: 0.48 – 0.71 µm B1: 0.50 – 0.59 µr B2: 0.61 – 0.68 µr B3: 0.78 – 0.89 µr B4: 1.58 – 1.75 µr	
Imaging swath	600 km x 120 km		
Image dynamics			
Base/height ratio (B/H)	~ 0,84 (± 20°)		
Absolute location accuracy (no ground control points, flat terrain)	10 m (1 σ)*	30 m (1 σ)*	350 m



HRS (High-Resolution Stereoscopic imaging instrument)

SPOT 6

Ciências ULisboa

SPOT-6 Satellite Sensor Specifications

Launch Date	September 9, 2012
Launch Vehicle	PSLV
Launch Location	Satish Dhawan Space Center (India)
Multispectral Imagery (4 bands)	Blue (0.455 µm – 0.525 µm) Green (0.530 µm – 0.590 µm) Red (0.625 µm – 0.695 µm) Near-Infrared (0.760 µm – 0.890 µm)
Resolution (GSD)	Panchromatic - 1.5m Multispectral - 6.0m (B,G,R,NIR)
Imaging Swath	60 Km at Nadir

Automatic ortho image with location accuracy of 10m CE90 using Reference3D

120 Km x 120 Km bi-strip or 60 Km x 180 Km tri-strip mapping in a single pass and delivery of mosaic

Stereo and tri-stereo acquisition of 60 Km x 60 Km scenes for production of DEM

6 tasking plans per day

Several weather forecasts per day to optimize tasking

Each tasking plan covers 24 hours

Up to 750 scenes per day per satellite

SPOT 6 & 7

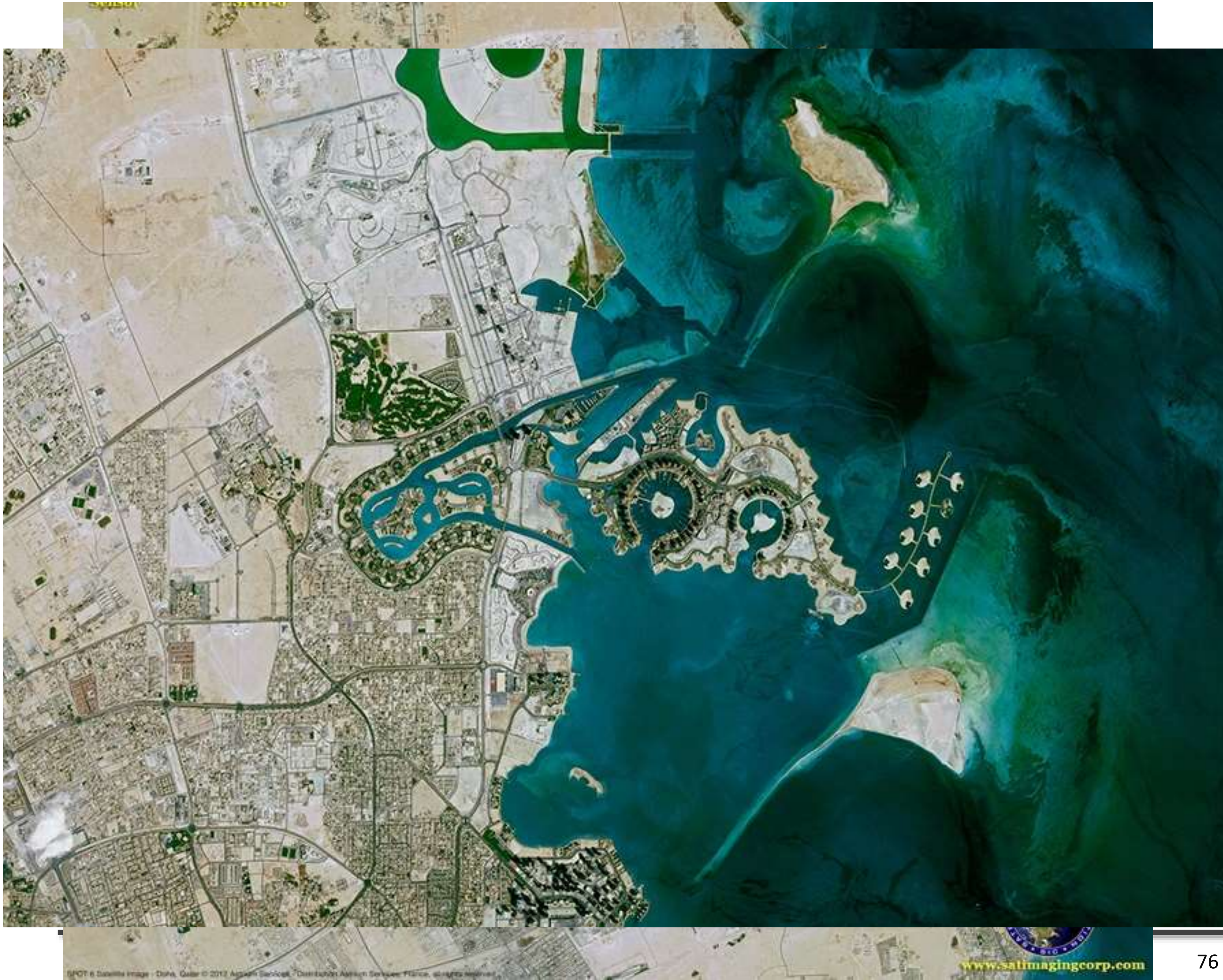
Like its twin, SPOT-7 covers wide areas in record time. With both satellites in orbit, acquisition capacity will be boosted to six million square kilometres per day – an area ten times the size of France.

Phased 180° apart in the same orbit, the SPOT family will now bring new capabilities especially in terms of sharpness, responsiveness and collection capacity:

•1.5m resolution suitable for 1:25.000 scale topographic mapping

•Daily revisits everywhere

SPOT 5 – Imagem 2.5 m


www.satimagingcorp.com

SPOT – Imagem 5 m

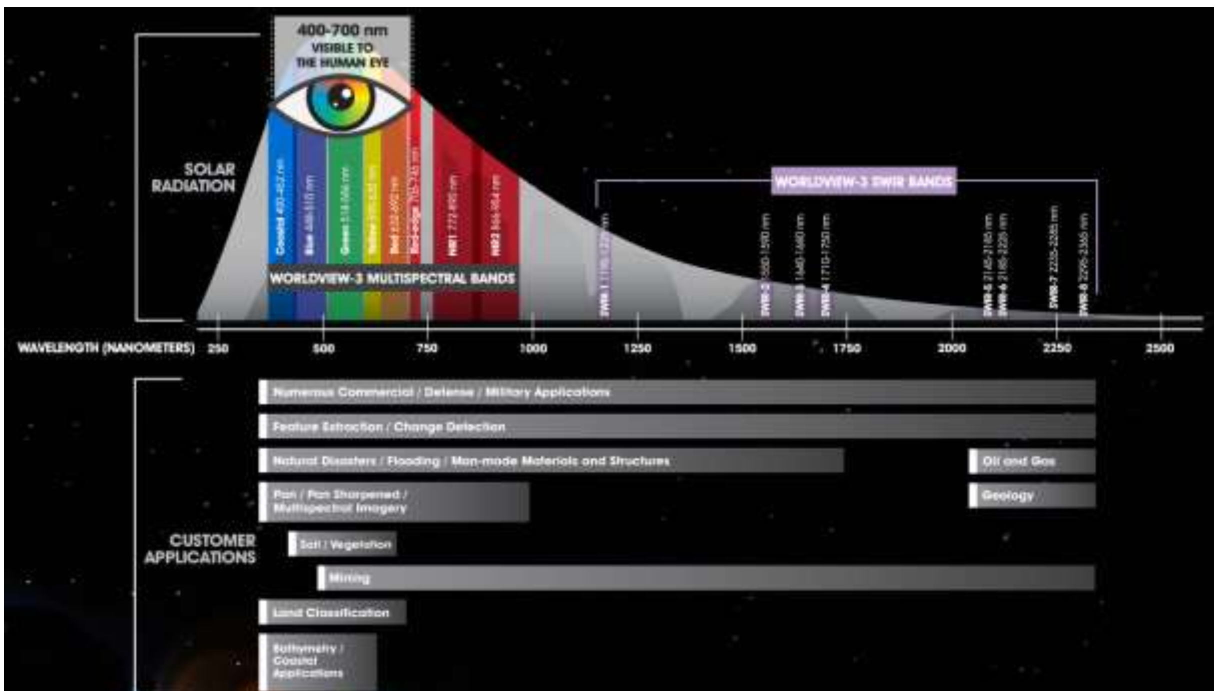
Ciências
ULisboa

Other Systems

http://www.satimagingcorp.com/satellite-sensors/worldview-3/

WorldView-3 satellite sensor is the first multi-payload, super-spectral, high-resolution commercial satellite sensor operating at an altitude of 617 km.

WorldView-3 provides **31 cm** panchromatic resolution, 1.24 m multispectral resolution, 3.7 m short wave infrared resolution.



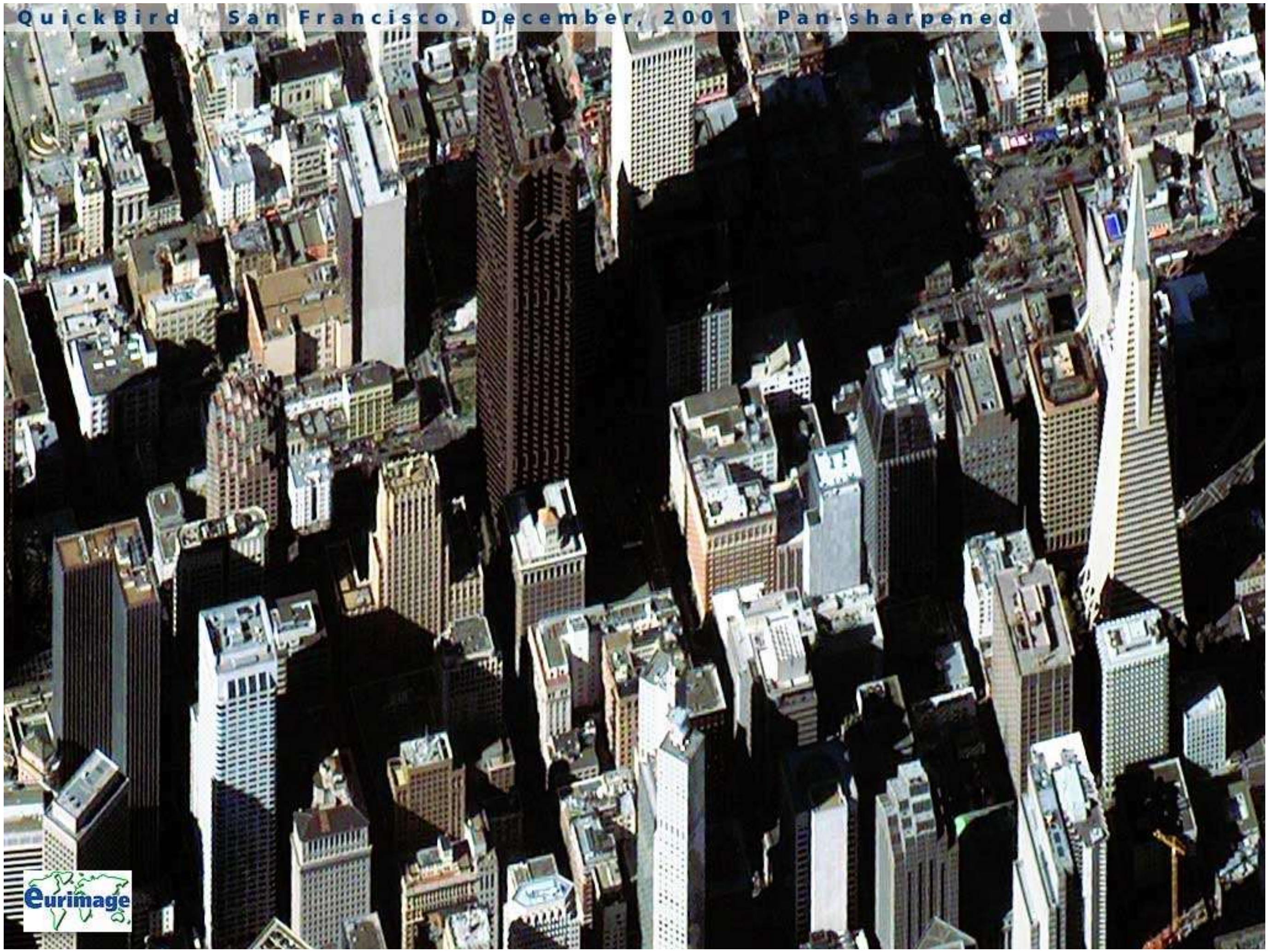
- GeoEye-1 (0.46m)
- GeoEye-2 (0.34m)
- WorldView-1 (0.46m)
- WorldView-2 (0.46m)
- WorldView-3 (0.31m)
- Pleiades-1A (0.5m)
- Pleiades-1B (0.5m)
- KOMPSAT-3A (0.55m)
- KOMPSAT-3 (0.7M)
- QuickBird (0.65m)
- IKONOS (0.82m)
- SkySat-1 (0.9m)
- SkySat-2 (0.9m)
- TripleSat (1m)
- TerraSAR-X
- SPOT-6 (1.5m)
- SPOT-7 (1.5m)
- Other Satellites (2m-20m)

IKONOS

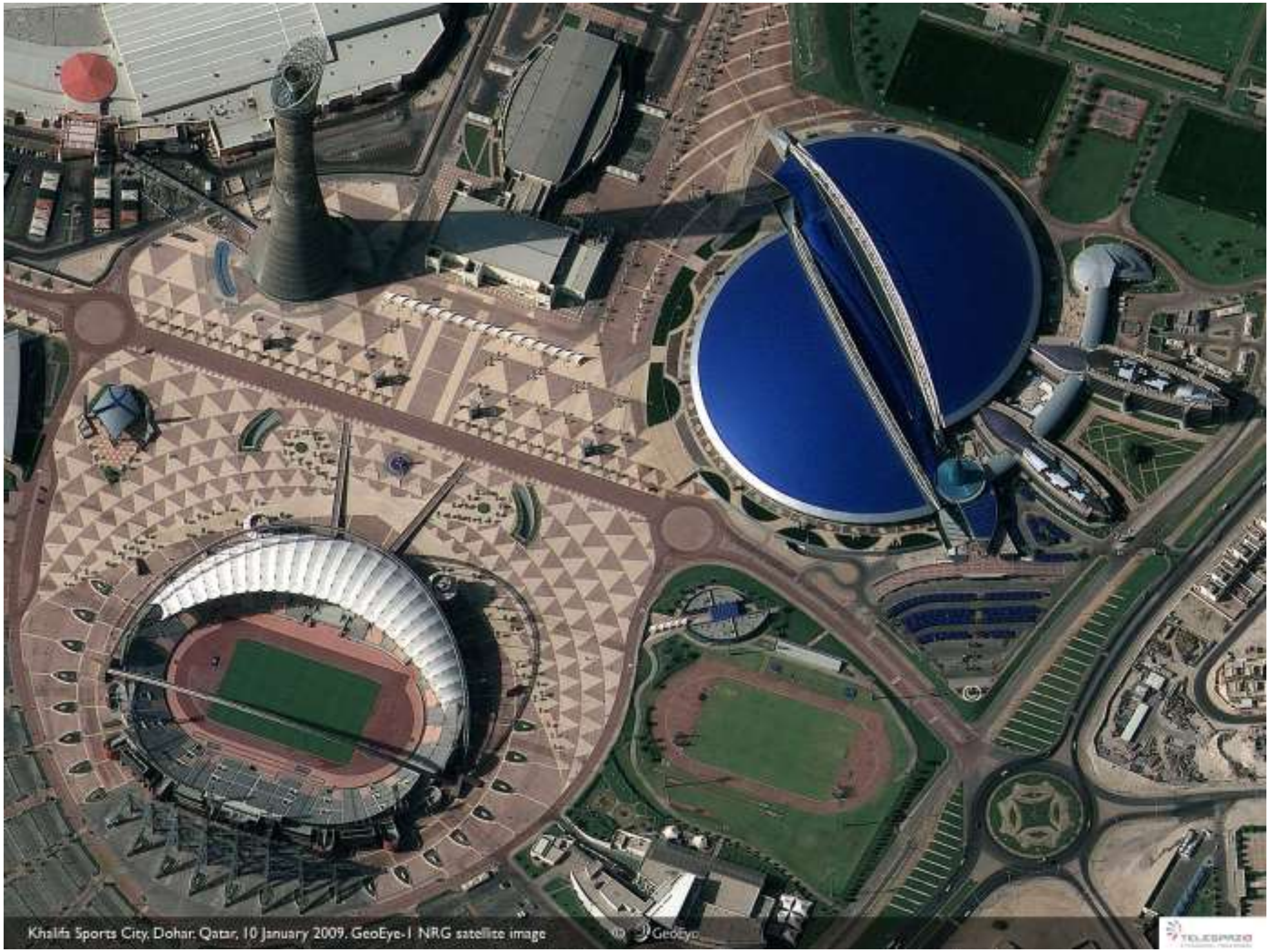
QUICKBIRD


QuickBird St Peter's, Rome, 23 March, 2002 Pan-sharpened MS
eurimage

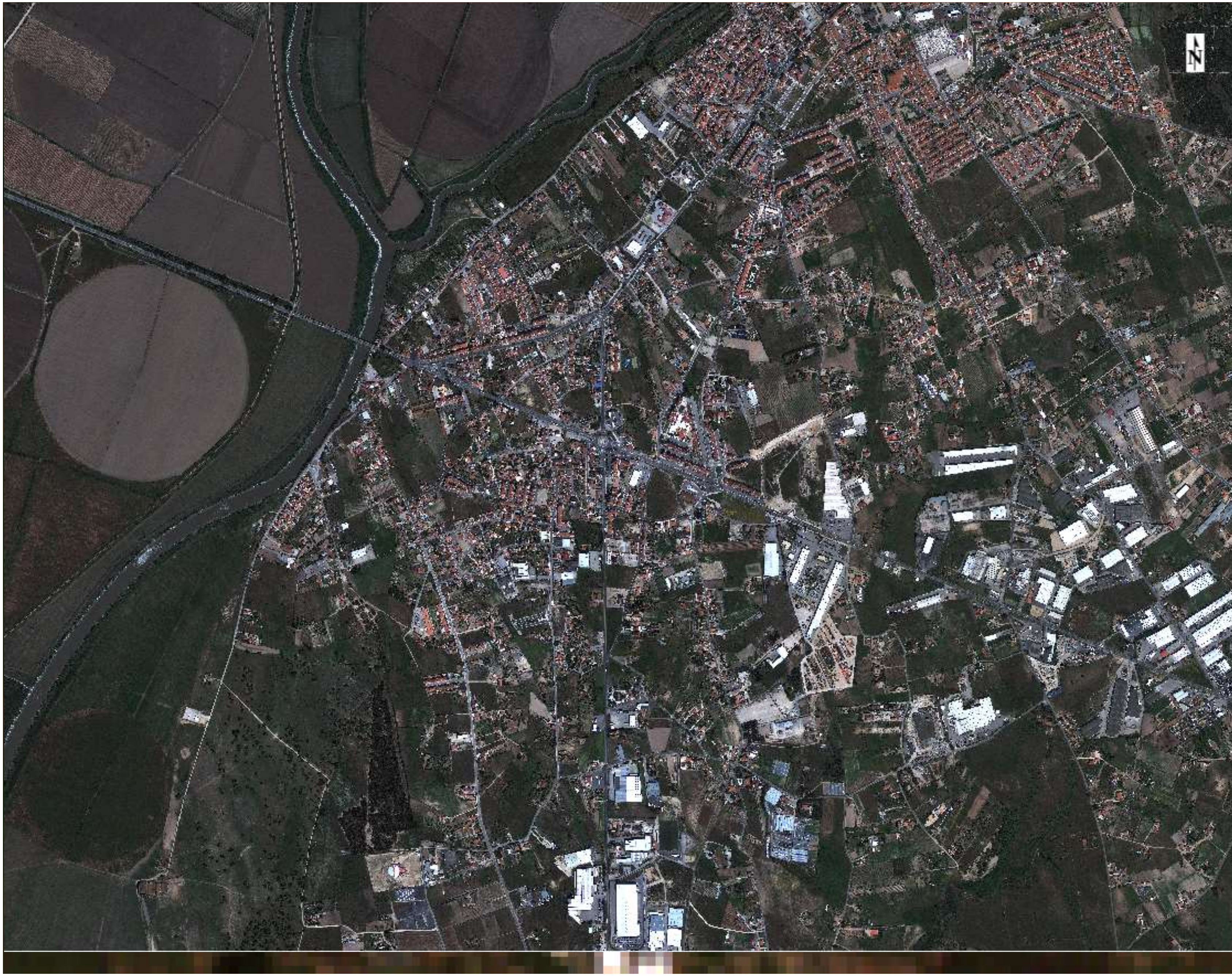
QUICKBIRD


QuickBird San Francisco, December, 2001 Pan-sharpened
eurimage

GeoEye


Khalifa Sports City, Dohar, Qatar, 10 January 2009. GeoEye-1 NRG satellite image


N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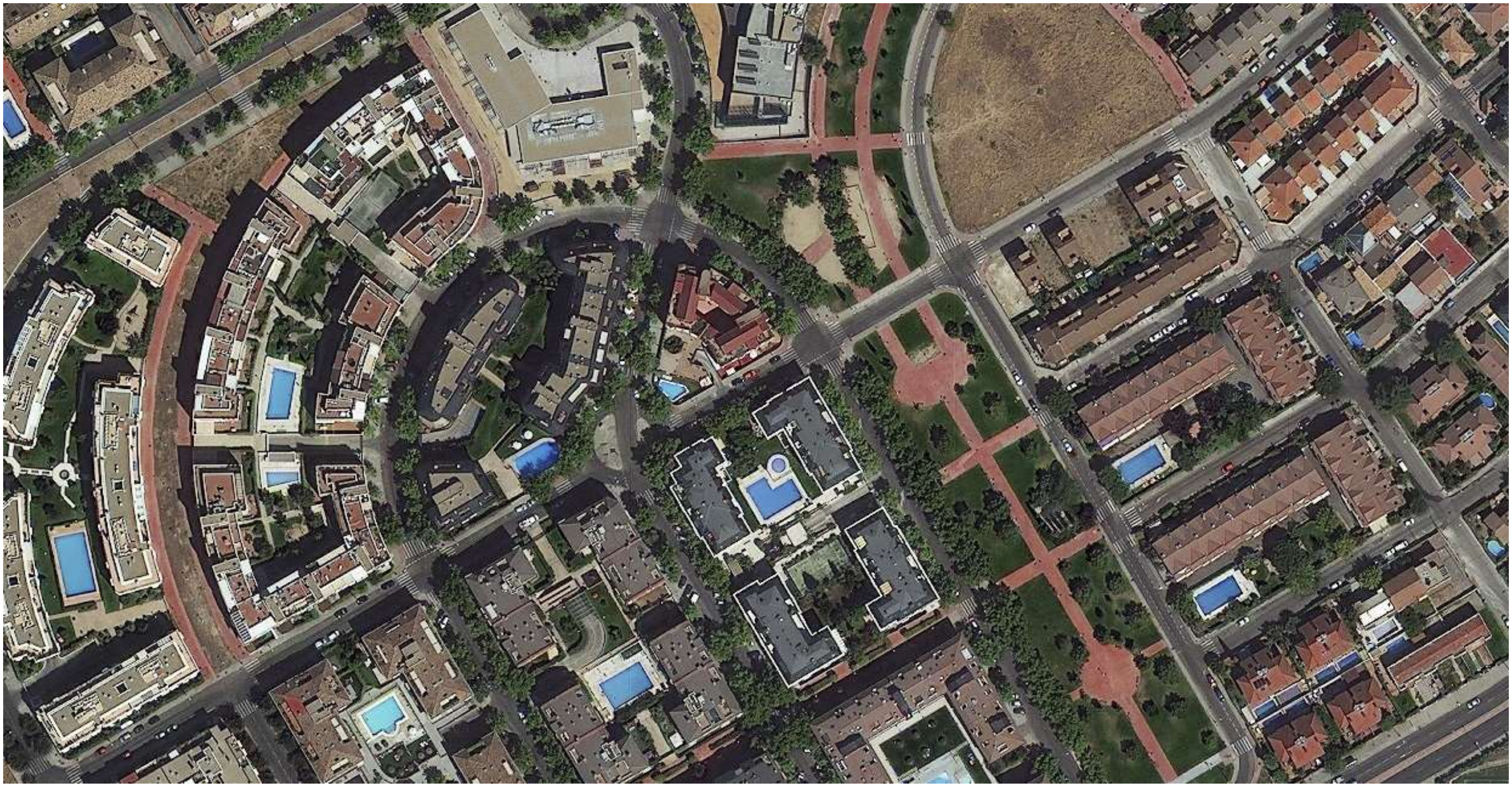
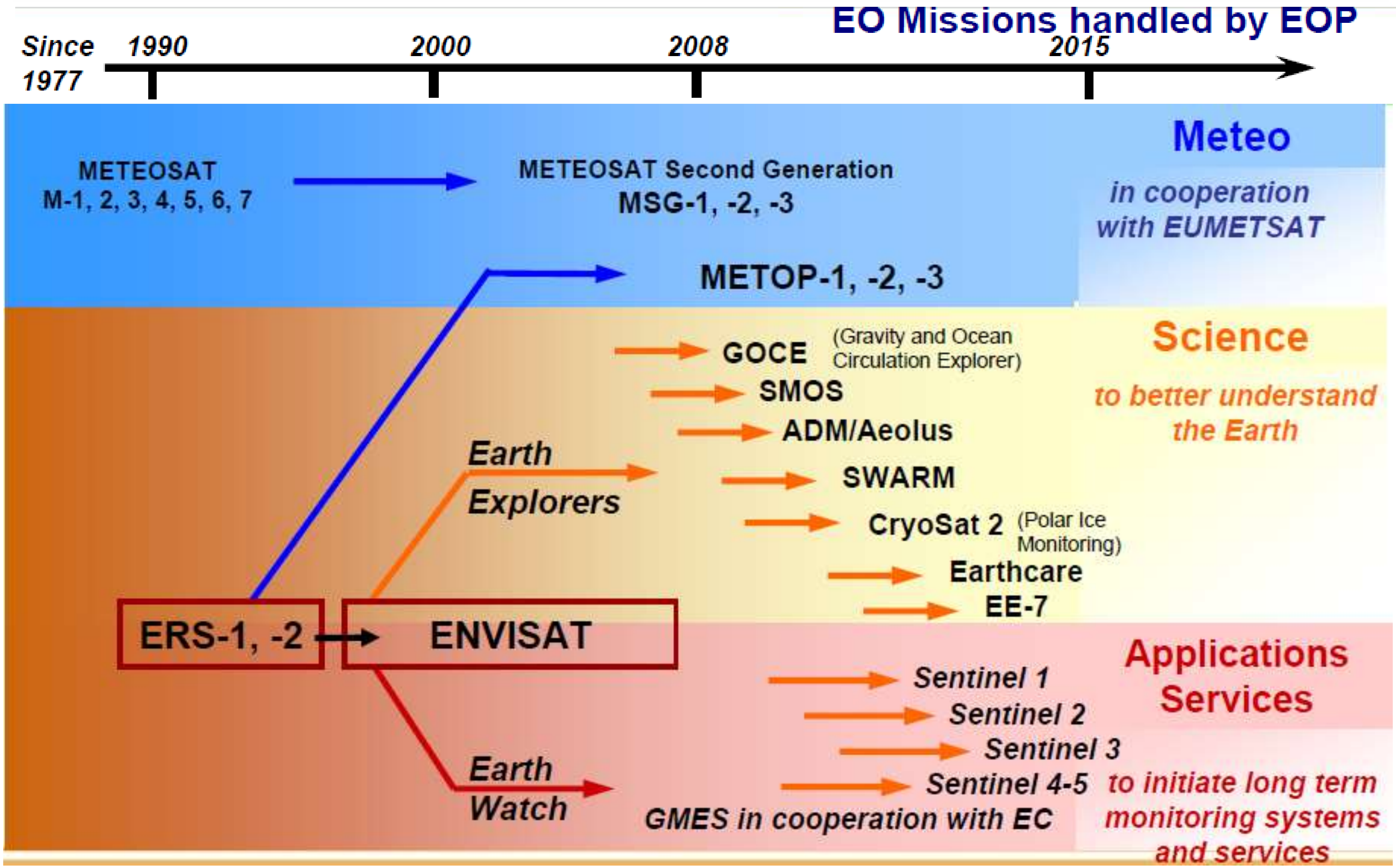
Worldview

8 bandas, 0.31 / 1.24 m

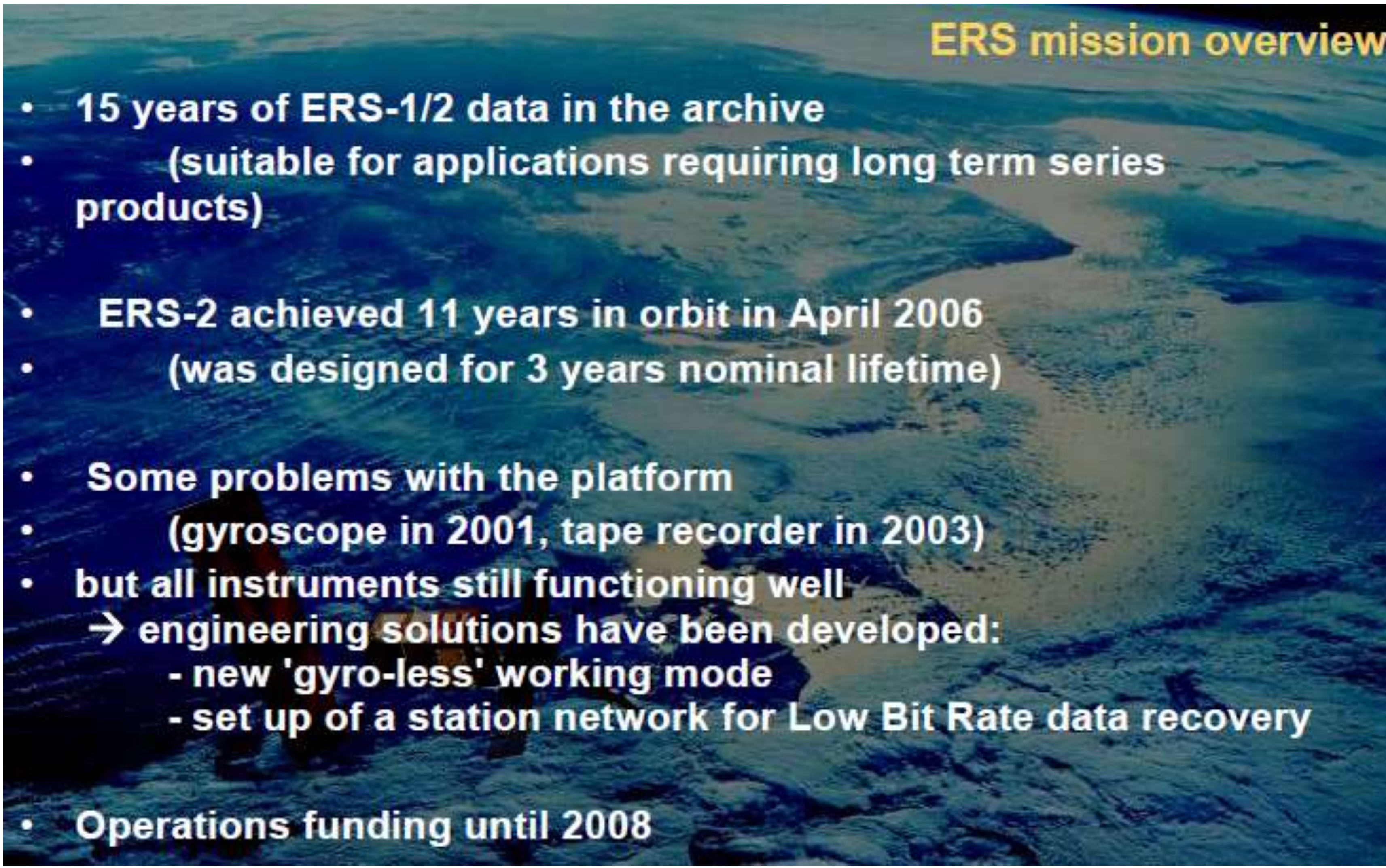



Worldview
2m
N

Satélites ESA



Missão ERS


ERS mission overview
• 15 years of ERS-1/2 data in the archive
• (suitable for applications requiring long term series products)
• ERS-2 achieved 11 years in orbit in April 2006
• (was designed for 3 years nominal lifetime)
• Some problems with the platform
• (gyroscope in 2001, tape recorder in 2003)
• but all instruments still functioning well
→ engineering solutions have been developed:
- new 'gyro-less' working mode
- set up of a station network for Low Bit Rate data recovery
• Operations funding until 2008

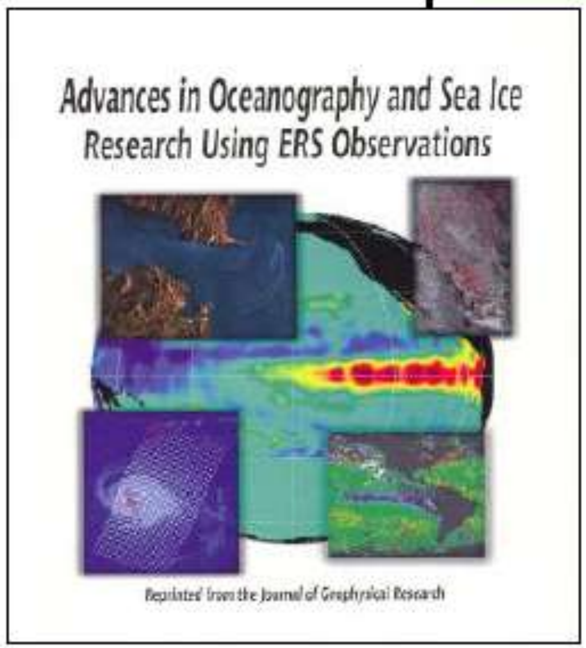
ERS-2 - satellite e payload status

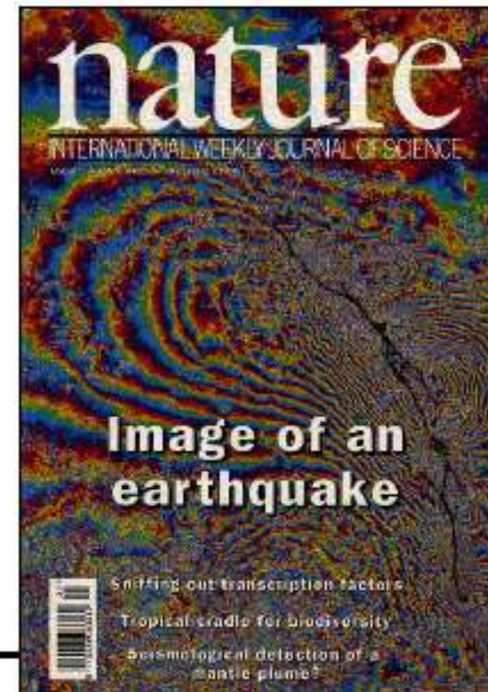
Mission elements	*Expected evolution*	*Comments*
Service Module	Good	Relaxed attitude control +- 2deg, all other sub-systems with full redundancy. SPOT-1 platform flown for 17 years before de-orbiting.
Propulsion and Hydrazine	Excellent	1/3 of hydrazine has been consumed within 11 years
Payload Equipment Bay	Fair	Tape Recorders Failed, Realtime mission only with some 40% global coverage. Transmission Tube redundancy available.
SAR Image Mode	Excellent	
SAR Wave Mode	Excellent	
Scatterometer	Fair	Sub System on redundant side
RA & MWR	Excellent	
ATSR	Good	Scan Mirror problem has been overcome by patches on ground
GOME	Good	Calibration lamp problem overcome by using sun measurements
PRARE	Excellent	Reduced surface transponders covering North & South Poles and Europe only; no redundancy

Missão ERS - Ciência

ERS and Volcanic activities

Oceanography and sea Ice





ERS and SAR Interferometry

Missão ENVISAT

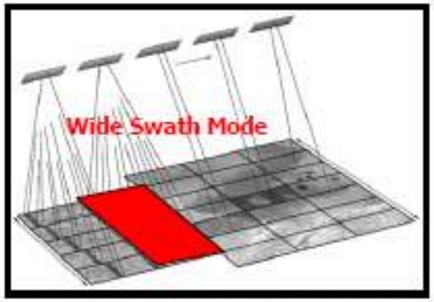
- Largest European satellite & largest worldwide EO satellite:
  - unique combination of 10 instruments addressing land, ocean, ice and atmosphere studies,
  - instruments working nominally, except MIPAS instrument
- Satellite OK with long-term operations capabilities:
  - 65 % of fuel available (about 5 years)
- 78 different types of data products
  - but many more geophysical parameters
- 250 Gigabytes of data products generated per day
- Nominal lifetime (5 years) ends in March 2007
  - but operations funding until end 2010

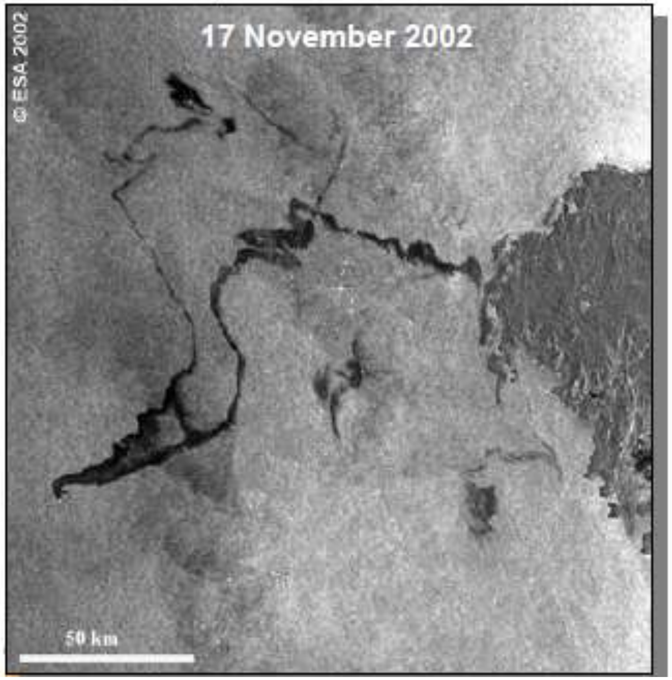
Missão ENVISAT - Status

Mission elements	Expected evolution	Comments
Service Module	Excellent	
Propulsion and Hydrazine	Fair	Main limiting factor of the mission
Payload Equipment Bay	Excellent	
ASAR	Fair	Sub-system on redundant side
MERIS	Excellent	
AATSR	Excellent	
RA-2	Fair	Recent anomaly with altimetric range measurement On ground correction tables
MWR	Good	
DORIS	Fair	Instrument on redundant side
SCIAMACHY	Excellent	
MIPAS	Bad	Progressive mechanical degradation in non redundant part. Used on campaign basis.
GOMOS	Fair	Instrument on redundant side. New operations scenario is satisfactory.

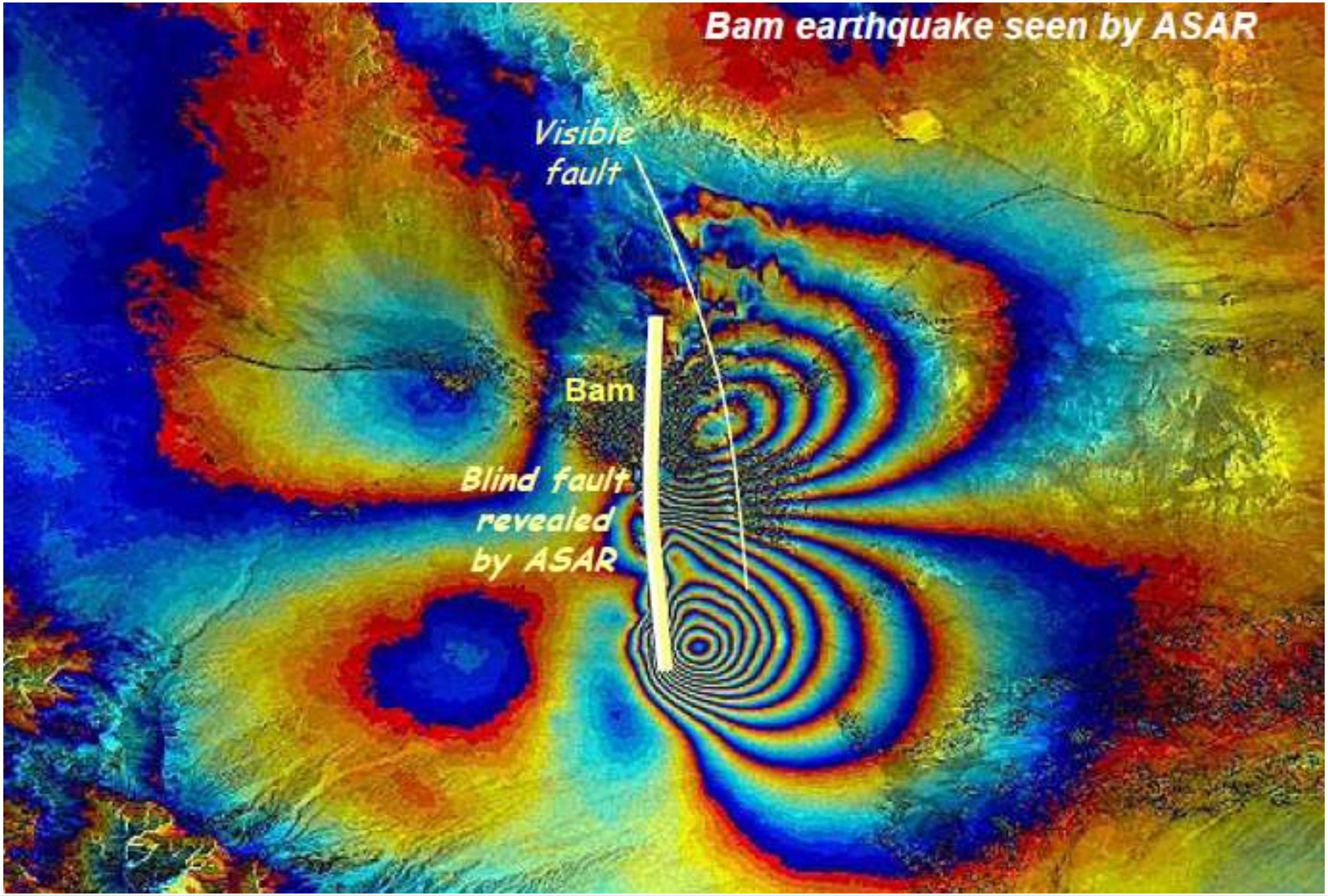
ENVISAT - ASAR

ENVISAT Imaging Radar





ENVISAT - ASAR



ESA – Earth Explorers

Earth Explorers – Core Missions

- **ESA-led missions to cover the primary research objectives of the Explorer's program:** *Earth interior, physical climate, geo-sphere & biosphere, atmosphere & marine environment*

GOCE

Earth gravity field and Geoid measurements

Launch: 2007

ADM-Aeolus

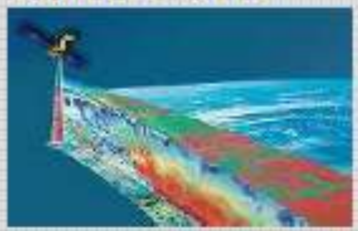
Windspeed vectors measurements

Launch: 2009

EarthCARE

Clouds, Aerosols & radiation measurements

Launch: 2012+



ESA – Earth Explorers

Earth Explorers – Opportunity Missions

- **Smaller missions with specific targets:** *Instrument provision to other programmes, research and technology demonstration (incl. new observing techniques)*

SMOS

Soil moisture and ocean salinity measurements

Launch: 2008

Cryosat-2

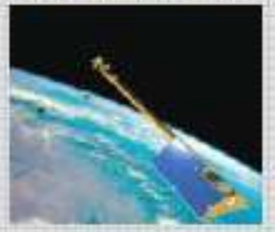
Ice elevation and ice thickness measurements

Launch: 2009

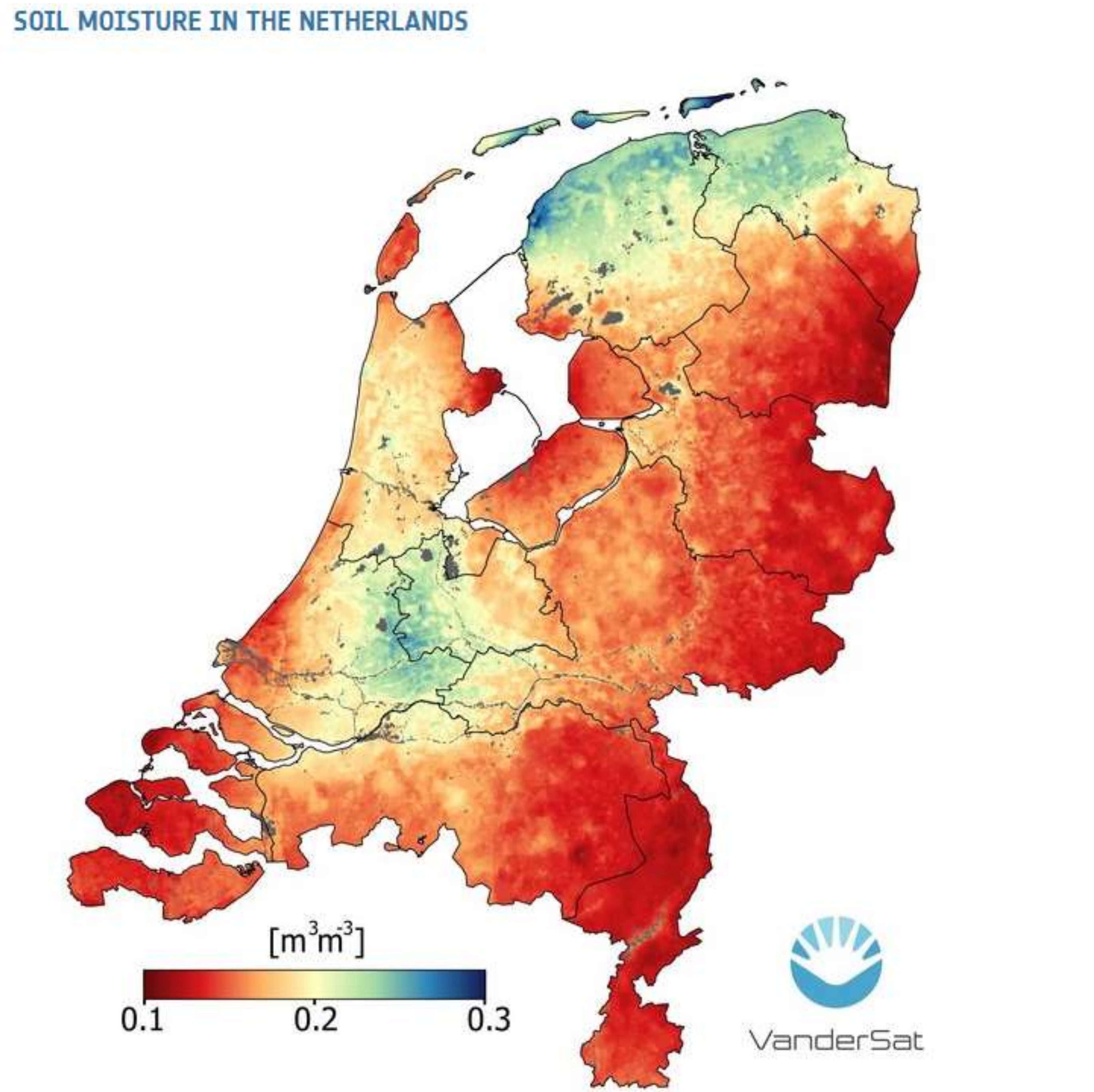
SWARM

Earth magnetic field & Earth core dynamics meas.

Launch: 2009+



Ciências
ULisboa



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1000 km
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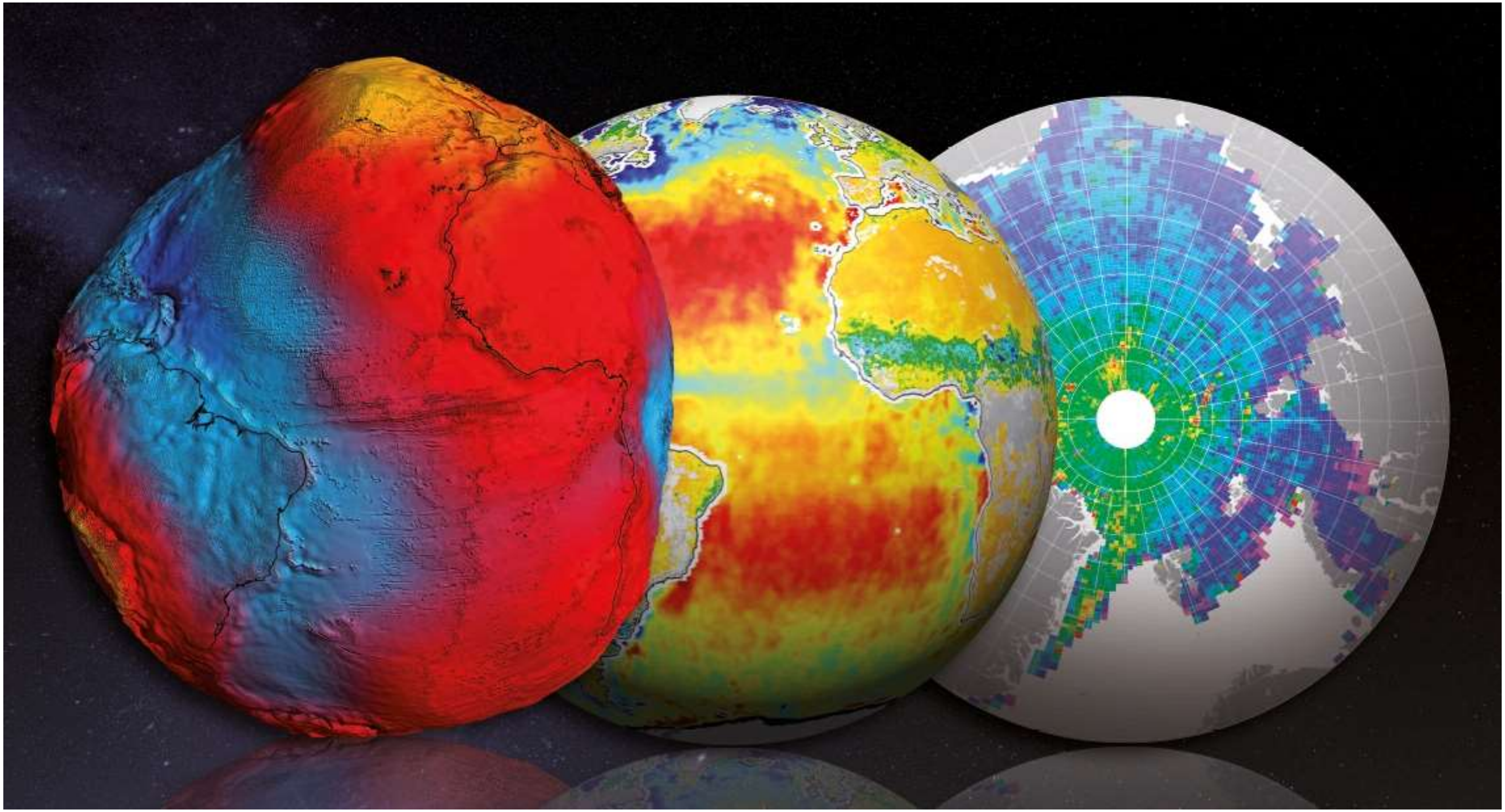
Earth Explorers (ESA)



GOCE SMOS CryoSAT

GMES

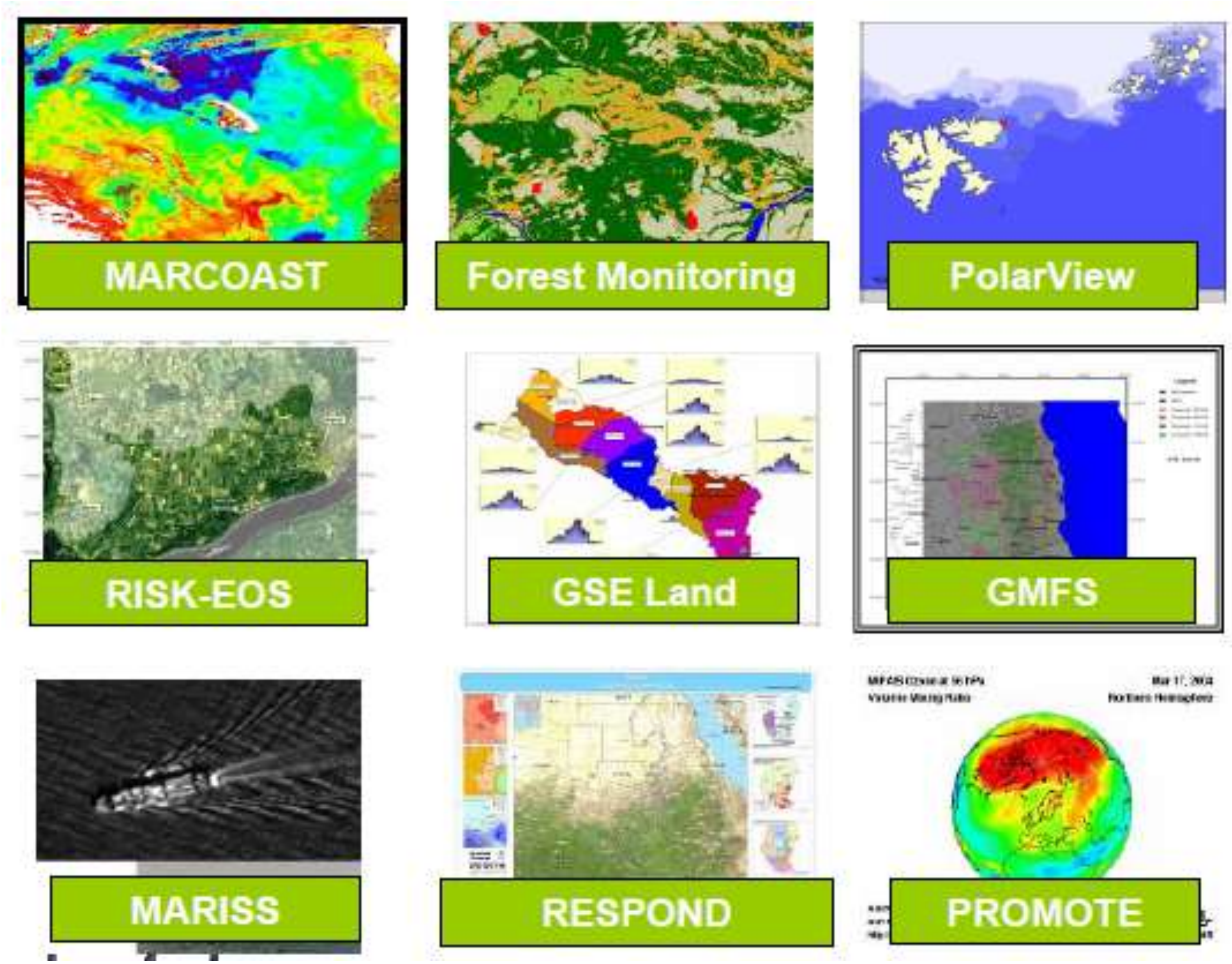
Global Monitoring for Environment and Security (GMES)

European autonomy in data sources for environment and security monitoring

and

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

GMES - Serviços



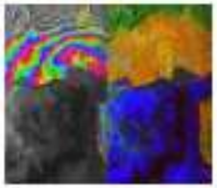
100 M€ by ESA MS

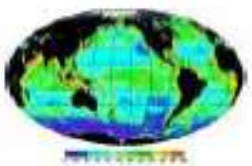
Period 2003-2008 (2009)

300+ user organisations

EC has invested another 100 M€

GMES – Componente Espacial / Copernicus – Componente Espacial



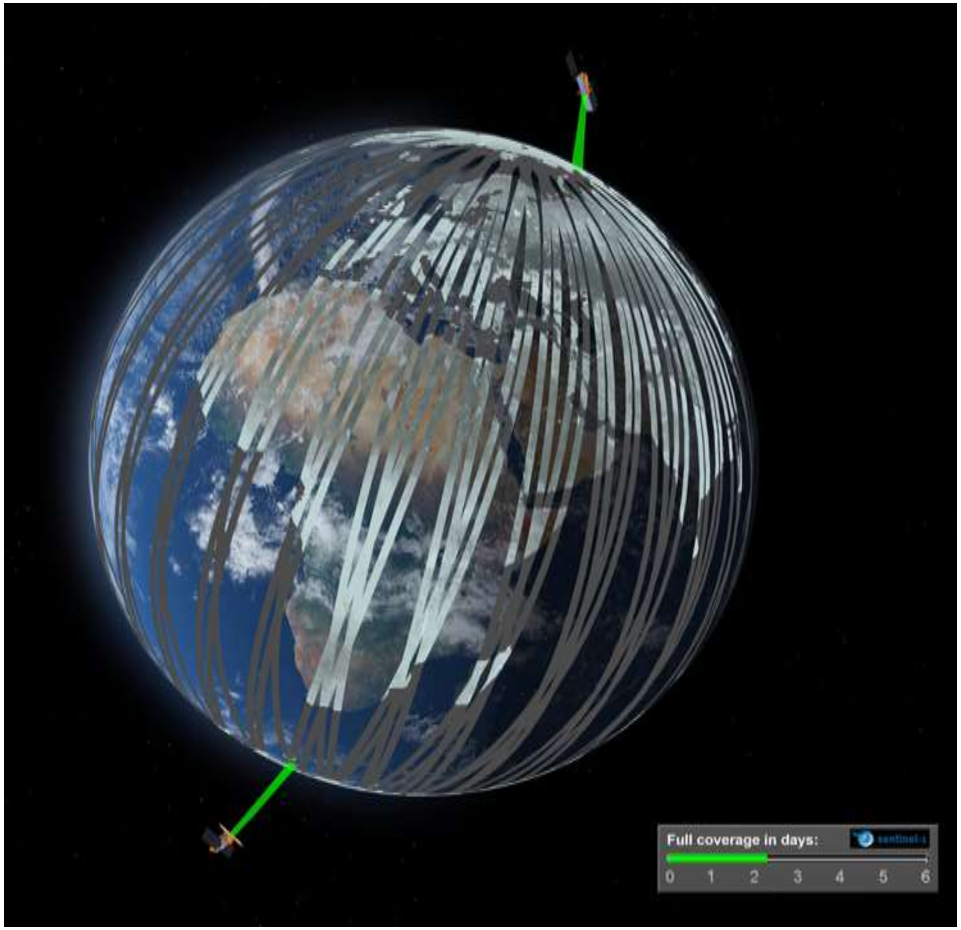


- **Sentinel 1 – SAR imaging**
  - All weather, day/night applications, interferometry, ocean/ice/land
- **Sentinel 2 – Superspectral imaging**
  - Continuity of Landsat, SPOT - type of data for land mapping
- **Sentinel 3 – Ocean monitoring**
  - Wide-swath ocean color, surface temperature and land mission & radar altimeter
- **Sentinel 4 – Geostationary atmospheric**
  - Atmospheric composition monitoring, trans-boundary pollution
- **Sentinel 5 – Low-orbit atmospheric**
  - Atmospheric composition monitoring

Sentinel -1

The Sentinel-1 mission is designed as a two-satellite constellation. The identical satellites orbit Earth 180° apart and at an altitude of almost 700 km. This configuration optimises coverage, offering a global revisit time of just six days.

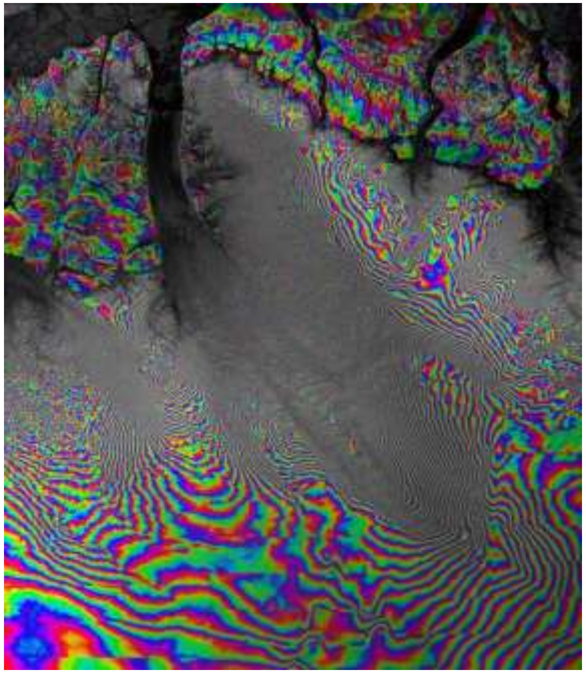
At the equator, however, the repeat frequency is just three days and less than one day over the Arctic. Europe, Canada and main shipping routes are covered in less than three days.



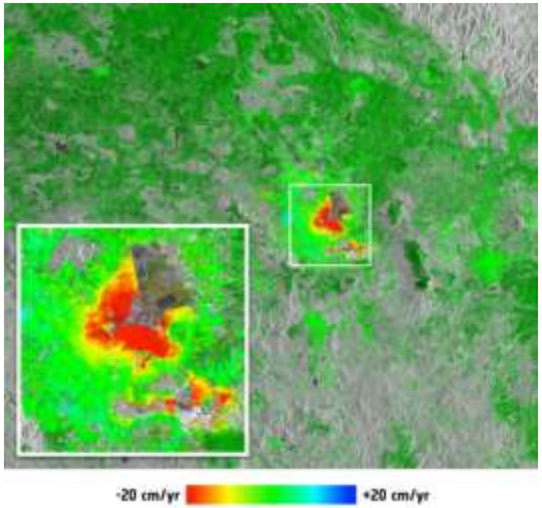
Sentinel -1

Aplicações

Oceano e Gelo



Changing lands



Emergency response

Sentinel -1

Visão Radar

The radar operates in two main modes: Interferometric Wide swath and Wave.

Interferometric Wide swath mode, the default mode over land, has a swath width of 250 km and a ground resolution of 5 x 20 m.

Wave mode acquisitions – which can help to determine the direction, wavelength and heights of waves on the open oceans – are 20 x 20 km, acquired alternately on two different incidence angles every 100 km.

There's also the potential for operating it in two additional modes: Stripmap (5m x 5m) and Extra Wide Swath 20mx 40m).

Sentinel -2

Sentinel-2 carries an innovative wide swath high-resolution multispectral imager with 13 spectral bands for a new perspective of our land and vegetation.

<u>Aplications:</u>
Plant Health, Changing lands, Water bodies, Disaster Mapping

The span of 13 spectral bands, from the visible and the near infrared to the shortwave infrared at different spatial resolutions ranging from 10 to 60 m takes land monitoring to an unprecedented level.

Sentinel-2 include three bands in the ‘red edge’,

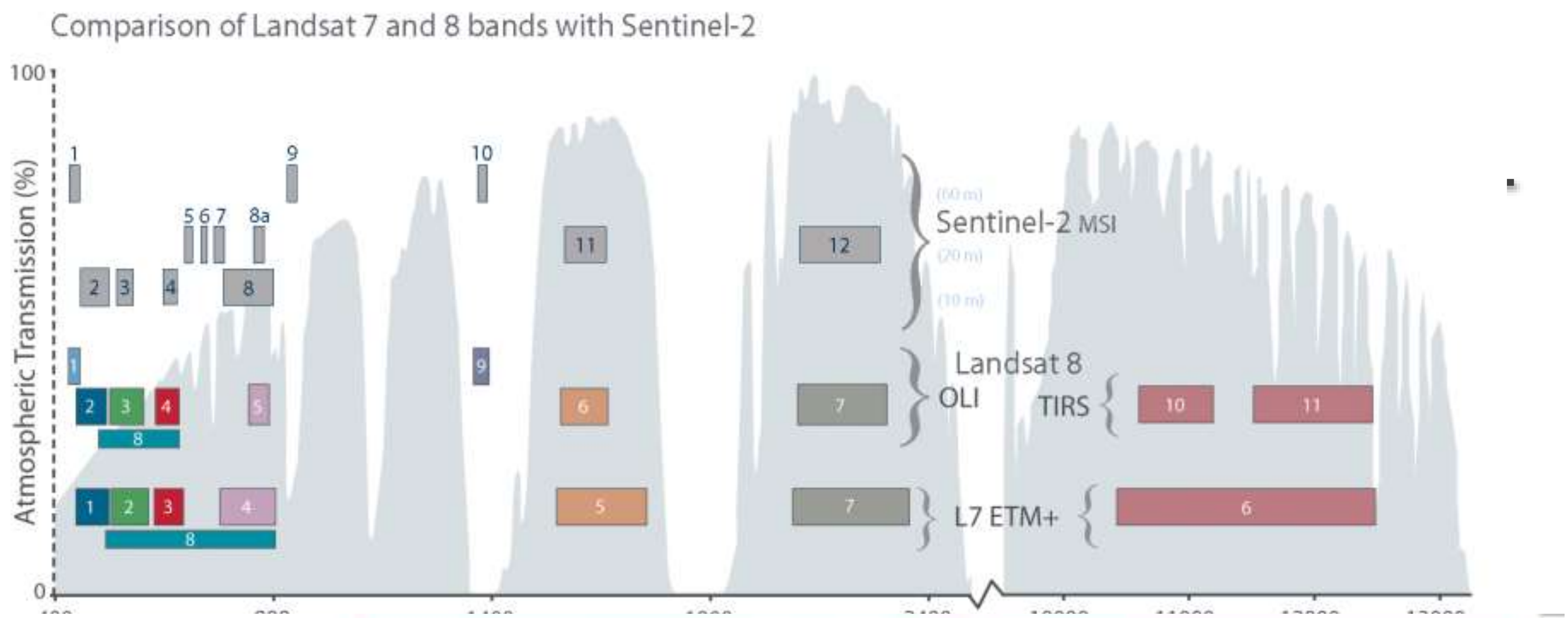
Sentinel -2

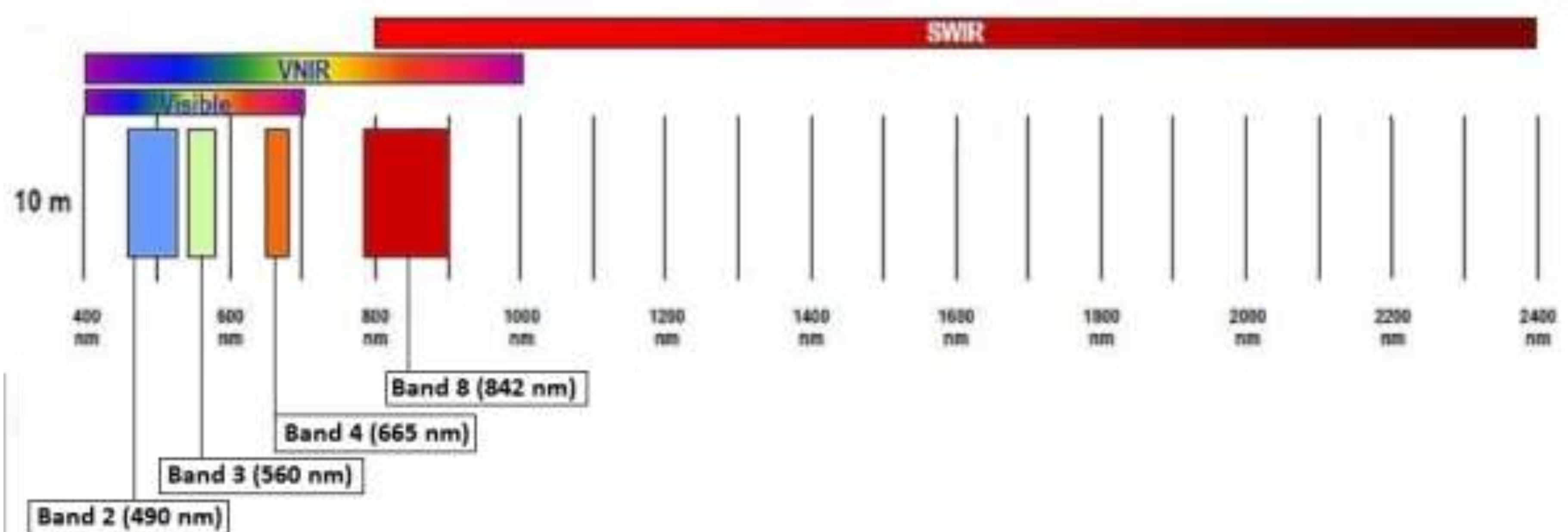
Launch: 23 June 2015

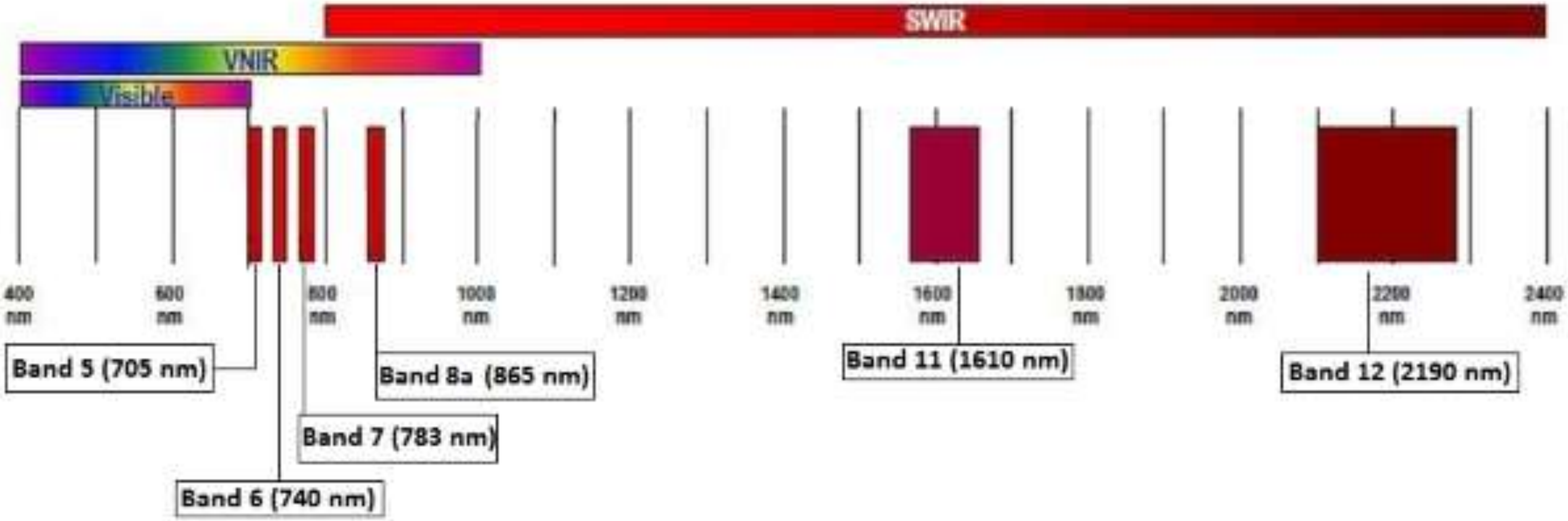
Orbit: Polar, Sun-synchronous at altitude of 786 km
Revisit time: Five days from two-satellite constellation (at equator)

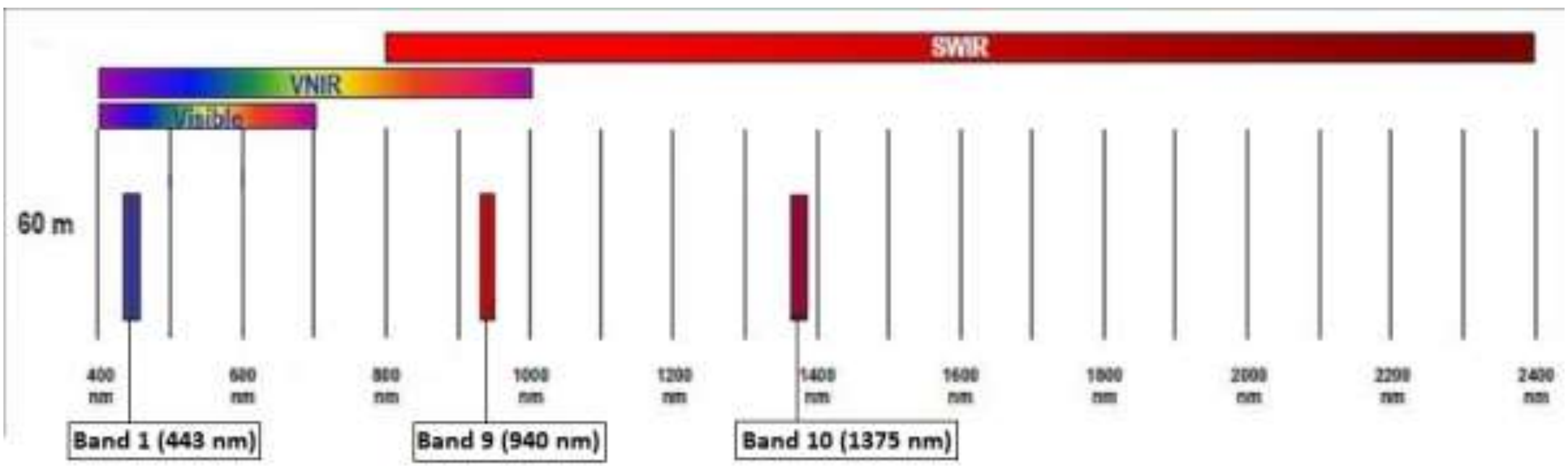
Satellite: 3.4 m long, 1.8 m wide, 2.35 m high

Instrument:
Multispectral imager (MSI) covering 13 spectral bands (443 nm–2190 nm)
with a swath width of 290 km and
spatial resolutions of :
10 m (4 visible and near-infrared bands),
20 m (6 red-edge/shortwave-infrared bands) and
60 m (3 atmospheric correction bands)

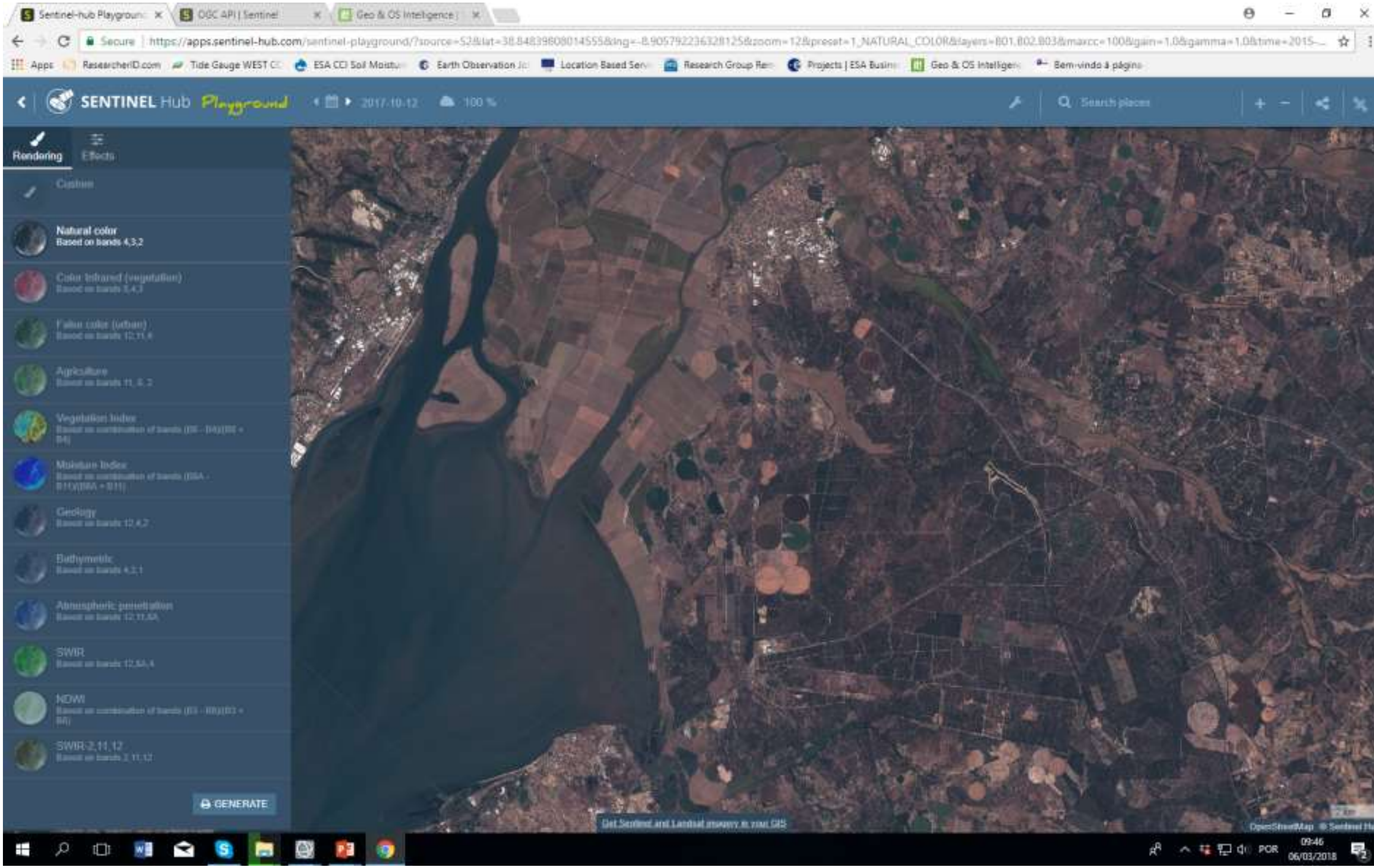

Comparison of Landsat 7 and 8 bands with Sentinel-2
Atmospheric Transmission (%)
100
0
Sentinel-2 MSI
(60 m)
(20 m)
(10 m)
Landsat 8
OLI
TIRS
L7 ETM+


SWIR
VNIR
Visible
10 m
400 nm
600 nm
800 nm
1000 nm
1200 nm
1400 nm
1600 nm
1800 nm
2000 nm
2200 nm
2400 nm
Band 8 (842 nm)
Band 4 (665 nm)
Band 3 (560 nm)
Band 2 (490 nm)

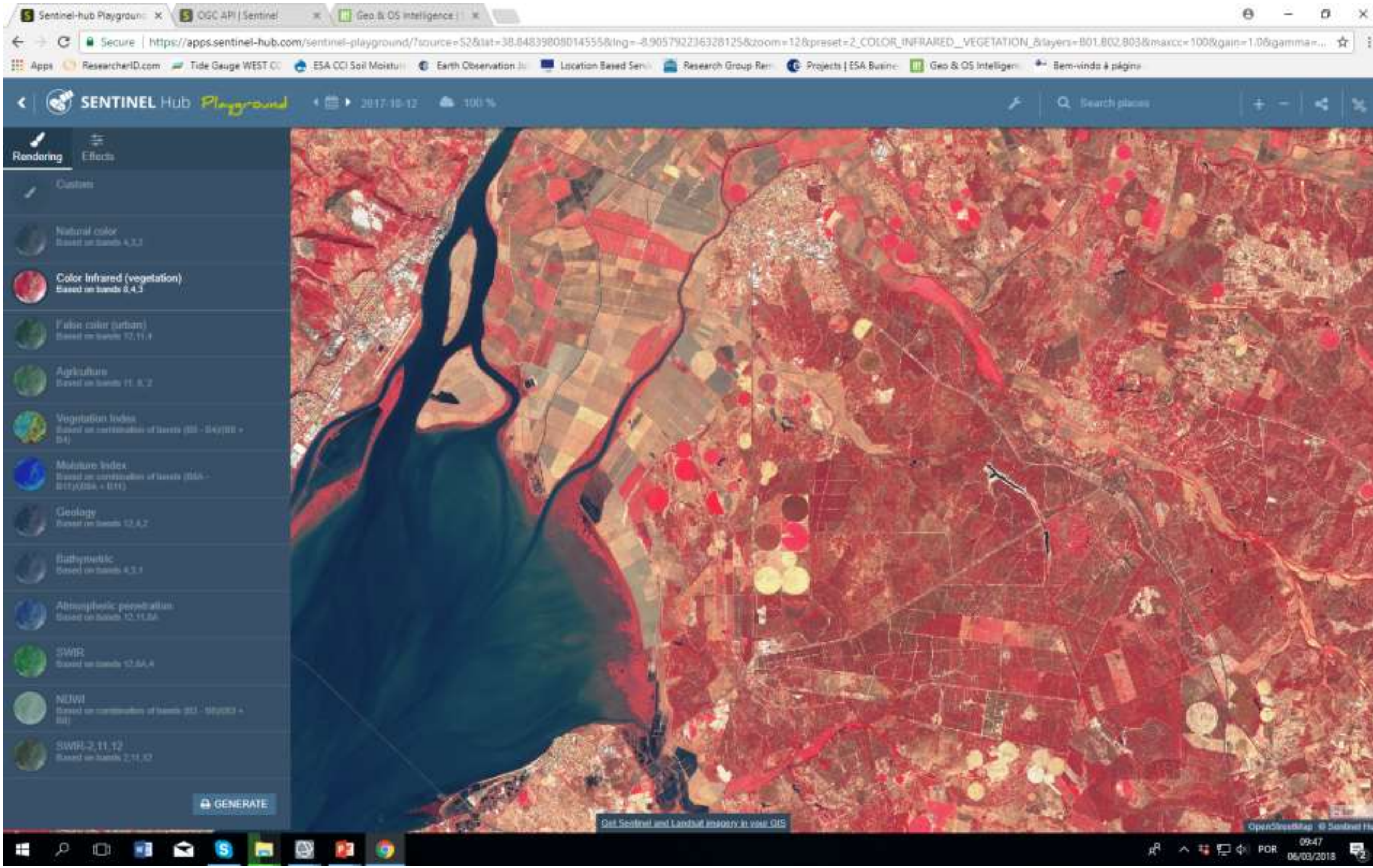

SWIR
VNIR
Visible
400 nm
600 nm
800 nm
1000 nm
1200 nm
1400 nm
1600 nm
1800 nm
2000 nm
2200 nm
2400 nm
Band 5 (705 nm)
Band 8a (865 nm)
Band 11 (1610 nm)
Band 12 (2190 nm)
Band 7 (783 nm)
Band 6 (740 nm)


SWIR
VNIR
Visible
60 m
400 nm
600 nm
800 nm
1000 nm
1200 nm
1400 nm
1600 nm
1800 nm
2000 nm
2200 nm
2400 nm
Band 1 (443 nm)
Band 9 (940 nm)
Band 10 (1375 nm)

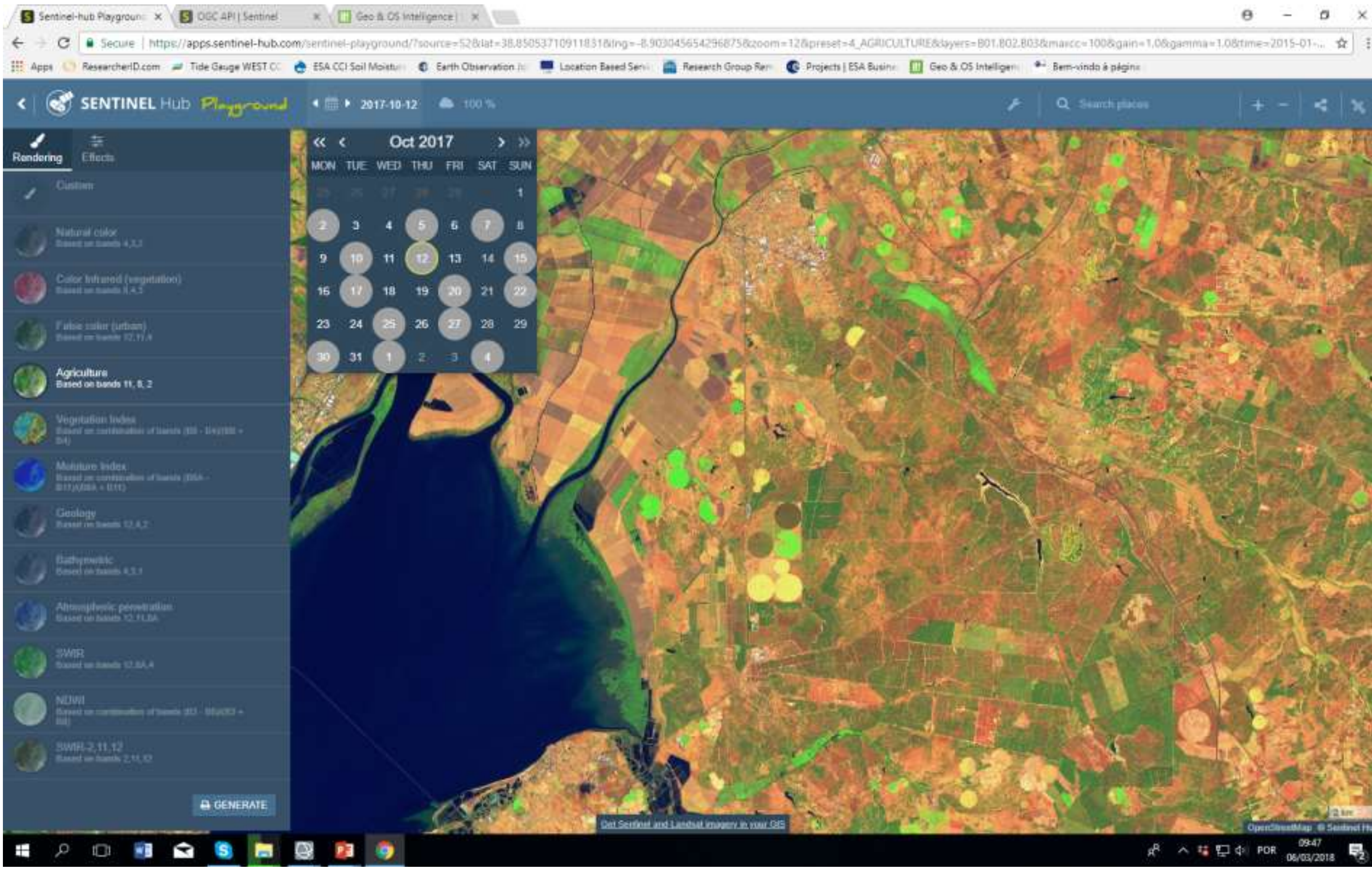
https://apps.sentinel-hub.com/sentinel-playground



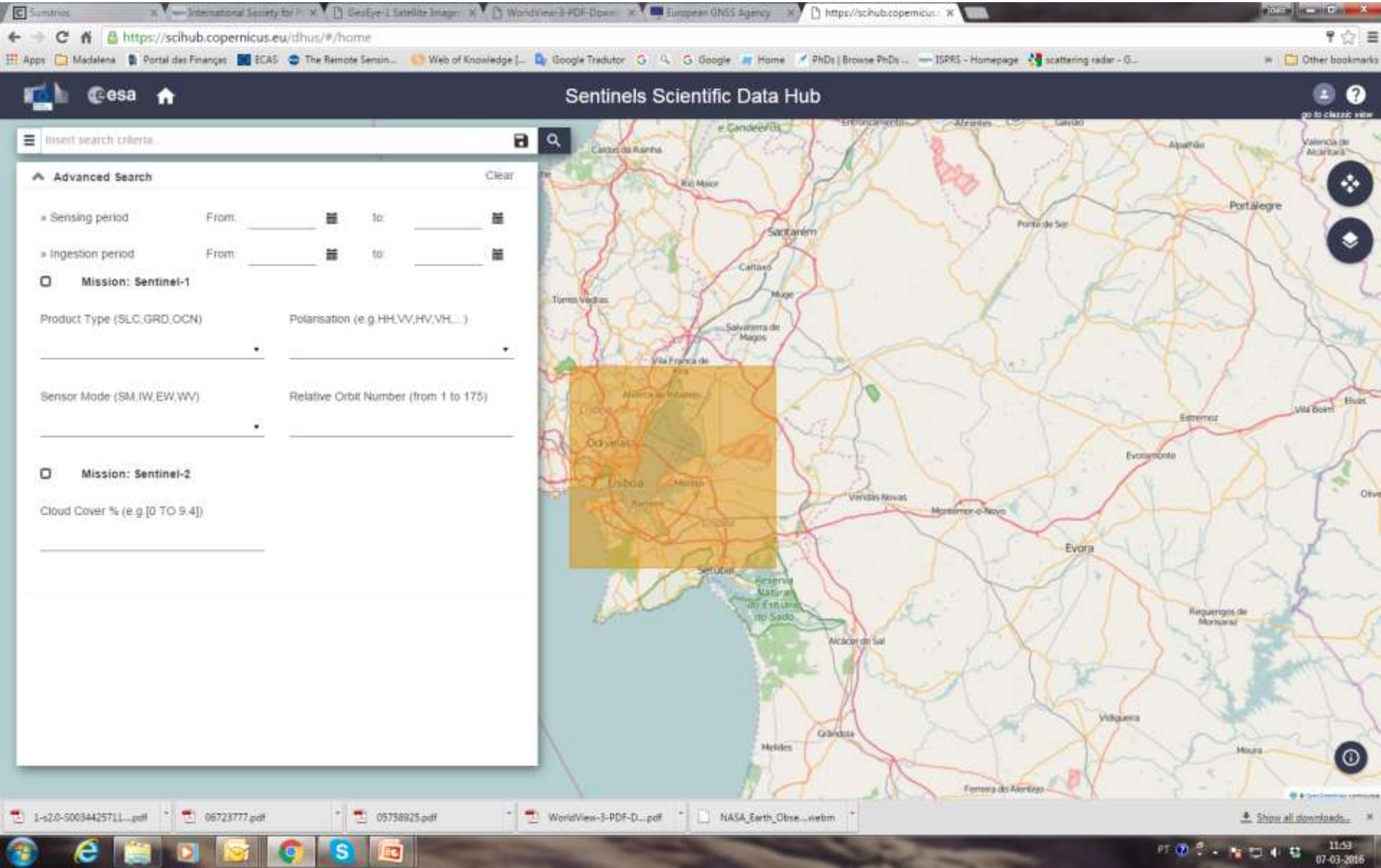
https://apps.sentinel-hub.com/sentinel-playground



https://apps.sentinel-hub.com/sentinel-playground



Sentinel Hub, https://scihub.copernicus.eu/dhus/#/home

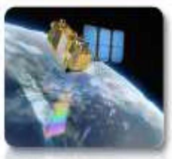


Sentinel Toolboxes

Sentinel Scientific Toolboxes

Sentinel-1 (A/B/C/D) – SAR Imaging
All weather, day/night applications, interferometry

SNAP 2.0-beta-07



Sentinel-2 (A/B/C/D) – Multi-Spectral Imaging
Land applications: urban, forest, agriculture,…
Continuity of Landsat, SPOT

Sentinel-3 (A/B/C/D) – Ocean & Land Monitoring
Wide-swath ocean color, vegetation, sea/land surface temperature and altimetry

- The Toolboxes are based on sound heritage but also offer innovative technologies for analysing, processing and visualizing EO data.
- The Toolboxes are implemented incrementally in several releases with additional functionality to the public.
- Available free of charge, in line with the Sentinel free and open data policy.

Ciências ULisboa

step
science toolbox exploitation platform

esa

ESA | STEP | TOOLBOXES | DOWNLOAD | GALLERY | DOCUMENTATION | COMMUNITY | THIRD PARTY PLUGINS

- SNAP
- Sentinel 1 Toolbox
- Sentinel 2 Toolbox
- Sentinel-3 Toolbox
- SMOS Toolbox
- Download
- Community
- Useful Links

Search...

Home > Toolboxes > SNAP

SNAP

A common architecture for all Sentinel Toolboxes is being jointly developed by Brockmann Consult, Array Systems Computing and C-S called the **Sentinel Application Platform** (SNAP).

The SNAP architecture is ideal for Earth Observation processing and analysis due to the following technological innovations: Extensibility, Portability, Modular Rich Client Platform, Generic EO Data Abstraction, Tiled Memory Management, and a Graph Processing Framework.

Feature Highlights

- Common architecture for all Toolboxes
- Very **fast image display and navigation** even of giga-pixel images
- Graph Processing Framework (GPF): for creating user-defined processing chains
- Advanced **layer management** allows adding and manipulation of new overlays such as images of other bands, images from WMS servers or ESRI shapefiles
- Rich **region-of-interest** definitions for **statistics** and various **plots**
- Easy **bitmask** definition and overlay
- Flexible **band arithmetic** using arbitrary mathematical expressions
- Accurate **reprojection** and **ortho-rectification** to common map projections,
- Geo-coding and rectification using **ground control points**
- Automatic SRTM DEM download and tile selection
- Product library for scanning and cataloguing large archives efficiently
- Multithreading and Multi-core processor support
- Integrated WorldWind visualisation

SNAP Frequently Asked Questions

SNAP is using the following technologies

seom
scientific exploitation of operational missions

2017

EO Open Science 2017

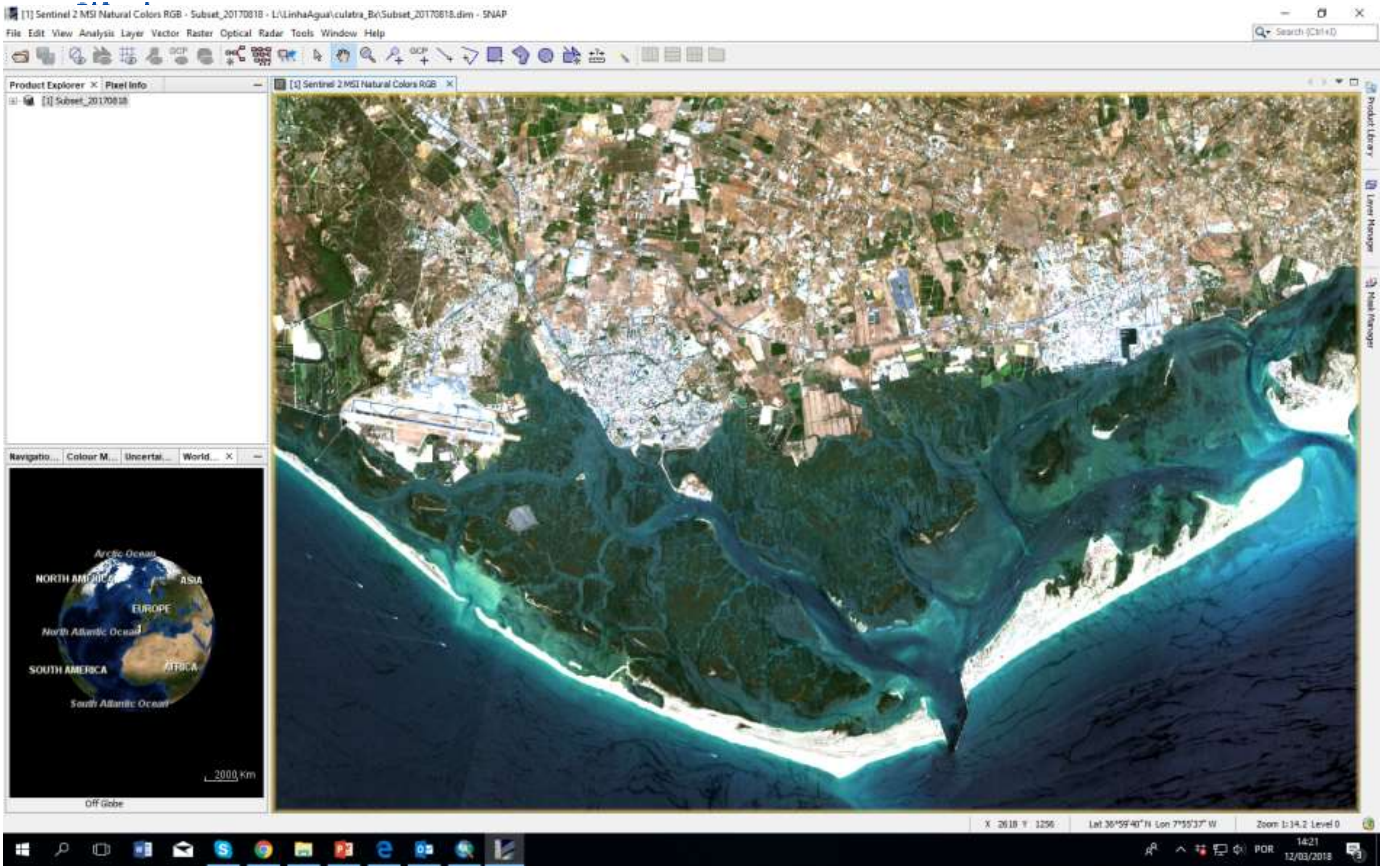
7th Advanced Land Training Course

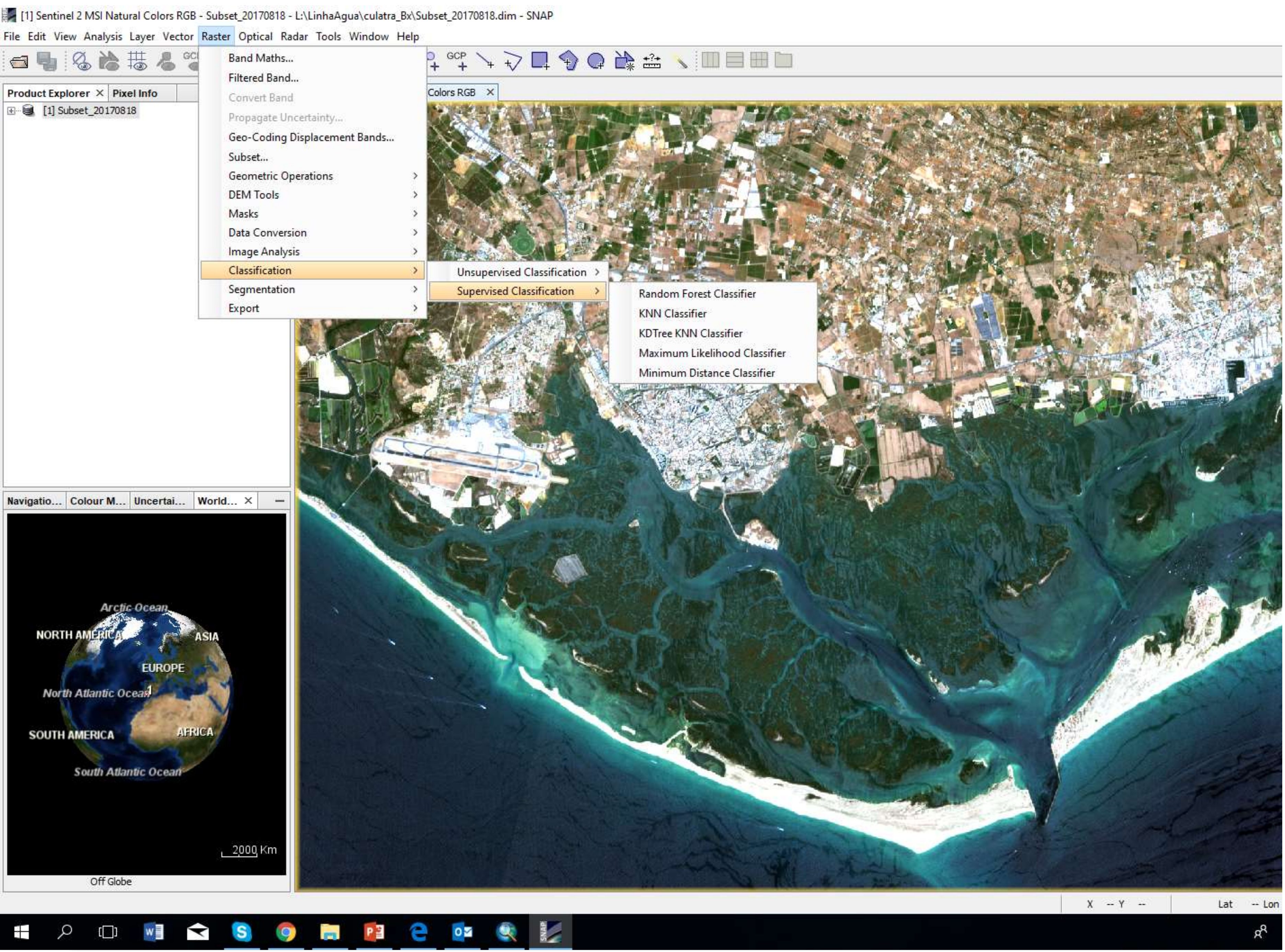
ESA POLinSAR 2017 Workshop

2016

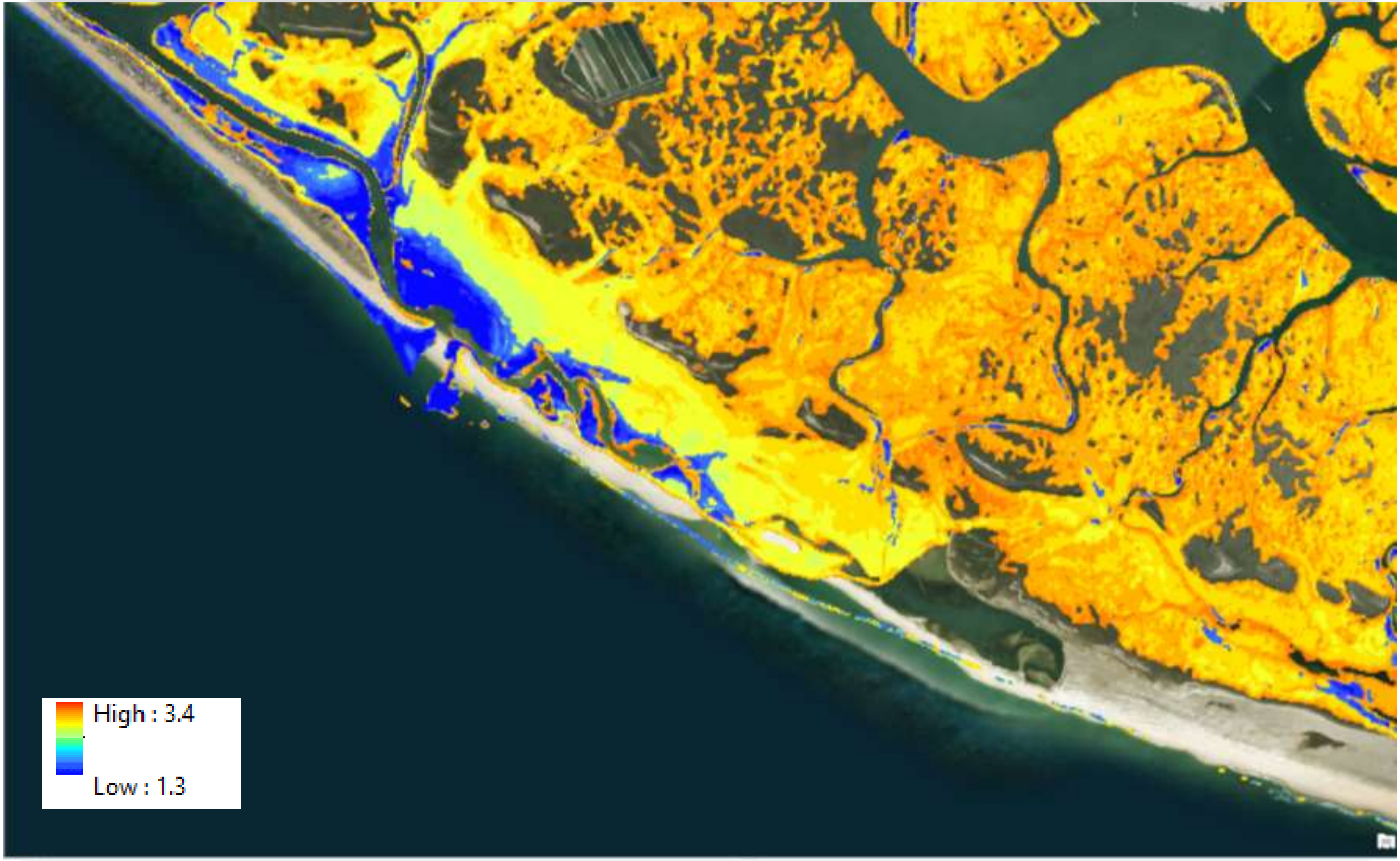
Colour and Light in the Ocean from Earth Observation

SNAP software




[1] Sentinel 2 MSI Natural Colors RGB - Subset_20170818 - L:\LinhaAgua\culatra_Bx\Subset_20170818.dim - SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Band Maths...
Filtered Band...
Convert Band
Propagate Uncertainty...
Geo-Coding Displacement Bands...
Subset...
Geometric Operations
DEM Tools
Masks
Data Conversion
Image Analysis
Classification
Segmentation
Export
Unsupervised Classification
Supervised Classification
Random Forest Classifier
KNN Classifier
KDTree KNN Classifier
Maximum Likelihood Classifier
Minimum Distance Classifier
Product Explorer
Pixel Info
[1] Subset_20170818
Colors RGB
Navigatio...
Colour M...
Uncertai...
World...
Arctic Ocean
NORTH AMERICA
ASIA
EUROPE
North Atlantic Ocean
SOUTH AMERICA
AFRICA
South Atlantic Ocean
2000 Km
Off Globe

Intertidal bathymetry


High : 3.4
Low : 1.3

Questões

Pode a Detecção Remota usar algo mais que a radiação electromagnética?

Resposta:

Embora o uso do termo detecção remota pressupõe o uso de radiação electromagnética, a definição mais geral de "aquisição de informação à distância", não exclui outras formas de energia. O uso do som é uma alternativa óbvia. Um exemplo são os sonares acústicos usados no mar.

Questões

Assumindo que a velocidade da luz é $3x10^8$ m/s. Se a frequência de uma onda electromagnética é de 500.000 GHz (giga hertz GHz = 10^9 Hz), qual é o comprimento de onda da radiação?
Expresse sua resposta em micrómetros (μm).

Resposta:

$c = \lambda f$

$3x10^8$ (m/s) = λ (m) ($500000x10^9$ Hz)

$\lambda = 3x10^8 / 5x10^{14} = 6 \times 10^{-7}$ m

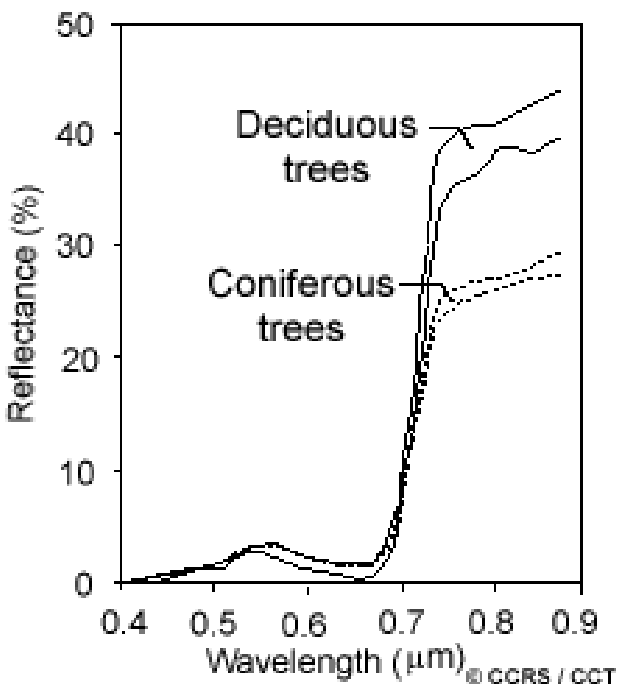
1 Hz = 1 s^{-1} (f=1/T)

Reposta : 0.6 μm

Questões

Se pretendêssemos mapear as árvores de folha caduca e as coníferas (por exemplo, pinheiros, ou abetos) numa floresta usando dados de DR, qual seria a melhor maneira de fazer este mapeamento?

Use as curvas de reflectância que ilustram o padrão de resposta espectral destas espécies para explicar a resposta.



Questões

Resposta:

Como ambos os tipos de árvores aparecem verdes ao olho nu não poderemos usar a banda do visível.

Olhando para as curvas da reflectância para os dois tipos de árvores, é claro que seria difícil distinguir com qualquer um dos comprimentos de onda visíveis.

No entanto, no infravermelho próximo, embora ambos os tipos reflictam uma parte significativa da radiação, são claramente separáveis.

Assim, um sistema de DR que detecte o infravermelho próximo (0,8 μm de comprimento de onda) seria ideal para esta finalidade.

Questões

Qual é a vantagem de se trabalhar com várias bandas espectrais como combinação colorida em vez de se examinar cada uma das imagens individualmente?

Resposta:

Combinando diferentes canais de diferentes comprimentos de onda numa imagem, podemos conseguir identificar combinações de reflectância entre os diferentes canais que evidenciem entidades/ caracteristicas que de outra forma não poderiam ser detectadas, se examinássemos um canal de cada vez.

Adicionalmente, estas combinações podem manifestar , elas mesmo, um subtil variação na cor (aos quais os nossos olhos sejam mais sensíveis) mais que as variações nos tons de cinzento que seriam vistos quando examinamos cada banda individualmente.

Questões

Uma imagem digitalizada, 2 bandas 7 x 7, sistema BIL

5	3	4	5	4	5	5	5	5	4	6	7	7	7	2	2	3	4	4	4	6	2	4

6	5	5	6	5	2	2	3	3	6	6	8	5	3	5	7	6	6	8	2	2	6	6

9	8	7	3	4	5	6	8	8	7	3	6	8	8	8	7	4	3	5	8	8	8	7

1	3	6	8	7	2	3	2	4	5	8	7	1	0	0	4	6	7	3	3	2	1	3

6	7	0	0	0	0

Questões

A imagem na sua forma convencional

PIXELS

		1	2	3	4	5	6	7
L	1							
I	2							
N	3							
E	4							
S	5							
	6							
	7							

BANDA ‘A’

PIXELS

		1	2	3	4	5	6	7
L	1							
I	2							
N	3							
E	4							
S	5							
	6							
	7							

BANDA ‘B’

Questões

A imagem na sua forma convencional

PIXELS

LINES		1	2	3	4	5	6	7
L	1	5	3	4	5	4	5	5
I	2	2	2	3	4	4	4	6
N	3	2	2	3	3	6	6	8
E	4	2	2	6	6	9	8	7
S	5	3	6	8	8	8	7	4
	6	3	6	8	7	2	3	2
	7	4	6	7	3	3	2	1

BANDA 'A'

PIXELS

LINES		1	2	3	4	5	6	7
L	1	5	5	4	6	7	7	7
I	2	2	4	6	5	5	6	5
N	3	5	3	5	7	6	6	8
E	4	3	4	5	6	8	8	7
S	5	3	5	8	8	8	7	1
	6	4	5	8	7	1	0	0
	7	3	6	7	0	0	0	0

BANDA 'B'

Questões

> LANDSAT has 15-degree field-of-view, 7000 pixels per spectral band. How much is the spatial resolution?

> Sabendo que o GFOV do Landsat é 185 km diga qual o valor do FOV.

> Sabendo que o Landsat tem um GIFOV de 30 m qual o valor de IFOV e quantos pixéis tem a imagem?

> Uma imagem com 4 bandas, 1000 x 3000 pixéis em formato float, quantos bytes tem?