

Detecção Remota Multiespectral



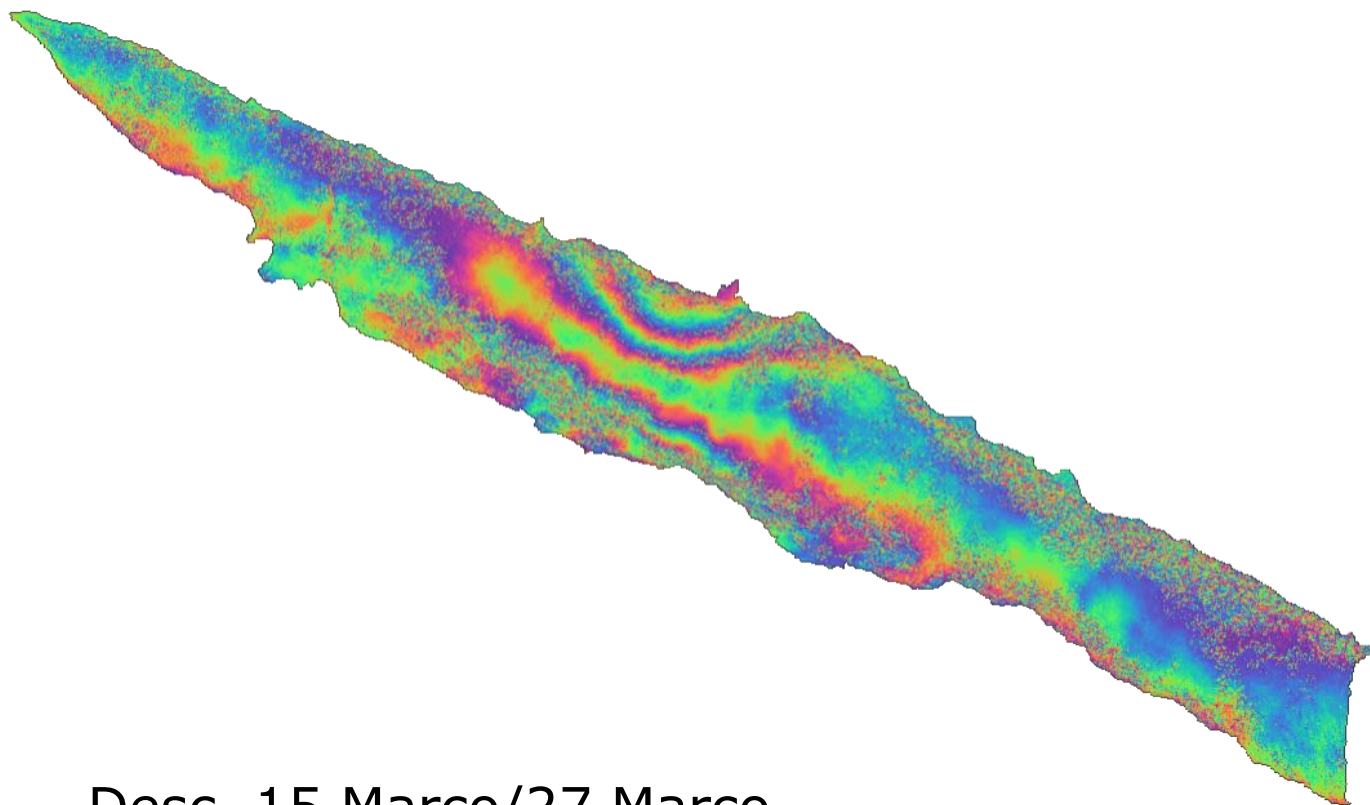
Capitulo 2 – Satélites e Sensores

- ❑ Satélites Meteorológicos
 - ❑ GOES, NOAA AVHRR, Outros satélites
- ❑ Altimetria Espacial
- ❑ Missões Geopotenciais Espaciais

- ❑ Missões Multiespetrais
 - ❑ LANSAT, SPOT, IRS, IKONOS, QuickBird, GeoEye-1

Crise Sismica ilha de S. Jorge

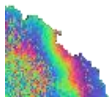
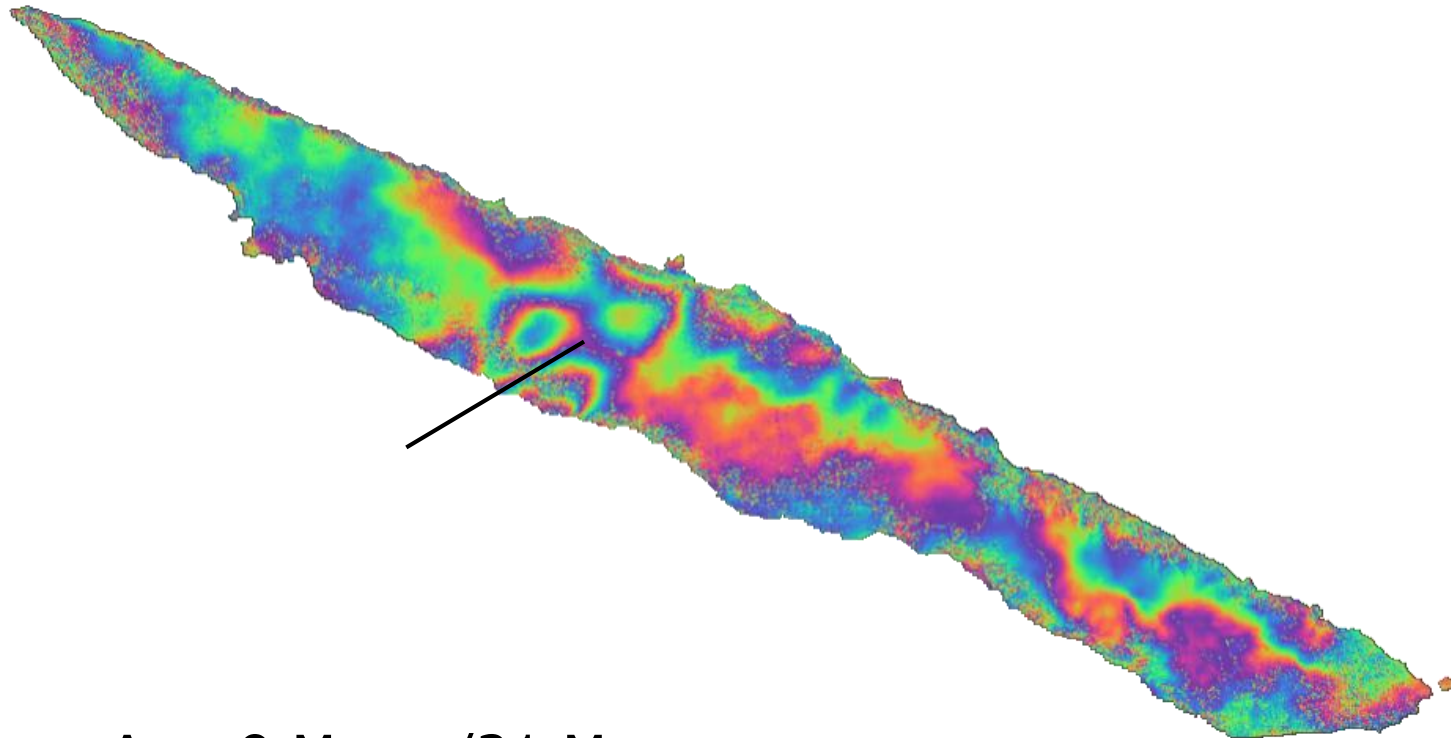
Interferograma SAR, Sentinel-1



Desc, 15 Março/27 Março

Crise Sismica ilha de S. Jorge

Interferograma SAR, Sentinel-1



Asc, 9 Março/21 Março

Using a 25-year record of satellite observations over the Getz region in West Antarctica, scientists have discovered that the pace at which glaciers flow towards the ocean is accelerating. This new research, which includes data from the Copernicus Sentinel-1 mission and ESA's CryoSat mission, will help determine if these glaciers could collapse in the next few decades and how this would affect future global sea-level rise.

Ice lost from Antarctica frequently hits the headlines, but this is the first time that scientists have studied this particular area in depth.

Led by scientists at the University of Leeds in the UK, the new research shows that between 1994 and 2018, all 14 glaciers in Getz accelerated, on average, by almost 25%, with three glaciers accelerating by over 44%.

The results, published today in *Nature Communications*, also reported that the glaciers lost a total of 315 gigatonnes of ice, adding 0.9 mm to global mean sea level – equivalent to 126 million Olympic swimming pools of water.



Journey to Destination Earth begins



Destination Earth initiative: an ambitious project that involves creating a digital replica of Earth to help us move towards a sustainable future.

Journey to Destination Earth begins

30 Março 2022.

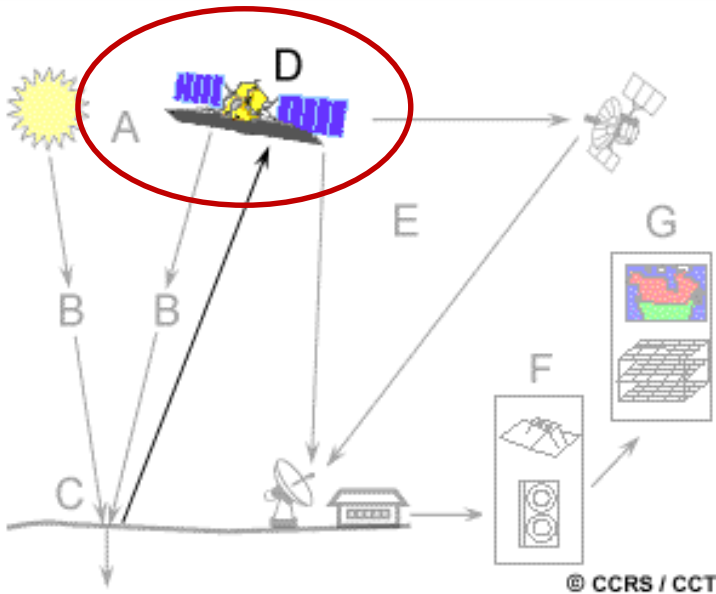
Today,
the European Commission, ESA,
the European Centre for Medium-Range Weather Forecasts (ECMWF) and
the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat)

celebrated the official launch of the **Destination Earth** initiative: an ambitious project that involves creating a digital replica of Earth to help us move towards a sustainable future.

Destination Earth (DestinE), led by the European Commission's DG Connect, aims to develop a highly accurate digital model of Earth that will monitor and predict environmental change and human impact. Using innovative Earth system models, cutting-edge computing, satellite data and machine learning, DestinE will allow its users to explore the effects of climate change on the different components of the Earth system, together with possible adaptation and mitigation strategies.

<https://youtu.be/FKVHZIGqEyw>

Missões de Observação da Terra



Meteorológicas

Geopotenciais

Altimetria de Satélite

Observação da Terra



ESA Home

About ESA

Space in Member States

Science & Exploration

Safety & Security

Applications

Enabling & Support

ESA Web TV

Videos

Images



Applications

Using space to benefit citizens and meet future challenges on Earth

GO TO TOPIC

Observing the Earth

OBSERVING THE EARTH

SENTINEL MISSIONS

EARTH EXPLORERS

METEOROLOGICAL MISSIONS

SPACE FOR OUR CLIMATE

Telecommunications

TELECOMMUNICATIONS & INTEGRATED APPLICATIONS

ARTES

CORE COMPETITIVENESS

PARTNERSHIP PROJECTS

ESA SPACE SOLUTIONS

Satellite navigation

NAVIGATION

GALILEO AND EGNOS

NAVISP

GNSS EVOLUTION

Observing the Earth

Latest

ALL

STORIES

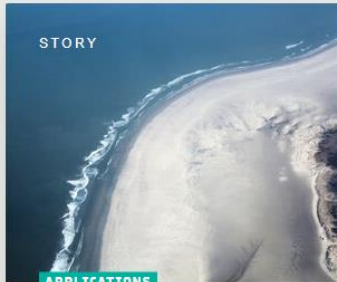
VIDEOS



**Earth from Space:
Barranquilla, Colombia**

01/04/2022 2733 VIEWS 48 LIKES

READ →



**Harmony in the
Wadden**

31/03/2022 2282 VIEWS 81 LIKES

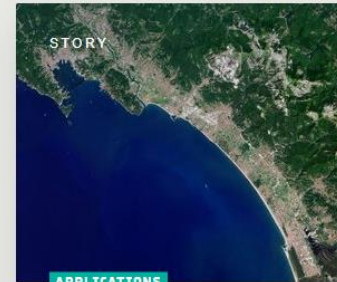
READ →



**Journey to Destination
Earth begins**

30/03/2022 4557 VIEWS 65 LIKES

READ →



**Earth from Space:
Carrara, Italy**

25/03/2022 13359 VIEWS 48 LIKES

READ →



**MTG-I weather
satellite passes tests
in preparation for lif...**

23/03/2022 2503 VIEWS 60 LIKES

READ →

Satélites / Sensores Meteorológicos



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

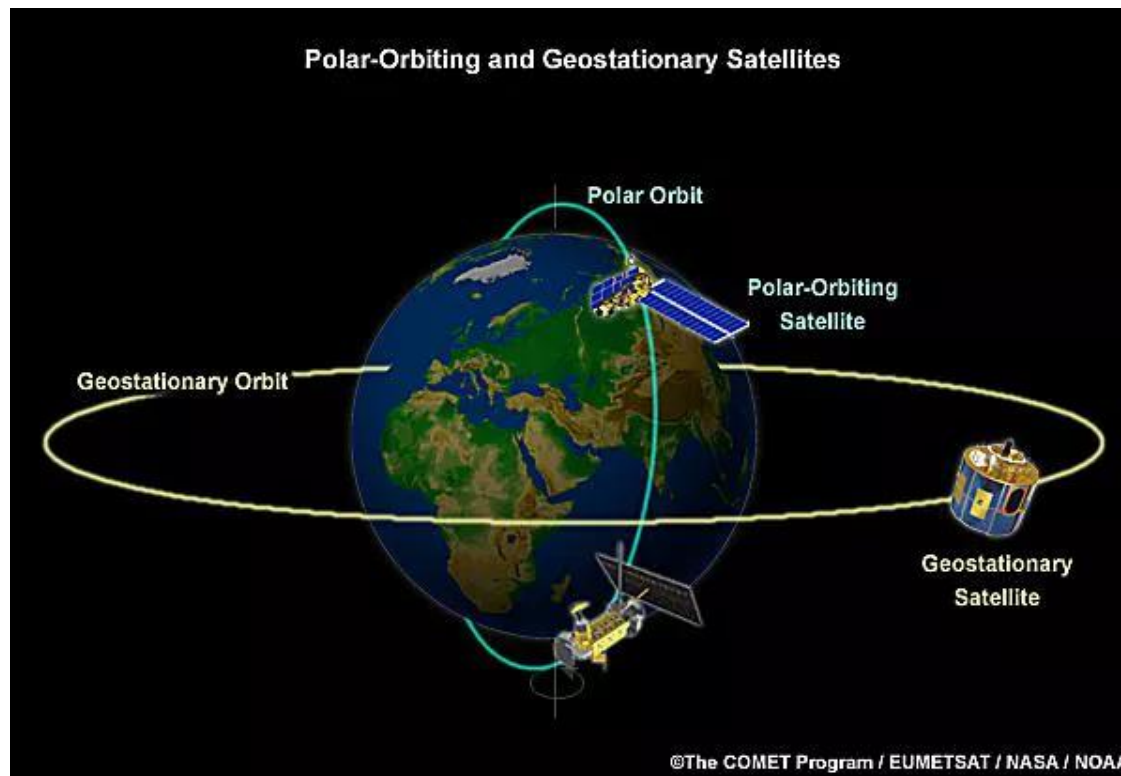
TIROS-1 : 1960, EUA.
(Television and Infrared Observation Satellite-1)

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)

Weather Satellites

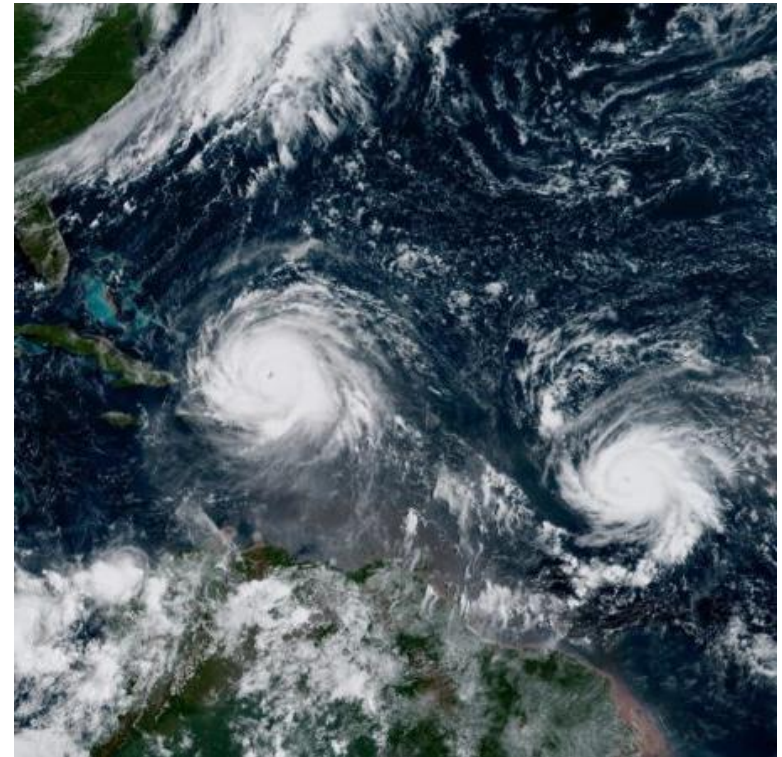
There are two kinds of weather satellites, **geostationary** and **polar orbiting**, each is best at detecting different types of weather events.



Weather Satellites

Weather satellite are primarily used to monitor the weather and climate of the Earth. Satellites can be **polar orbiting**, covering the entire Earth asynchronously, or **geostationary**, flying over the same spot on the equator.

Meteorological satellites monitor **clouds** and **cloud systems** (such as hurricanes), but are also used to monitor **environmental events** that interact with the atmosphere and have broad areal coverage, such as wildfires, volcanic ash clouds, dust storms, snow cover, sea ice, and ocean temperatures.



Weather Satellites

Some current operational weather satellites

Actors	Satellites	Orbit	Orbital Position
US	GOES-R Series	Geostationary	Western hemisphere
NOAA/NASA	JPSS-1 Mission	Polar-orbiting	Global coverage
Europe	MSG Series	Geostationary	Europe, Africa and the Indian Ocean
EUMETSAT/ESA	EPS-SG Series	Polar-orbiting	Global coverage



EUMETSAT



esa

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 70° em longitude que fornecem uma cobertura permanente da América.



Weather Satellites



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

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



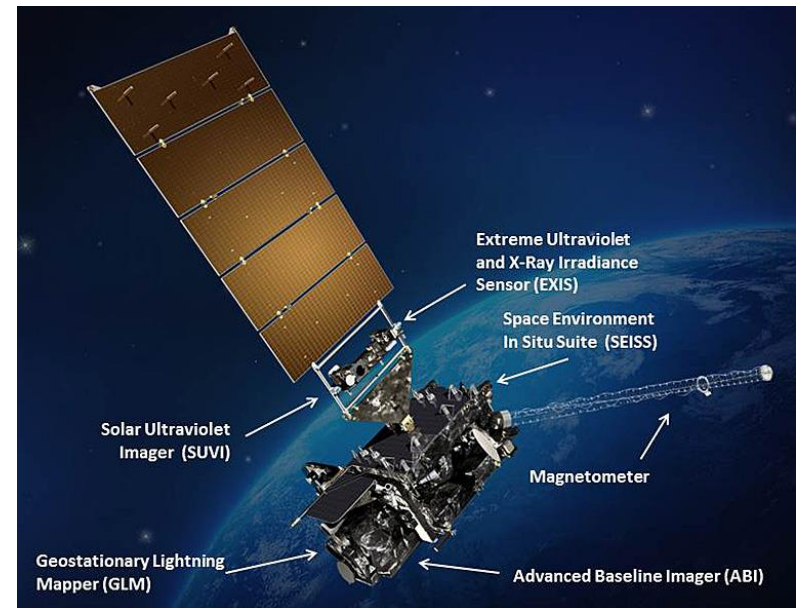
GOES - Bandas

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



The **Advanced Baseline Imager (ABI)** is the primary instrument on the GOES-R Series spacecraft for imaging Earth's weather, oceans and environment.

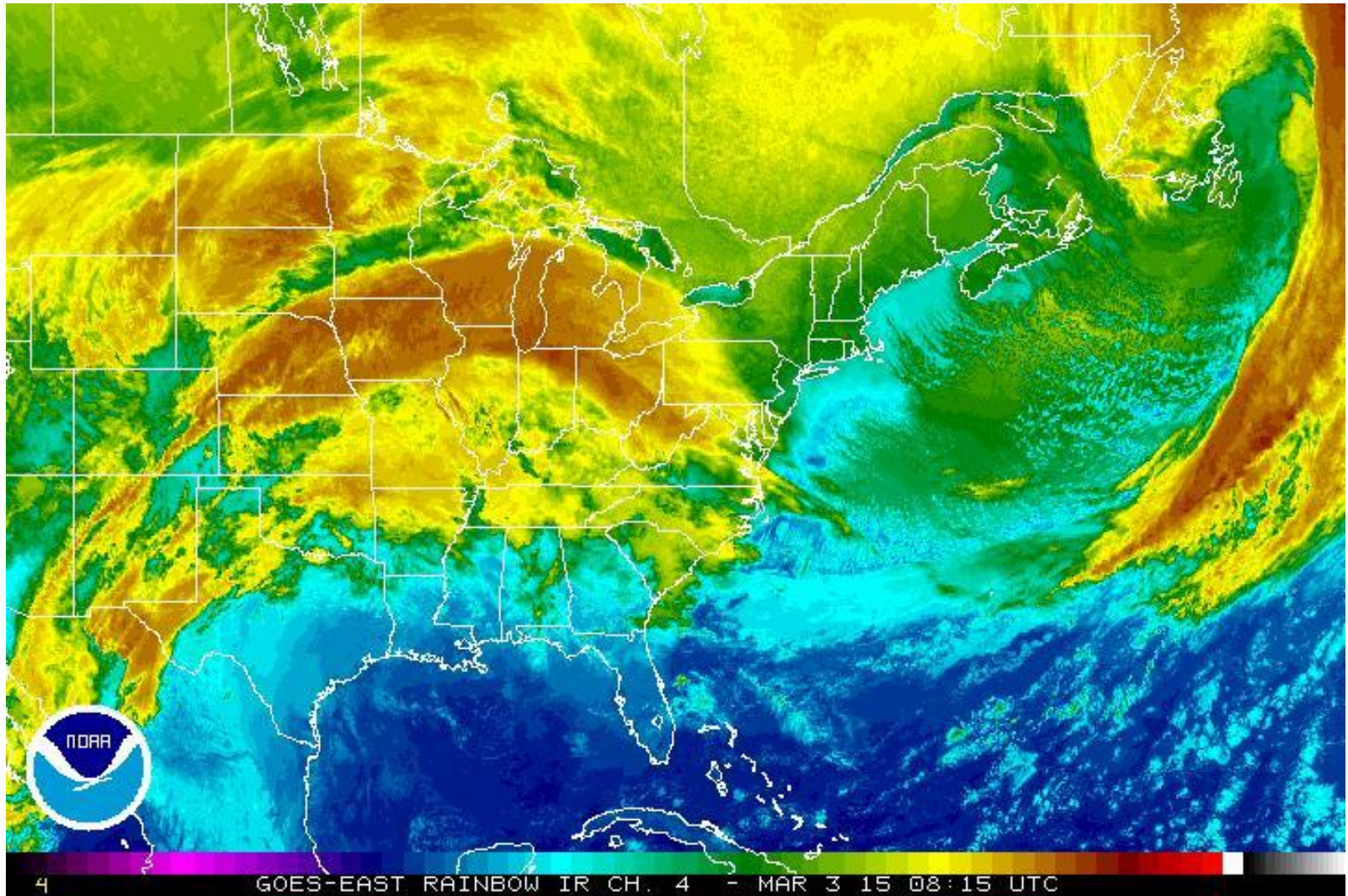
ABI views Earth with **16 spectral bands** (compared to five on previous GOES), including two visible channels, four near-infrared channels, and ten infrared channels. It provides three times more spectral information, four times the spatial resolution (1km), and five times faster coverage than previous GOES.





GOES

Ciências
ULisboa



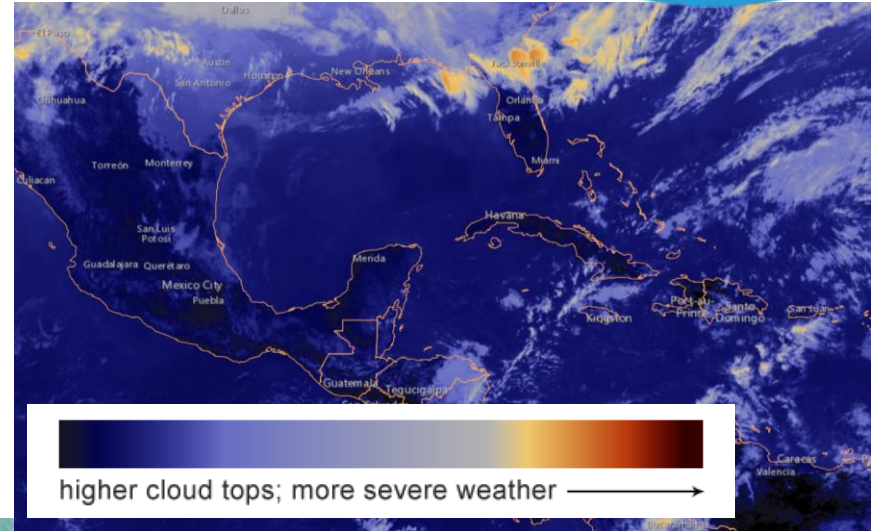


Weather Satellites



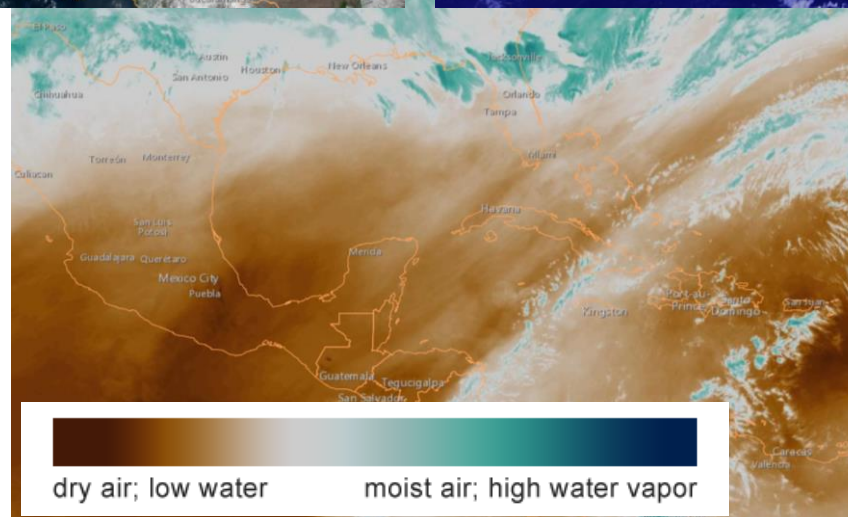
How the human eye would see Earth from space during daylight hours

Geocolor Map



higher cloud tops; more severe weather →

Infrared Map



dry air; low water moist air; high water vapor

Water vapor Map

A **NOAA** é responsável por outra série de satélites usados em aplicações meteorológicas, os NOAA-1..-15.

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)

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.

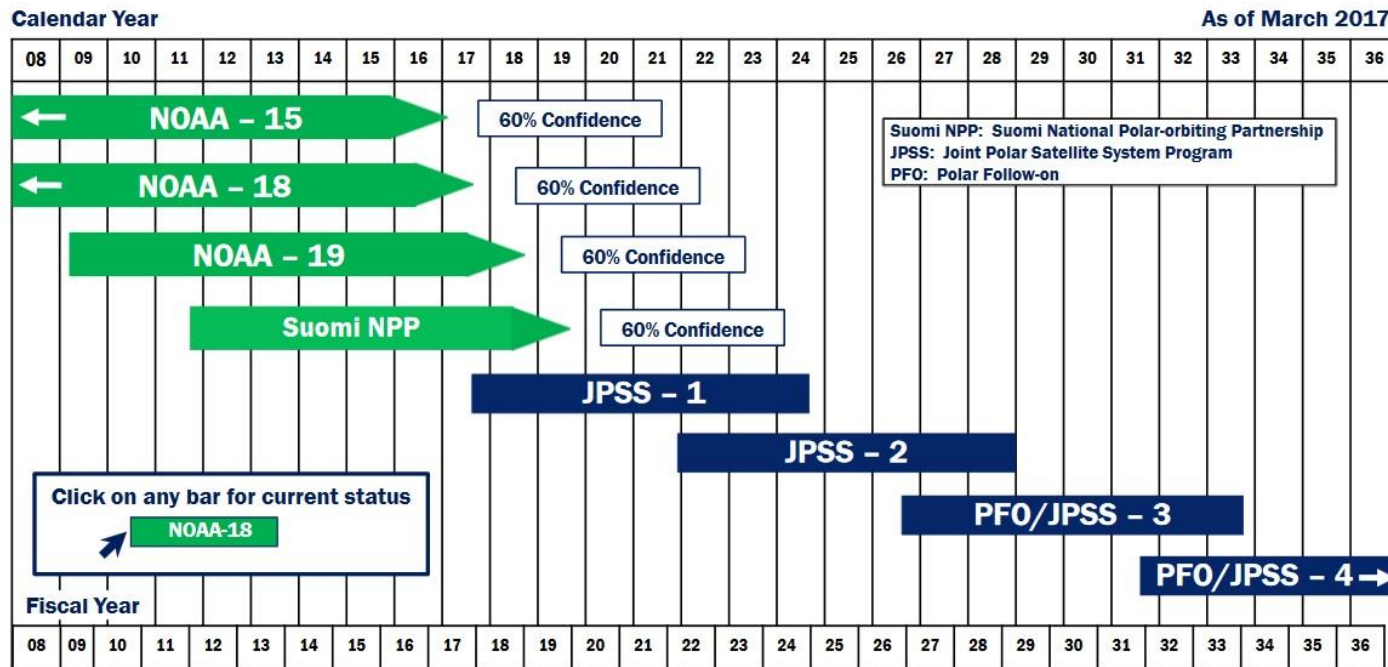
$$\text{GIFOV} = 2 * H * \tan(\text{IFOV}/2)$$



Weather Satellites



NOAA Polar Satellite Programs Continuity of Weather Observations

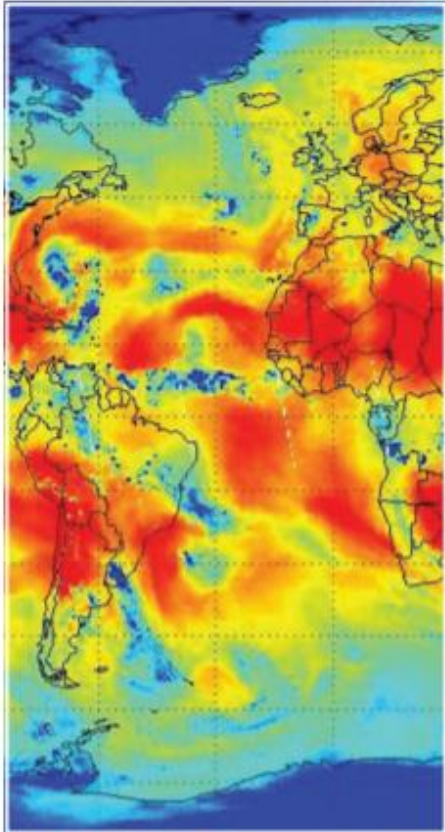


Approved: 
Assistant Administrator for Satellite and Information Services

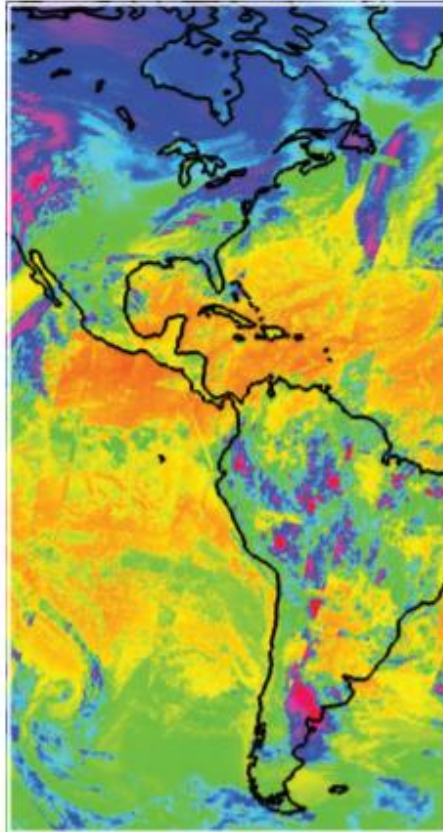
	In orbit and operating		Planned Mission Life, from Planned Launch Date
	Launched before Jan 2008		Planned Mission Life Beyond 2036
	Reliability analysis-based extended weather observation life estimate (60% confidence) for satellites on orbit for a minimum of one year – Most recent analysis: July 2016		

Instrument	Spectral coverage	Resolution	Mission
ATMS Advanced Technology Microwave Sounder	22 bands from 23 GHz to 183 GHz	15.8-74.8 km	Provide sounding profiles of atmospheric temperature and moisture in conjunction with CrIS
CrIS Cross-Track Infrared Sounder	1305 bands from 3.92 μm to 15.38 μm	FOV 14 km 1km vertical layer	Produce high vertical resolution temperature and water vapor information needed to maintain and improve weather forecast skill out to 5 to 7 days in advance
VIIRS Visible Infrared Imaging Radiometer Suite	22 bands Coverage from 412 nm to 12 μm	400 m	Collects images and radiometric data used to provide information on the Earth's clouds, atmosphere, oceans and land surfaces
OMPS Ozone Mapping and Profiler Suite	Mapper 0.3-0.38 μm Profiler 0.25-0.31 μm	Mapper 50 km Profiler 250 km	Measures the concentration of ozone in the Earth's atmosphere and tracks the health of the ozone layer

Weather Satellites



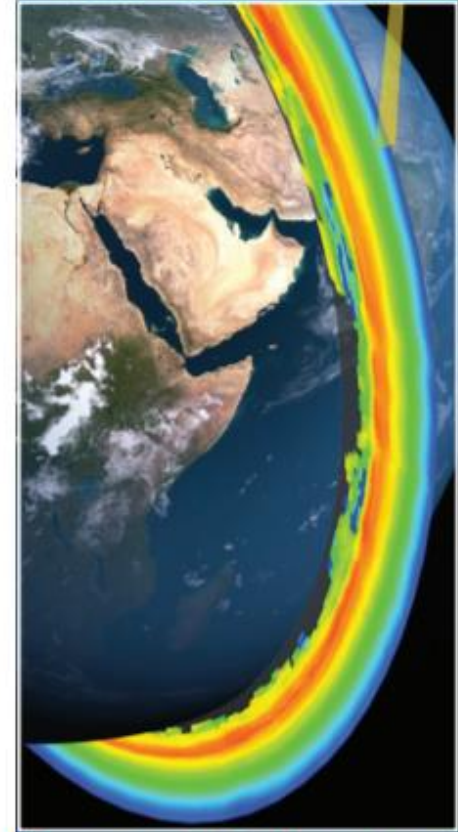
ATMS channel 18-microwave antenna temperature at 183.3 GHz. 11/08/2011



Composite of three days of CrIS data Jan 21, 23, 25th, 2012 - Credit: NOAA/NASA



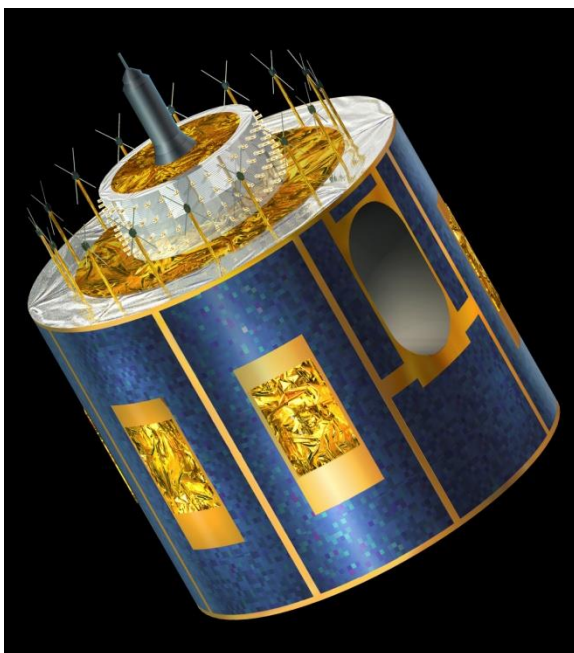
Tropical Cyclone Chapala as seen by Suomi NPP's VIIRS instrument on 11/1/2015
Credit: NOAA/NASA



Cross-section of the Earth's ozone layer as measured by the DMPS - Credit: NOAA/NASA

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 está operacional desde 2021.

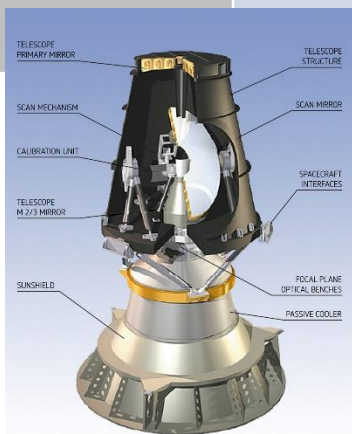


Estes satélites têm dois instrumentos:

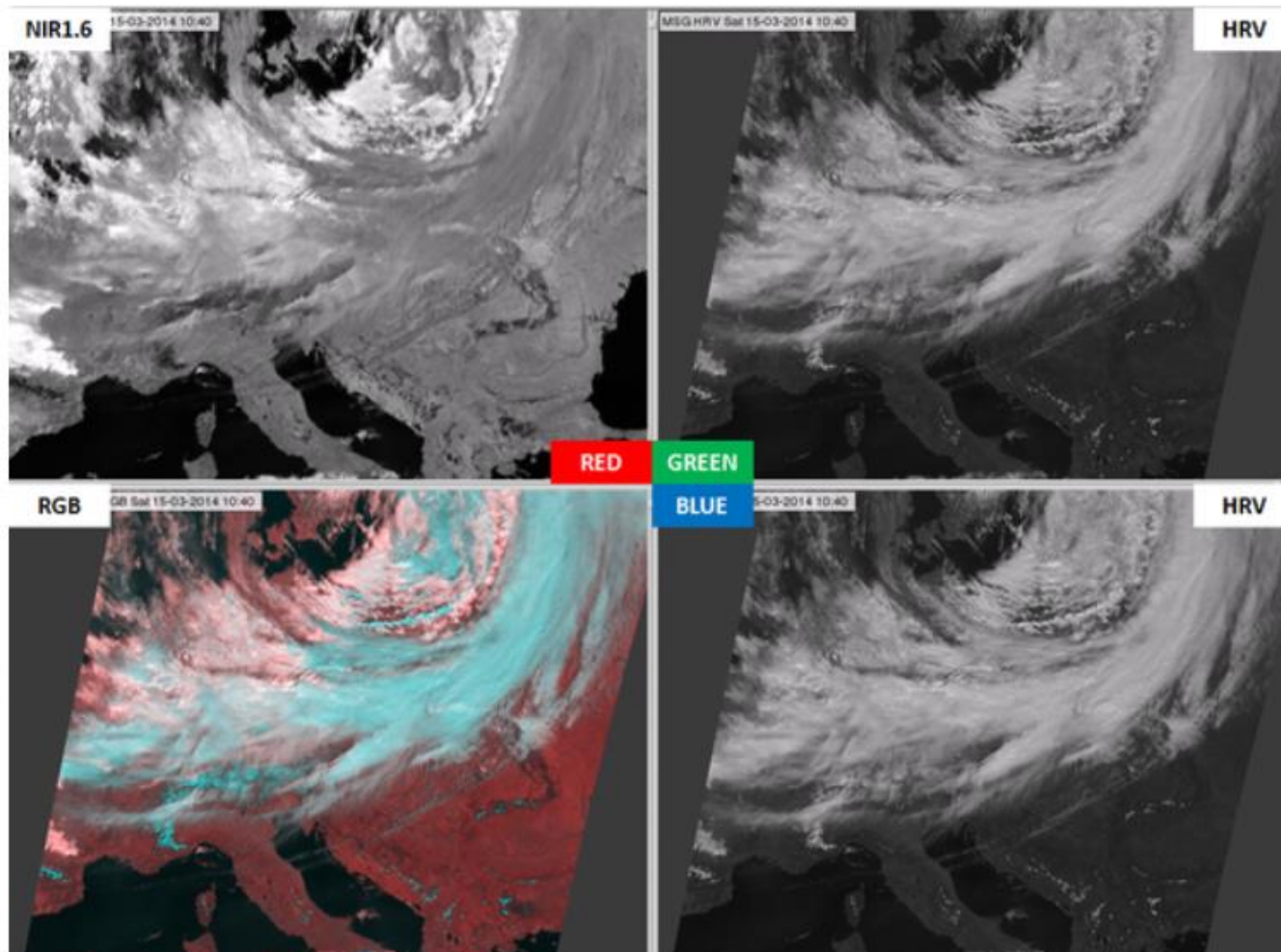
SERIVI (Spinning Enhanced Visible and InfraRed Imager) com 12 canais espectrais. Tem como objectivo a previsão meteorológica.

GERB (Geostationary Earth Radiation Budget) que suporta estudos climáticos

Instrument	Spectral coverage	Resolution	Mission
SEVIRI Spinning Enhanced Visible and InfraRed Imager	8 bands in the thermal infrared from 3.9 to 13.4 μm	3 km	Provide permanent data about the temperatures of clouds, land and sea surfaces
	4 visible/NIR bands from 0.4 to 1.6 μm	1 km for the high resolution visible band 3 km for the NIR and the 3 other visible bands	NIR allows to discriminate clouds from snow and water clouds from ice clouds. In combination with the 2 visible bands VIS0.6 and VIS0.8, it improves the observation of aerosol, soil moisture and vegetation index.



Weather Satellites

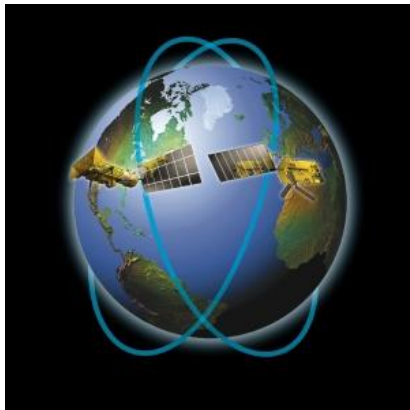


NIR1.6 (upper left), HRV (upper and bottom right) and HRV Fog RGB image (bottom left) for 15 March 2014

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 foi 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

Instrument	
<p>IASI Infrared Atmospheric Sounding Interferometer</p>	<p>Infrared Michelson Interferometer for temperature sounding, water vapour, and ozone monitoring. IASI covers the spectral range from 3.62-15.5 μm, 2112 km swath width and a resolution of 12 km at nadir.</p>
<p>AMSU-A Advanced Microwave Sounding Unit A1 and A2</p>	<p>Microwave sounder for temperature sounding under clear and overcast conditions, 15 channels in the 23 to 90 GHz frequency range.</p>
<p>MHS Microwave Humidity Sounder</p>	<p>MHS is a self-calibrating, cross-track scanning, five-channel microwave, full-power radiometer operating in the 89 to 190 GHz range to provide information on atmospheric water vapour.</p>
<p>HIRS High Resolution Infrared Radiation sounder/4</p>	<p>Atmospheric Sounder for temperature and humidity profiles, surface temperature, cloud parameters and total ozone, 19 infrared channels (3.8-15μm), one visible channel.</p>

Instrument	
<p>GOME-2 Global Ozone Monitoring Experiment-2</p>	<p>Nadir viewing UV and visible spectrometer to measure radiation back-scattered from the atmosphere and reflected from the earth surface in the UV and visible range 240-790 nm with a spectral resolution of 0.2-0.4 nm</p>
<p>AVHRR Advanced Very High Resolution Radiometer/3</p>	<p>Visible/infrared imaging radiometer for global measurement of cloud cover, sea surface temperature, ice, snow and vegetation cover and characteristics, six channels.</p>
<p>ASCAT Advanced Scatterometer</p>	<p>Pulsed radar in C-band at 5.2555 GHz for global sea surface wind vector measurement. ASCAT has two 500 km wide swaths with spatial resolution <50 km.</p>
<p>GRAS Global Navigation Satellite System Receiver for Atmospheric Sounding</p>	<p>Radio occultation receiver for atmosphere sounding of temperature and humidity profiles.</p>

28 September 2012

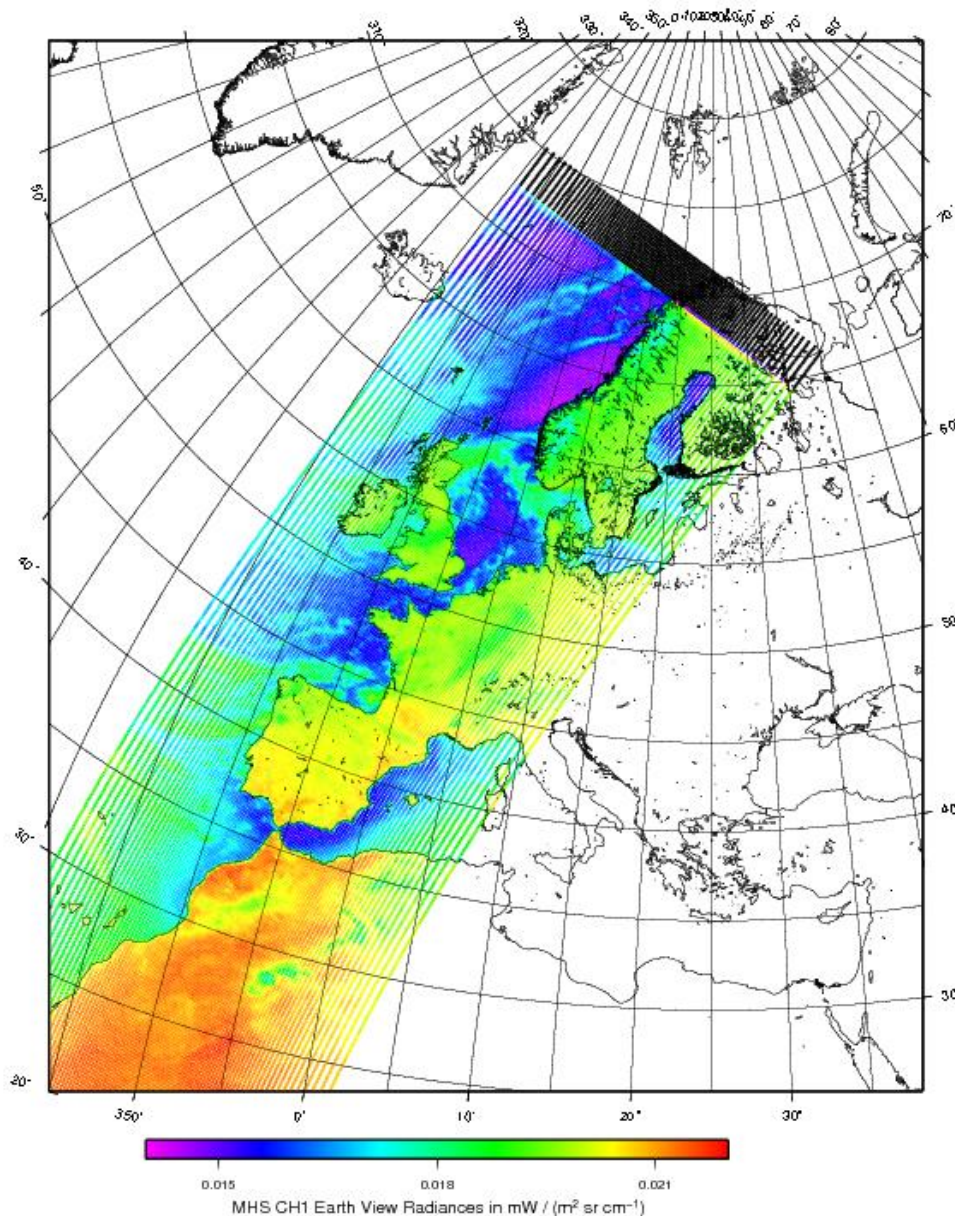
Four of the instruments on the Metop-B weather satellite (AMSU-A, ASCAT, MHS, GRAS) have been activated this week and are delivering data.

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

Metop-B MHS, Orbit 110, 25/09/12 10:06:51 to 10:24:51





Sentinel – 4 & Sentinel – 5

The instrument will be carried on the MetOp-SG A satellite.

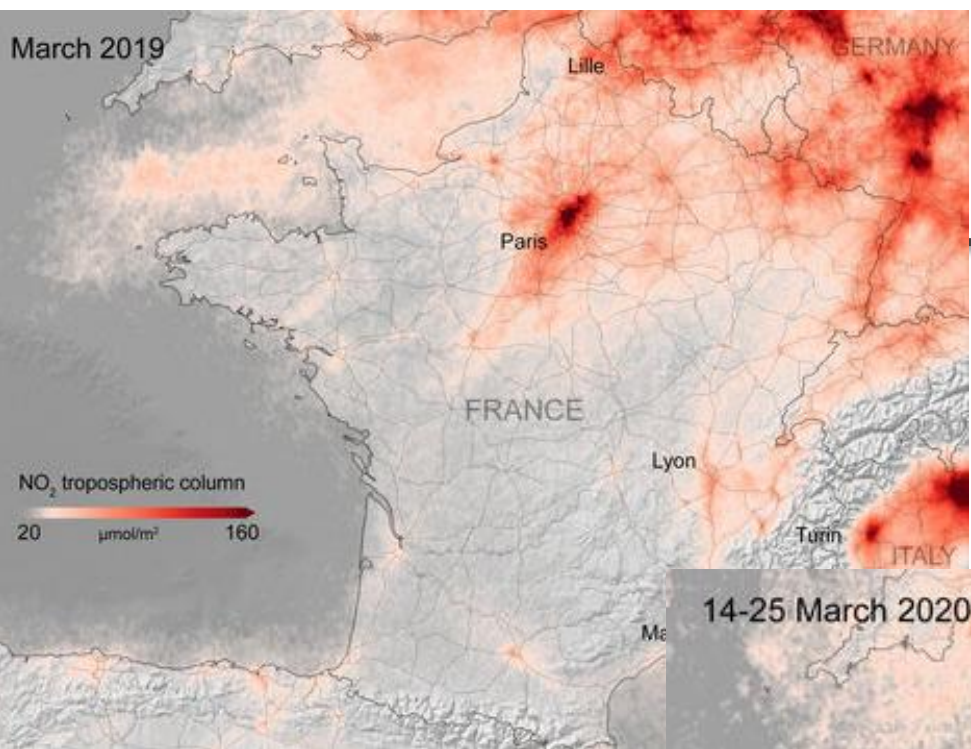
The missions SENTINEL-4, -5 and -5 precursor (S4, S5, S5P, respectively) are conceived as complementary elements of a constellation serving the specific needs of the Copernicus Atmospheric Monitoring Services (CAMS).

SENTINEL-5 is focused on air quality and composition-climate interaction with the main data products being O₃, NO₂, SO₂, HCHO, CHOCHO and aerosols.

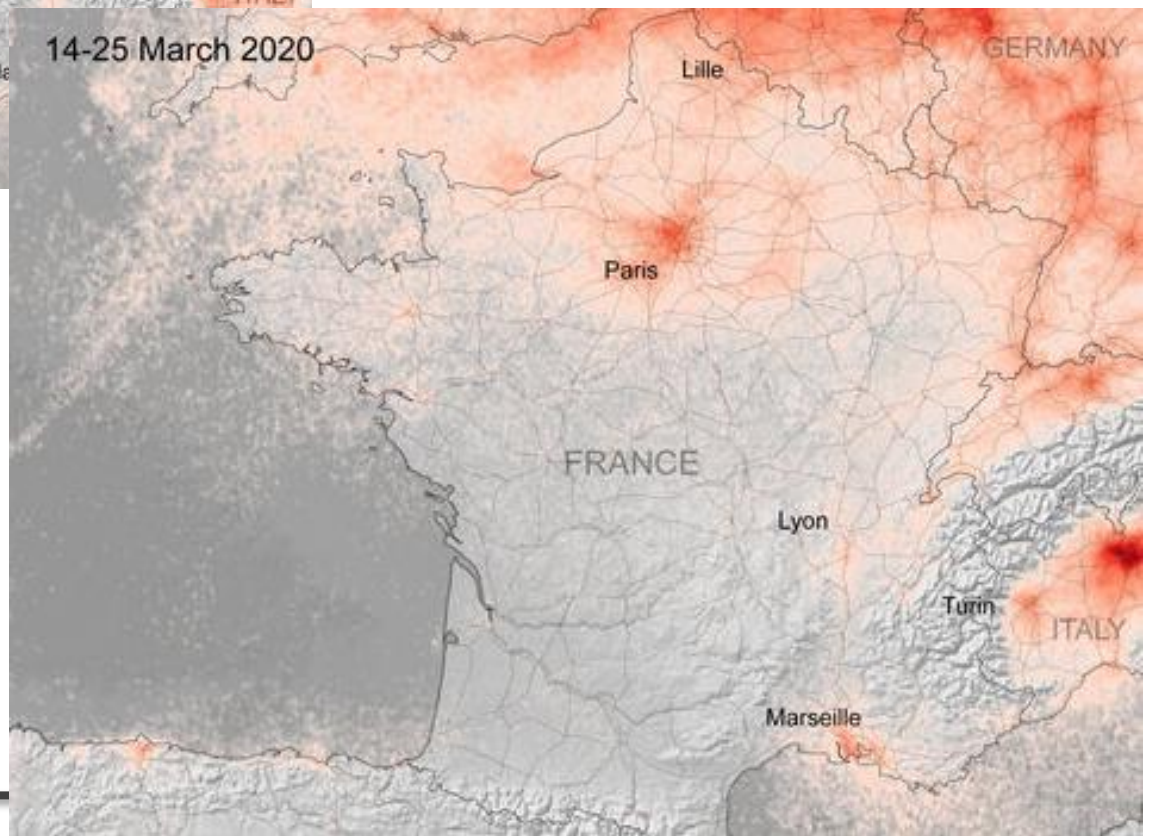
Additionally SENTINEL-5 will also deliver quality parameters for CO, CH₄, and stratospheric O₃ with daily global coverage for climate, air quality, and ozone/surface UV applications.

The SENTINEL-5 mission consists of high resolution spectrometer system operating in the ultraviolet to shortwave infrared range with 7 different spectral bands: UV-1 (270-300nm), UV-2 (300-370nm), VIS (370-500nm), NIR-1 (685-710nm), NIR-2 (745-773nm), SWIR-1 (1590-1675nm) and SWIR-3 (2305-2385nm).

March 2019

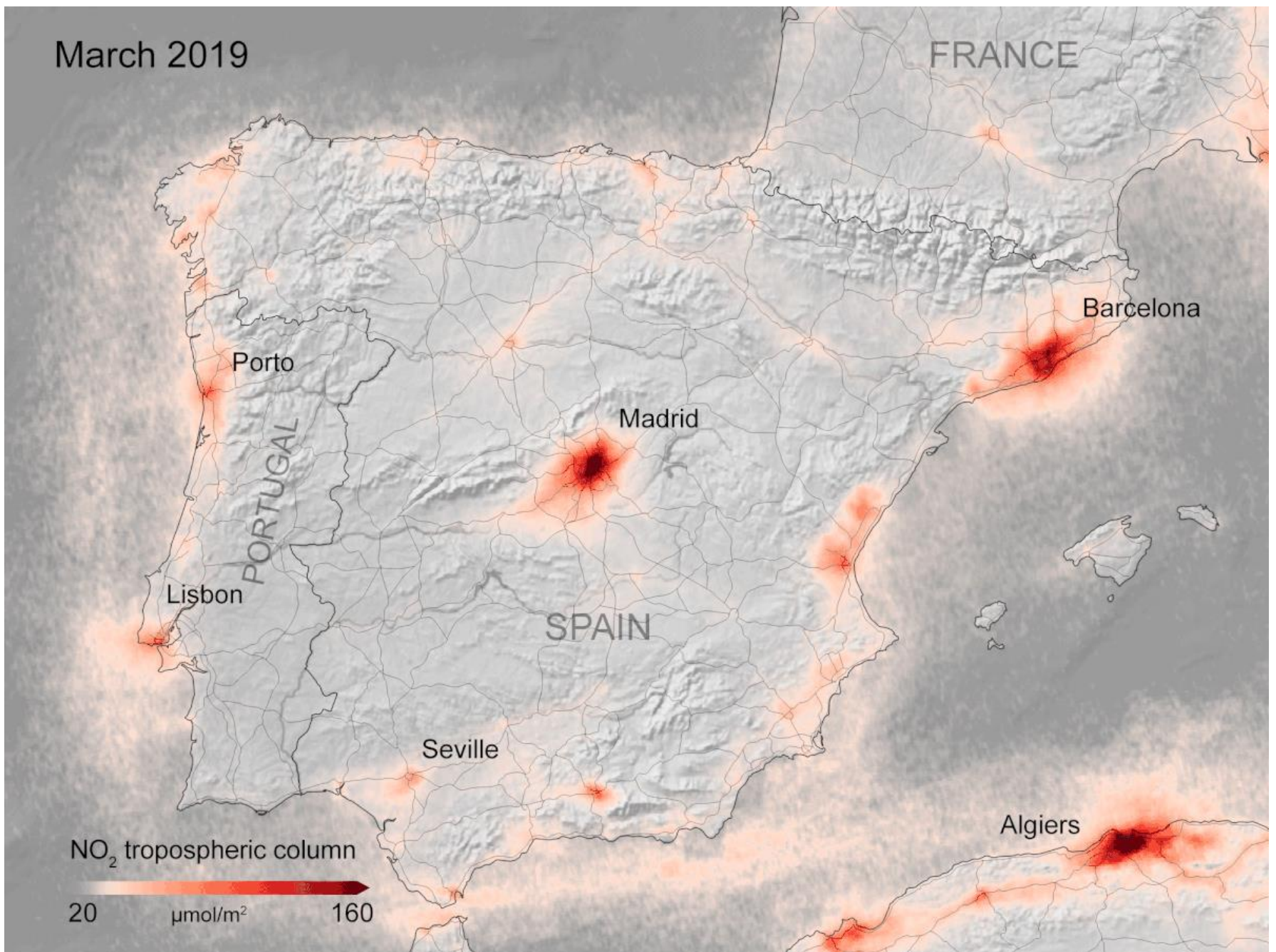



14-25 March 2020



March 2021


March 2019





LSA SAF
Land Surface Analysis

LAND SURFACE ANALYSIS SATELLITE APPLICATIONS FACILITY



Guest

- About
- Home
- Overview
- Links
- Contacts
- Site Map
- Site Search
- News
- Messages
- Workshops
- Forum
- Products
- Description
- Development Status
- Documents
- List
- Publications
- User Support

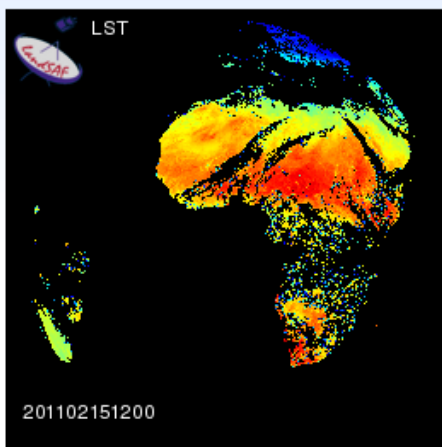
Home

The scope of Land Surface Analysis Satellite Applications Facility (LSA SAF) is to increase benefit from EUMETSAT Satellite (MSG and EPS) data related to:

- Land
- Land-Atmosphere interaction
- Biospheric Applications

The LSA SAF performs:

- R&D Programs.
- Operational Activities
 - Generation
 - Archiving
 - Dissemination



LST
201102151200

[See colour legends...](#)

of land surface related products.

Latest News:

Product Development Status:

MSG/SEVIRI based products

Wild Fires

- Fire Radiative Power - PIXEL
- Fire Radiative Power - GRID

Vegetation Parameters

- Fraction of Vegetation Cover
- Leaf Area Index
- Fraction of Absorbed Photosynthetic Active Radiation

Snow Cover

- Snow Cover (daily)
- Snow Cover (15 mins)

Other

- Bi-Directional Reflectance Factor
- Land Surface Emissivity

Albedo

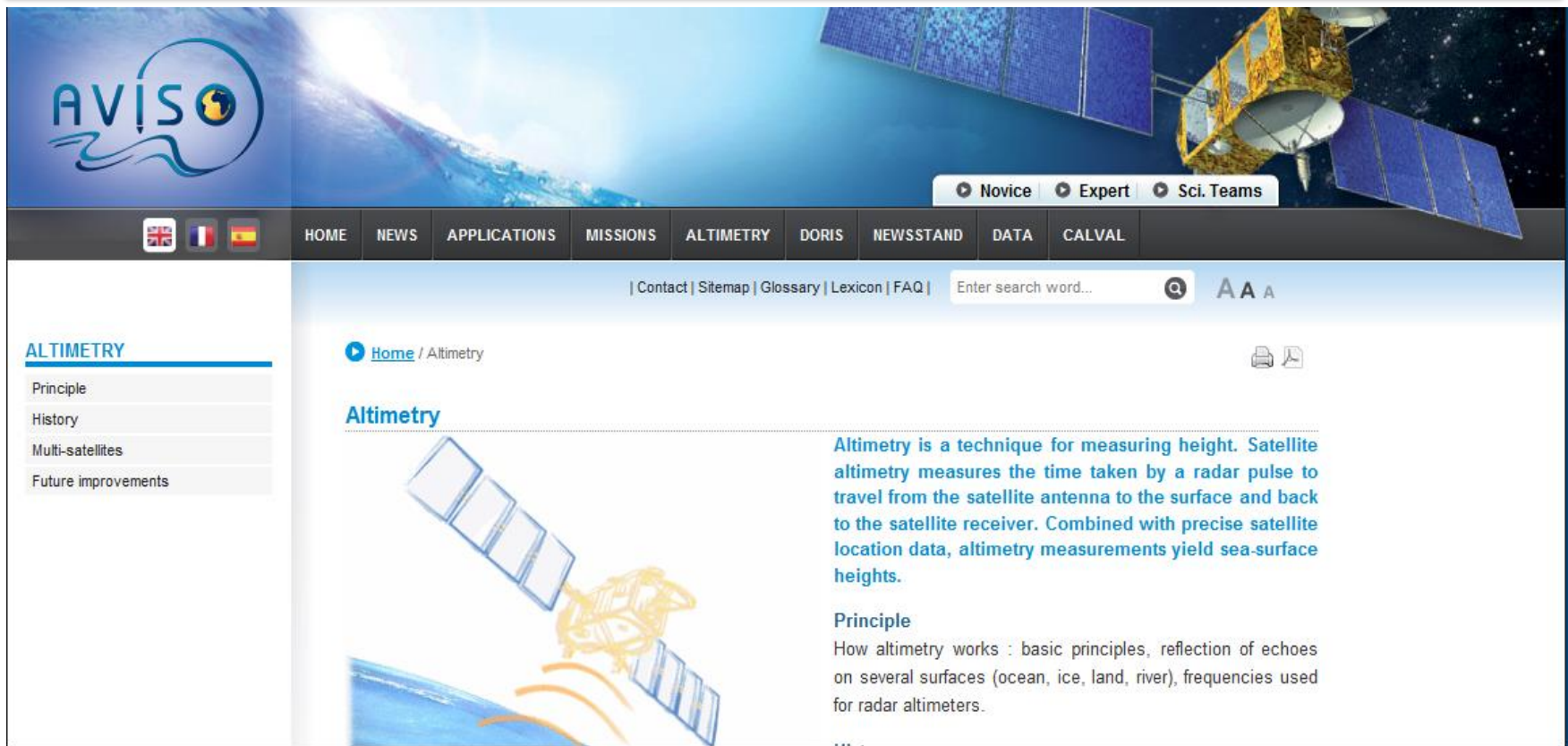
- Surface Albedo
- MSG Ten Day Surface Albedo

Land Surface Temperature

- Land Surface Temperature (15 mins)

Altimetria Espacial / Satellite Altimetry

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.

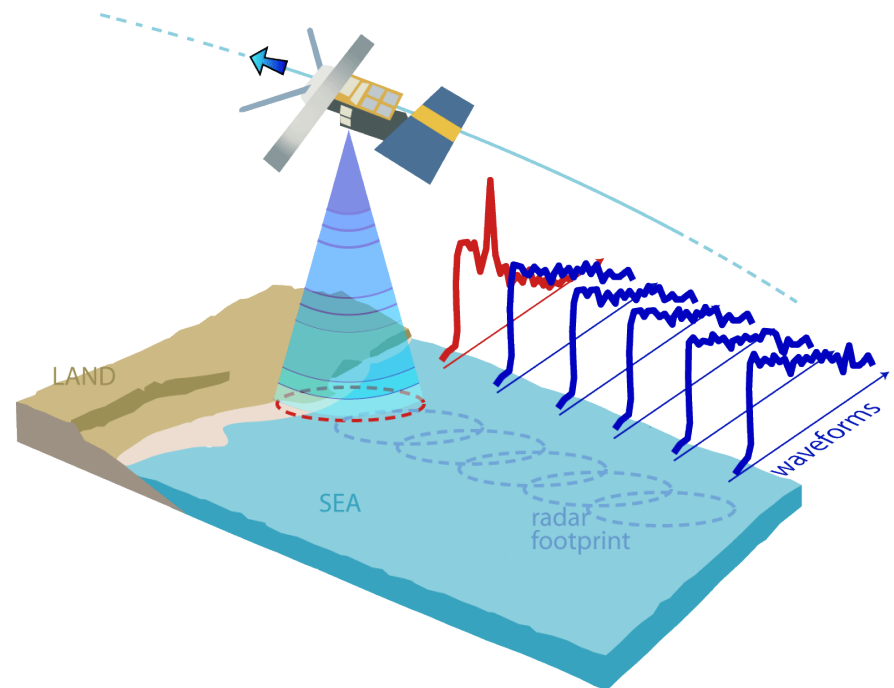


The screenshot shows the AVISO website's Altimetry page. The header features the AVISO logo and a navigation menu with options like HOME, NEWS, APPLICATIONS, MISSIONS, ALTIMETRY, DORIS, NEWSSTAND, DATA, and CALVAL. A search bar and language selection icons are also present. The main content area includes a breadcrumb trail (Home / Altimetry), a sub-header for Altimetry, and a detailed description of the technique. The description states: "Altimetry is a technique for measuring height. Satellite altimetry measures the time taken by a radar pulse to travel from the satellite antenna to the surface and back to the satellite receiver. Combined with precise satellite location data, altimetry measurements yield sea-surface heights." Below this, a section titled "Principle" explains the basic principles, reflection of echoes on various surfaces (ocean, ice, land, river), and the frequencies used for radar altimeters. An illustration of a satellite in orbit is visible on the left side of the page.

Satellite Altimetry

Altimetry is a technique for measuring height. **Satellite altimetry** measures the time taken by a radar pulse to travel from the satellite antenna to the surface and back to the satellite receiver. Combined with precise satellite location data, altimetry measurements yield **sea-surface heights**.

The magnitude and shape of the echoes (or waveforms) also contain information about the characteristics of the surface which caused the reflection. The best results are obtained over the **ocean**, which is spatially homogeneous.

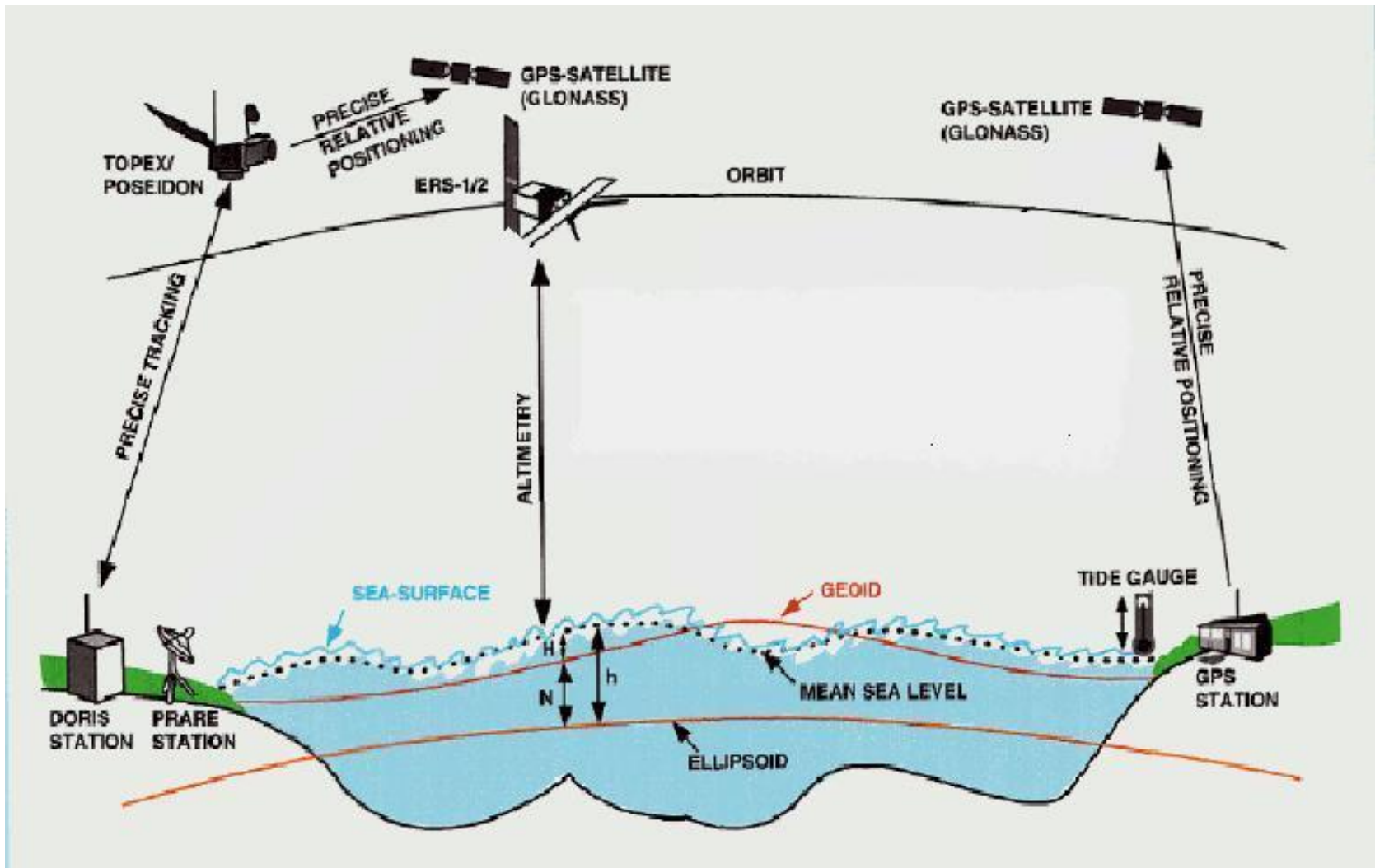


Altimetria Espacial



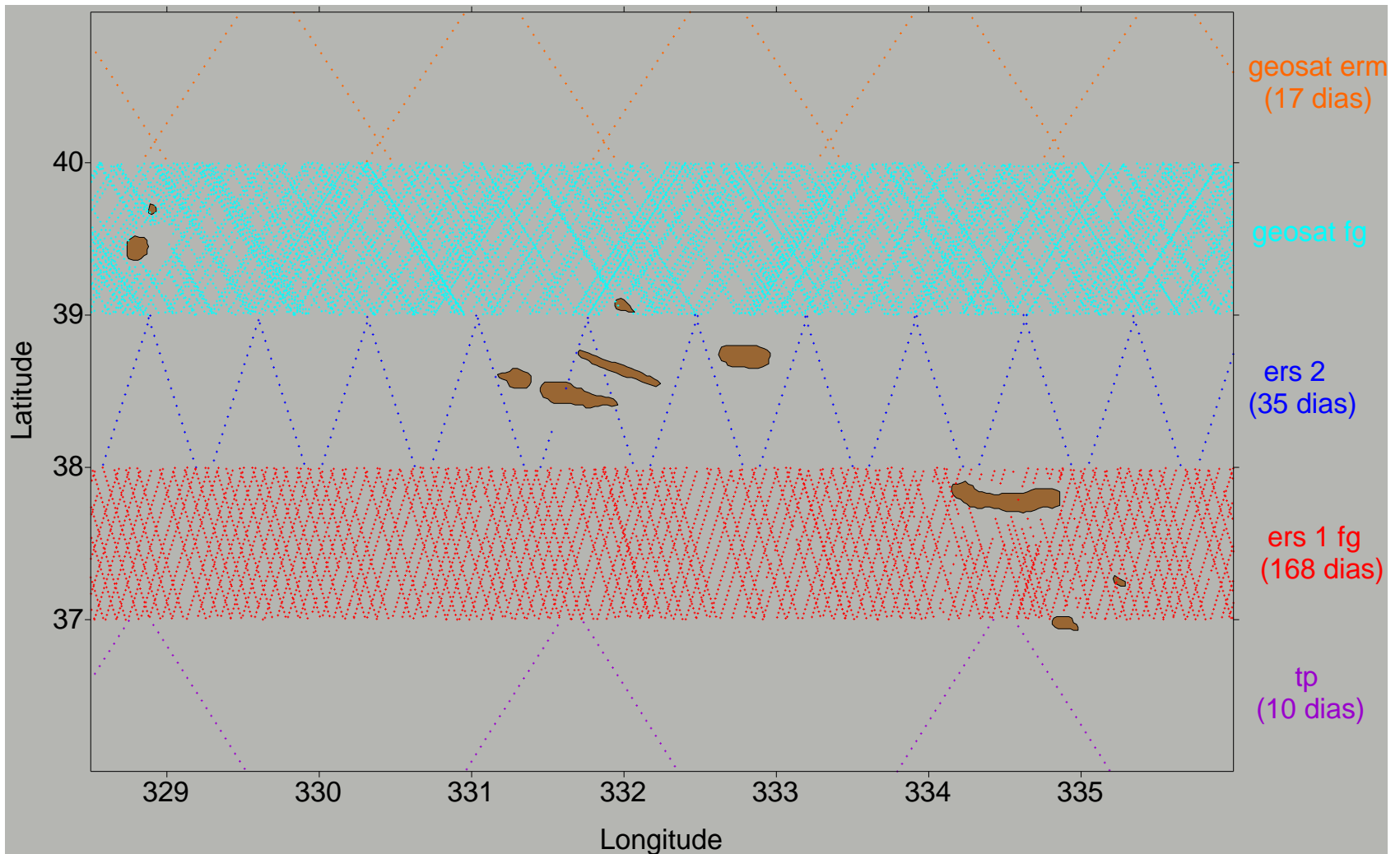
O resultado da Altimetria Espacial são as altitudes da superfície do mar, ou topografia do mar (Sea Surface Heights)

Altimetria Espacial

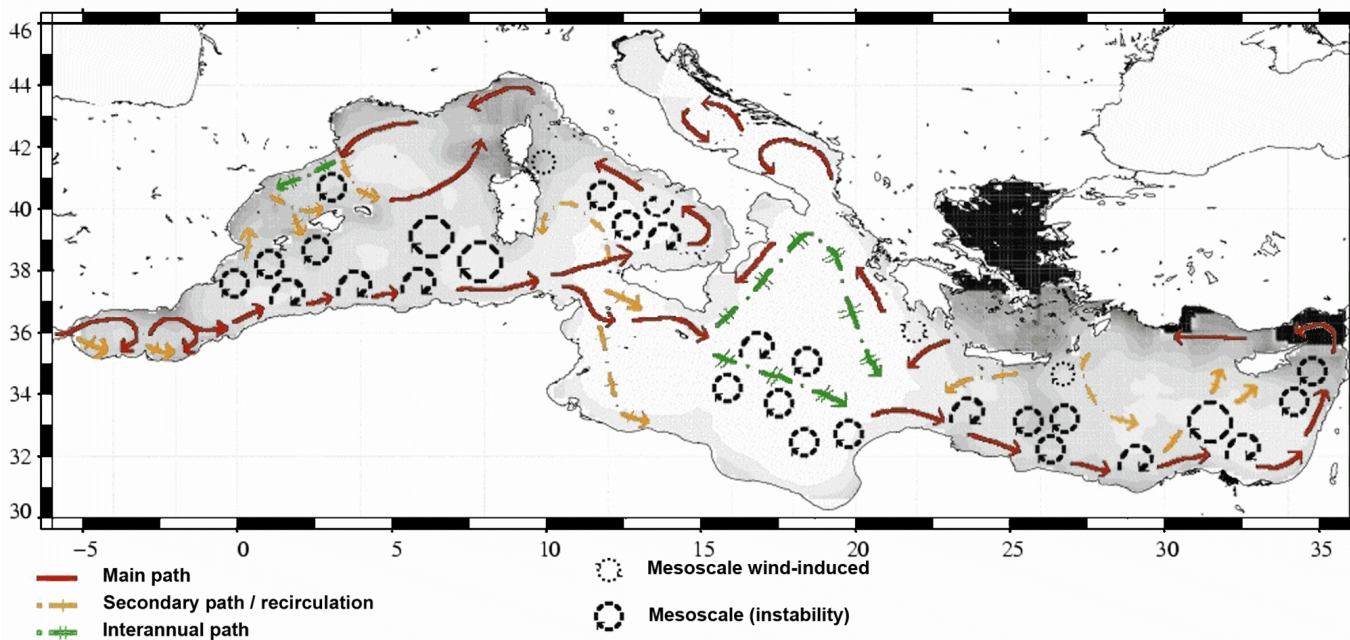
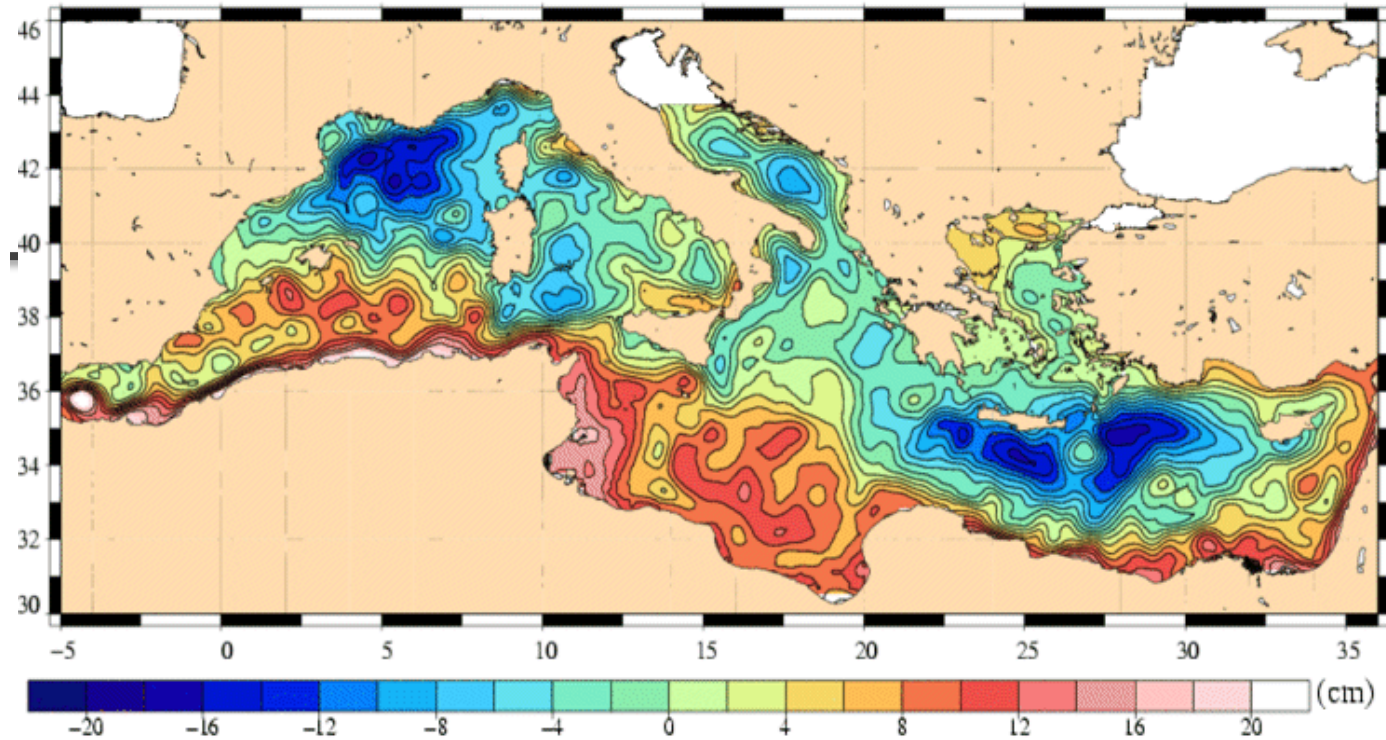




Altimetria Espacial

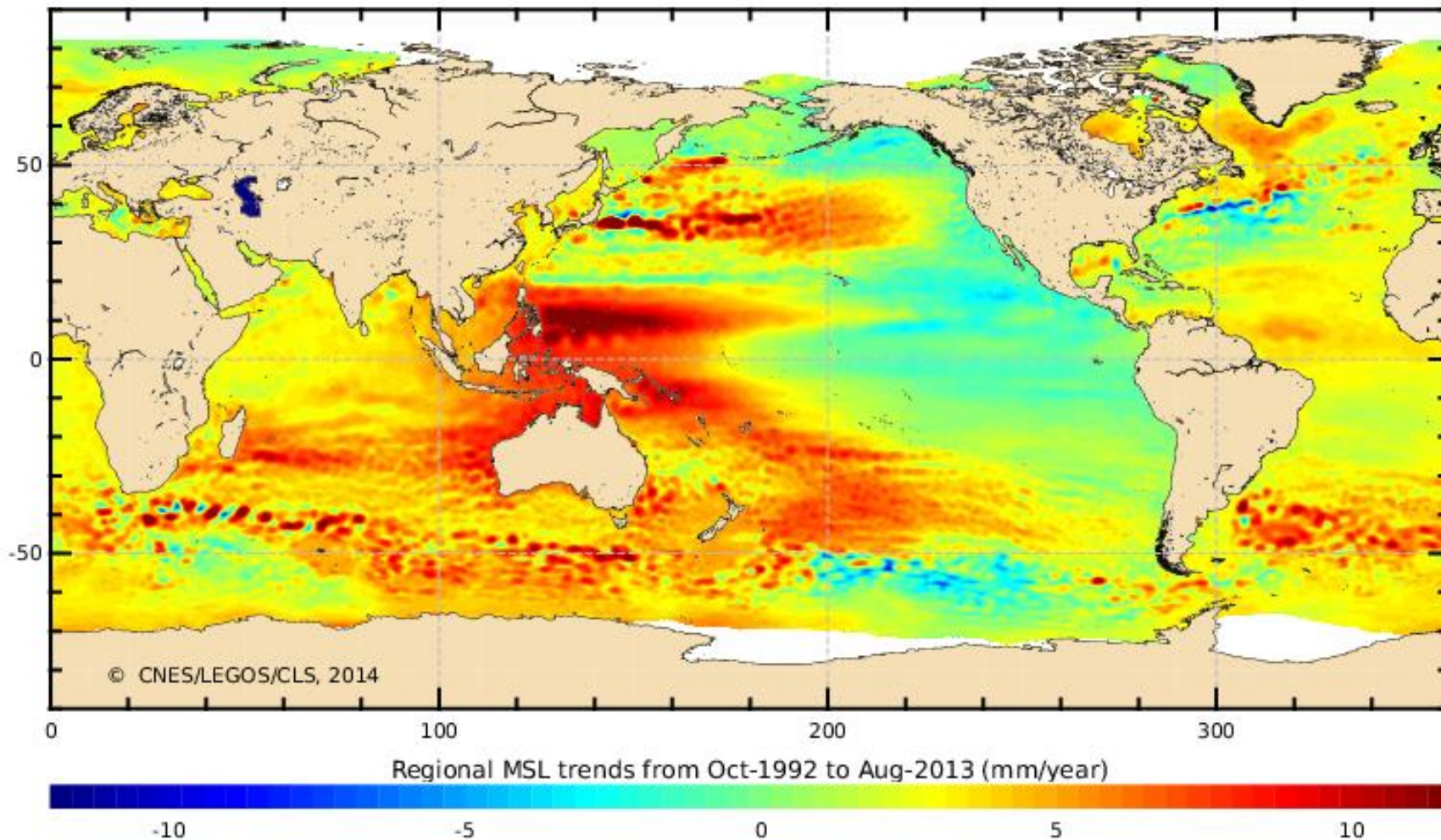


Topografia Dinâmica Média (1993-1999).
 Calculada a partir de dados altimétricos, dados Grace e gravimetria de satélite.



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

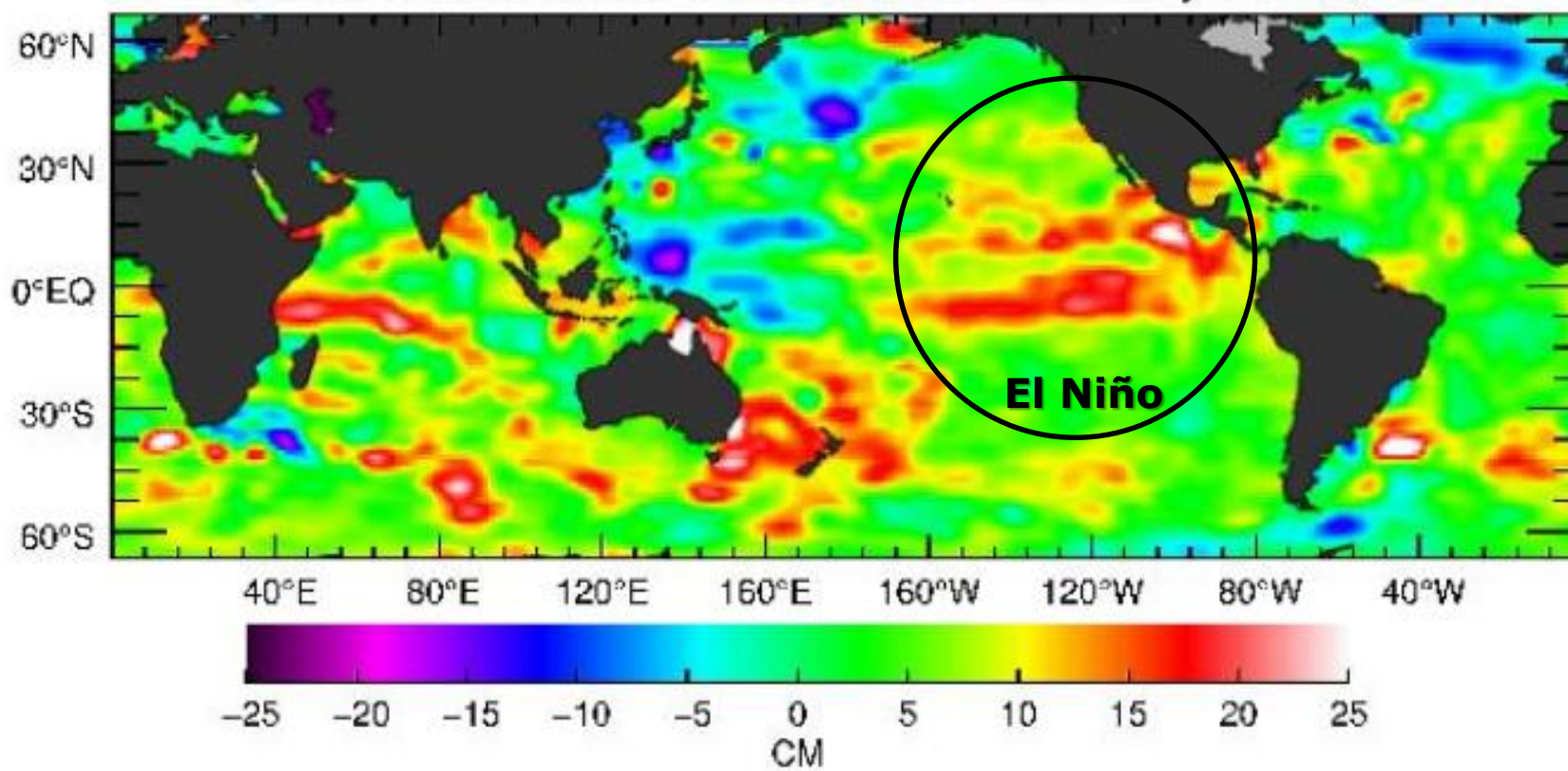
Altimetria Espacial



Satellite Altimetry



Jason-3 Sea Level Anomalies for February 12-22, 2016

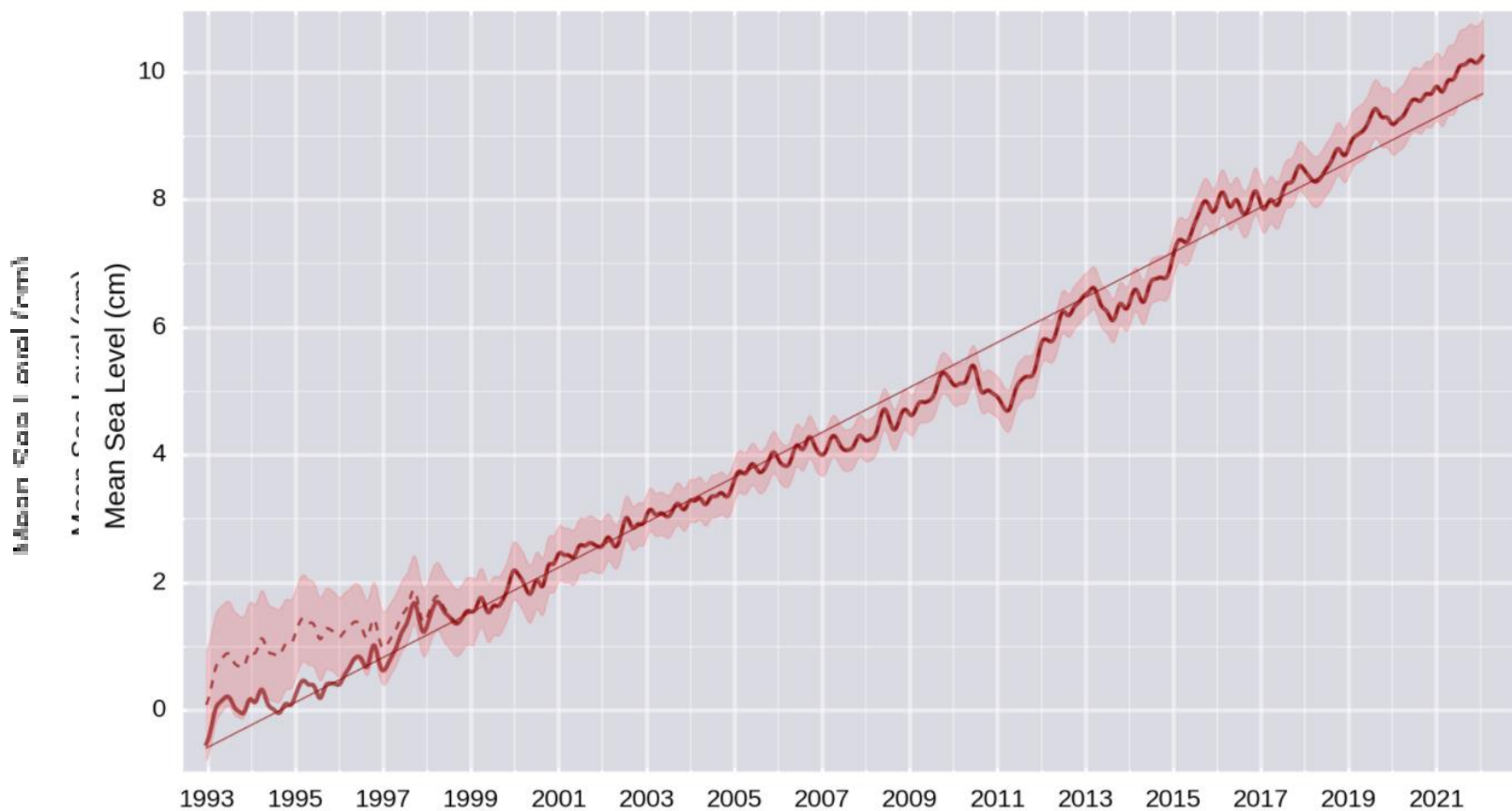


Altimetria Espacial

Latest MSL Measurement
01 February, 2022

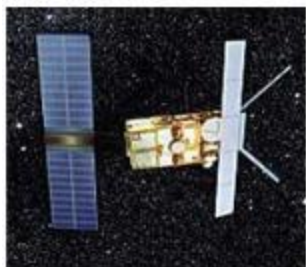
+3.53 mm/yr

Reference GMSL - corrected for GIA

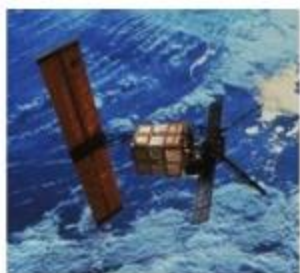


© CNES, LEGOS, CLS

ESA Altimetry Missions



ERS1



ERS2



ENVISAT



CryoSat



Sentinel-3



European Space Agency

Sentinel-3 is primarily an **ocean mission**, however, the mission is also able to provide atmospheric and land applications. The **Sentinel-3** mission continues the monitoring of the sea state, wind speed, sea-ice and ice thickness as started by the ERS-1 (1991), ERS-2 (1995), Envisat (2002) and CryoSat (2010) missions.

The Sentinel-3 mission's main objective is to measure **sea-surface topography**, sea-and land-surface **temperature** and ocean- and **land-surface colour** with high-end accuracy and reliability in support of **ocean forecasting systems**, and for **environmental** and **climate monitoring**.



Sentinel -3

SENTINEL-3 is an European Earth Observation satellite mission developed to support

GMES ocean, land, atmospheric, emergency, security and cryospheric applications.

The SENTINEL-3 mission is jointly operated by ESA and EUMETSAT to deliver operational ocean and land observation services.

The spacecraft carries four main instruments:

[OLCI](#): Ocean and Land Colour Instrument

[SLSTR](#): Sea and Land Surface Temperature Instrument

[SRAL](#): SAR Radar Altimeter

[MWR](#): Microwave Radiometer.



Sentinel-6 (NASA/ESA)

Sentinel-6 Michael Freilich

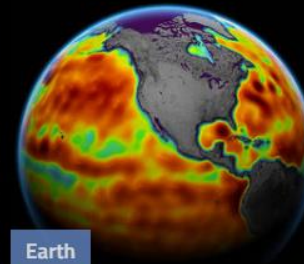
Sentinel-6 Overview Images Videos Media Resources

Related Topics

- Climate
- Earth
- NASA JPL
- Water
- All Topics A-Z

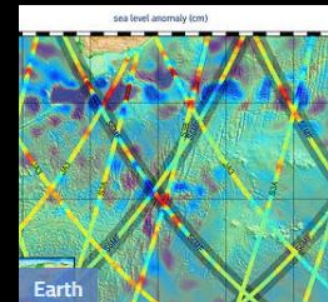


Water



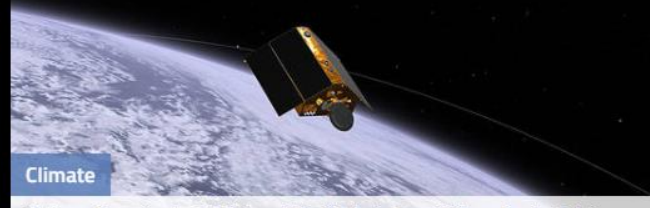
Earth

Major Ocean-Observing
Satellite Starts Providing...



Earth

NASA, US, European
Partner Satellite Returns...



Climate

Sentinel-6

The mission

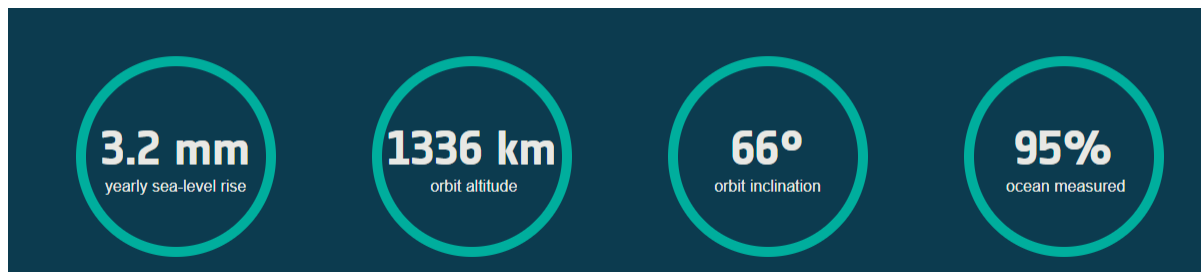
With global mean sea level rising because of climate change, Copernicus Sentinel-6 is the next radar altimetry reference mission to extend the legacy of sea-surface height measurements until at least 2030. The satellite carries a Poseidon-4 radar altimeter and a microwave radiometer.

The launch

Date: 21 November 2020

Site: Vandenberg, California, US

Rocket: SpaceX Falcon 9



<https://youtu.be/OXf4Mf4TQeI>

Gestão · Docente | MDPI | Editor Decision | Full article: A methodology for in... | ESA - Journey to Destination Earth... | Interagency Sea Level Rise Scen... |

sealevel.nasa.gov/task-force-scenario-tool

Joao Catalao | Publ... | Dashboard - Airbnb | Activobank Simplifica | COVID-19 - Página... | European Space Ag... | AICENTER | Web of Science [v.5... | Tutorials - STEP | ICEYE - Your Choice...

EARTHDATA INTERAGENCY SEA LEVEL RISE SCENARIO TOOL Sea Level Change

Interagency Sea Level Rise Scenario Tool

Median projections for global, regional, and local sea level rise scenarios from 2020 to 2150, relative to a 2000 baseline. [More](#)

[View global projection >](#)
[View regional projections >](#)

DATA MAP OPTIONS

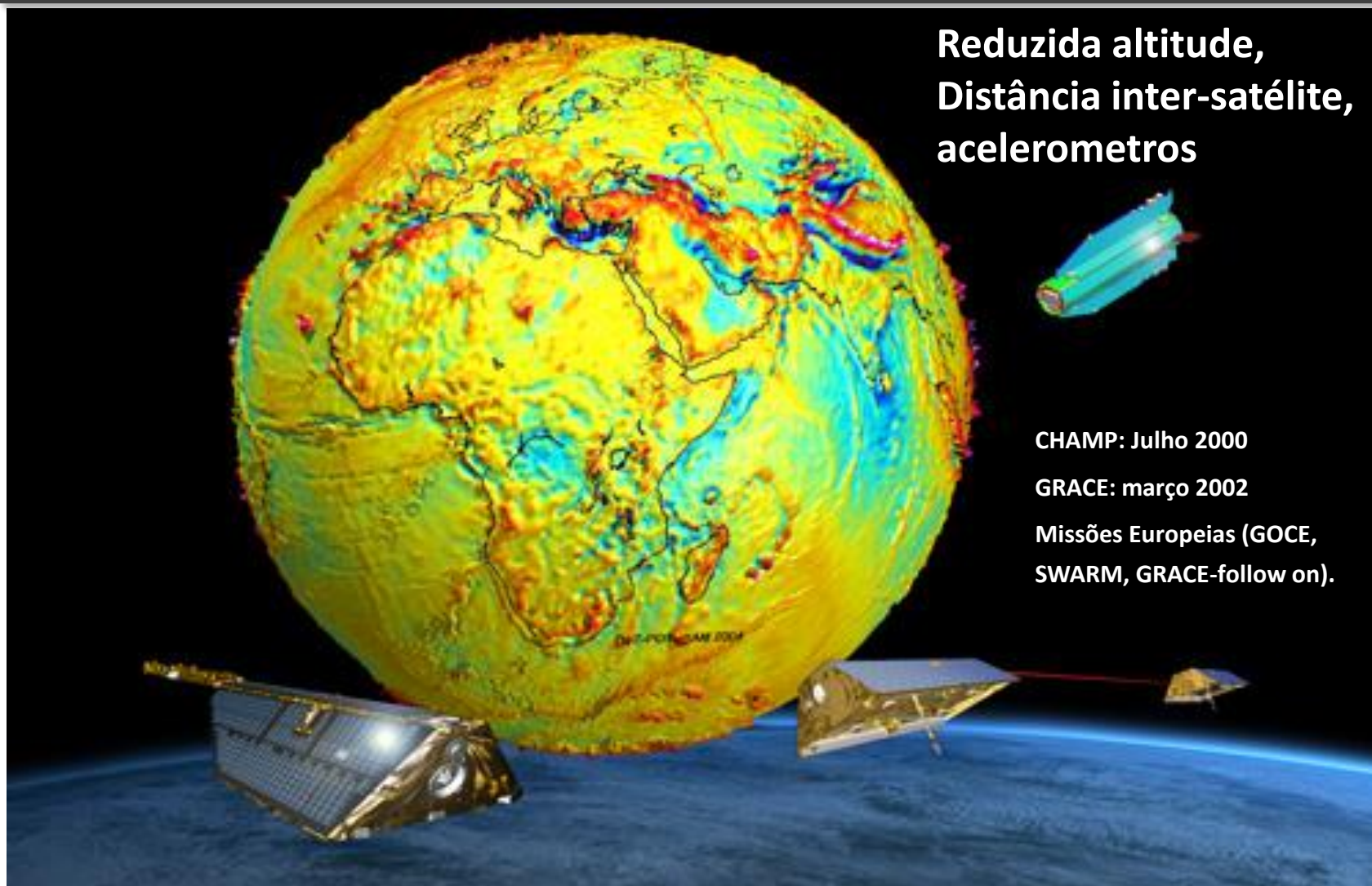
Decades
2050

Scenario
Intermediate

UPDATE MAP

<https://sealevel.nasa.gov/task-force-scenario-tool>

Missões Geopotenciais Espaciais



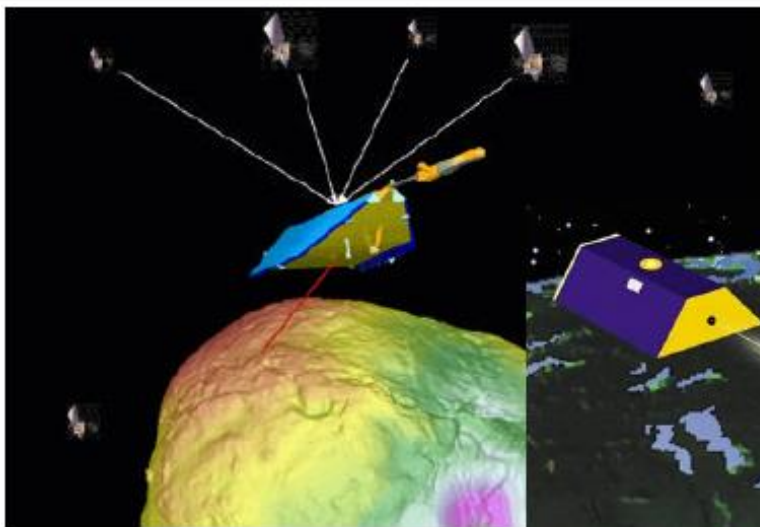
Reduzida altitude,
Distância inter-satélite,
acelerómetros

CHAMP: Julho 2000

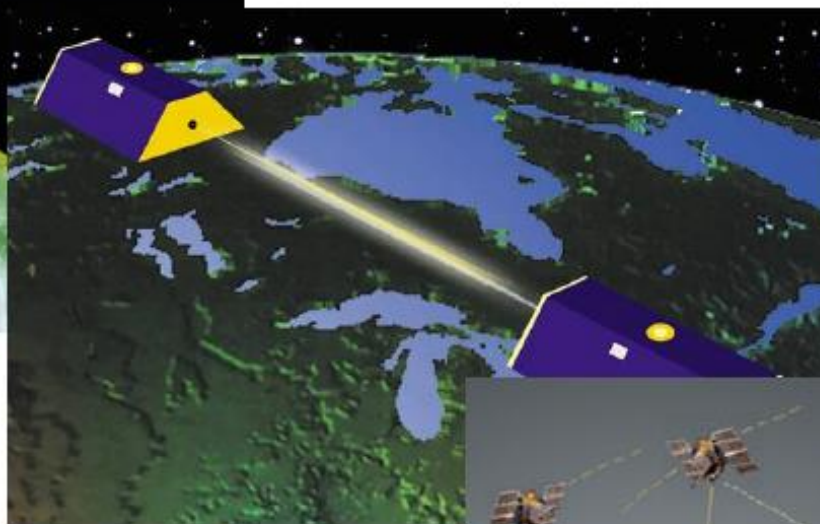
GRACE: março 2002

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

Missões Geopotenciais Espaciais



CHAMP



GRACE

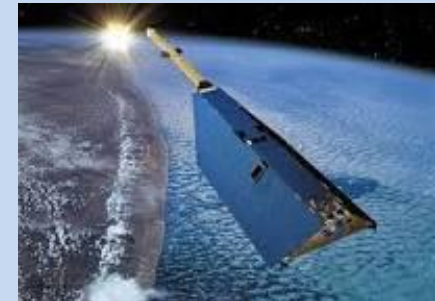


GOCE

Gravity Field Missions

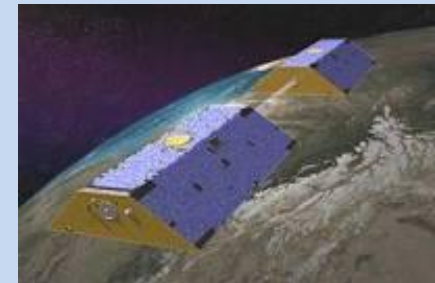
CHAMP

Magnetic field determination/
Temporal variations of the
gravity field



GRACE GRACE-FO (2017)

Improved knowledge of the
geoid estimates of time
variable components

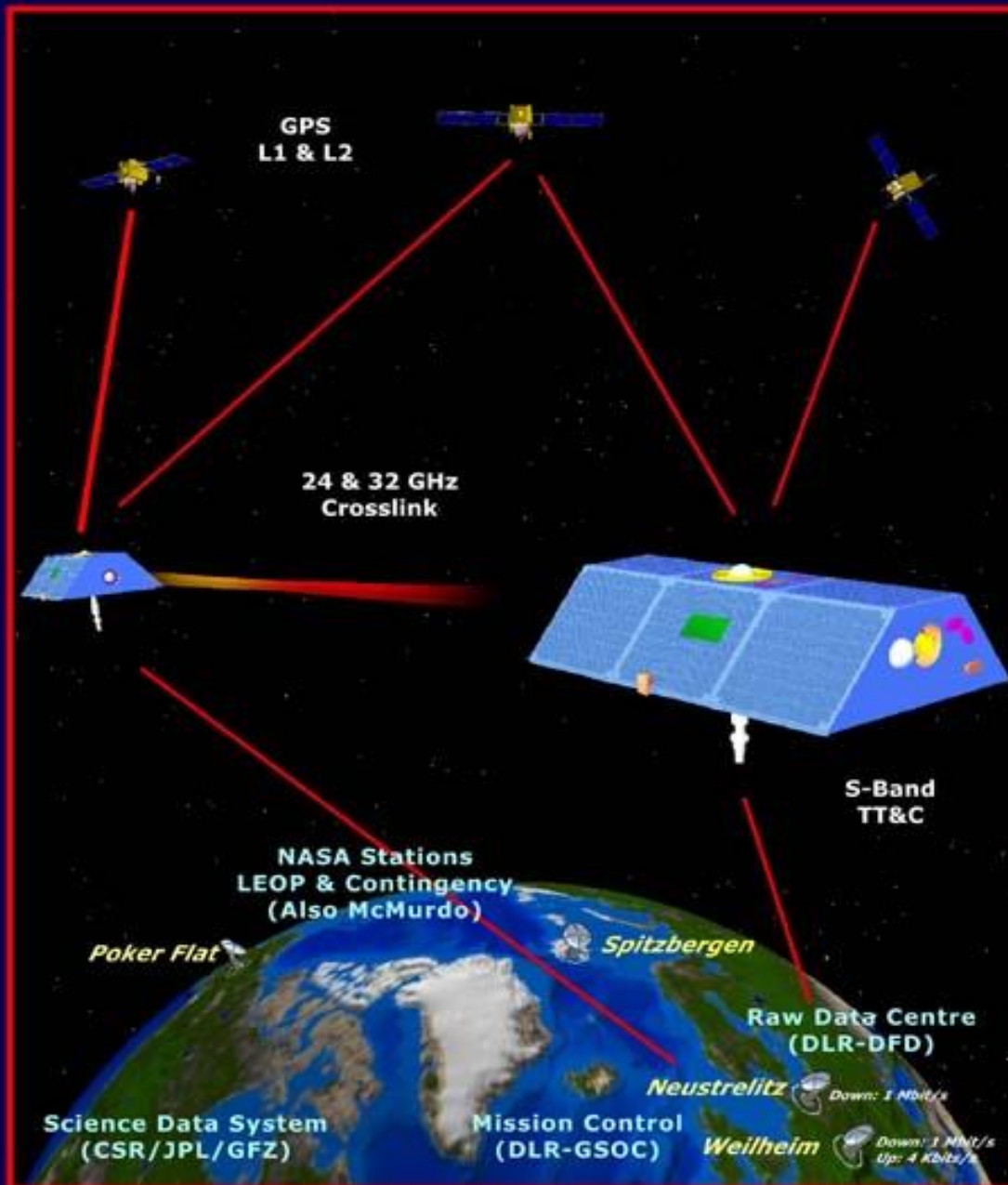


GOCE

Highly precise static geoid
determination



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

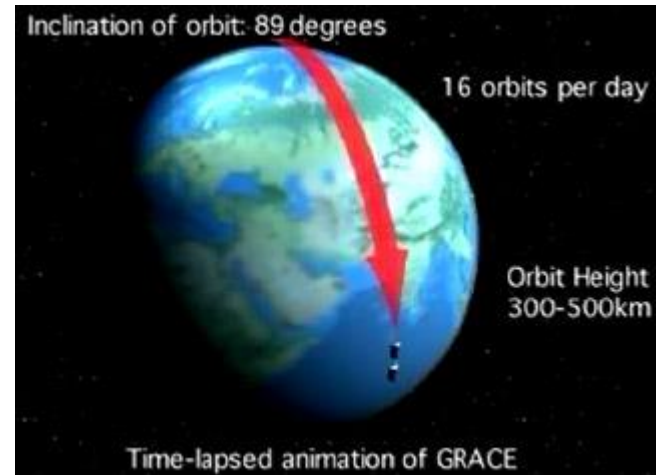
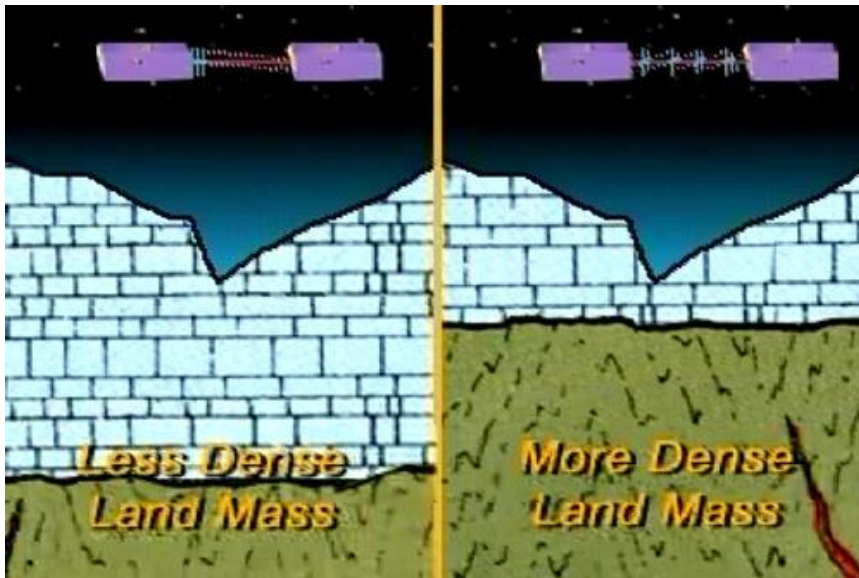
Eccentricity: ~0.001

Lifetime: 5 years

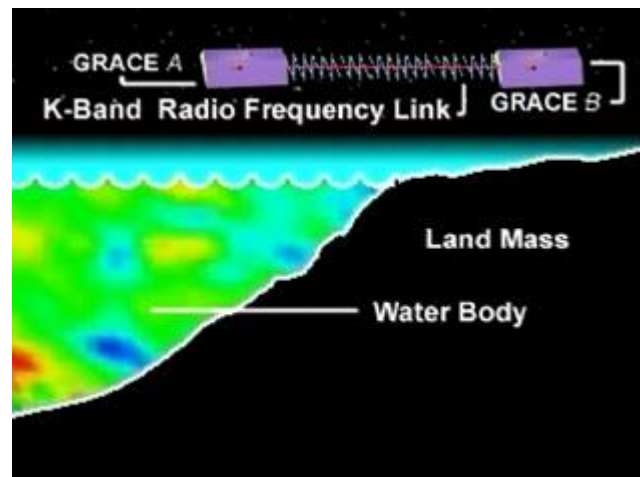
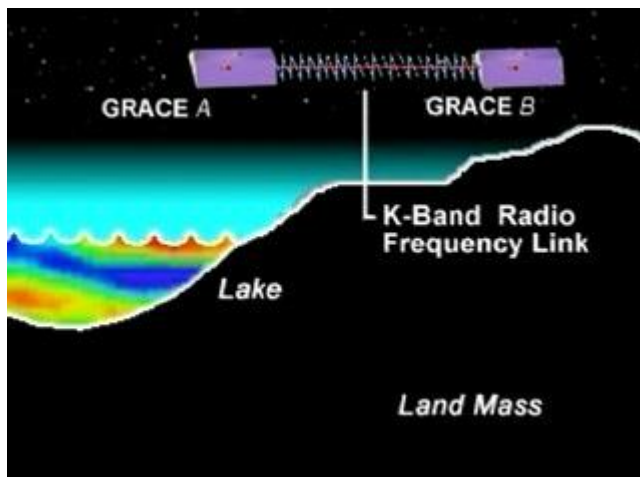
Non-Repeat Ground Track

Earth Pointed, 3-Axis Stable

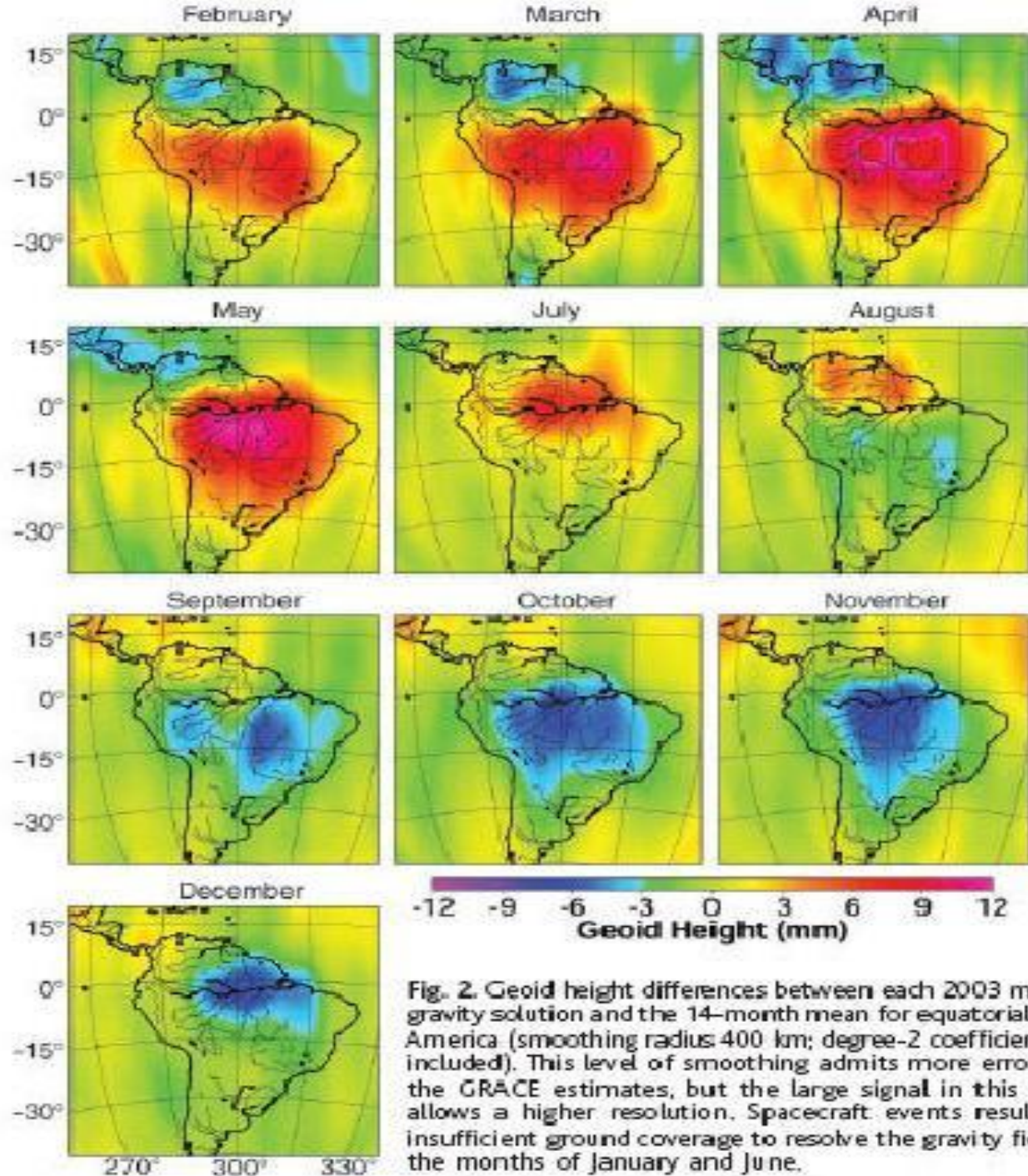
GRACE



Distância = 220 km



GRACE



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

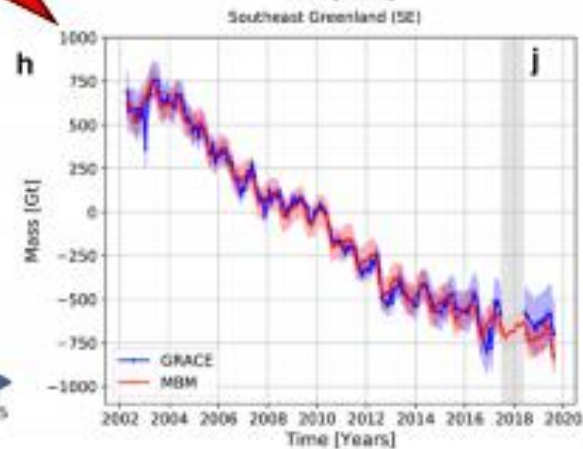
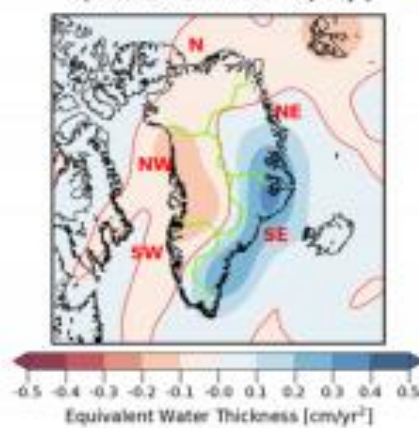
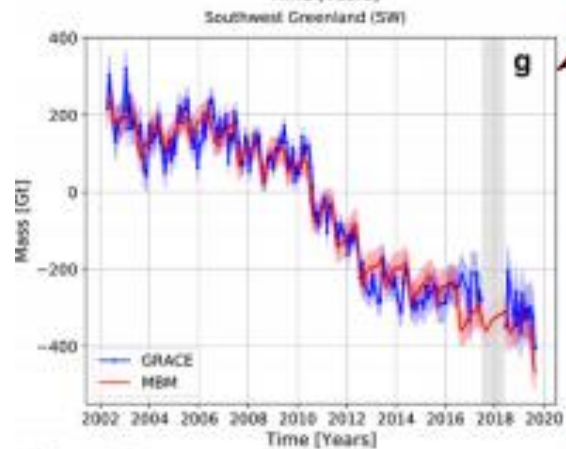
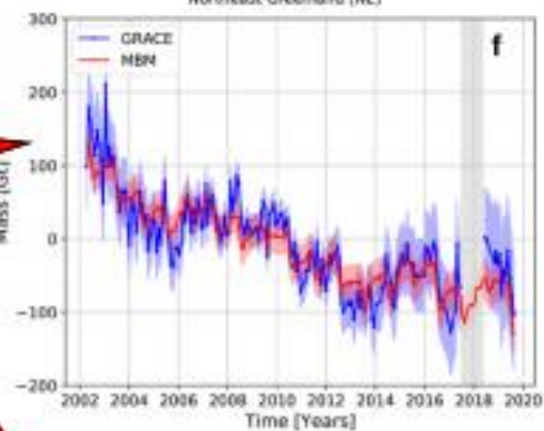
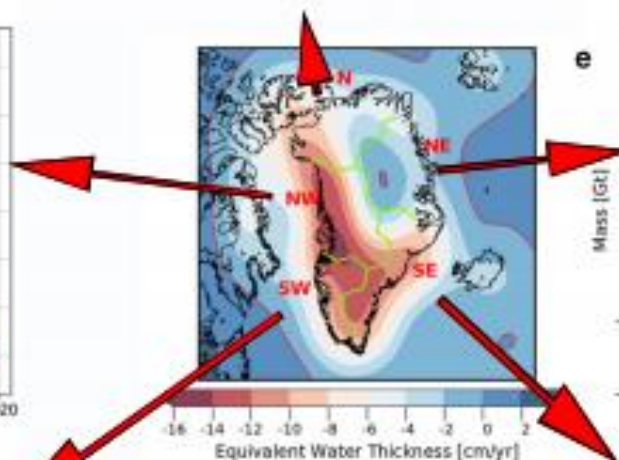
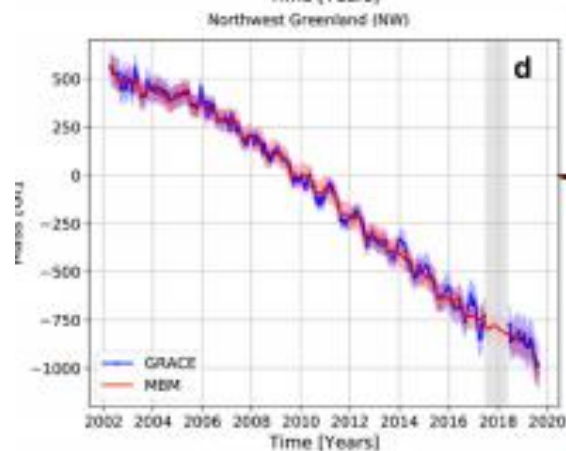
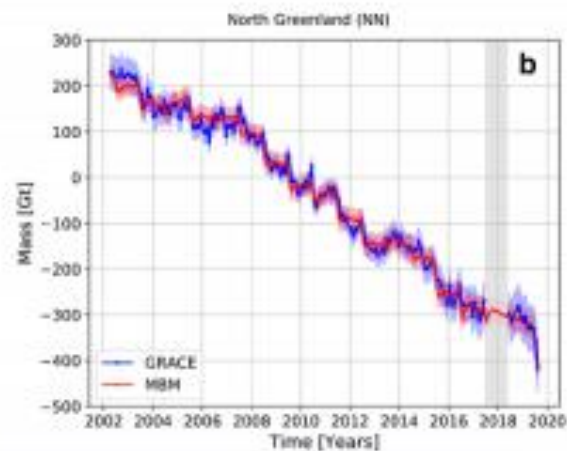
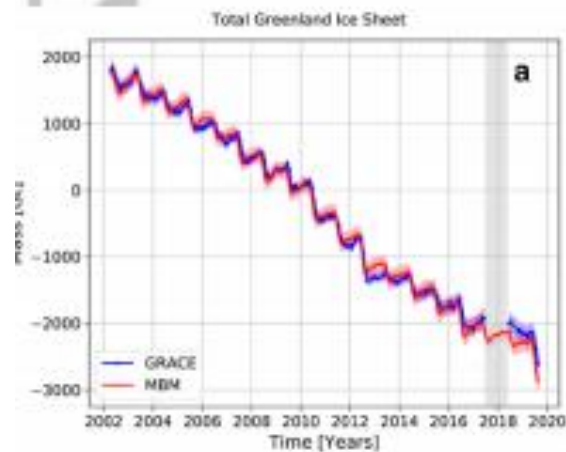
Fig. 2. Geoid height differences between each 2003 monthly gravity solution and the 14-month mean for equatorial South America (smoothing radius 400 km; degree-2 coefficients not included). This level of smoothing admits more error from the GRACE estimates, but the large signal in this region allows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

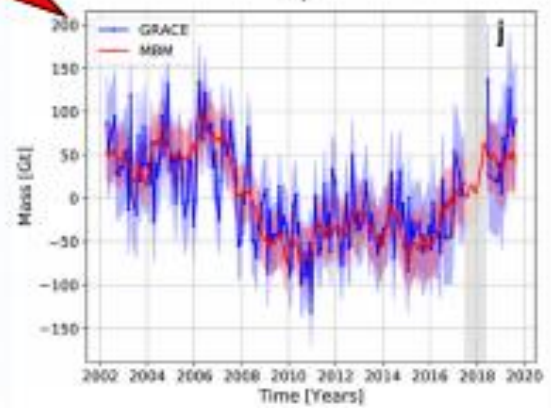
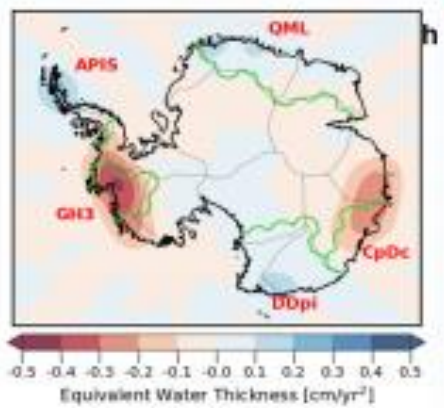
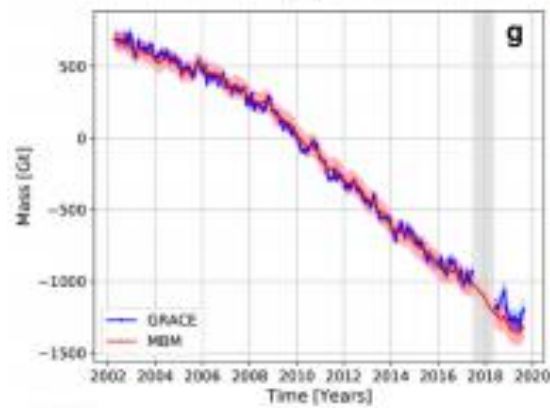
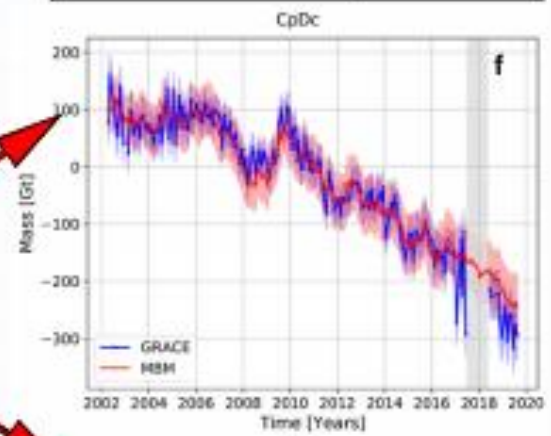
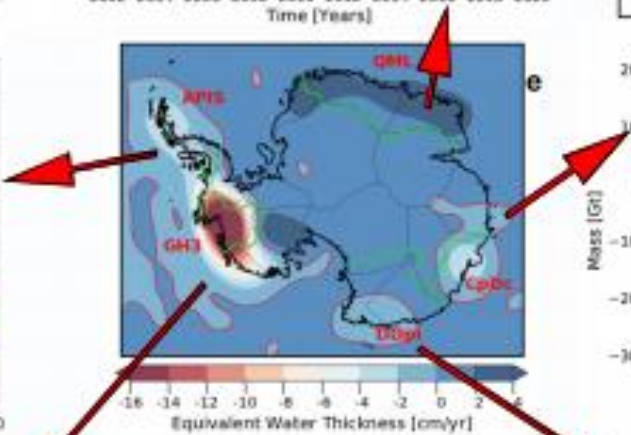
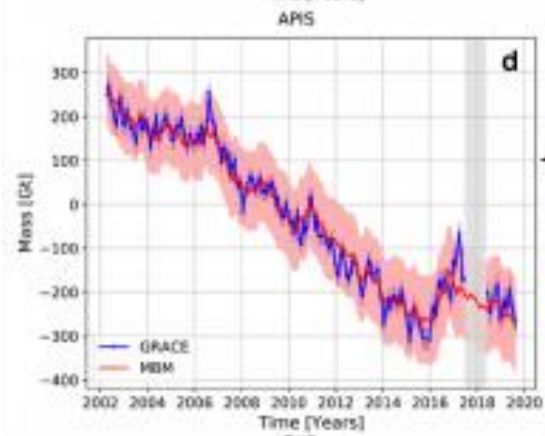
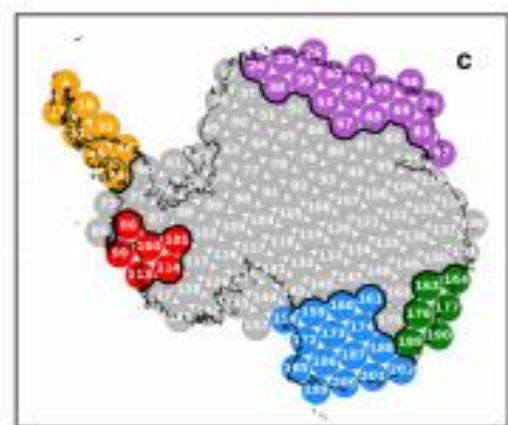
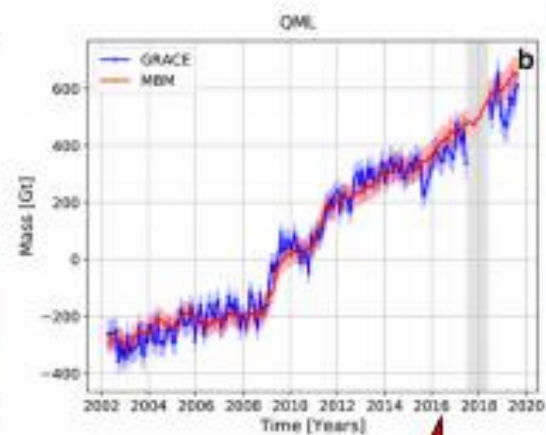
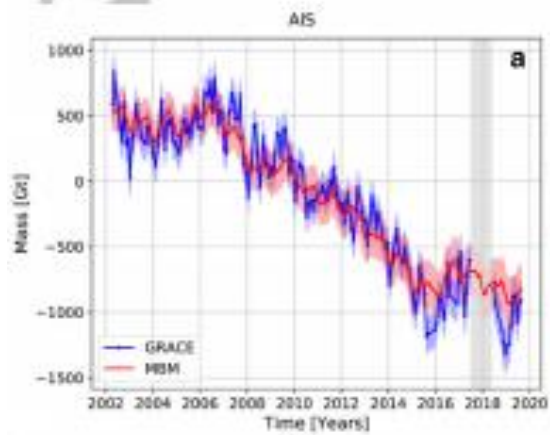
Abstract

In Greenland, the GRACE-FO data reveal an exceptional summer loss of 600 Gigatonnes in 2019 following two cold summers.

In Antarctica, ongoing high mass losses in the Amundsen Sea Embayment of West Antarctica, the Antarctic Peninsula, and Wilkes Land in East Antarctica cumulate to 2130, 560, and 370 Gigatonnes, respectively, since 2002.

A cumulative mass gain of 980 Gigatonnes in Queen Maud Land since 2009, however, led to a pause in the acceleration in mass loss from Antarctica after 2016.





Gravity Field Missions

The three missions are based on different space segments which have in common their extremely **low and (almost) polar orbit**, continuous and three-dimensional tracking by **GPS** and their ability to separate non-gravitational from gravitational signal parts.

GOCE's main objective is to measure the geoid with an **accuracy of about 1 cm, gravity anomalies of 1mGal** and a **spatial half-wavelength resolution of about 70 km** (determine the static Earth gravity field down to features of 100 km-70 km - half wavelength - in terms of spatial resolution).

GOCE

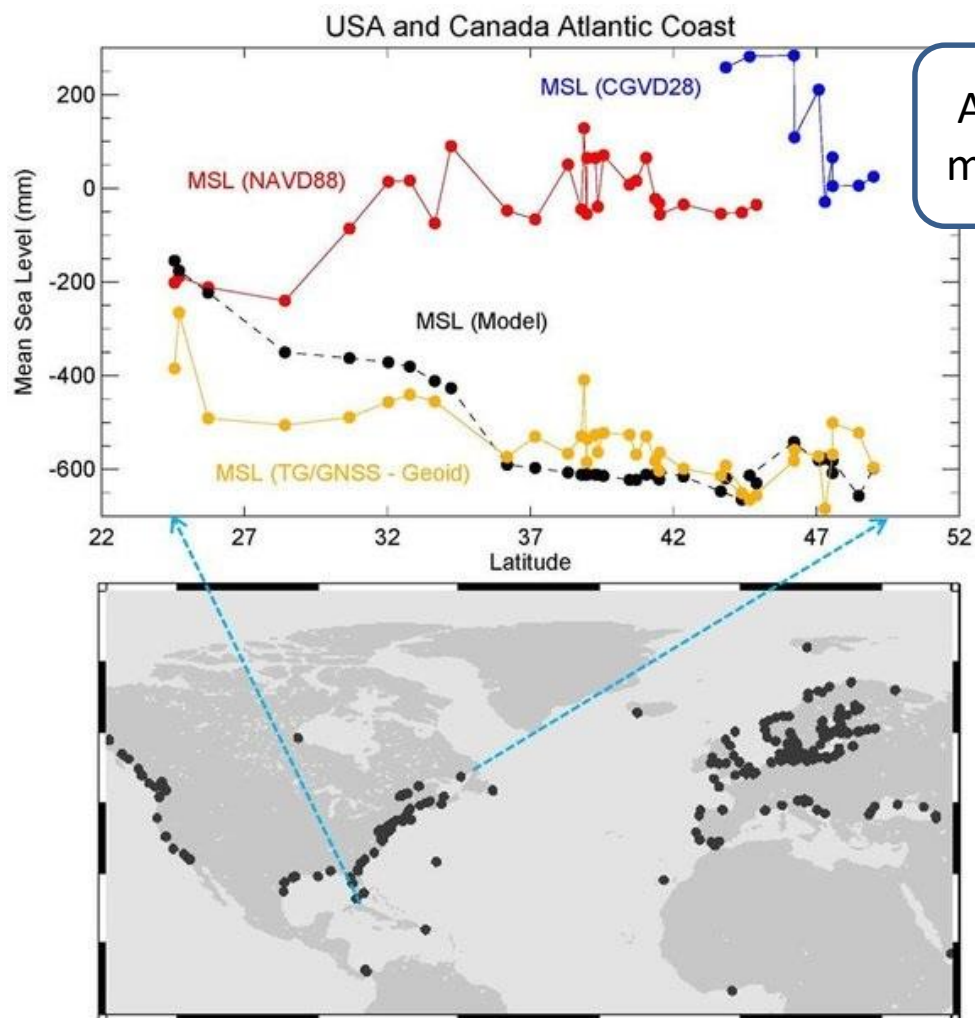


Mean Sea Level

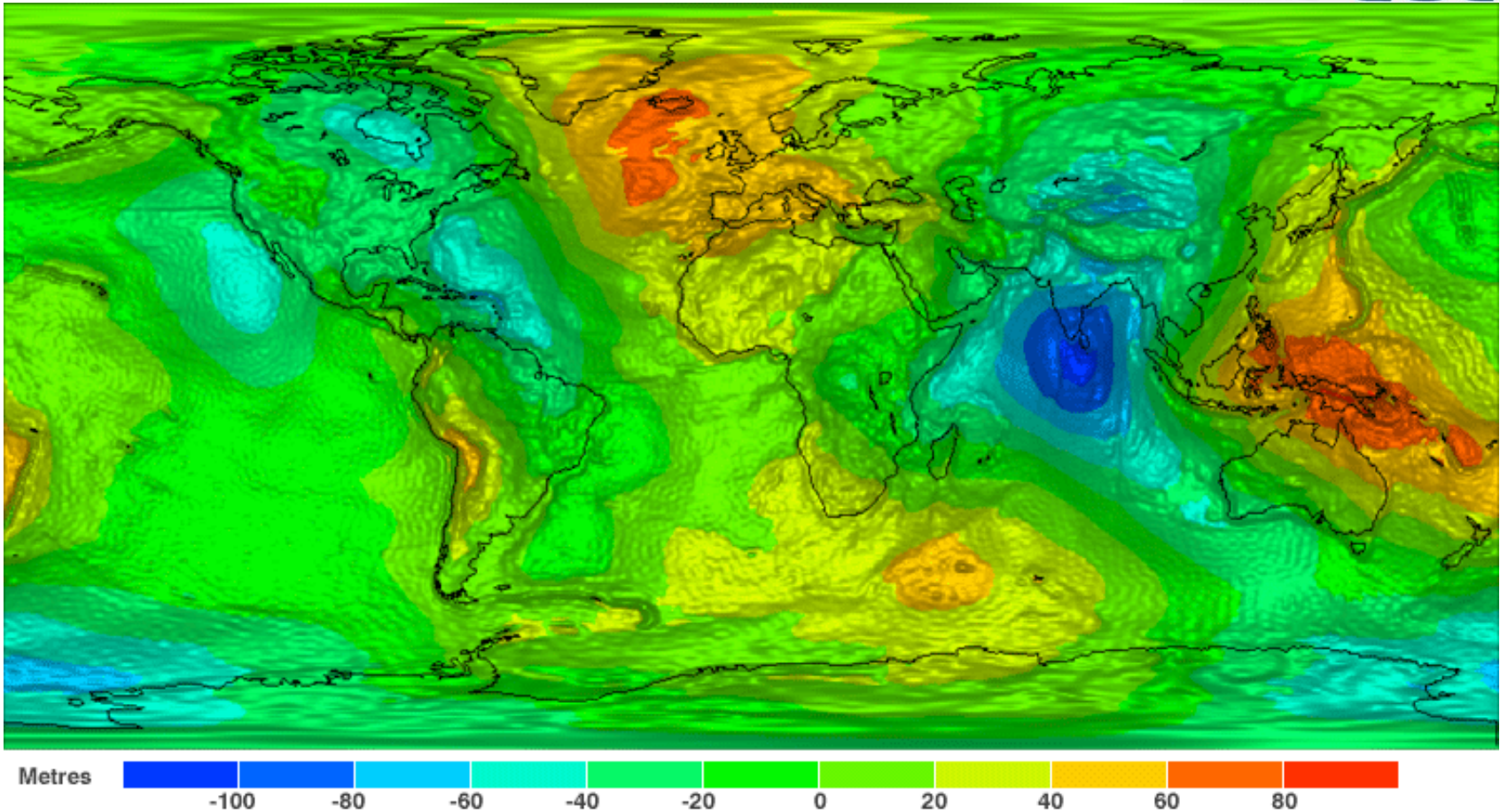
Philip Woodworth from the National Oceanography Centre Liverpool said, “GOCE has resolved this old debate in the oceanographers’ favour.

“The results prove conclusively that sea level decreases going north along the North American Atlantic coastline, in agreement with the ocean models.”

Fev. 2103



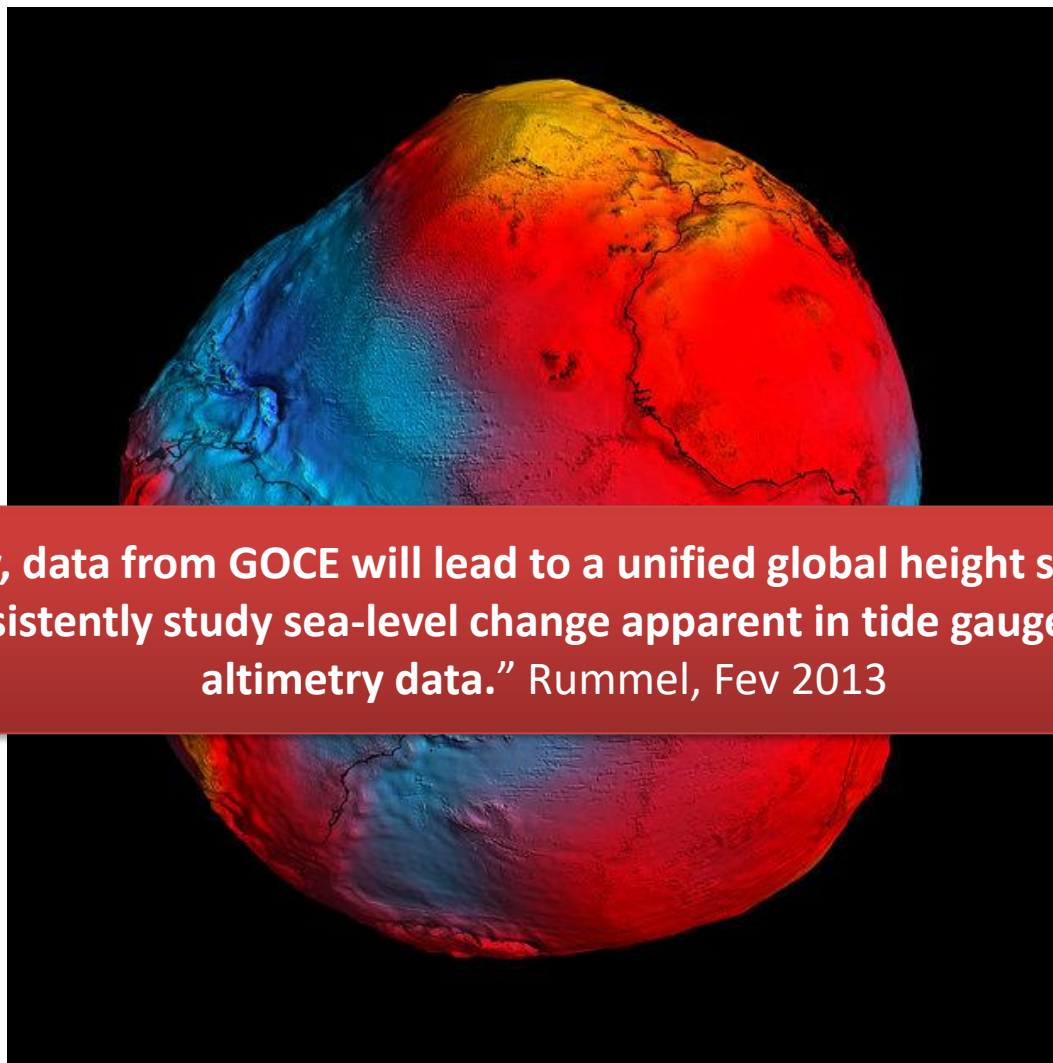
Gravity Field Missions



Global gravity model based on GOCE satellite data



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

Earth Observation Satellites

Landsat Missions: Imaging the Earth Since 1972

Earth Resources Technology Satellite (ERTS-1), later renamed **Landsat-1**, was launched on July 23, 1972.

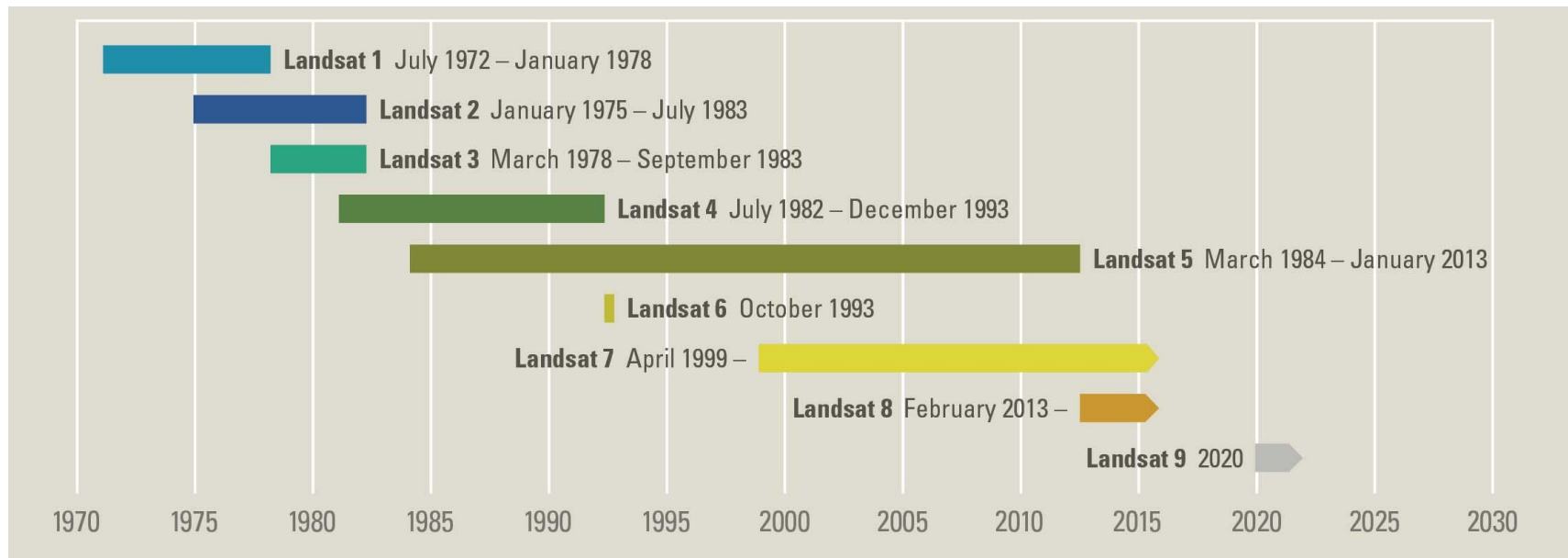
The launches of **Landsat-2**, **Landsat-3**, and **Landsat-4** followed in 1975, 1978, and 1982, respectively.



Earth Observation Satellites

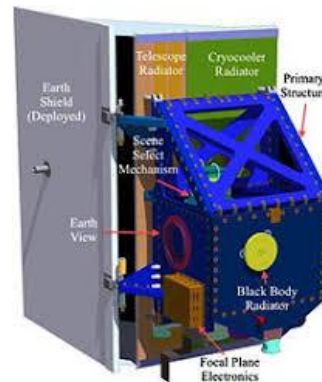
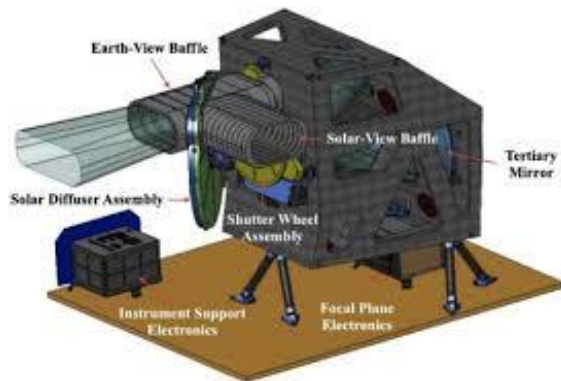
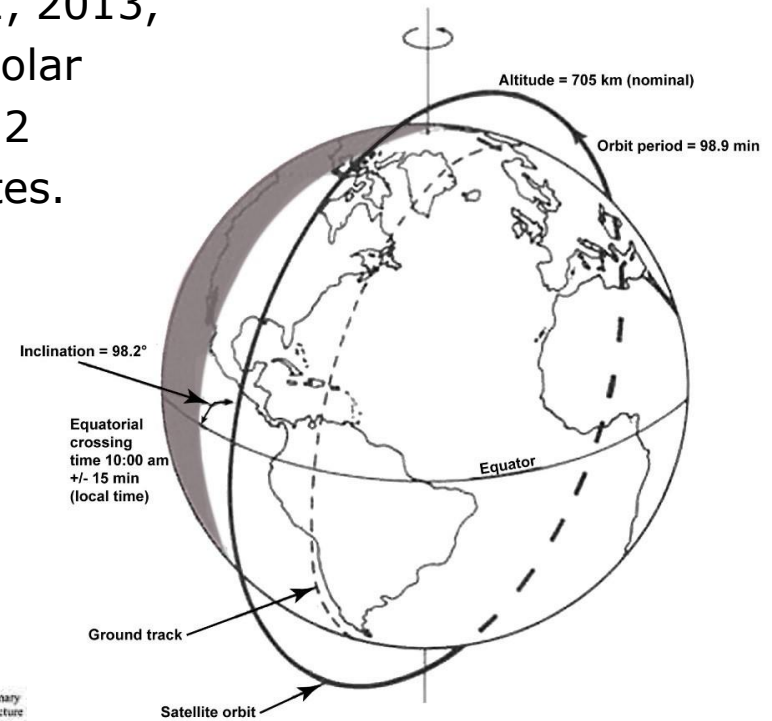
Landsat-5, launched in 1984, lasting 28 years and 10 months, officially setting a new Guinness World Record for "longest-operating Earth observation satellite."

Landsat-7 successfully launched in 1999 and, along with **Landsat-8**, launched in 2013, continues to provide daily global data. **Landsat-9** was launched in September 2021 (8 days revisit time).

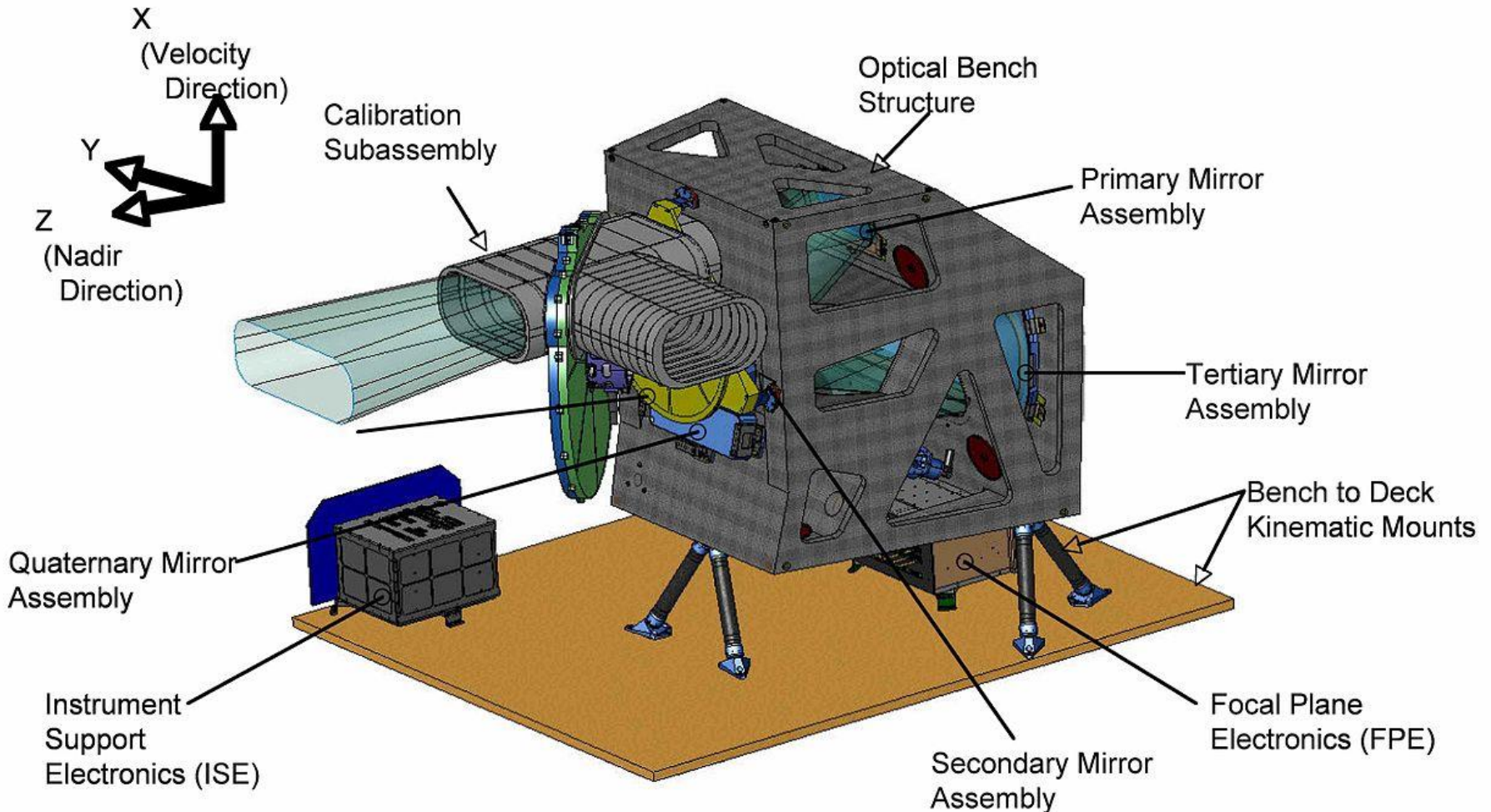


Landsat-8 satellite, launched on February 11, 2013, orbits the Earth in a sun-synchronous, near-polar orbit, at an altitude of 705 km, inclined at 98.2 degrees, and circles the Earth every 99 minutes.

Landsat-8 carries two pushbroom instruments: the **Operational Land Imager (OLI)** and the **Thermal Infrared Sensor (TIRS)**.



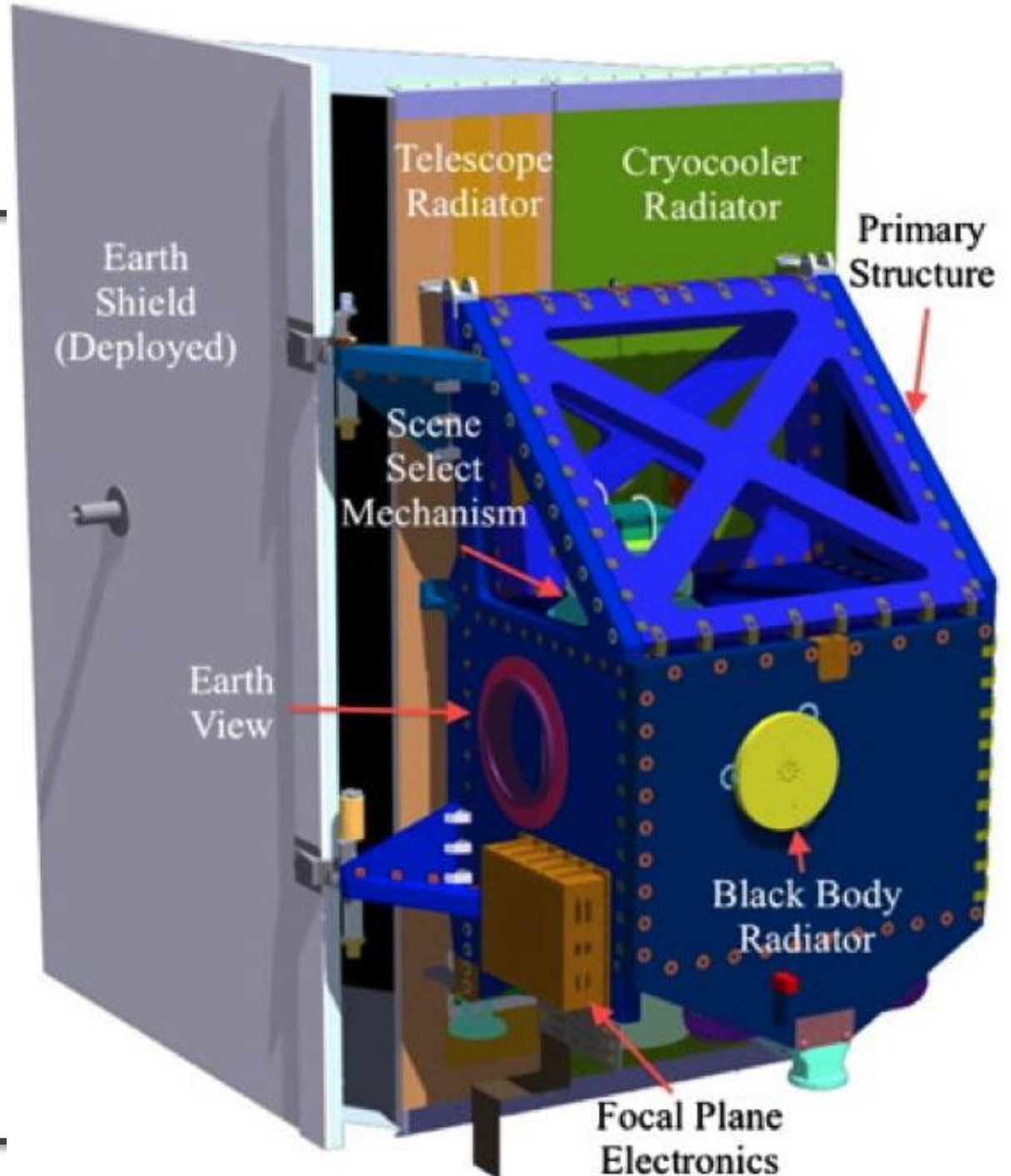
OLI Instrument Overview



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>)



Thermal InfraRed
Sensor (TIRS)



Earth Observation Satellites



Spectral Resolution	11 spectral bands OLI - 9 spectral bands, including a panchromatic band TIRS - 2 spectral bands
Spatial Resolution	15 m - 1 OLI panchromatic band 30 m - 8 OLI bands 100 m - 2 TIRS spectral bands
Radiometric Resolution	12-bits (16-bits when processed into Level-1 data products)
Temporal Resolution	16-day repeat cycle
Swath Width/ Scene Size	170 km x 185 km (106 mi x 115 mi) (7000*30m=210km)

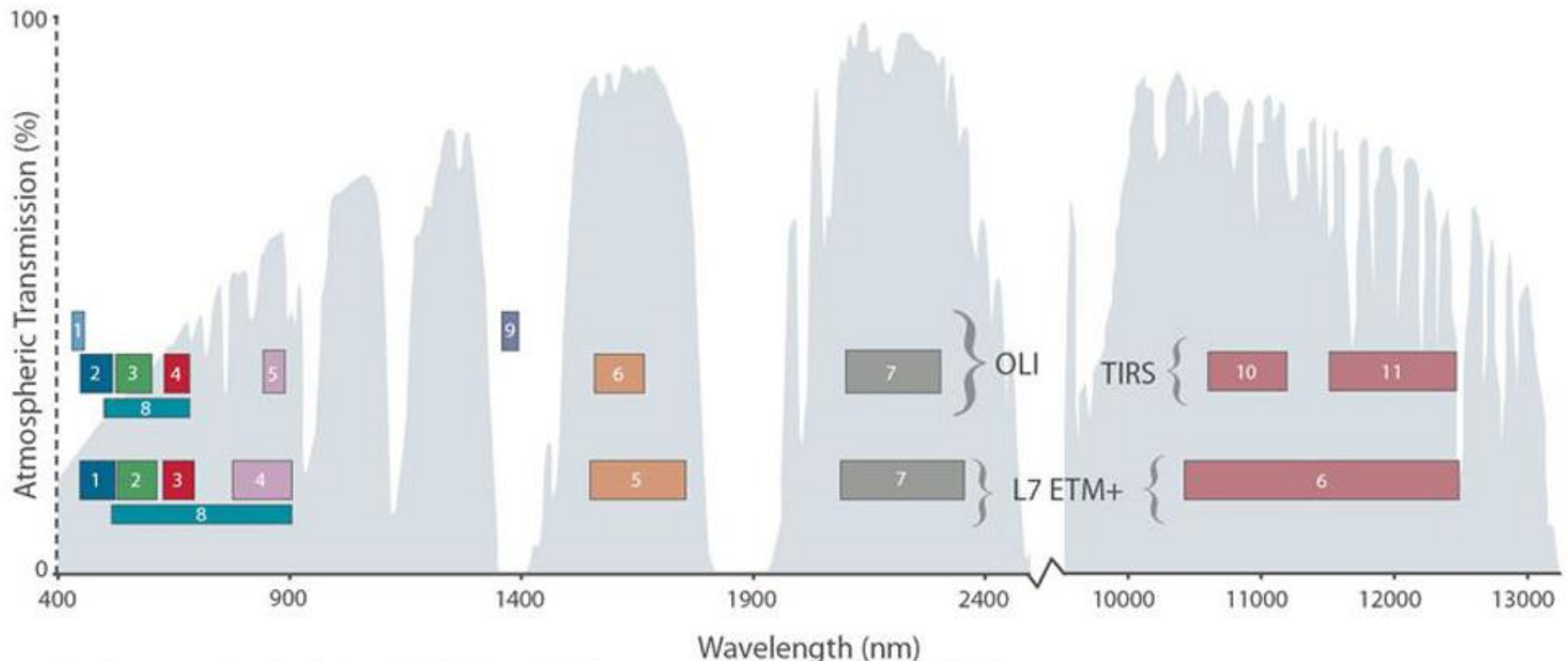


Earth Observation Satellites



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	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 – Bands wavelenght



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

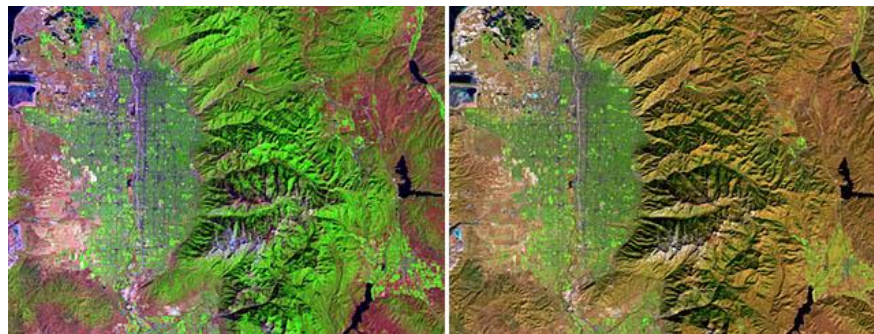
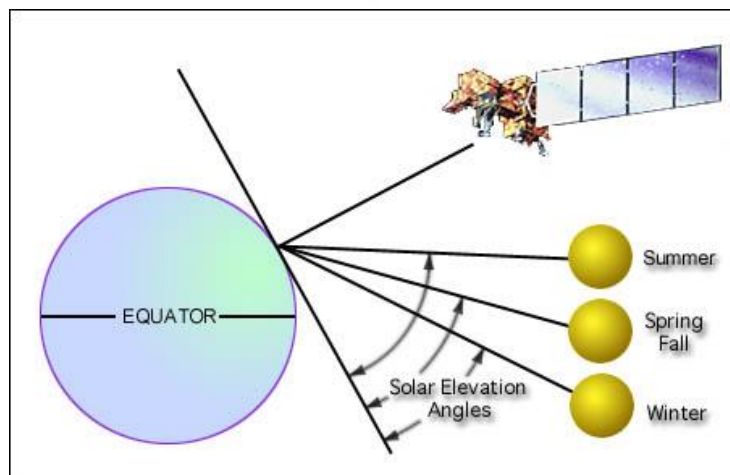
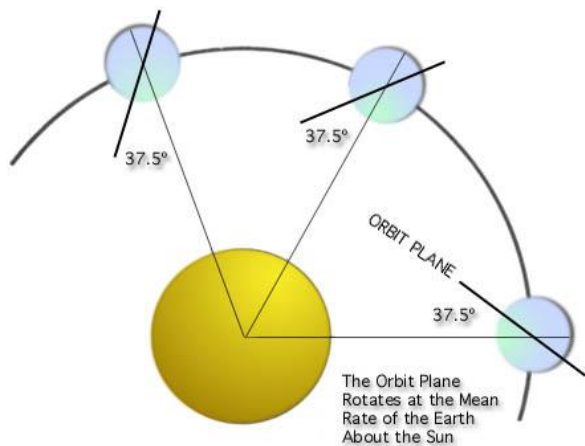
Note: atmospheric transmission values for this graphic were calculated using MODTRAN for a summertime mid-latitude hazy atmosphere (circa 5 km visibility).

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

Radiometric quantization (12-bits)

LANDSAT – sazonal effects

Nodo descendente às 10:00



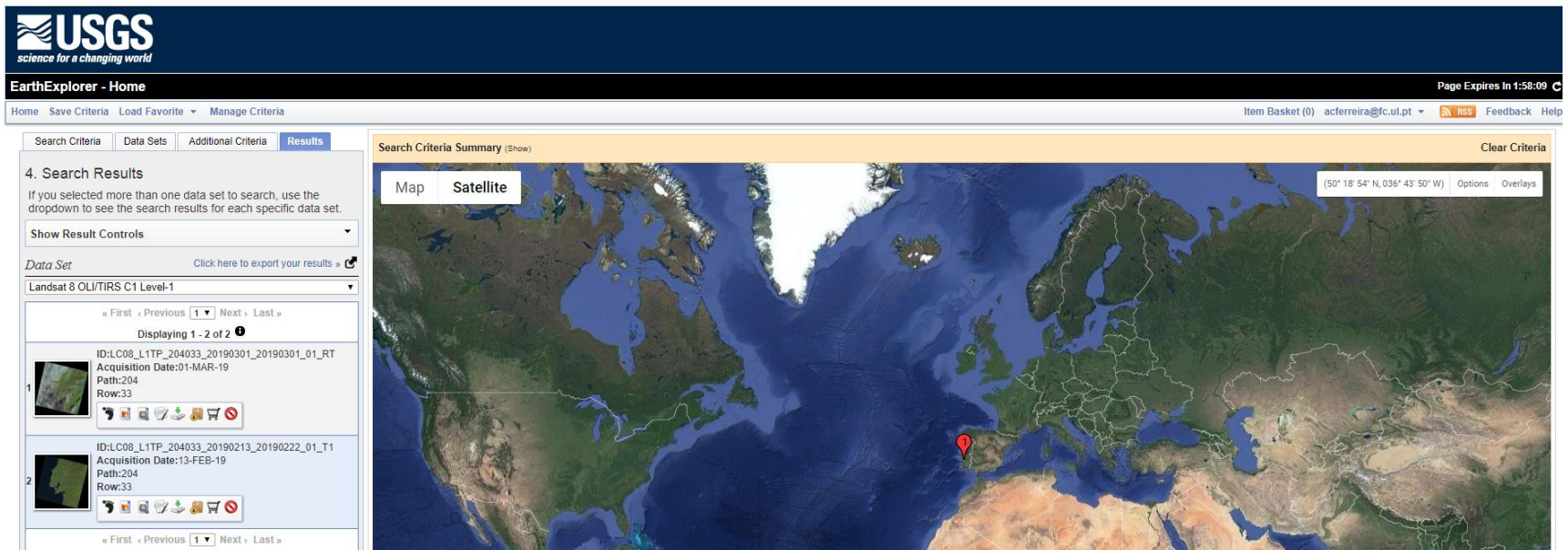
Effects of Seasonal Changes on Solar Elevation Angle



The **USGS Earth Explorer** is a quick and easy way to download free Landsat imagery and other remote sensing data.

<https://earthexplorer.usgs.gov/>

Images are delivered as .tar.gz compressed files (approximately 1 GB) which are unzipped as GeoTIFF files (approximately 2 GB).



The screenshot shows the USGS Earth Explorer website interface. The top navigation bar includes the USGS logo and the text "science for a changing world". Below the navigation bar, there are tabs for "Search Criteria", "Data Sets", "Additional Criteria", and "Results". The main content area displays search results for "Landsat 8 OLI/TIRS C1 Level-1". The results are listed in a table with columns for "Data Set", "Acquisition Date", "Path", and "Row". Two results are shown, each with a thumbnail image and a set of icons for actions like download, print, and share. The interface also includes a "Search Criteria Summary" section with a "Map" and "Satellite" view, and a "Clear Criteria" button.

Earth Observation Satellites



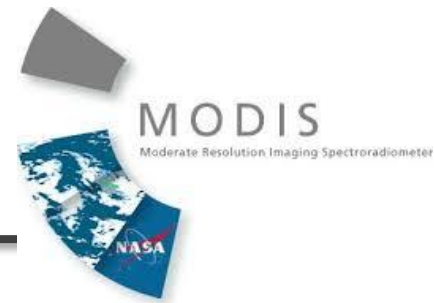
Landsat-8 (13.02.2019)



MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the **Terra** (December 1999, originally known as EOS AM) and **Aqua** (May, 2002, originally known as EOS PM) satellites.

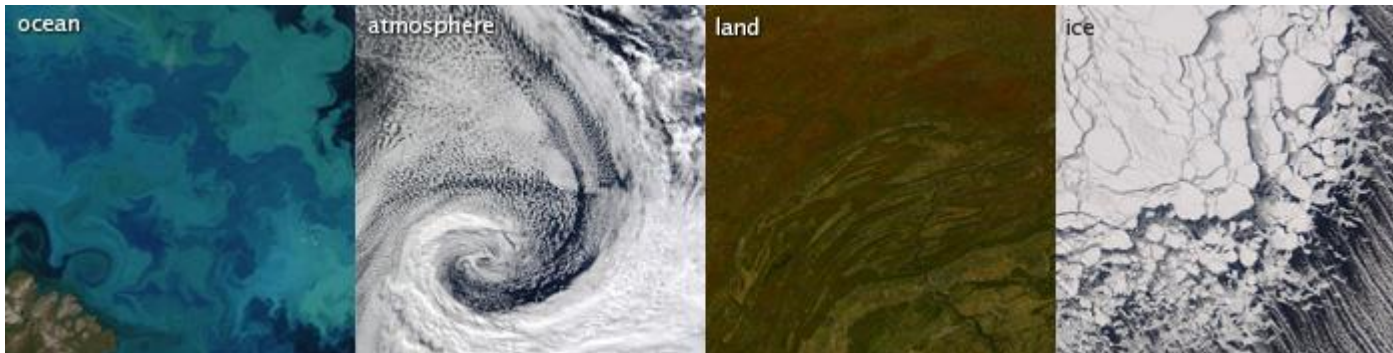
Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning (10:30 am), while **Aqua** passes south to north over the equator in the afternoon (01:30 pm).





The MODIS instrument, operating both the Terra and Aqua spacecraft, has a viewing **swath width of 2,330 km** and views the entire surface of the Earth every 1 to 2 days, acquiring data in **36 spectral bands** between 0.4 and 14.4 μm , at three spatial resolutions - 250m, 500m, and 1,000m.

The many **data products** derived from MODIS observations describe features of the **land**, **oceans** and the **atmosphere** that can be used for studies of processes and trends on local to global scales.





MODIS level 1 data, geolocation, cloud mask, and atmosphere products:

<http://ladsweb.nascom.nasa.gov/>

MODIS land products:

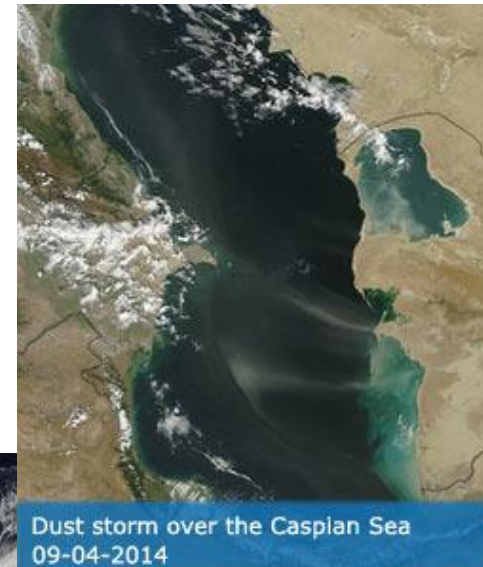
<https://lpdaac.usgs.gov/>

MODIS cryosphere products:

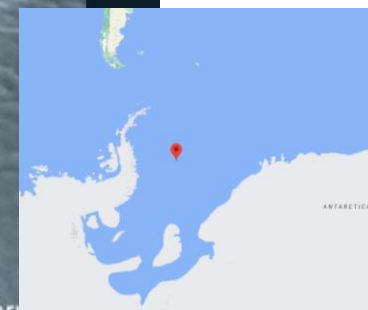
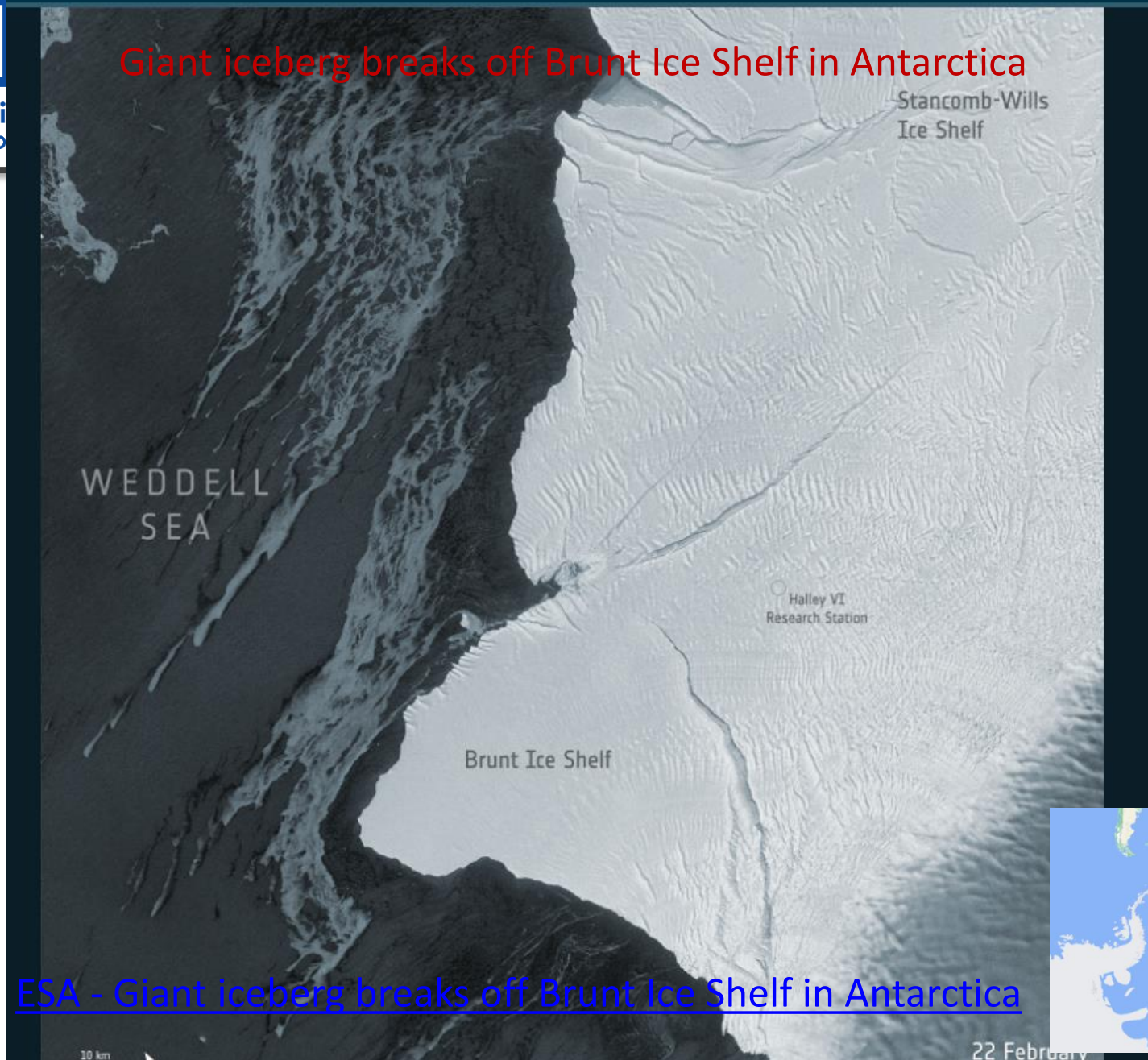
<http://nsidc.org/daac/modis/index.html>

MODIS ocean color and sea surface temperature products:

<http://oceancolor.gsfc.nasa.gov/>



Giant iceberg breaks off Brunt Ice Shelf in Antarctica



[ESA - Giant iceberg breaks off Brunt Ice Shelf in Antarctica](#)

22 February

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

2048 km swath

AVHRR, MODIS

- spatial resolution, 250m, 500m, 1000m
- spectral coverage, VIS, NIR, SWIR, MWIR, TIR
- calibrated @ $\leq 5\%$ absolute

- global coverage, 2 days
- nadir only

Landsat

- spatial resolution, 15m, 30m
- spectral coverage, VIS, NIR, SWIR, TIR
- calibrated @ $\leq 10\%$ absolute

- 16 day orbital repeat
- seasonal global coverage capability
- nadir only

IRS

- spatial resolution 36m, 72m
- spectral coverage, VIS, NIR
- relative calibration

- 22 day orbital repeat
- nadir only

SPOT

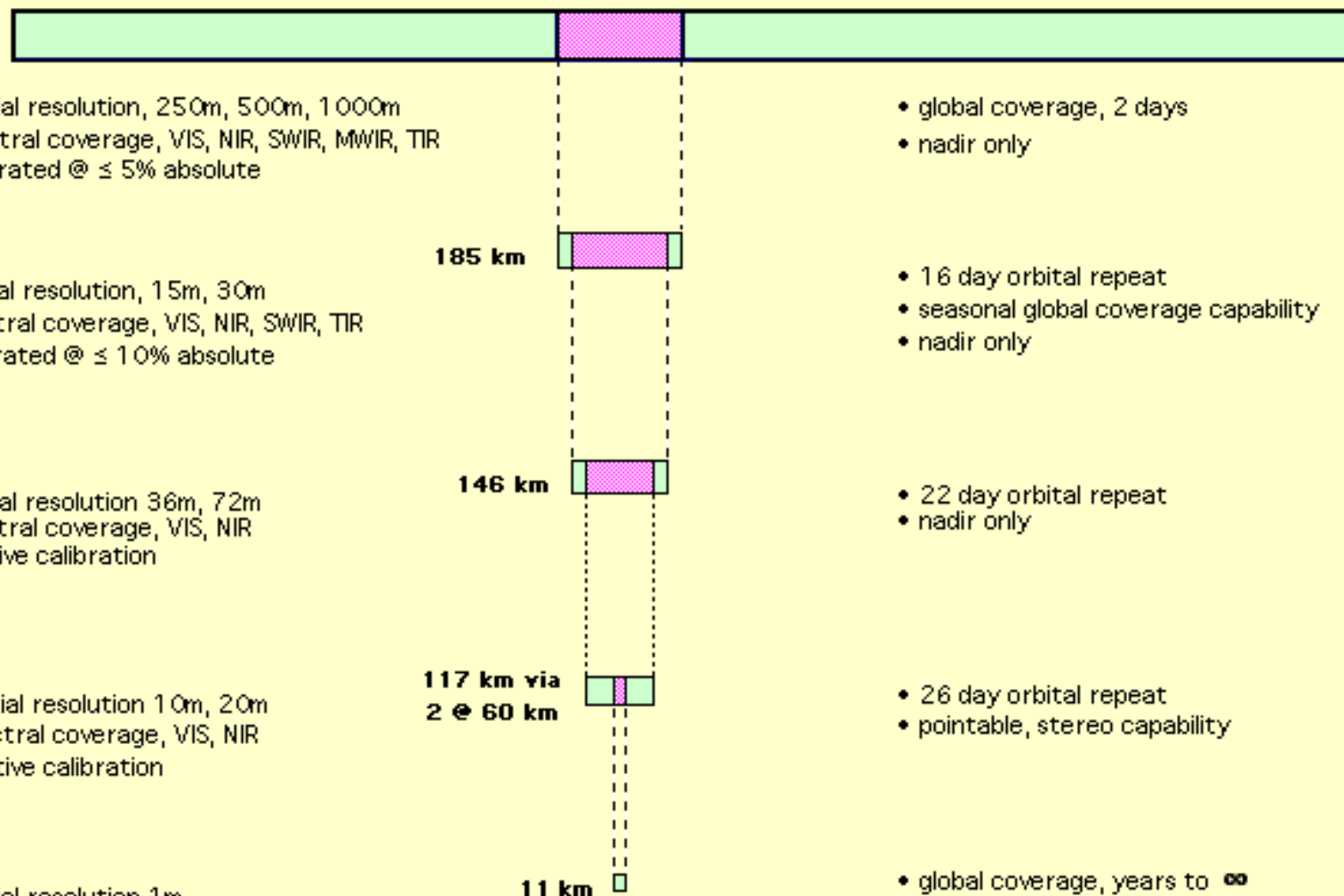
- spatial resolution 10m, 20m
- spectral coverage, VIS, NIR
- relative calibration

- 26 day orbital repeat
- pointable, stereo capability

IKONOS

- spatial resolution 1m
- spectral coverage, panchromatic
- calibrated @ $\leq 10\%$ absolute

- global coverage, years to ∞
- pointable, stereo capability



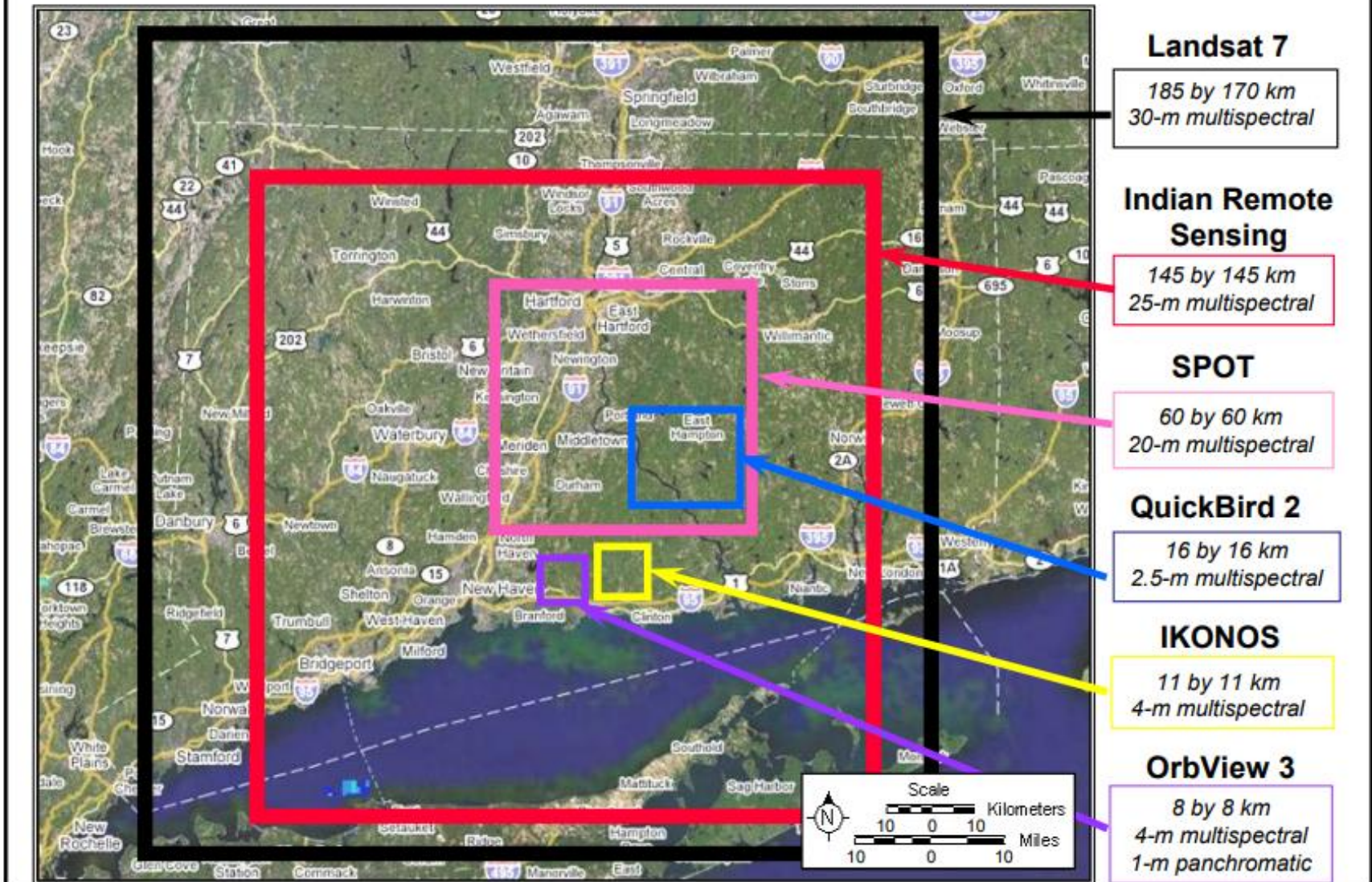
Looking More Closely at Resolution



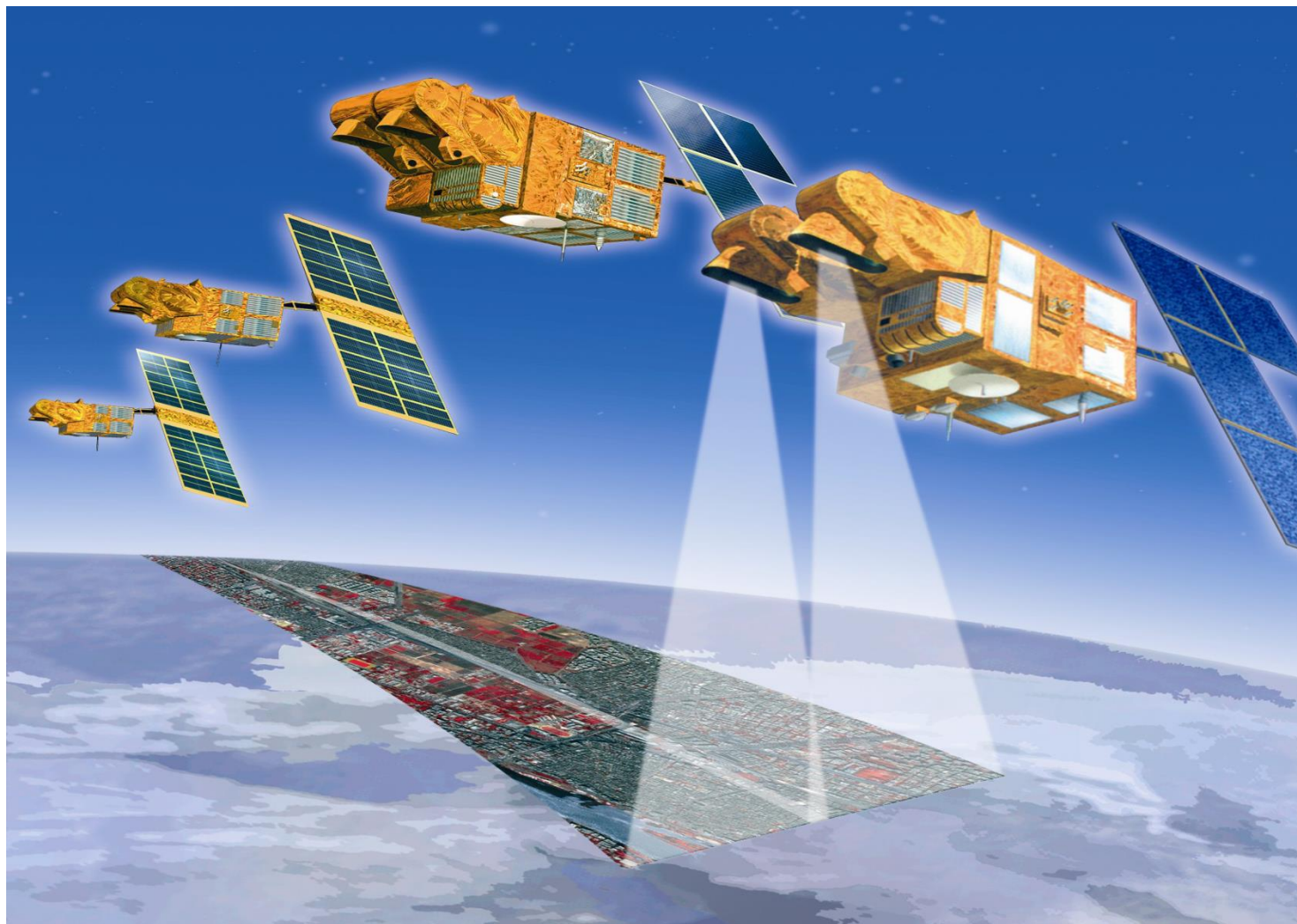
Looking More Closely at Resolution



Selected Satellite Footprints

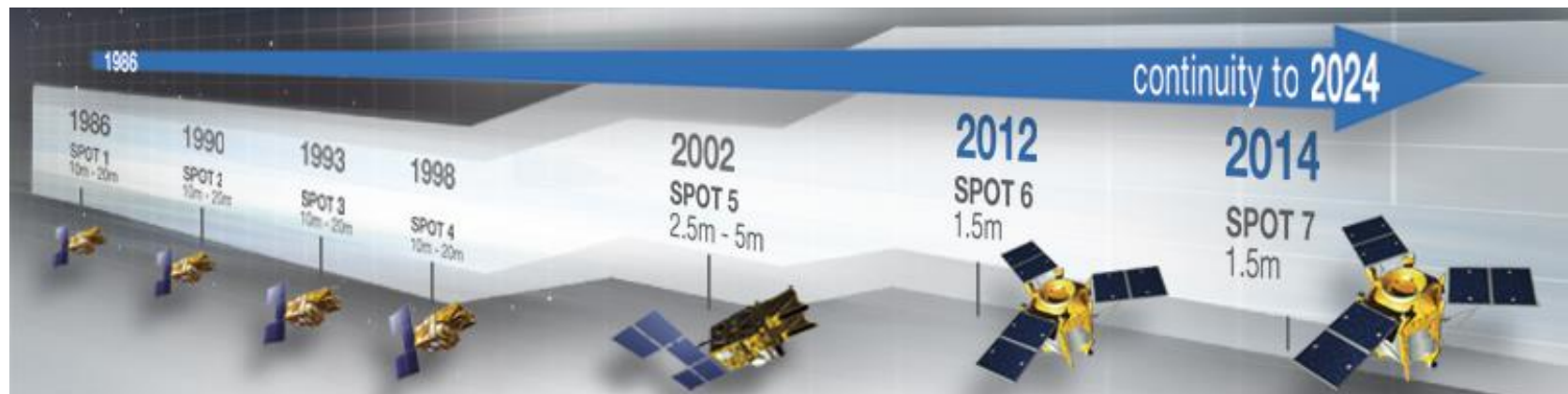


SPOT (Système Pour l'Observation de la Terre)



The SPOT Constellation

The system has been operational since 1986 when **SPOT-1** was launched. SPOT-2 was placed in orbit in January 1990, followed by SPOT-3 in September 1993, SPOT-4 in March 1998 and SPOT-5 in May 2002. System continuity is assured by the **SPOT-6** and **SPOT-7** constellation.



SPOT – Eletromagnetic Spectrum

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

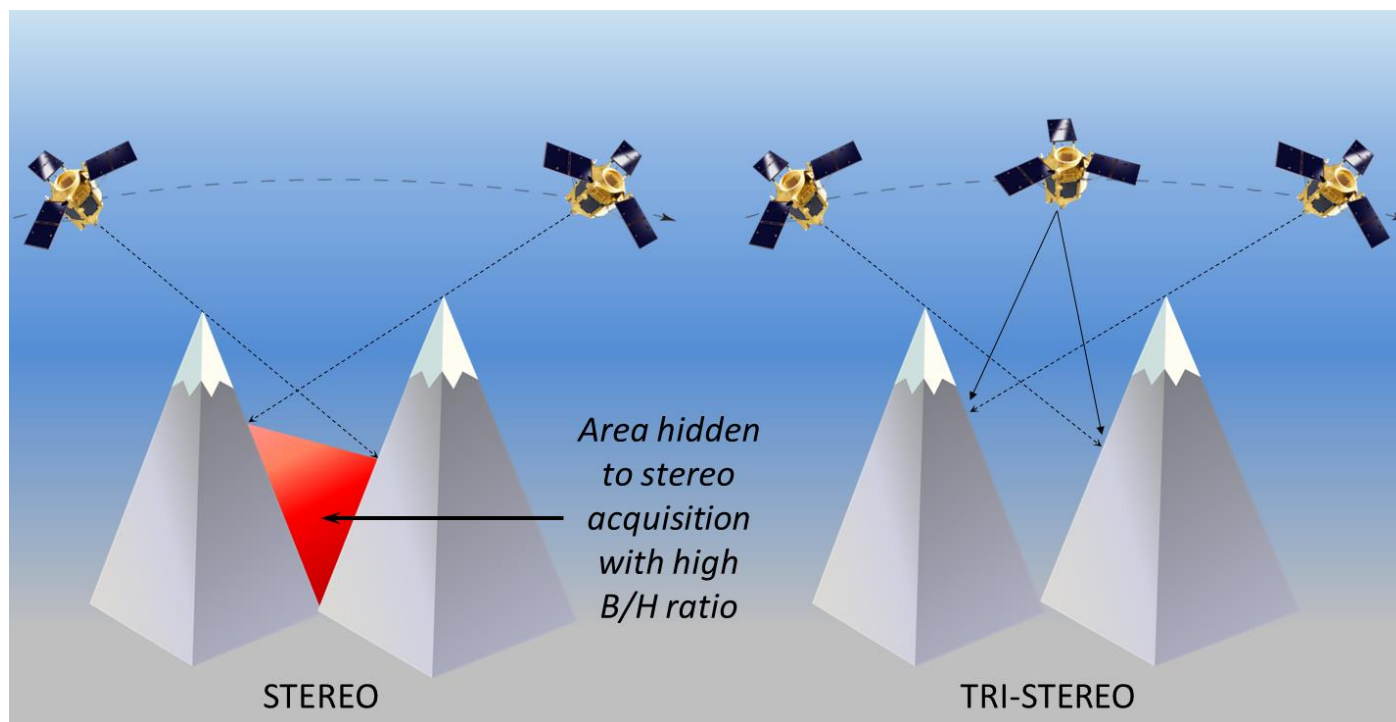
SPOT – Stereoscropy

		Stereoscopic Instruments	
		SPOT 5	
Instrument	HRS along-track stereoviewing	HRG stereoviewing capab 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 μm B2: 0.61 – 0.68 μm B3: 0.78 – 0.89 μm B4: 1.58 – 1.75 μm	
Imaging swath	600 km x 120 km		
Image dynamics			
Base/height ratio (B/H)	~ 0,84 ($\pm 20^\circ$)		
Absolute location accuracy (no ground control points, flat terrain)	10 m (1σ)*	30 m (1σ)*	350 m



HRS (High-Resolution Stereoscopic imaging instrument)

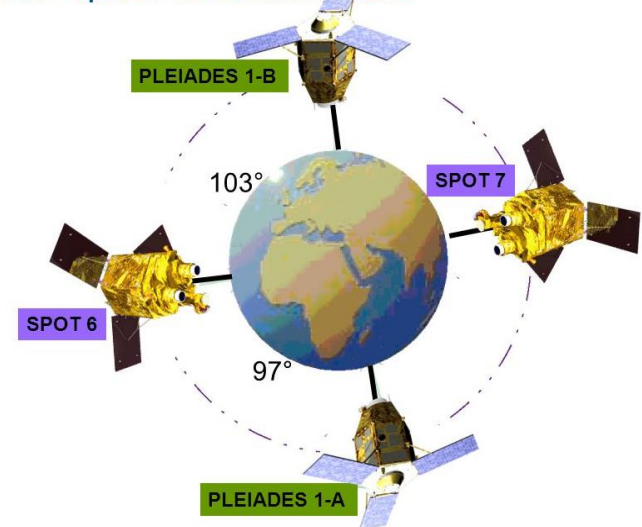
Both SPOT and Pleiades have **stereoscopic image acquisition capability** along the track (forward/backward): along-track stereo pairs and stereo triplets.



SPOT-6 satellite joined the **Pleiades Constellation** and later **SPOT-7** in 2014 after proposed launch.

SPOT-6 and **SPOT-7** will cover wider areas with a resolution of **1.5m**, **Pléiades-1A** (2011) and **Pléiades-1B** (2012) will be focused on more targeted zones with a greater level of detail (**50 cm** products).

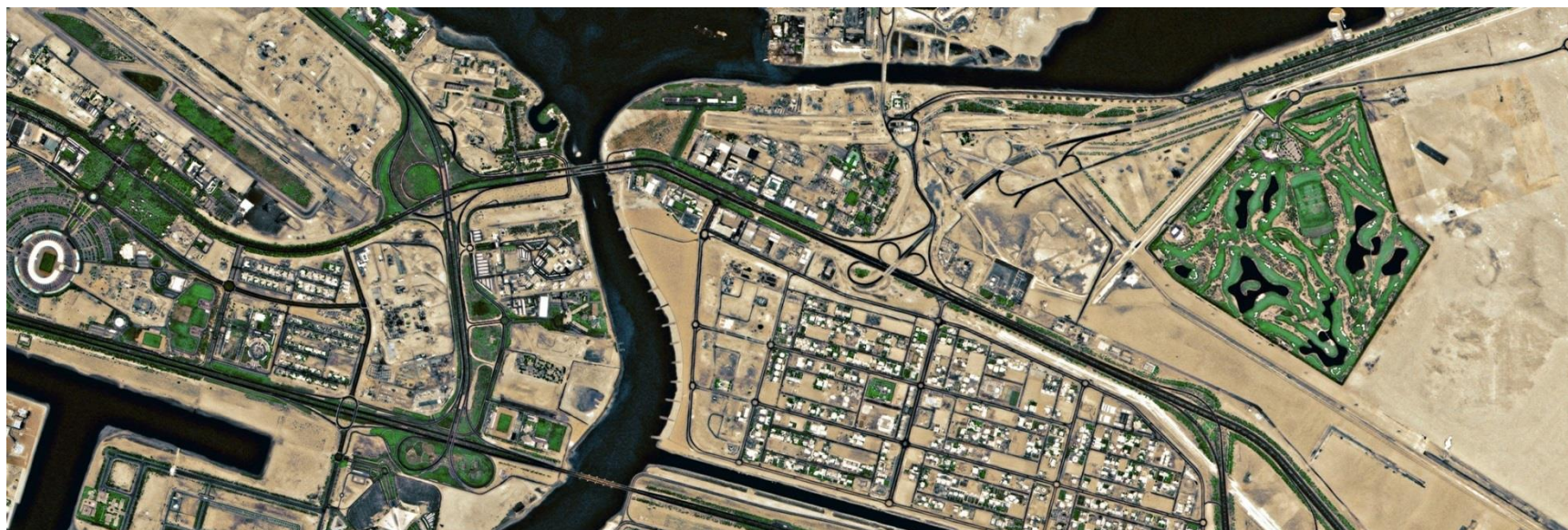
PLEIADES + Spot 6/7 constellation in 2012



	SPOT-6/7	Pleiades-1A/1B
Spectral Resolution	5 spectral bands, including a panchromatic band	5 spectral bands, including a panchromatic band
Spatial Resolution	1.5 m - panchromatic band 6 m - 4 multispectral bands (B,G,R,NIR)	0.5 m - panchromatic band 2 m - 4 multispectral bands (B,G,R,NIR)
Radiometric Resolution	12-bits	12-bits
Temporal Resolution	Twice daily, anywhere	Daily (Pleiades-1A and 1B)
Swath Width/ Scene Size	60 km at nadir	20 km at nadir

Same orbital plane. Inclination 98.2 degrees, Repeat cycle 26 days

SPOT 5 – Imagem 2.5 m

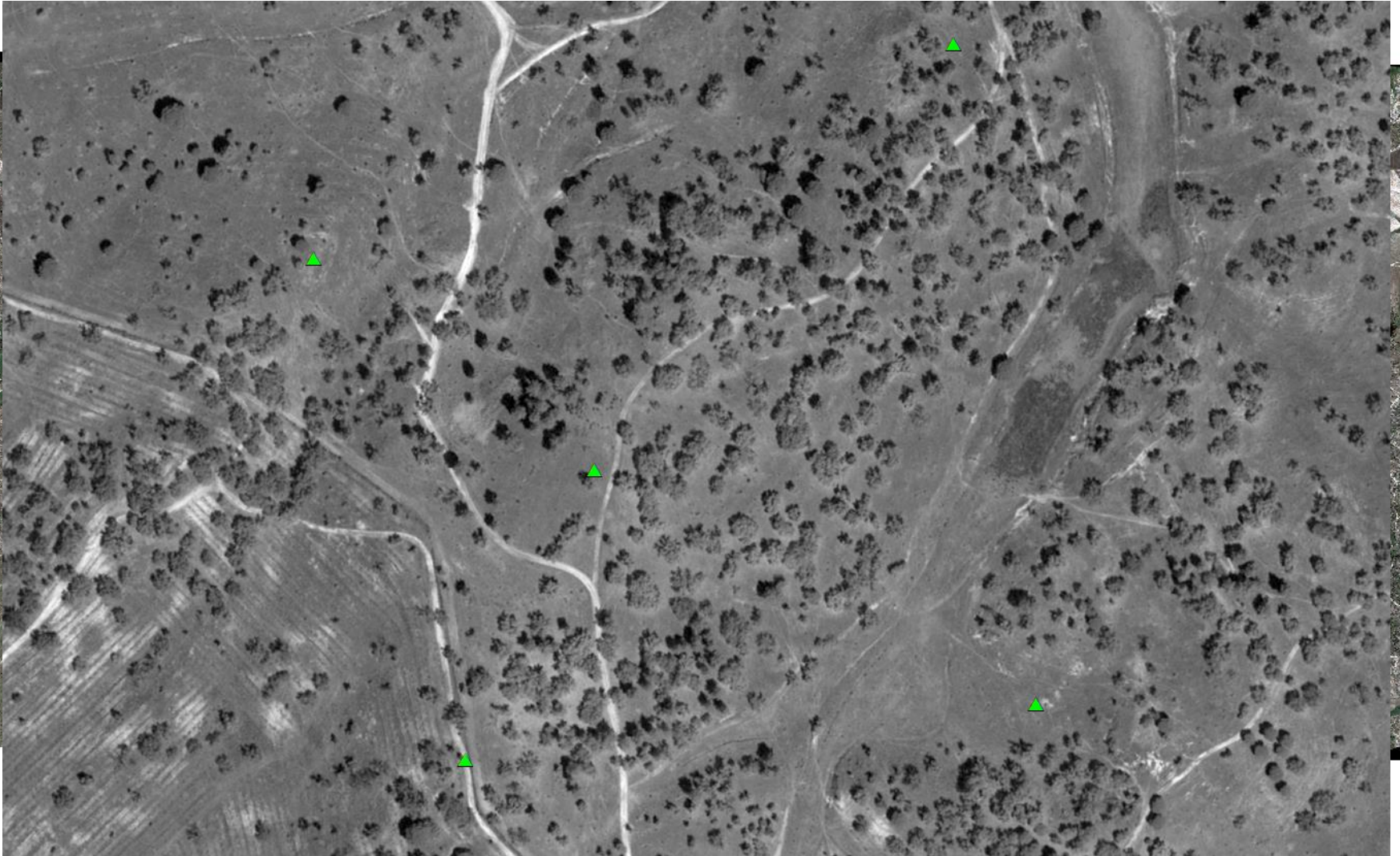




SPOT – Imagem 5 m



Pleiades – Pan, resolução 0.5 m





Pleiades – resolução 2 m

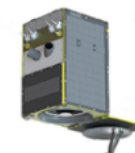
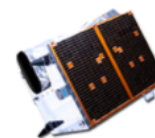
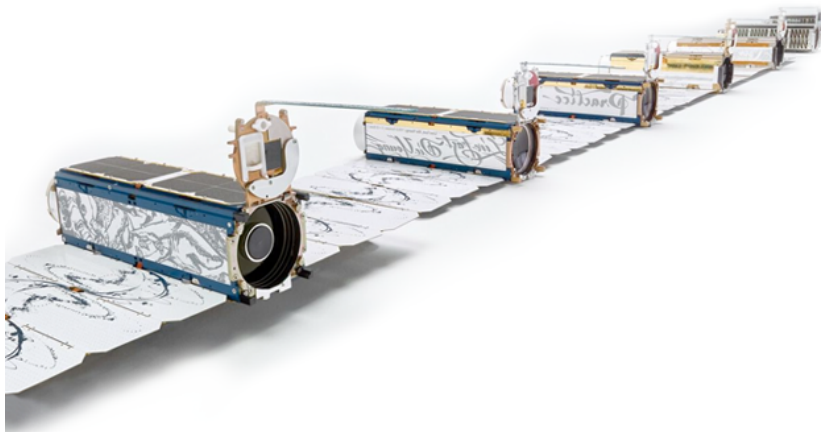


Our constellations

Planet operates more than 200 satellites that together provide an unprecedented dataset of Earth observation imagery. With a unique combination of coverage, frequency, and resolution Planet delivers geospatial insights at the speed of change, helping you get the most nuanced understanding of changing ground conditions.



Planet's constellation of satellites orbit the poles every 90 minutes, capturing the entire Earth's landmass every day.



180+

PLANETSCOPE

5

RAPIDEYE

21

SKYSAT

Collection capacity

350M+ km²/day

Archive back to 2009

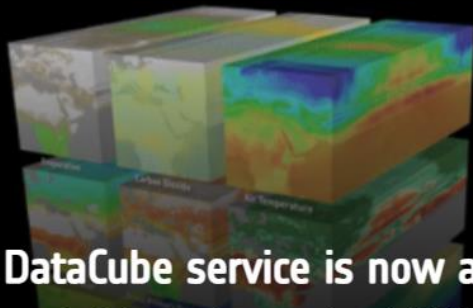
400K km²/day

PLANETSCOPE INSTRUMENTS

Explore instruments used in PlanetScope mission.

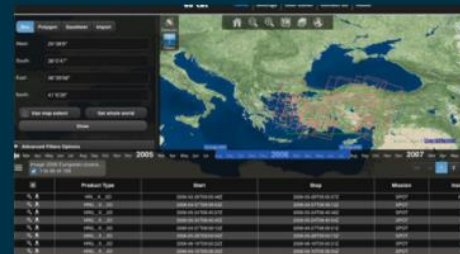
EXPLORE INSTRUMENTS

Featured



ESA's new DataCube service is now available

ESA is pleased to announce the deployment of a new service, called ESA PDGS-DataCube, enabling multi-temporal and pixel-based access to a subset of the data available in the European Space Agency dissemination services.



ESA's Earth Observation Catalogue and its services

EO-CAT is the EO Catalogue tool allowing users to search ESA and Third Party Mission collections.



PlanetScope

About PlanetScope

The PlanetScope satellite constellation consists of mu

Mission Parameters

Orbit altitude	475 km
Orbit type	Sun-synchronous
Orbit inclination	98°
Repeat Cycle	Daily
Equator Crossing Time	9:30 - 11:30 am (local solar time)

PlanetScope Camera

The PlanetScope camera on each DOVE cubesat operates currently in four bands - red, green,

Sensor Type	Three-band frame Imager or four-band frame Imager with a split-frame NIR filter (DOVE-C) Four-band frame imager with butcher-block filter providing blue, green, red, and NIR stripes (DOVE-R) Eight-band frame imager with butcher-block filter providing blue, green, red, red-edge, and NIR stripes (SuperDove)
Spectral Bands	Blue 455 – 515 nm Green 500 – 590 nm Red 590 – 670 nm RedEdge 733 – 748 nm NIR 780 – 860 nm
Ground Sample Distance (nadir)	3.9
Frame Size	24 km x 8 km (approximate) for DOVE-C 24 km x 16 km (approximate) for DOVE-R 32.5 km x 19.6 km (approximate) for SuperDove
Maximum Image Strip per orbit	20,000 km ²
Revisit Time	Daily at nadir (2017)
Image Capture Capacity	200 million km ² /day

VISUAL PRECISION, ANALYTIC POWER

Access color-corrected 3-band and sensor-calibrated multispectral products. Basic, orthorectified, radiance, and surface reflectance imagery are available.



PLANETSCOPE



RAPIDEYE



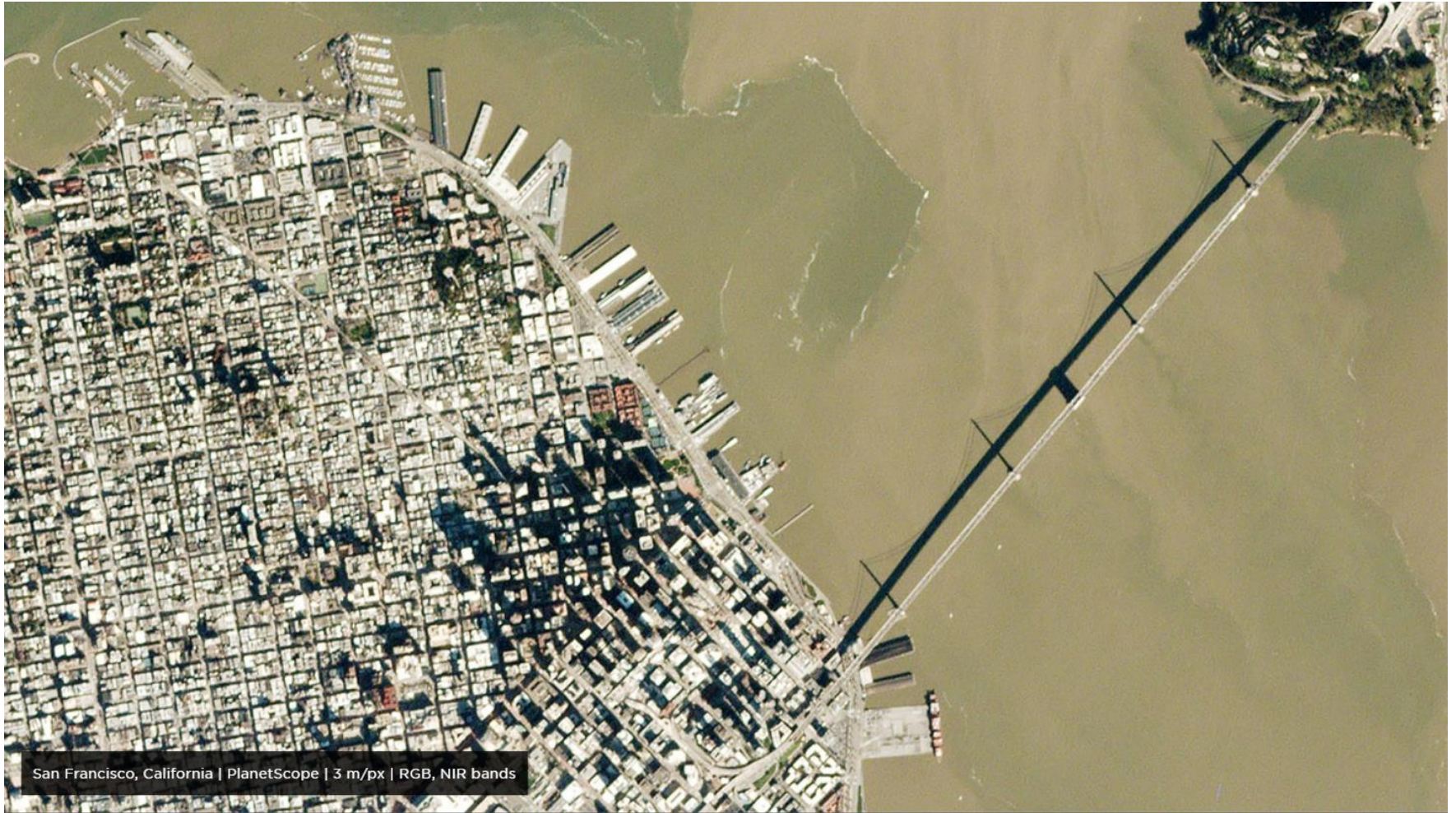
SKYSAT

	PLANETSCOPE	RAPIDEYE	SKYSAT
Bands	4 (RGB, NIR)	5 (RGB, red edge, NIR)	5 (RGB, NIR, pan)
Products	Color enhanced Visual Analytic	Color enhanced Visual Analytic	Visual Panchromatic Pansharpened multispectral Analytic
Pixel Resampled	3 m	5 m	Visual, panchromatic, pansharpened multispectral: 0.5m
Radiometric Resolution		Visual: 8 bit Analytic: 16 bit	Visual: 8 bit Analytic, panchromatic, and pansharpened multispectral: 16 bit
Positional Accuracy			<10 m RMSE
File Format			GeoTIFF



Ciências
ULisboa

PlanetScope



San Francisco, California | PlanetScope | 3 m/px | RGB, NIR bands

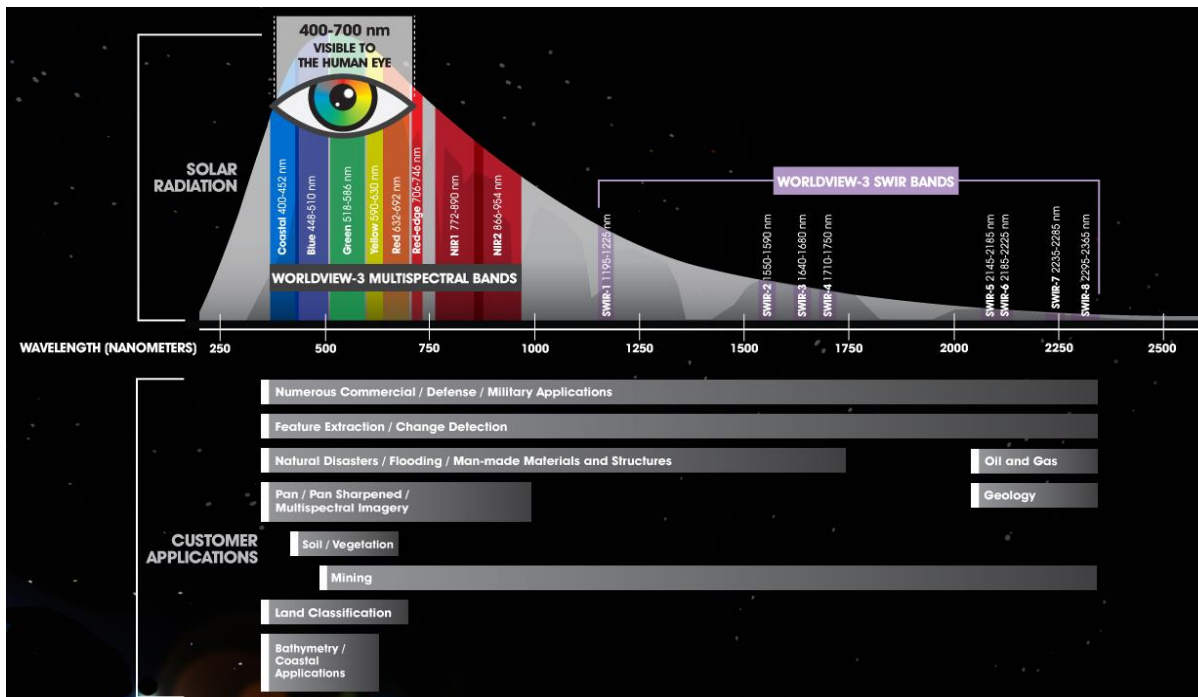


Other Systems

<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)



Ciências
ULisboa

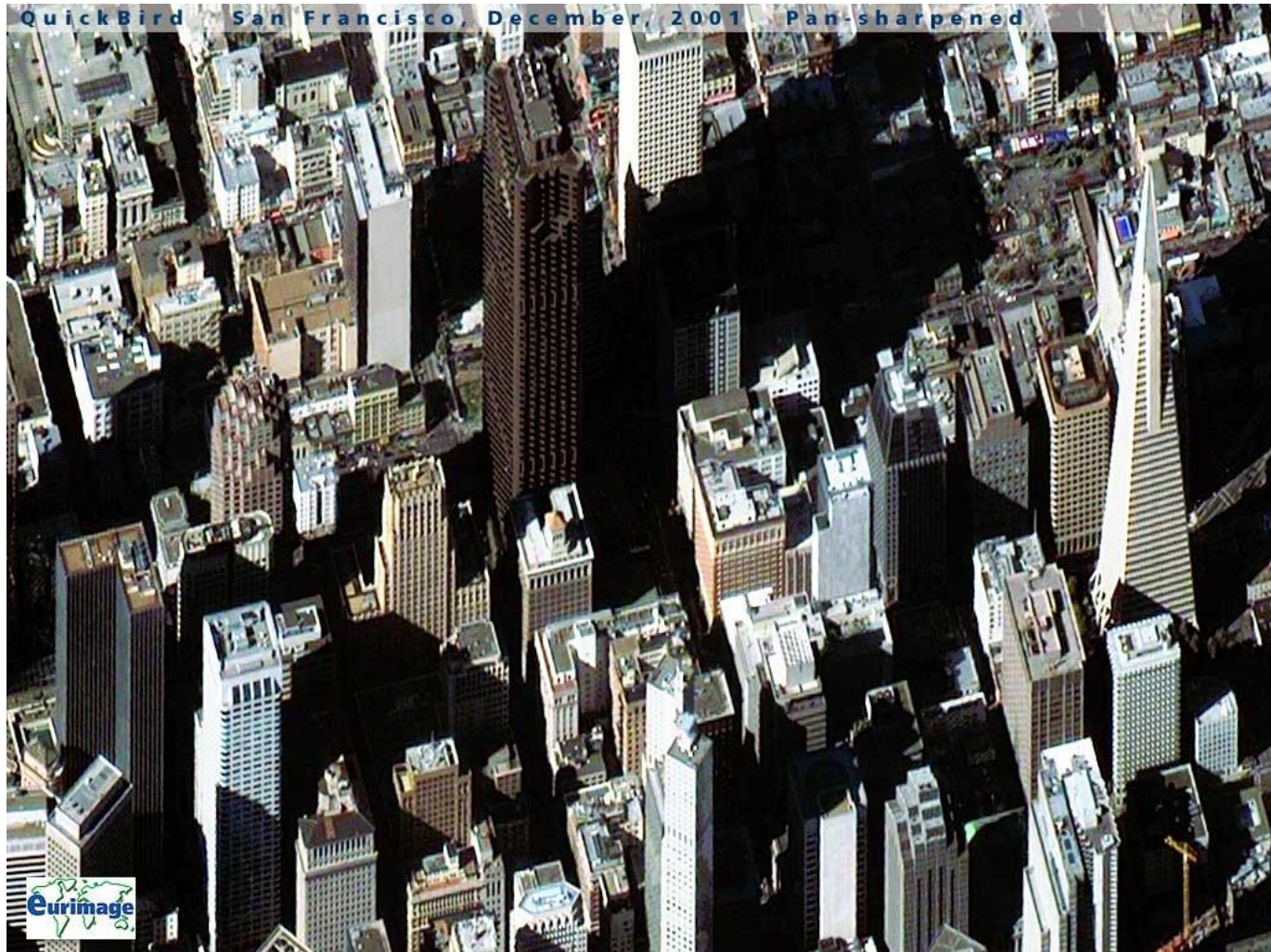
QUICKBIRD





Ciências
ULisboa

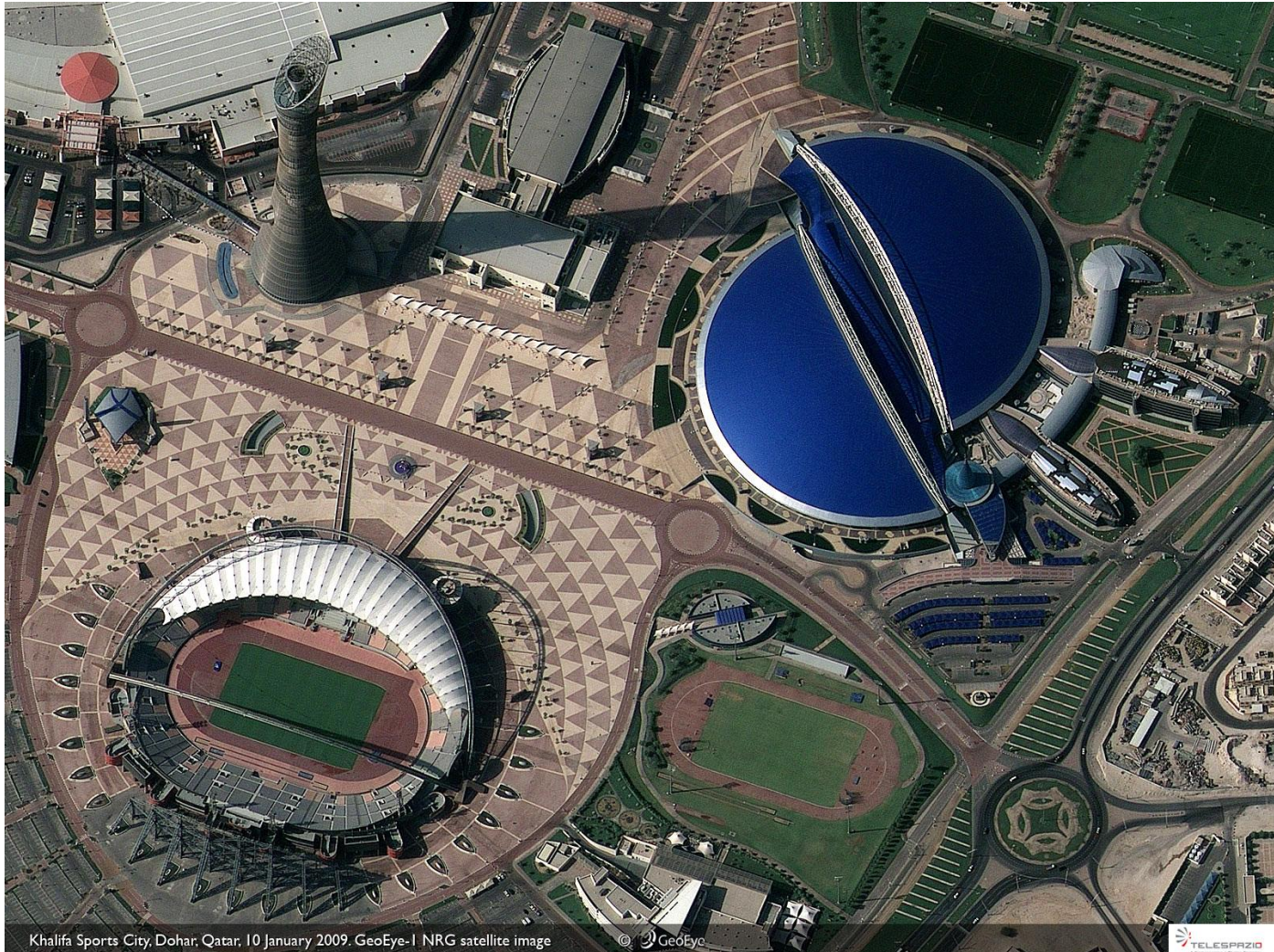
QUICKBIRD





Ciências
ULisboa

GeoEye

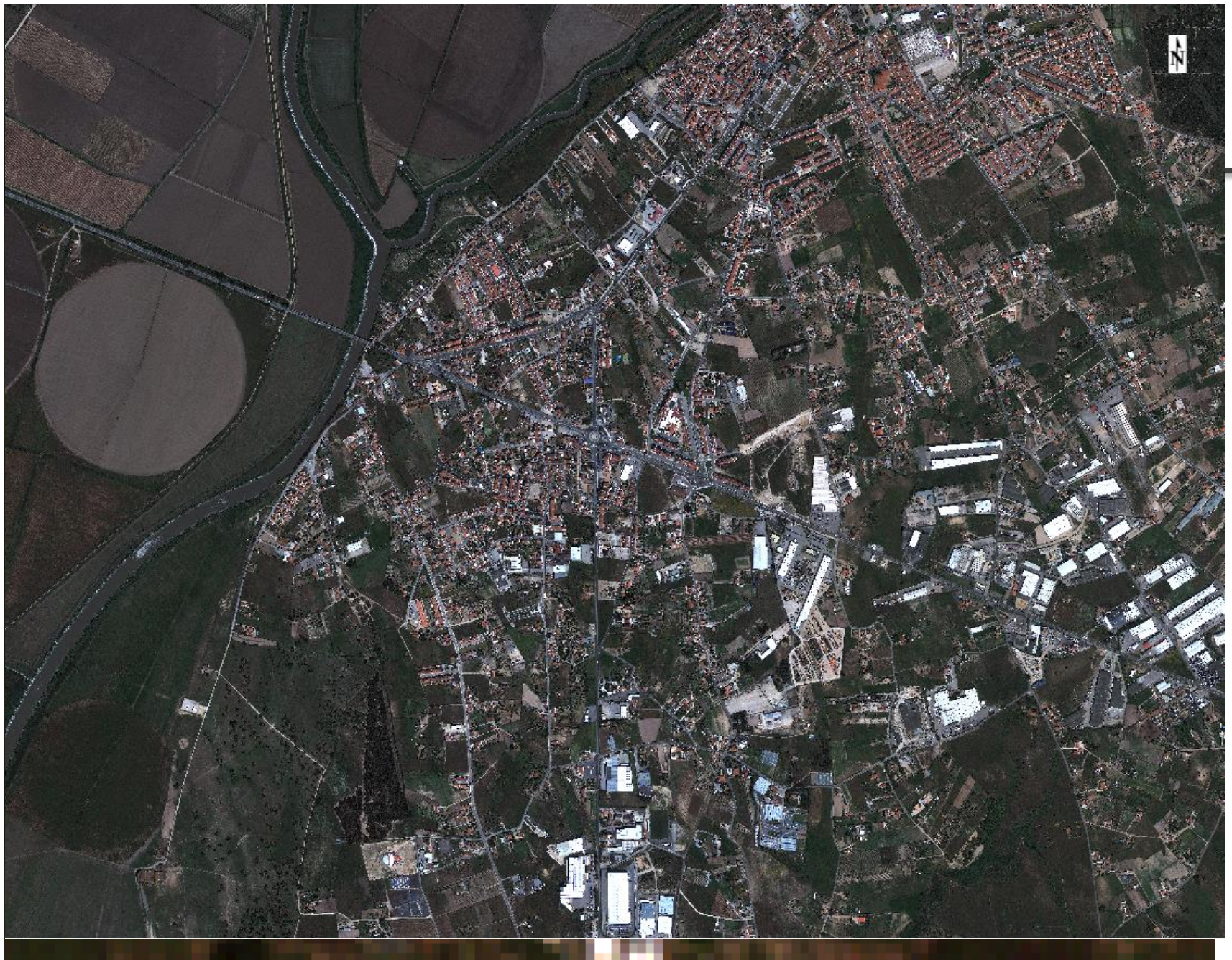


Khalifa Sports City, Dohar, Qatar, 10 January 2009. GeoEye-1 NRG satellite image

© GeoEye





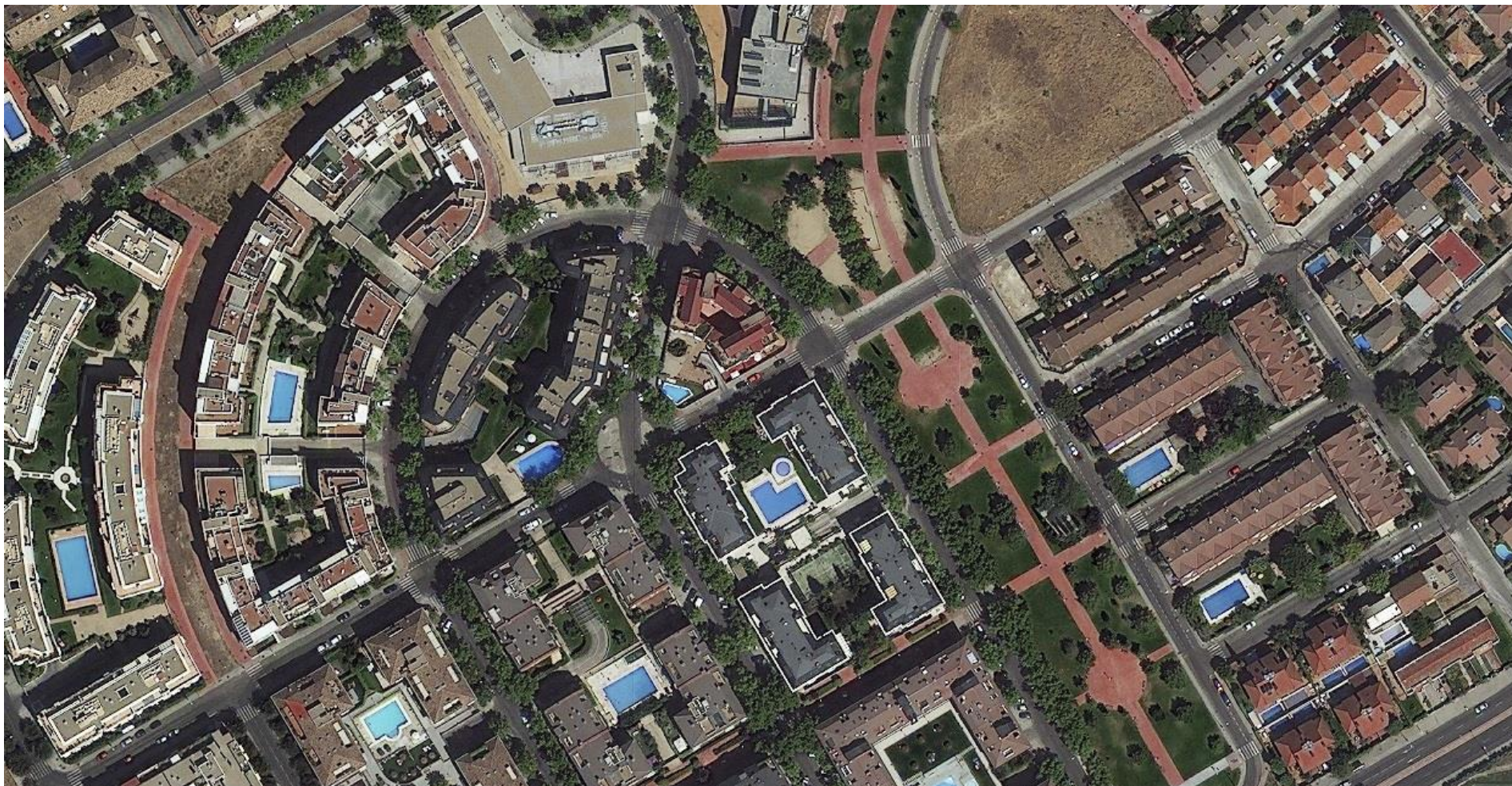




Ciências
ULisboa

Worldview

8 bandas, 0.31 / 1.24 m





Worldview
2m





ESA Missions

EO Missions handled by EOP

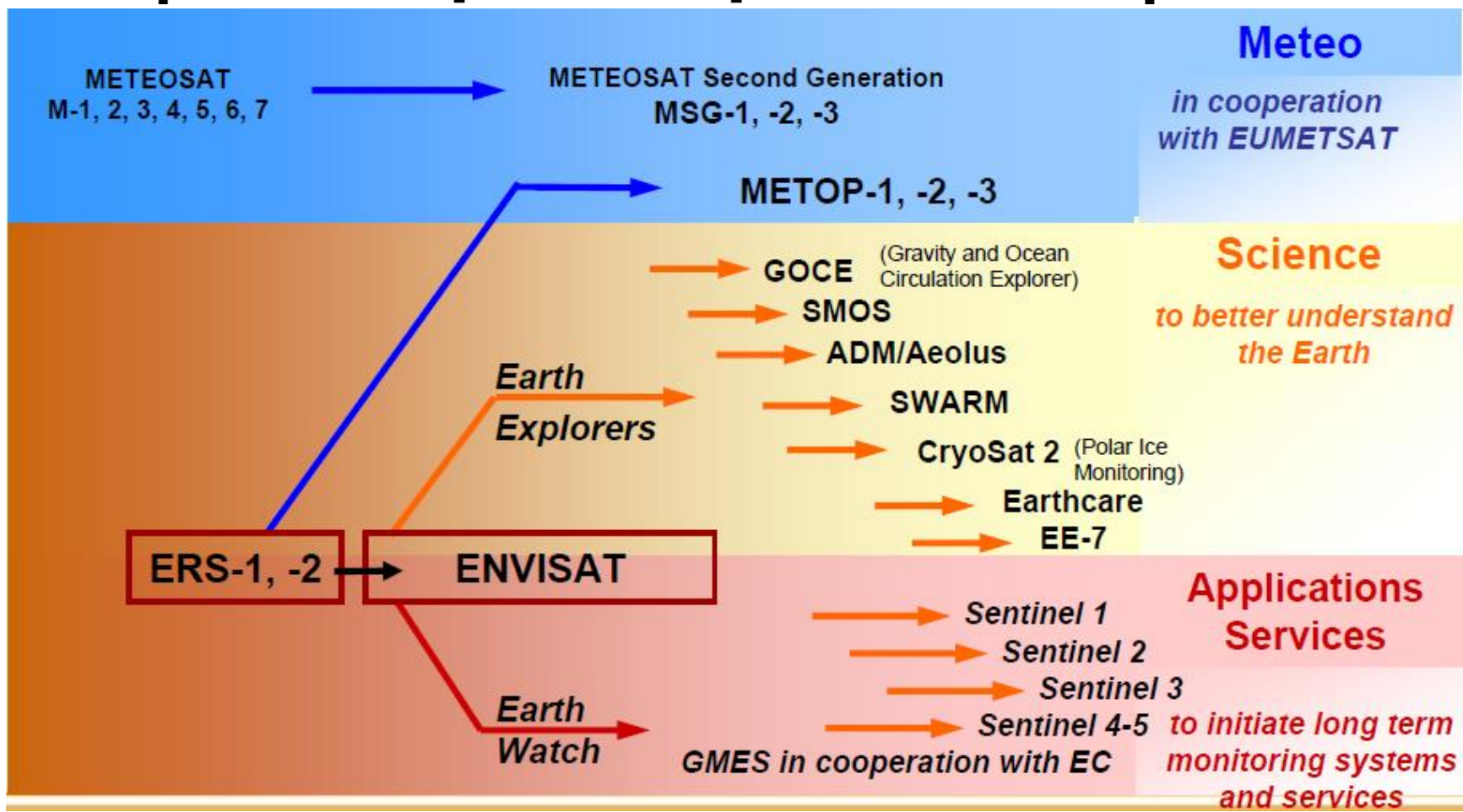
Since
1977

1990

2000

2008

2015



ERS mission (European Remote Sensing)

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

ENVISAT Mission

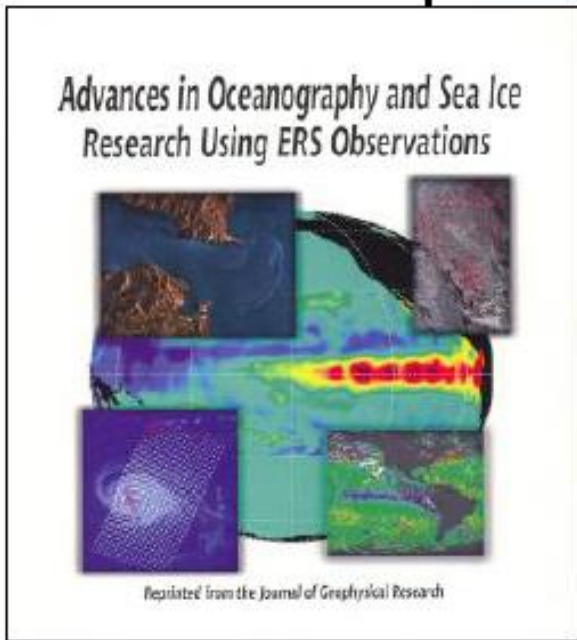
- ❑ **Largest European satellite & largest worldwide EO satellite:**
 - unique combination of 10 instruments addressing land, ocean, ice and atmosphere studies,
 - instruments working nominally, except MIPAS instrument
- ❑ **Satellite OK with long-term operations capabilities:**
 - 65 % of fuel available (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

ERS missions - Science

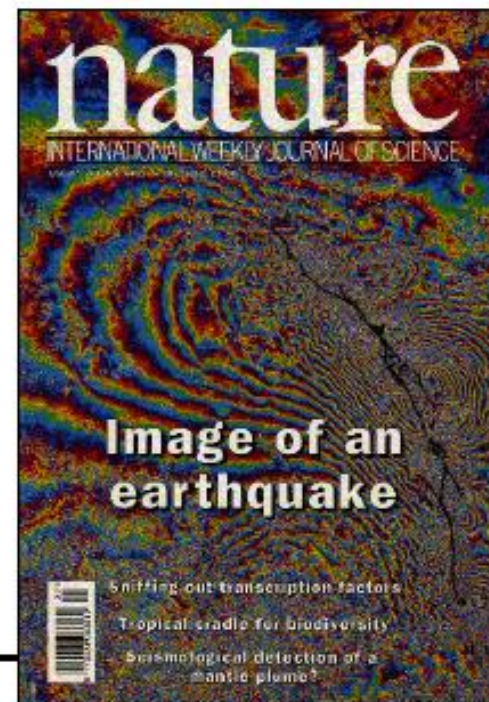


ERS and Volcanic activities

Oceanography and sea Ice

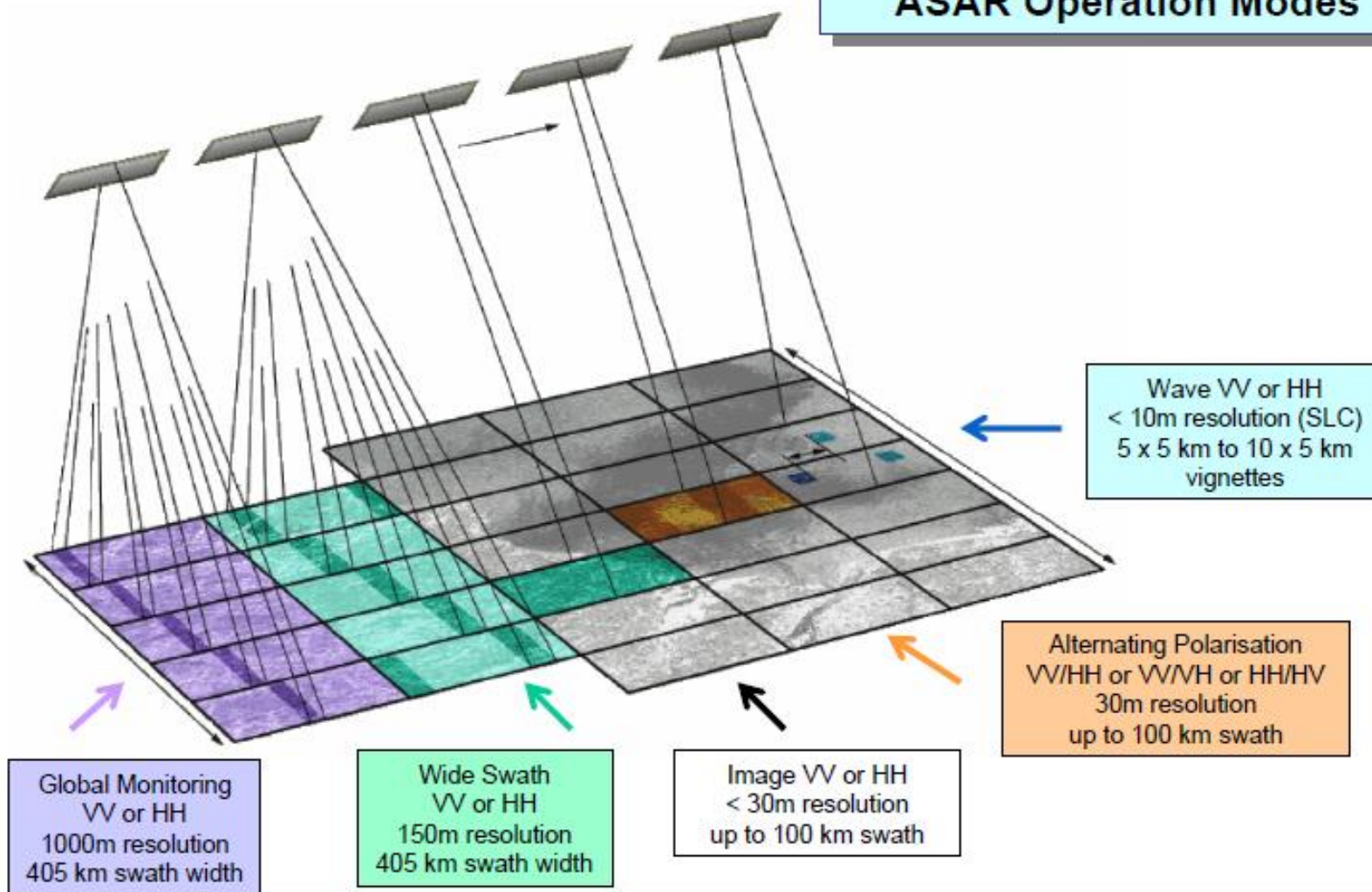


ERS and SAR Interferometry



ENVISAT - ASAR

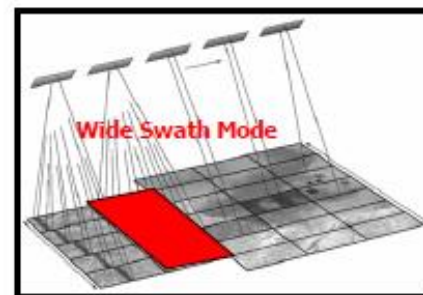
ASAR Operation Modes



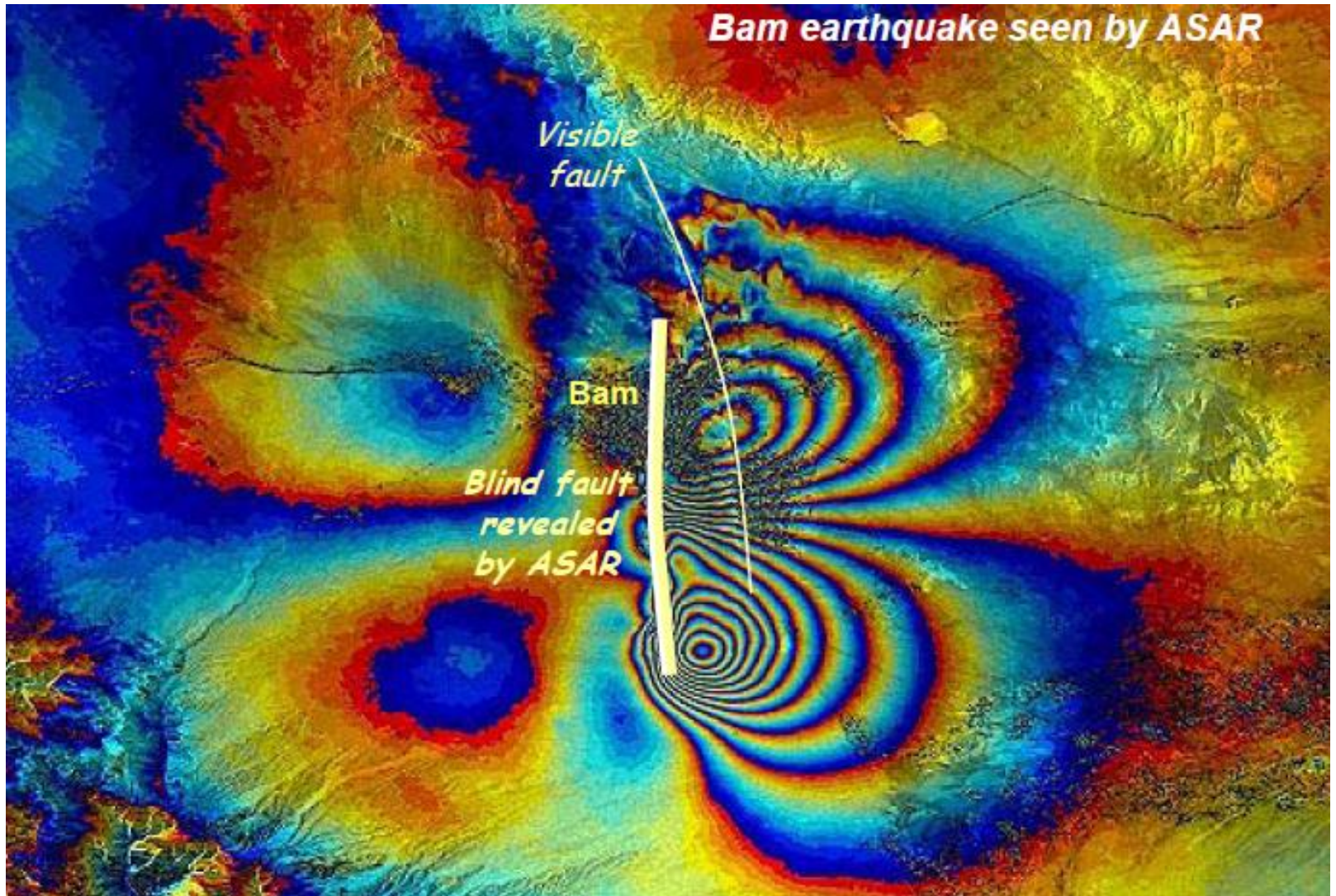
ENVISAT - ASAR



ENVISAT Imaging Radar



ENVISAT - ASAR



Earth Explorers – Core Missions

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

GOCE

Earth gravity field
and Geoid
measurements

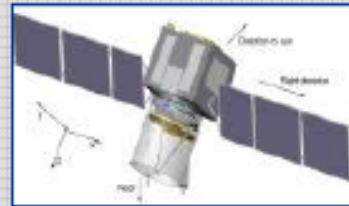
Launch: 2007



ADM-Aeolus

Windspeed
vectors
measurements

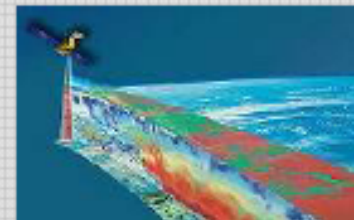
Launch: 2009



EarthCARE

Clouds, Aerosols
& radiation
measurements

Launch: 2012+



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

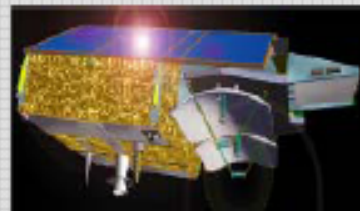
Launch: 2008



Cryosat-2

Ice elevation and ice thickness measurements

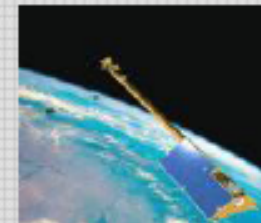
Launch: 2009



SWARM

Earth magnetic field & Earth core dynamics meas.

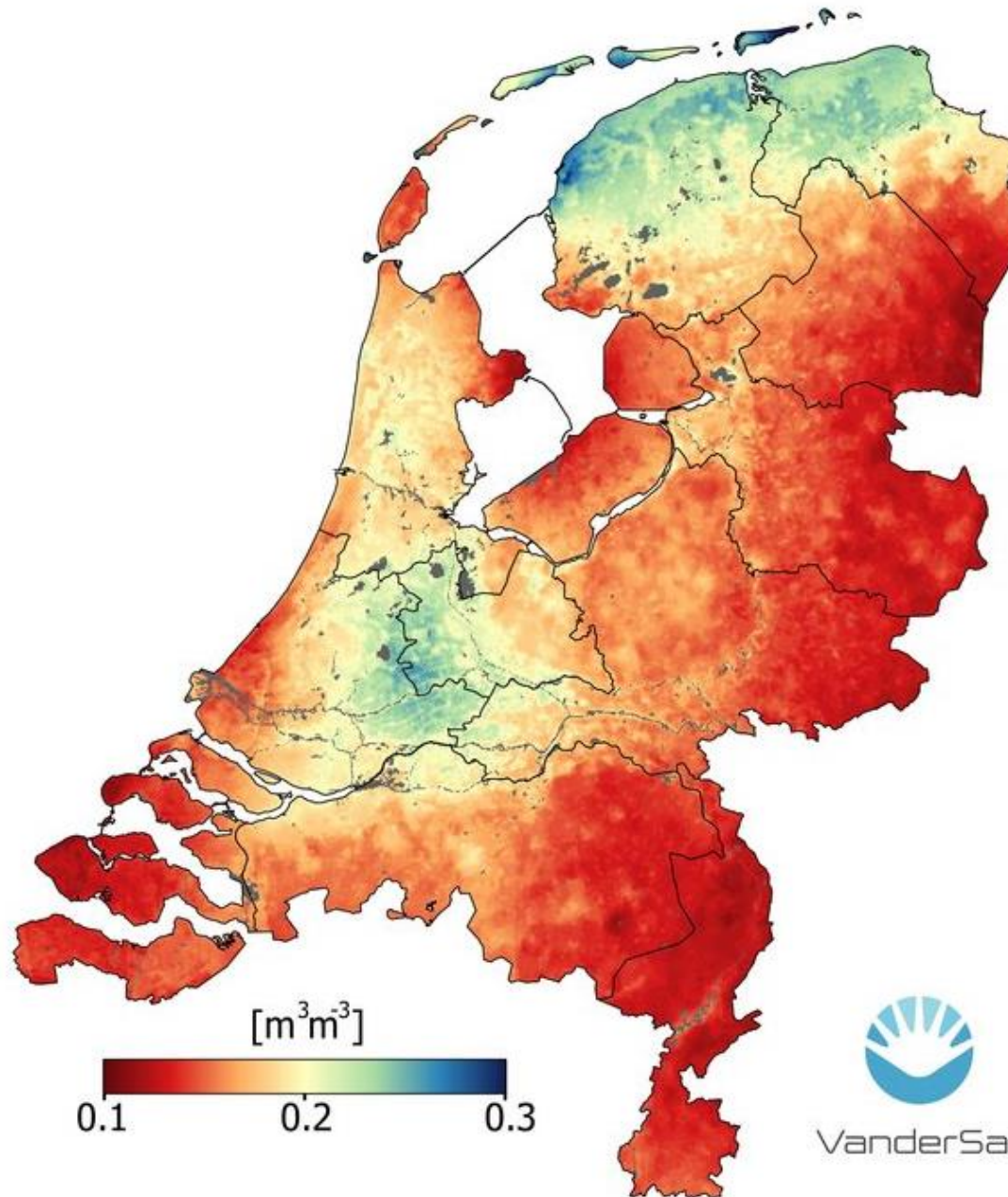
Launch: 2009+





Ciências
ULisboa

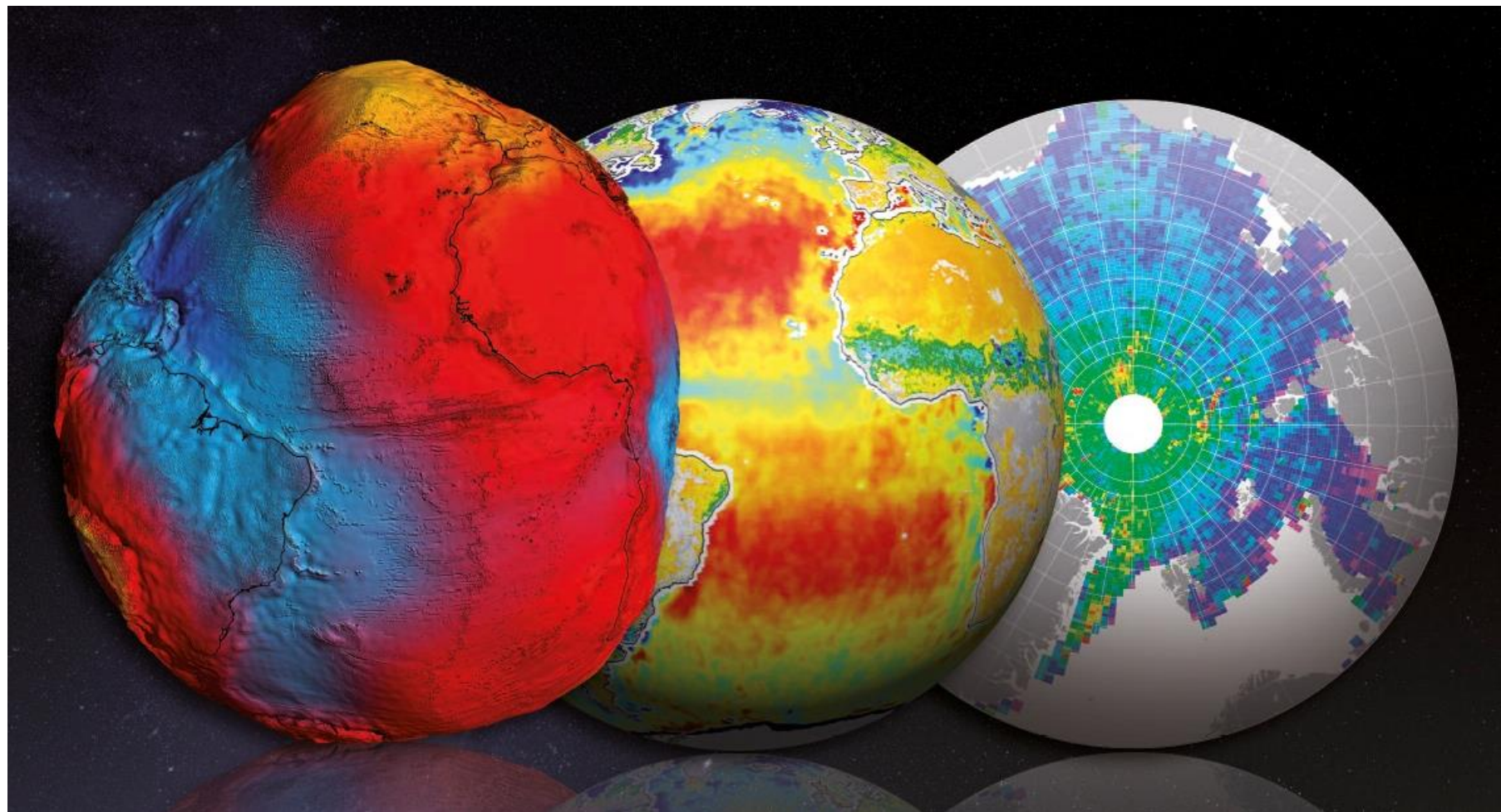
SOIL MOISTURE IN THE NETHERLANDS



re the
ossible
satellite

ie
1000 km
phase-

Earth Explorers (ESA)



GOCE

SMOS

CryoSAT

Global Monitoring for Environment and Security (GMES)

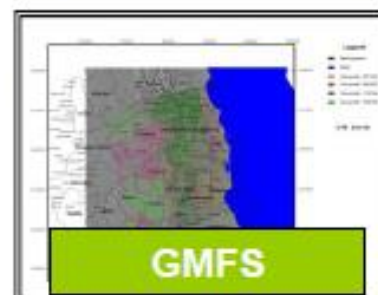
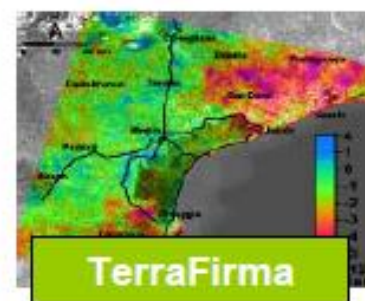
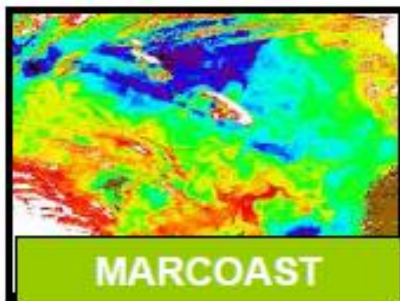


European autonomy in data sources for environment
and security monitoring

and

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

GMES - Services

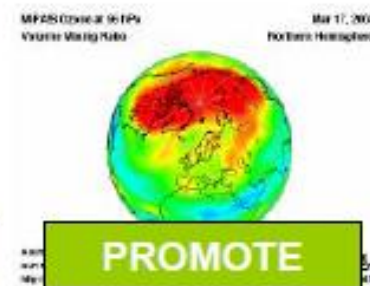


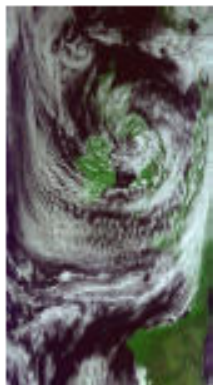
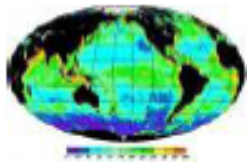
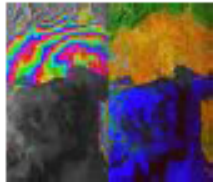
**100 M€ by ESA
MS**

**Period 2003-
2008 (2009)**

**300+ user
organisations**

**EC has
invested
another 100 M€**



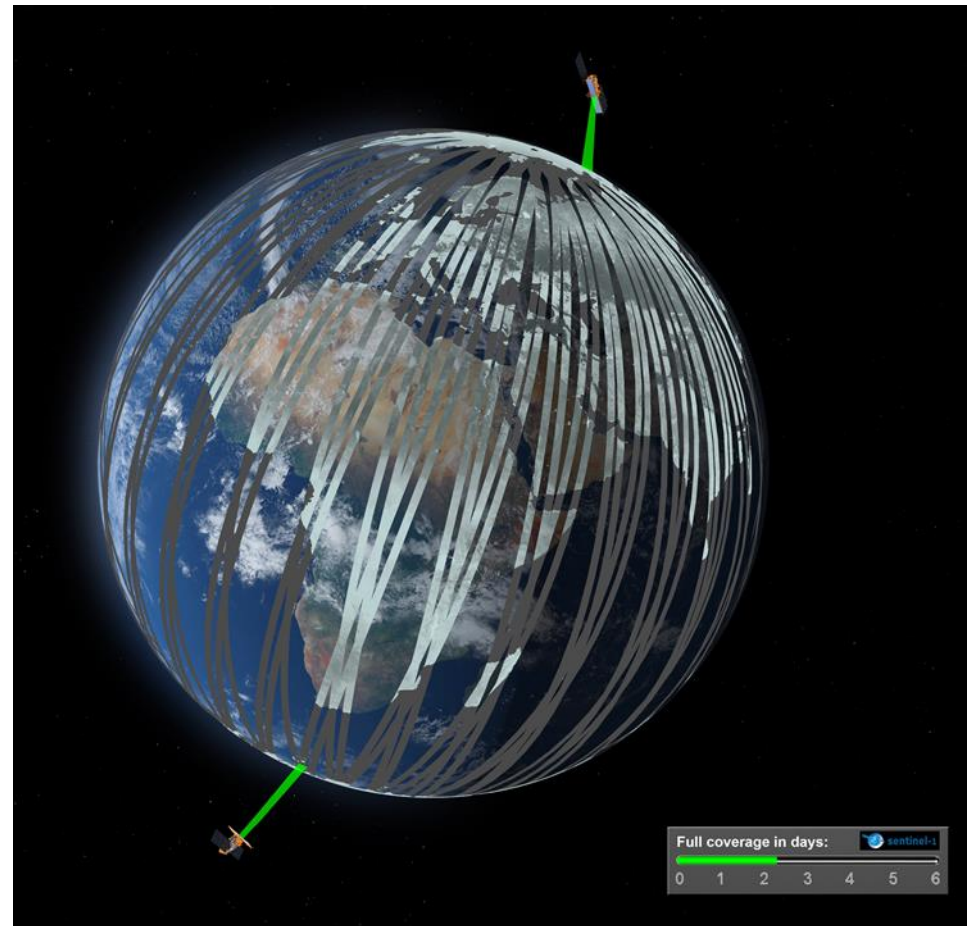


- **Sentinel 1 – SAR imaging**
 - All weather, day/night applications, interferometry, ocean/ice/land
- **Sentinel 2 – Superspectral imaging**
 - Continuity of Landsat, SPOT - type of data for land mapping
- **Sentinel 3 – Ocean monitoring**
 - Wide-swath ocean color, surface temperature and land mission & 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-2 Mission

Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other.

It aims at monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of Earth's surface changes.

The coverage limits are from between latitudes 56° south and 84° north.

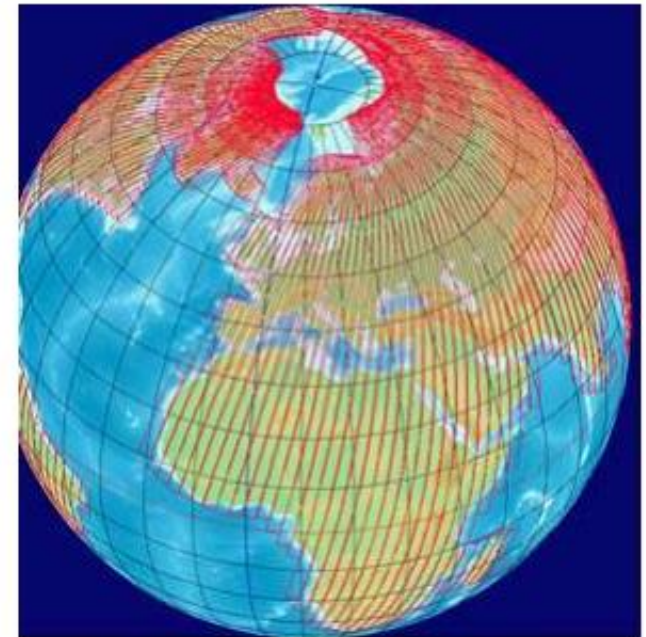
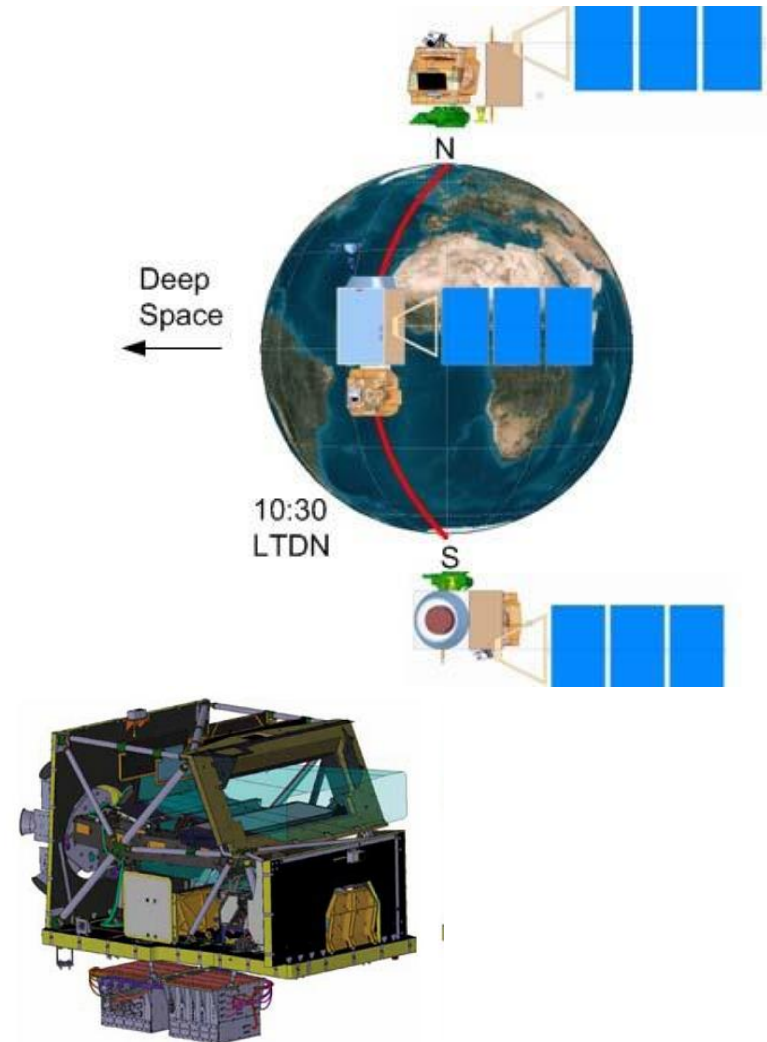


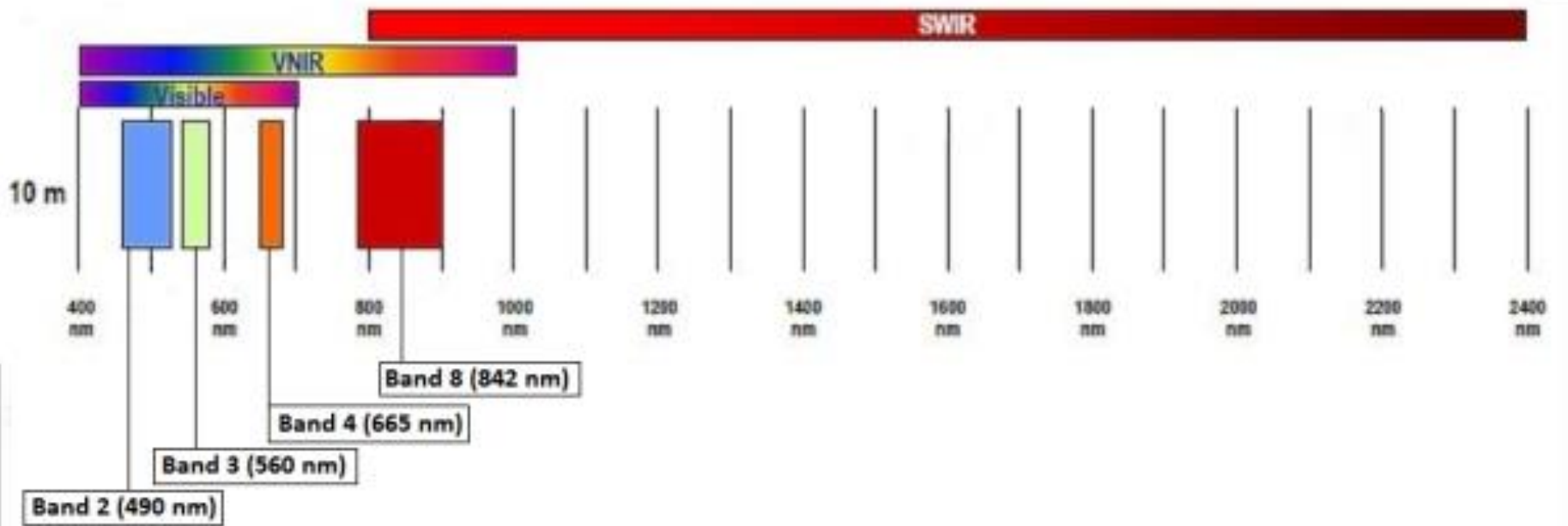
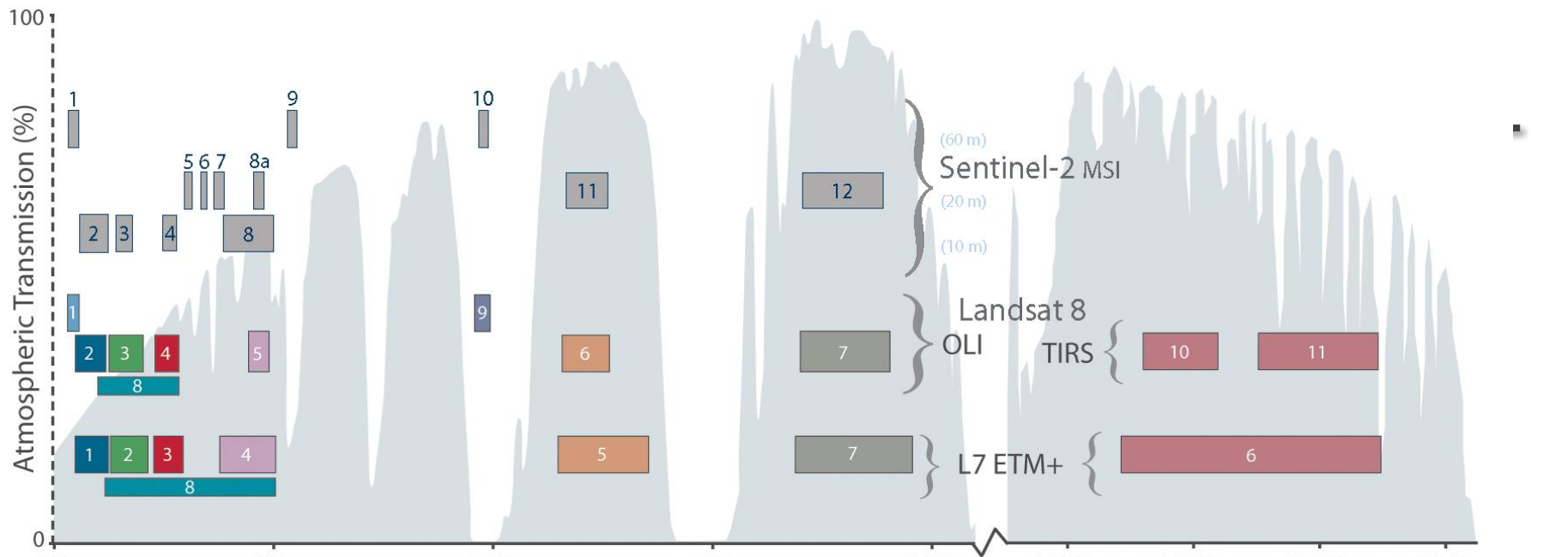
Figure 22: Modelled Sentinel-2 Coverage

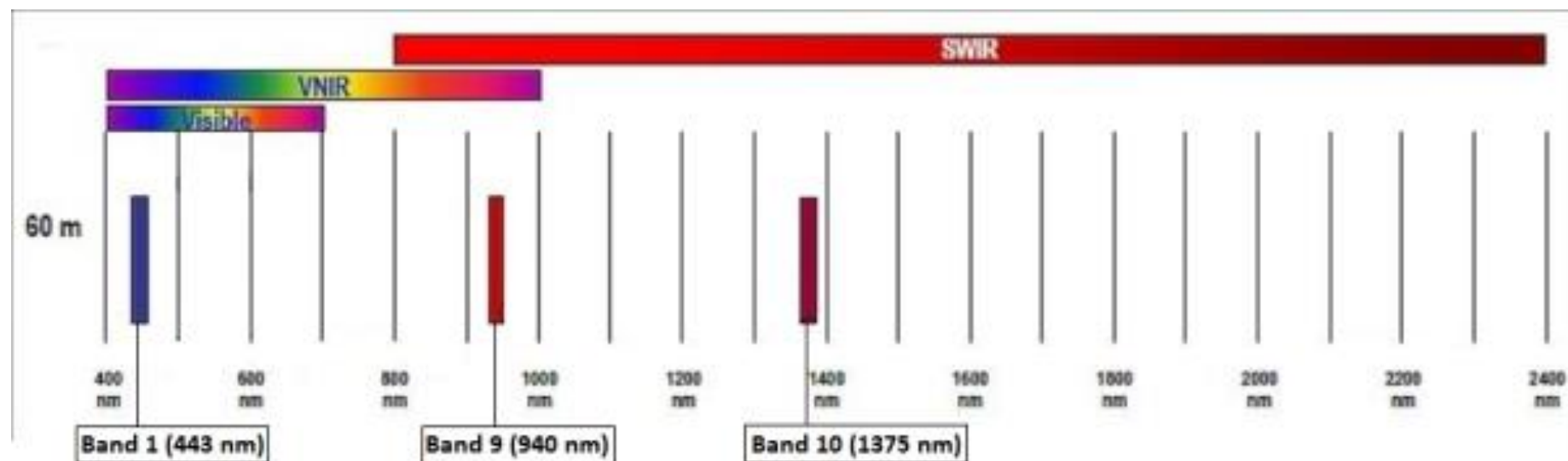
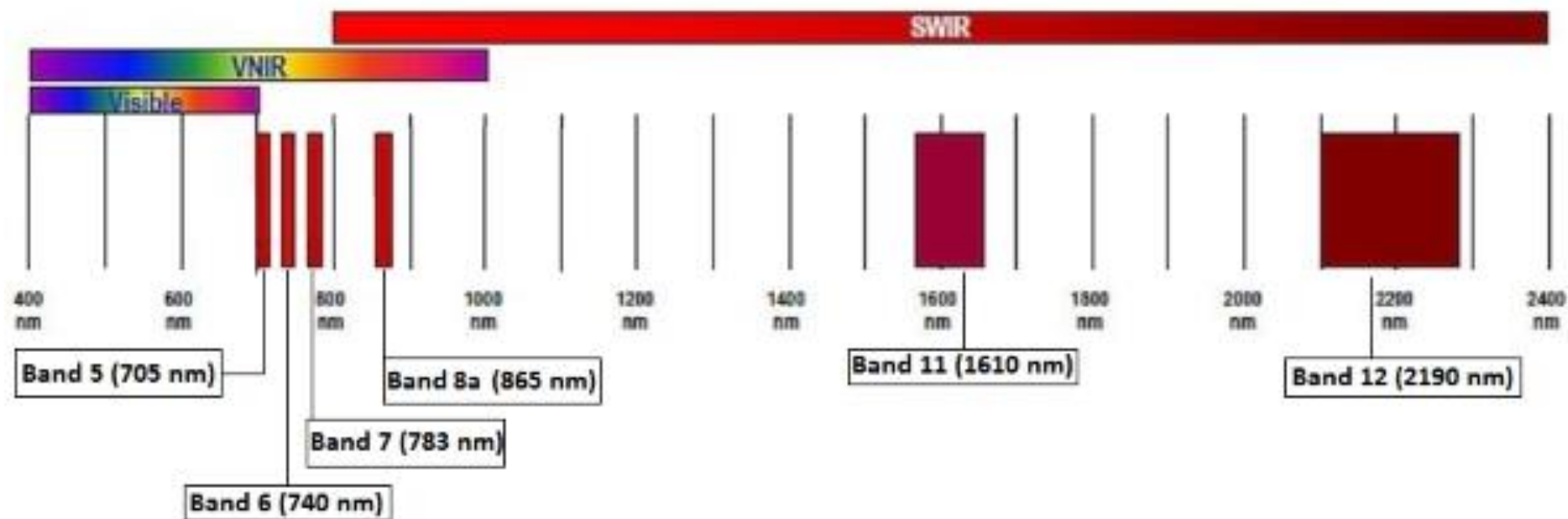
The **Sentinel-2** satellites are placed in the same sun-synchronous orbit, phased at 180° to each other, at an altitude of 786 km and an inclination of 98.5 degrees for 14.3 revolutions per day and a 10:30 Local Time of **Descending Node** that has been chosen to minimize cloud cover and ensure a good solar illumination of Earth's surface.

Sentinel-2 carries a single pushbroom sensor: the **Multispectral Imager (MSI)** that covers 13 spectral bands.



Comparison of Landsat 7 and 8 bands with Sentinel-2







Sentinel-hub Playground | OGC API | Sentinel | Geo & OS Intelligence

Secure | https://apps.sentinel-hub.com/sentinel-playground/?source=S2&lat=38.84839808014555&lng=-8.905792236328125&zoom=12&preset=1_NATURAL_COLOR&layers=B01,B02,B03&maxcc=100&gain=1.0&gamma=1.0&time=2015-...

Apps | ResearcherID.com | Tide Gauge WEST CO | ESA CCI Soil Moisture | Earth Observation Job | Location Based Service | Research Group Rem | Projects | ESA Busine | Geo & OS Intelligence | Bem-vindo à página

SENTINEL Hub Playground | 2017-10-12 | 100 % | Search places | + - | Share | Print

Rendering | Effects

- Custom
- Natural color
Based on bands 4,3,2
- Color Infrared (vegetation)
Based on bands 8,4,3
- False color (urban)
Based on bands 12,11,4
- Agriculture
Based on bands 11, 8, 2
- Vegetation Index
Based on combination of bands (B8 - B4)/(B6 + B4)
- Moisture Index
Based on combination of bands (B8A - B11)/(B8A + B11)
- Geology
Based on bands 12,4,2
- Bathymetric
Based on bands 4,3,1
- Atmospheric penetration
Based on bands 12,11,8A
- SWIR
Based on bands 12,8A,4
- NDWI
Based on combination of bands (B3 - B8)/(B3 + B8)
- SWIR-2,11,12
Based on bands 2,11,12

GENERATE

Get Sentinel and Landsat imagery in your GIS

OpenStreetMap | Sentinel Hub

Windows taskbar: File Explorer, Mail, S, Edge, PowerPoint, Chrome

System tray: 09:46, 06/03/2018



Sentinel-hub Playground x OGC API | Sentinel x Geo & OS Intelligence | x

Secure | https://apps.sentinel-hub.com/sentinel-playground/?source=S2&lat=38.84839808014555&lng=-8.905792236328125&zoom=12&preset=2_COLOR_INFRARED_VEGETATION_&layers=B01,B02,B03&maxcc=100&gain=1.0&gamma=...

Apps ResearcherID.com Tide Gauge WEST CC ESA CCI Soil Moisture Earth Observation Job Location Based Service Research Group Rem Projects | ESA Business Geo & OS Intelligence Bem-vindo à página

SENTINEL Hub Playground 2017-10-12 100 % Search places

Rendering Effects

- Custom
- Natural color
Based on bands 4,3,2
- Color Infrared (vegetation)**
Based on bands 8,4,3
- False color (urban)
Based on bands 12,11,4
- Agriculture
Based on bands 11, 8, 2
- Vegetation Index
Based on combination of bands (B8 - B4)/(B8 + B4)
- Moisture Index
Based on combination of bands (B8A - B11)/(B8A + B11)
- Geology
Based on bands 12,4,2
- Bathymetric
Based on bands 4,3,1
- Atmospheric penetration
Based on bands 12,11,8A
- SWIR
Based on bands 12,8A,4
- NDWI
Based on combination of bands (B3 - B8)/(B3 + B8)
- SWIR-2,11,12
Based on bands 2,11,12

GENERATE

Get Sentinel and Landsat imagery in your GIS

OpenStreetMap Sentinel Hub 2 km

Windows taskbar: 09:47 06/03/2018



- Rendering Effects
- Custom
 - Natural color
Based on bands 4,3,2
 - Color Infrared (vegetation)
Based on bands 8,4,3
 - False color (urban)
Based on bands 12,11,4
 - Agriculture
Based on bands 11, 8, 2
 - Vegetation Index
Based on combination of bands (B8 - B4)/(B8 + B4)
 - Moisture Index
Based on combination of bands (B8A - B11)/(B8A + B11)
 - Geology
Based on bands 12,4,2
 - Bathymetric
Based on bands 4,3,1
 - Atmospheric penetration
Based on bands 12,11,8A
 - SWIR
Based on bands 12,8A,4
 - NDWI
Based on combination of bands (B3 - B8)/(B3 + B8)
 - SWIR-2,11,12
Based on bands 2,11,12
- GENERATE

