

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

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 abril 2023.

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>

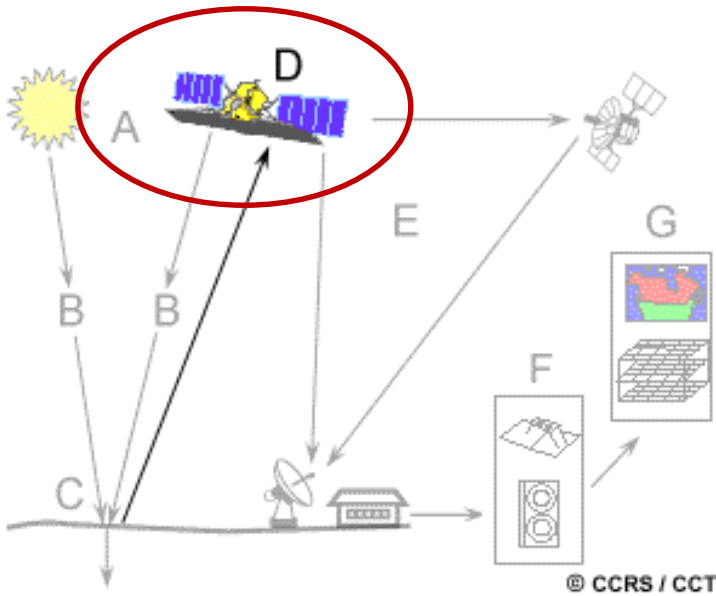
A ICEYE lançou e colocou em órbita com sucesso seis novos satélites SAR com resolução de 25 cm. Os satélites foram integrados pela Exolaunch e decolaram com sucesso em 30 de março a bordo da missão de compartilhamento de carga Transporter-16 com a SpaceX, a partir da Base da Força Espacial de Vandenberg, na Califórnia, EUA. Cada satélite estabeleceu comunicação, e as operações de comissionamento de rotina estão em andamento.

Os novos satélites servirão à constelação comercial da ICEYE, juntamente com missões nacionais dedicadas, incluindo a ICEYE US, o programa MikroSAR das Forças Armadas da Polônia e a CTI Aeroespacial, representando a Força Aérea Portuguesa, o CEiiA e a GEOSAT na iniciativa Atlantic Constellation.

Com essa implantação, a empresa continua a aumentar a capacidade soberana de imagem e a resiliência para governos que exigem monitoramento contínuo, rápido, confiável e de alta fidelidade, dia ou noite e em qualquer condição climática.

Em toda a Europa, nas Américas e na região Indo-Pacífico, as nações estão elevando a inteligência espacial de vantagem estratégica a requisito operacional. A ICEYE está possibilitando essa mudança ao fornecer capacidades soberanas de ISR em meses, em vez de anos, por uma fração do custo dos programas tradicionais. Ao fornecer acesso ágil e de alta frequência de revisitação sob controle nacional

Missões de Observação da Terra



Meteorológicas

Altimetria de Satélite

Geopotenciais

Observação da Terra



MISSION PROGRAMMES

Explore the European Space Agency's Earth Observation satellite missions. Learn all about ESA's dedicated Earth Explorers or collaborations with other agencies through the Third Party Missions programme.



Earth Explorers

ESA's Earth Explorer missions are dedicated to addressing key scientific challenges identified by the EO community...

[EXPLORE MORE](#)



Heritage Missions

ESA's Heritage missions programme preserves 30 years of historical data from more than 45 satellite missions that are no longer operational...

[EXPLORE MORE](#)



Third Party Missions

Through the TPM programme, ESA offers data from a wide range of EO satellite missions developed and operated by other agencies...

[EXPLORE MORE](#)



Earth Watch

ESA's Earth Watch programme consists of missions developed and operated in partnership with other organisations...

[EXPLORE MORE](#)

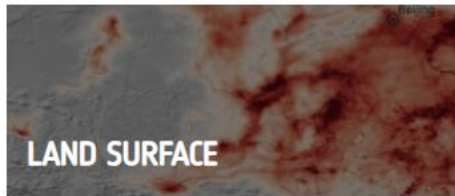
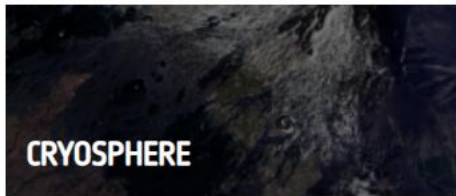
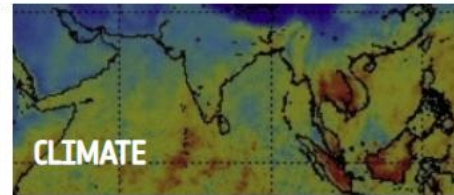


Copernicus Sentinels

The Copernicus Sentinel missions are state of the art Earth observation satellites developed as part of an initiative between ESA and the EC...

[EXPLORE MORE](#) ↗

BROWSE MISSIONS BY DATA APPLICATION

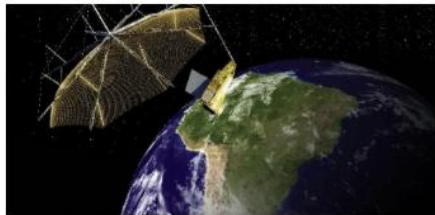




FEATURED MISSIONS

[Find More Missions >>](#)

Explore the European Space Agency's Earth Observation satellite missions. Learn all about ESA's dedicated Earth Explorers or collaborations with other agencies through the Third Party Missions programme



BIOMASS

Current
Earth Explorers

The objective of the Biomass mission is to determine the global distribution of forest biomass....



EARTHCARE

Current
Earth Explorers

EarthCARE examines the role clouds and aerosols play in trapping infrared radiation emitted from Earth's surface....



SWARM

Current
Earth Explorers

Swarm is dedicated to creating a highly detailed survey of Earth's geomagnetic field and its temporal evolution as well as the electric field...



CRYOSAT

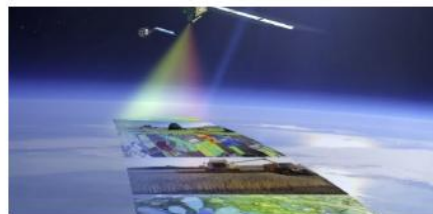
Current
Earth Explorers

CryoSat determines variations in the thickness of continental ice sheets and marine ice cover. Europe's first ice mission is an advanced radar...



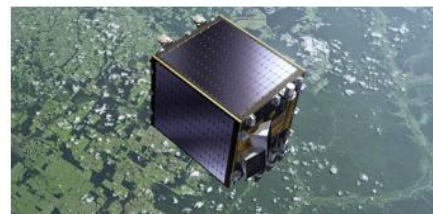
SMOS

Current
Earth Explorers



FLEX

Upcoming
Earth Explorers



PROBA-V

Current
Earth Watch



PROBA-1

Past
Third Party Missions

Satélites / Sensores Meteorológicos



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

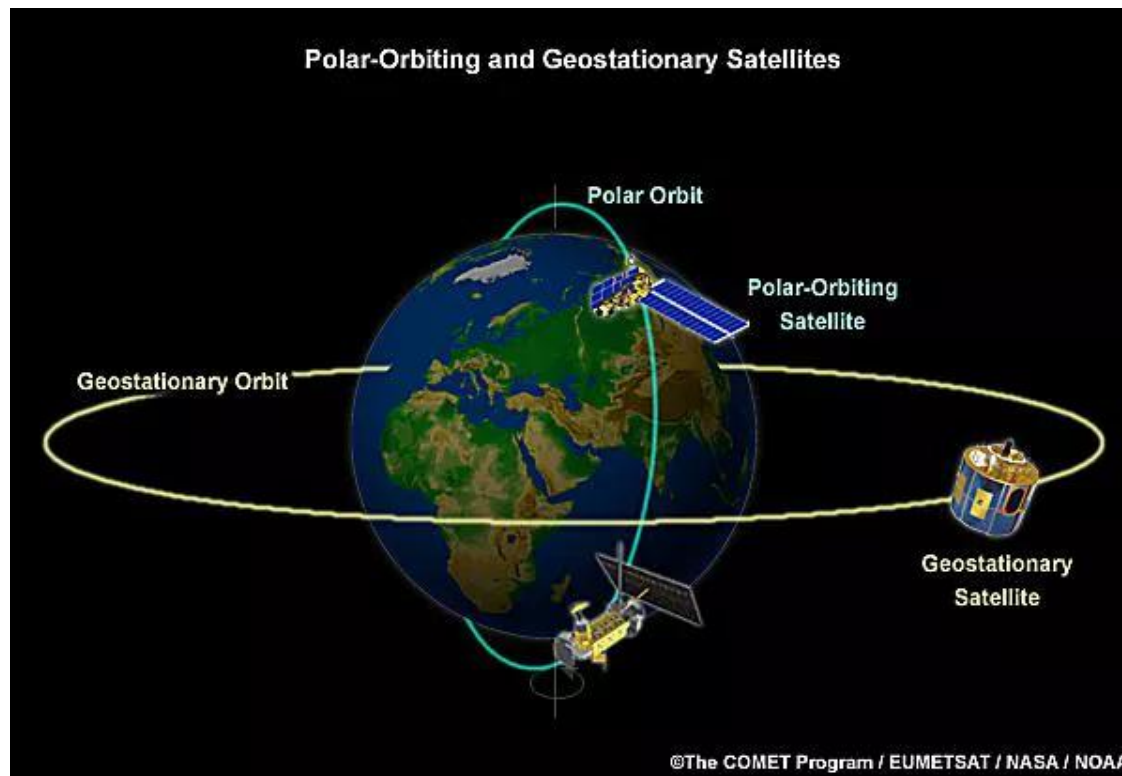
TIROS-1 : 1960, EUA.
(Television and Infrared Observation Satellite-1)

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.



GOES (Geostationary Operational Environmental Satellite)



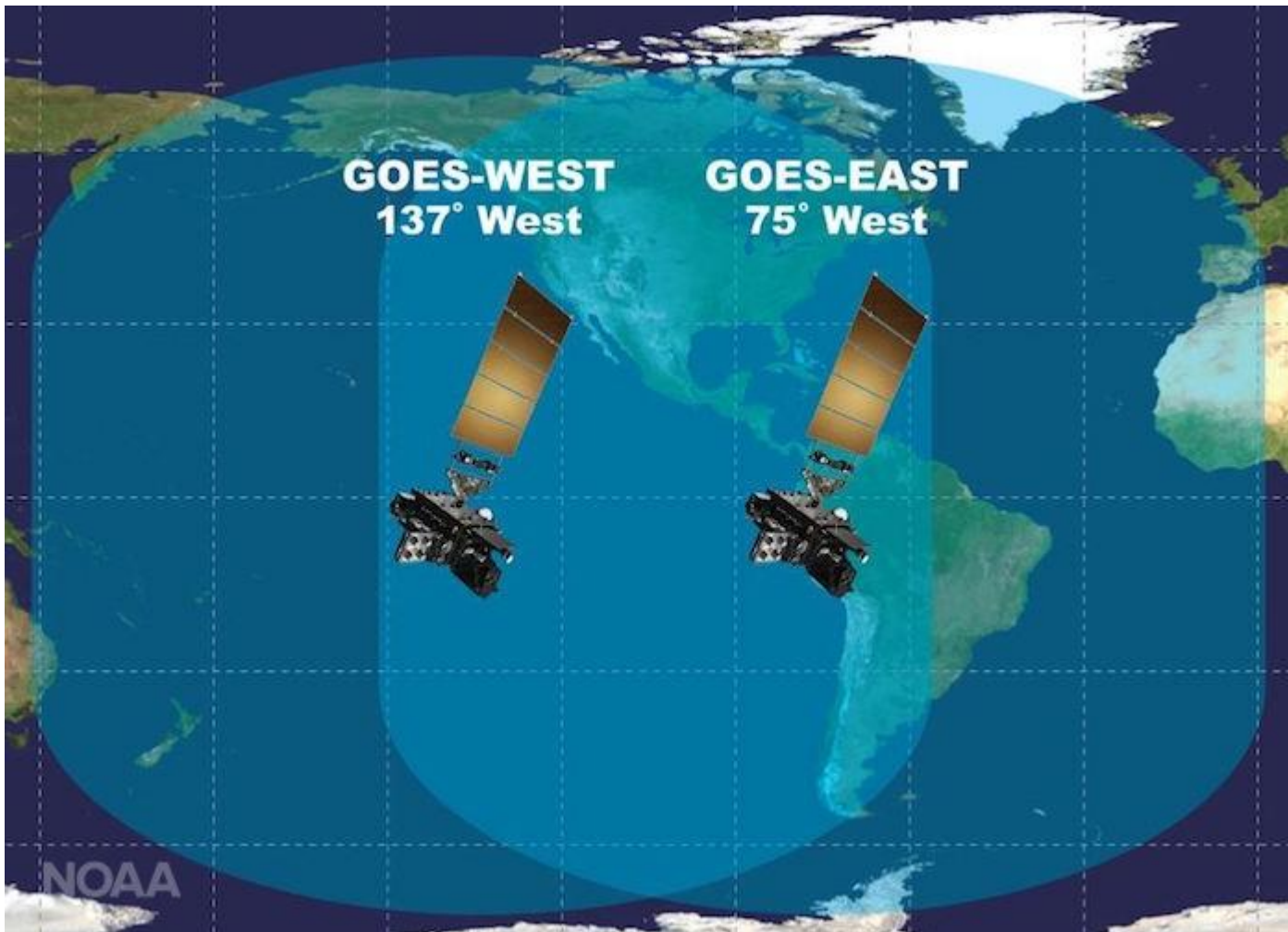
Imagem de um furacão
EUA, Setembro de 1996

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.

GOES - 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:

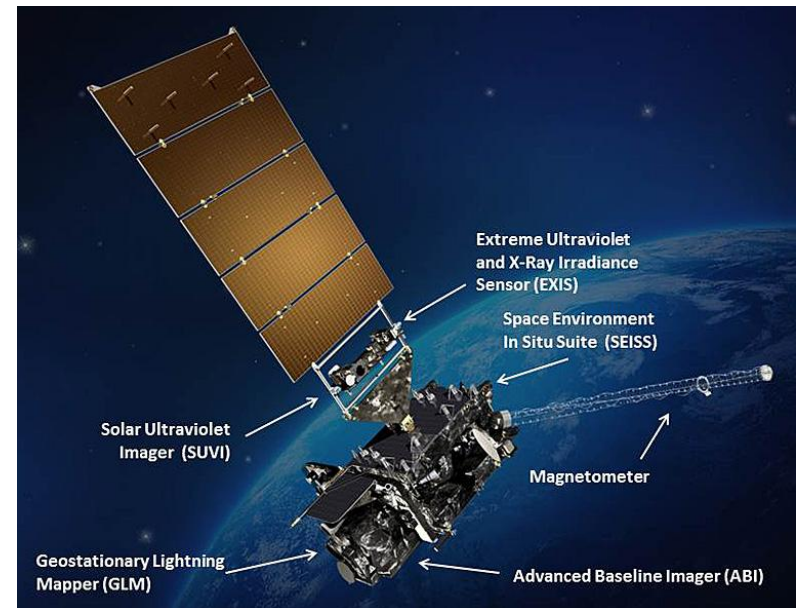
- a temperatura da atmosfera,
- ventos e
- cobertura de nuvens.

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.

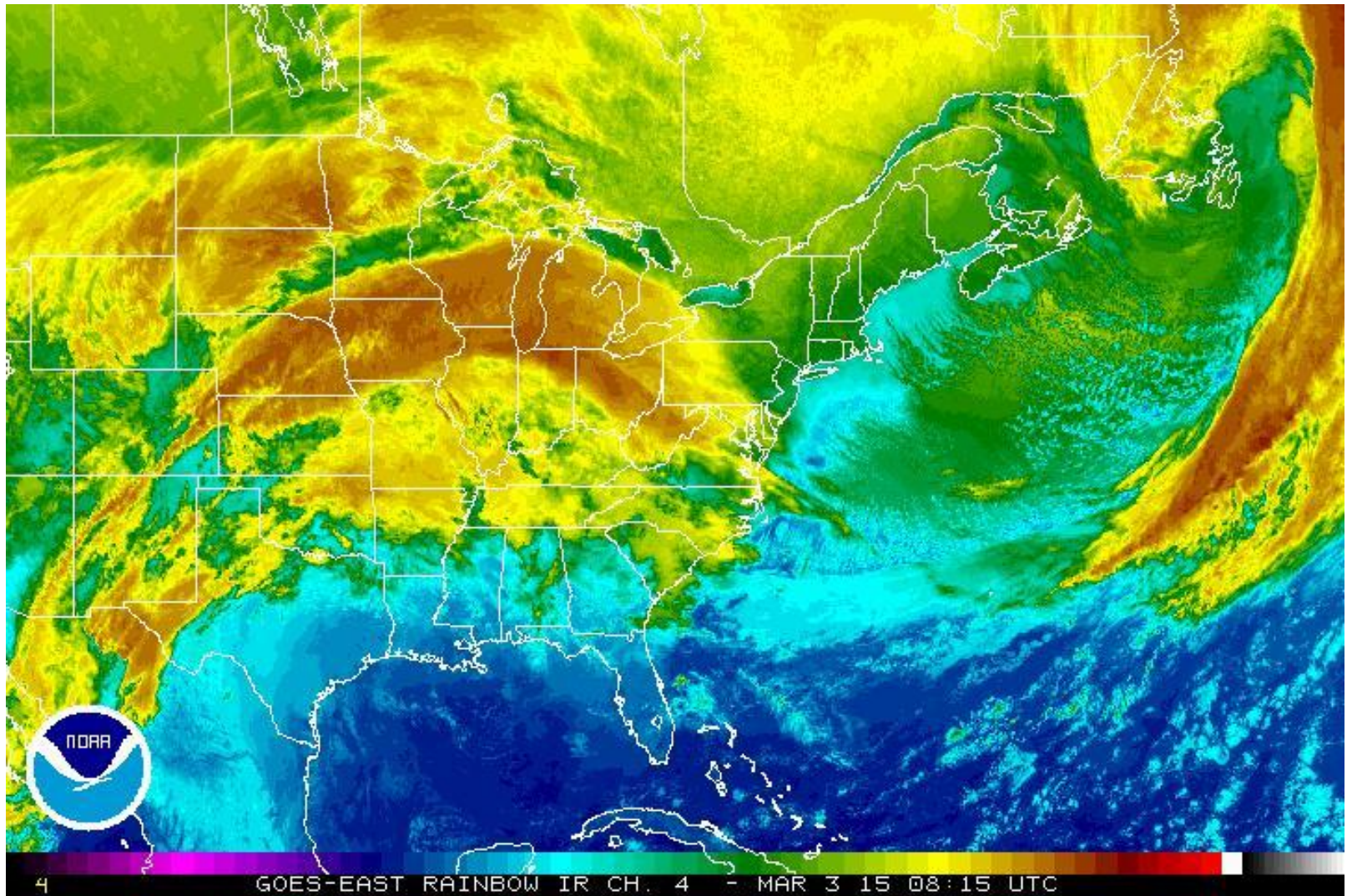
ABI views Earth with **16 spectral bands** (compared to five on previous GOES), including two visible channels, four near-infrared channels, and ten infrared channels. It provides three times more spectral information, four times the spatial resolution (1km), and five times faster coverage than previous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





GOES

Ciências
ULisboa



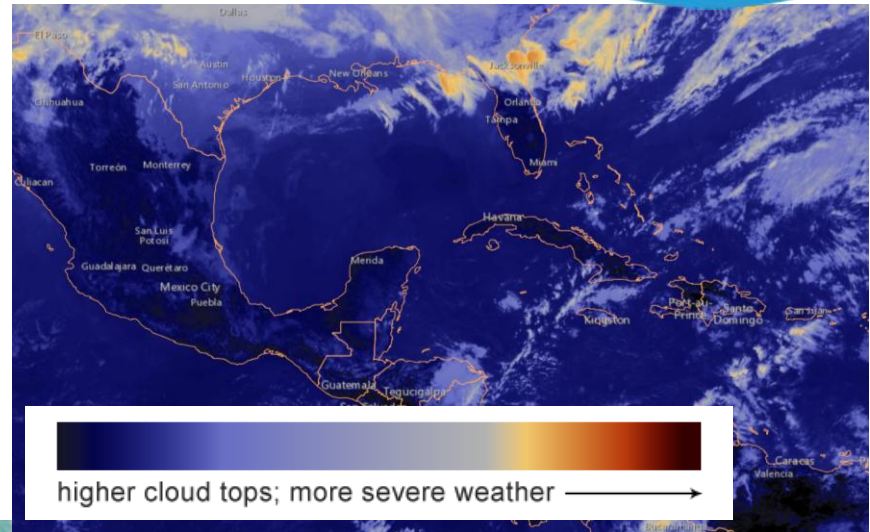


Weather Satellites



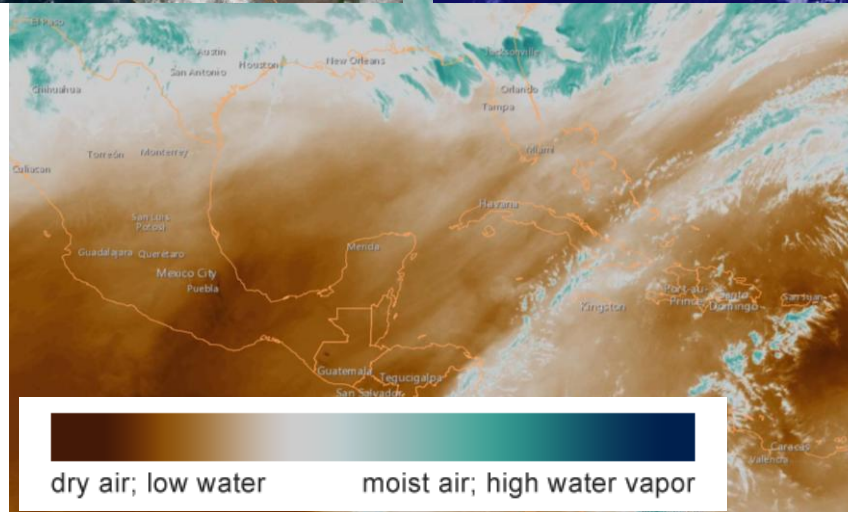
How the human eye would see Earth from space during daylight hours

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.

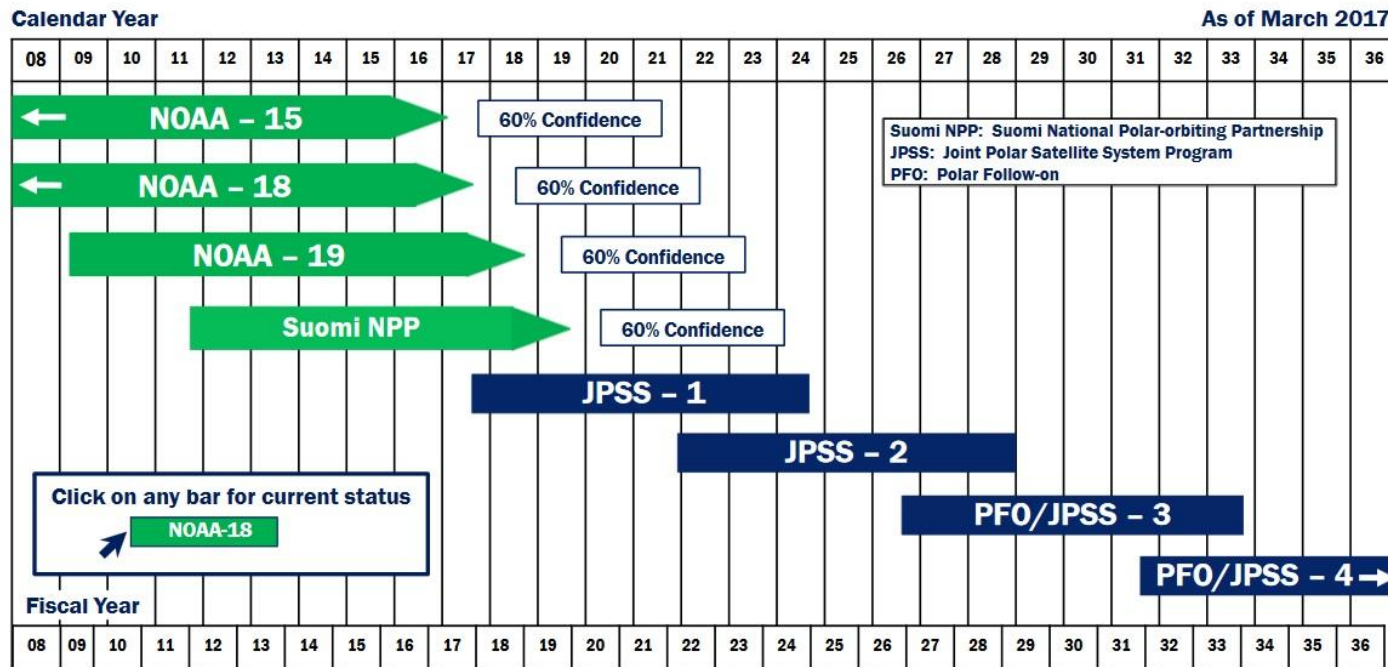
$$\text{GIFOV} = 2 * H * \tan (\text{IFOV}/2)$$



Weather Satellites



NOAA Polar Satellite Programs Continuity of Weather Observations



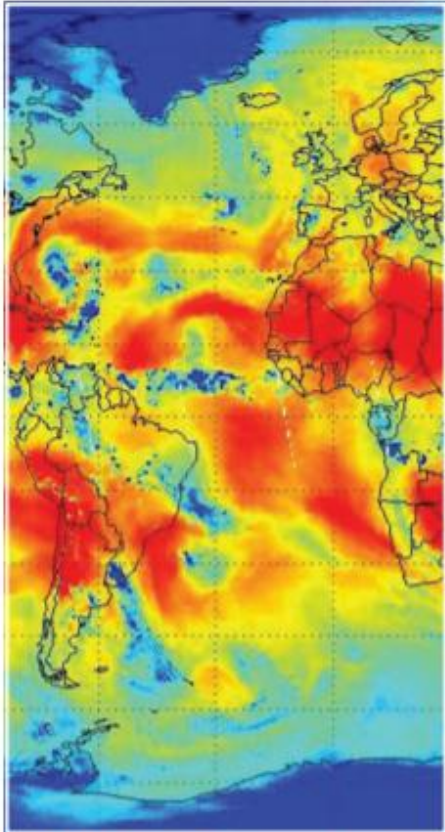
Approved: 
Assistant Administrator for Satellite and Information Services

	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		

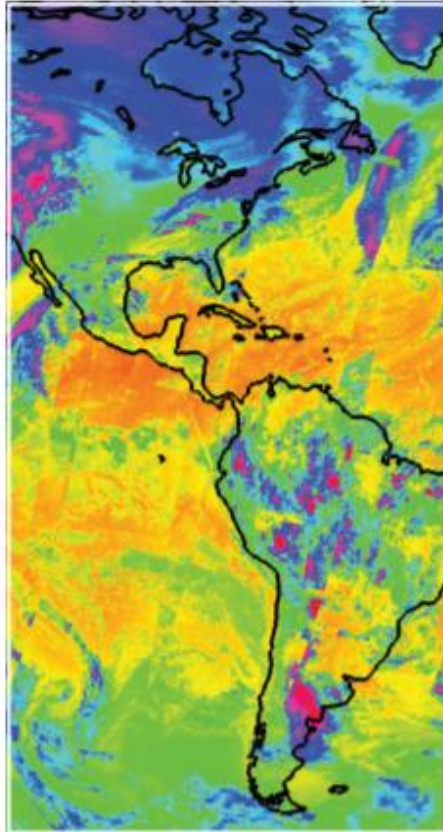
Instrument	Spectral coverage	Resolution	Mission
ATMS Advanced Technology Microwave Sounder	22 bands from 23 GHz to 183 GHz	15.8-74.8 km	Provide sounding profiles of atmospheric temperature and moisture in conjunction with CrIS
CrIS Cross-Track Infrared Sounder	1305 bands from 3.92 μm to 15.38 μm	FOV 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



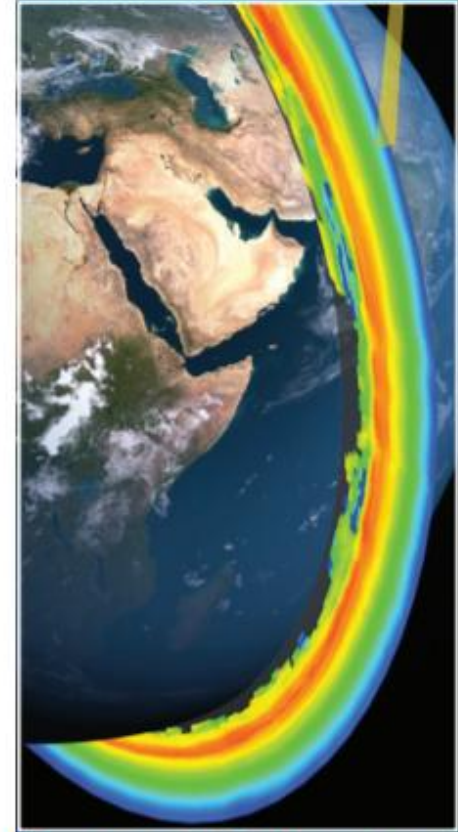
ATMS channel 18-microwave antenna temperature at 183.3 GHz. 11/08/2011



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



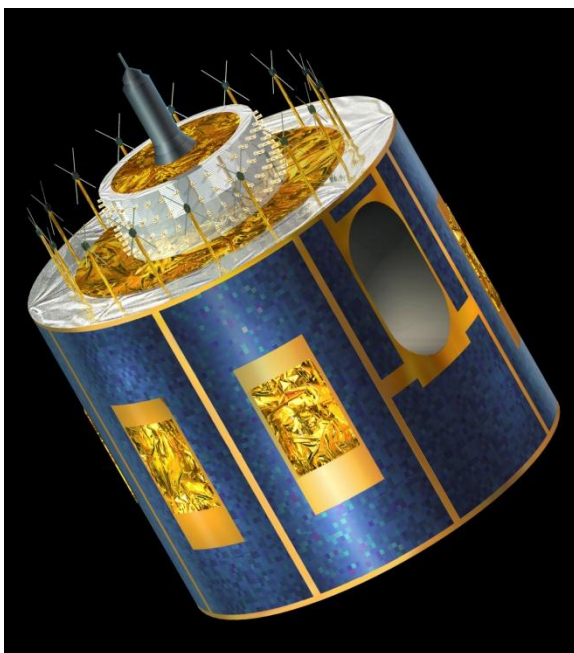
Tropical Cyclone Chapala as seen by Suomi NPP's VIIRS instrument on 11/1/2015
Credit: NOAA/NASA



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.

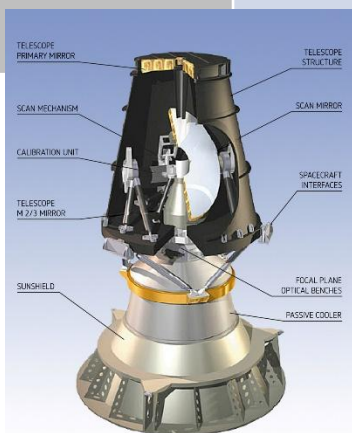


Estes satélites têm dois instrumentos:

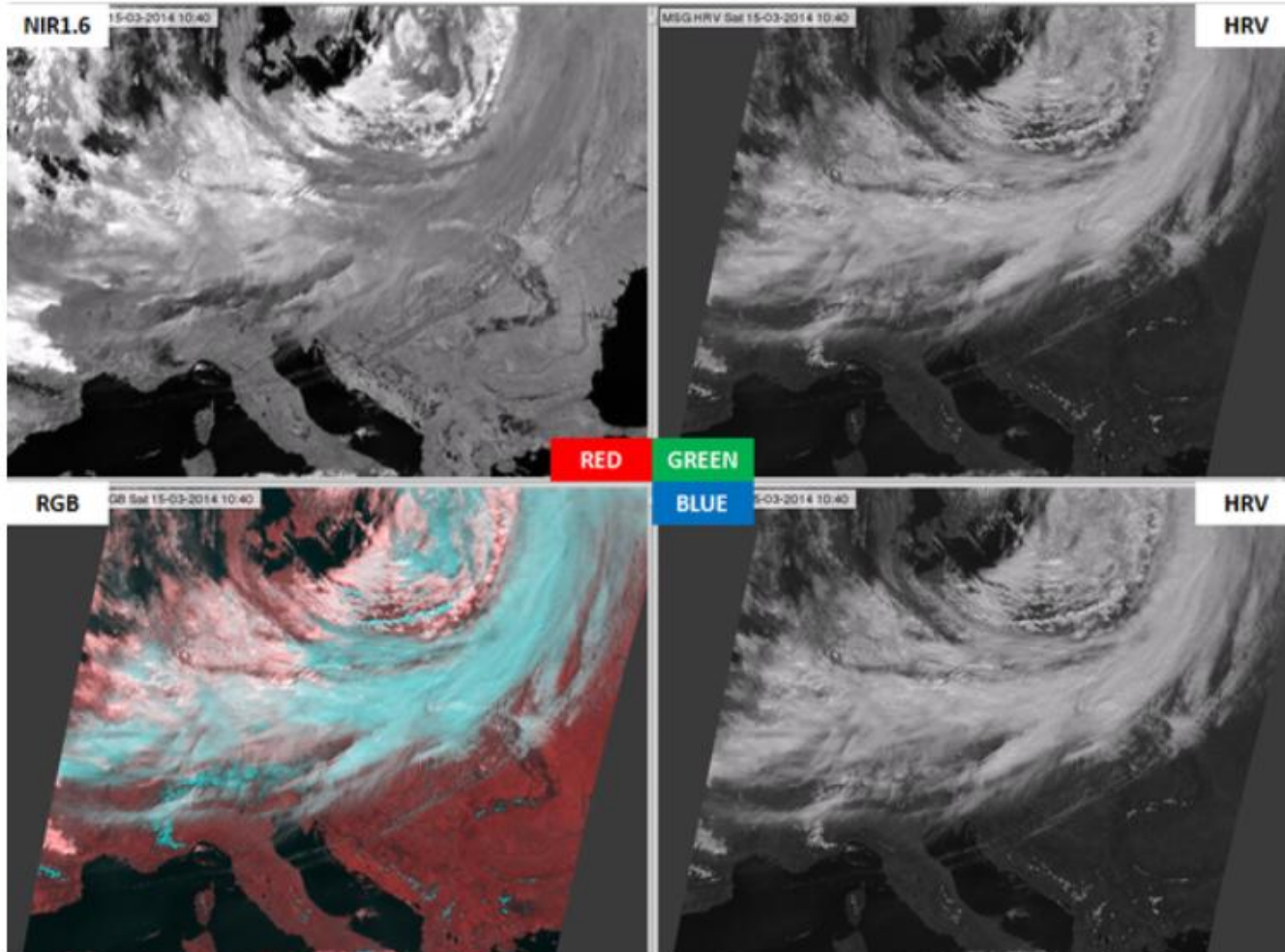
SERIVI (Spinning Enhanced Visible and InfraRed Imager) com 12 canais espectrais. Tem como objectivo a previsão meteorológica.

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

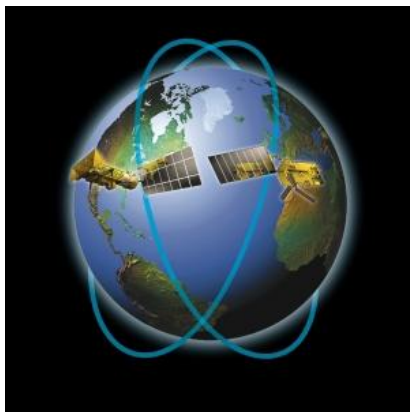


NIR1.6 (upper left), HRV (upper and bottom right) and HRV Fog RGB image (bottom left) for 15 March 2014

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	
IASI Infrared Atmospheric Sounding Interferometer	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.
AMSU-A Advanced Microwave Sounding Unit A1 and A2	Microwave sounder for temperature sounding under clear and overcast conditions, 15 channels in the 23 to 90 GHz frequency range.
MHS Microwave Humidity Sounder	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.
HIRS High Resolution Infrared Radiation sounder/4	Atmospheric Sounder for temperature and humidity profiles, surface temperature, cloud parameters and total ozone, 19 infrared channels (3.8-15 μm), one visible channel.

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

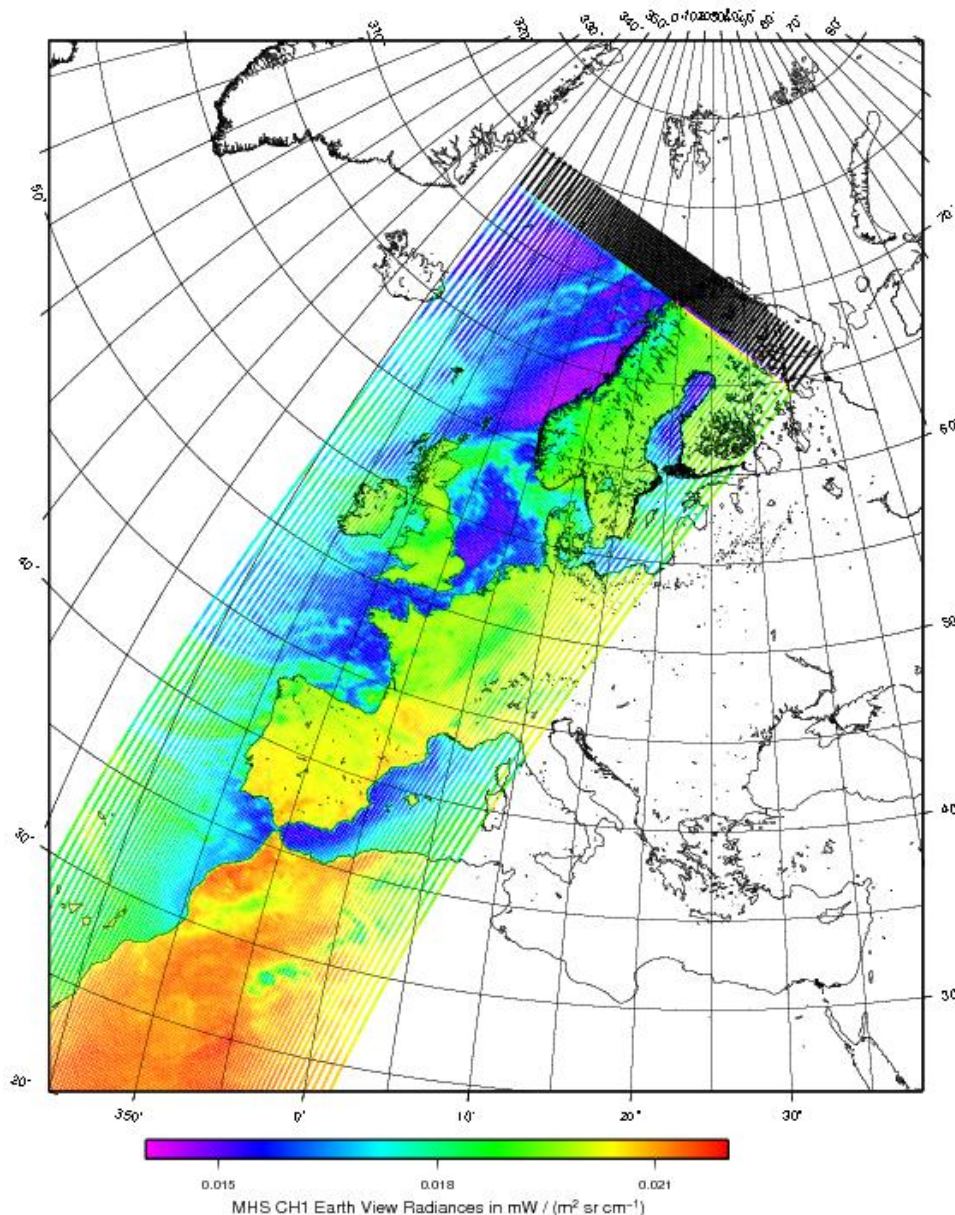
Four of the instruments on the Metop-B weather satellite (AMSU-A, ASCAT, MHS, GRAS) have been activated this week and are delivering data.

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.

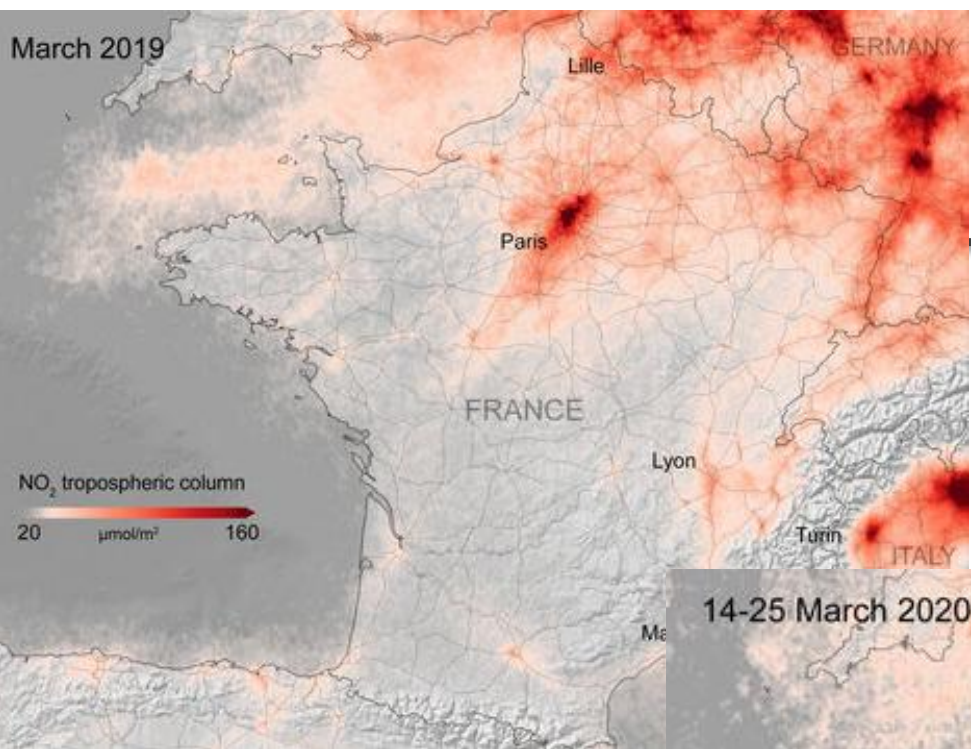
The missions SENTINEL-4, -5 and -5 precursor (S4, S5, S5P, respectively) are conceived as complementary elements of a constellation serving the specific needs of the Copernicus Atmospheric Monitoring Services (CAMS).

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

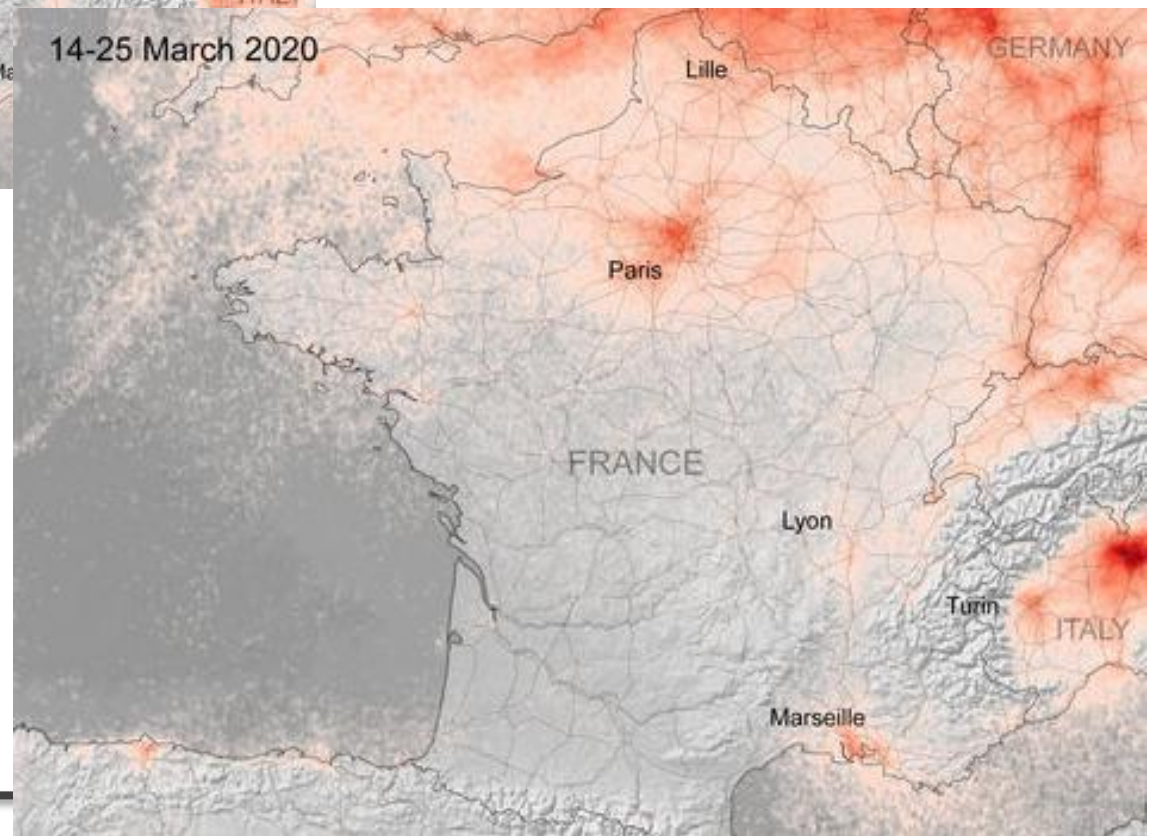
Additionally SENTINEL-5 will also deliver quality parameters for CO, CH₄, and stratospheric O₃ with daily global coverage for climate, air quality, and ozone/surface UV applications.

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

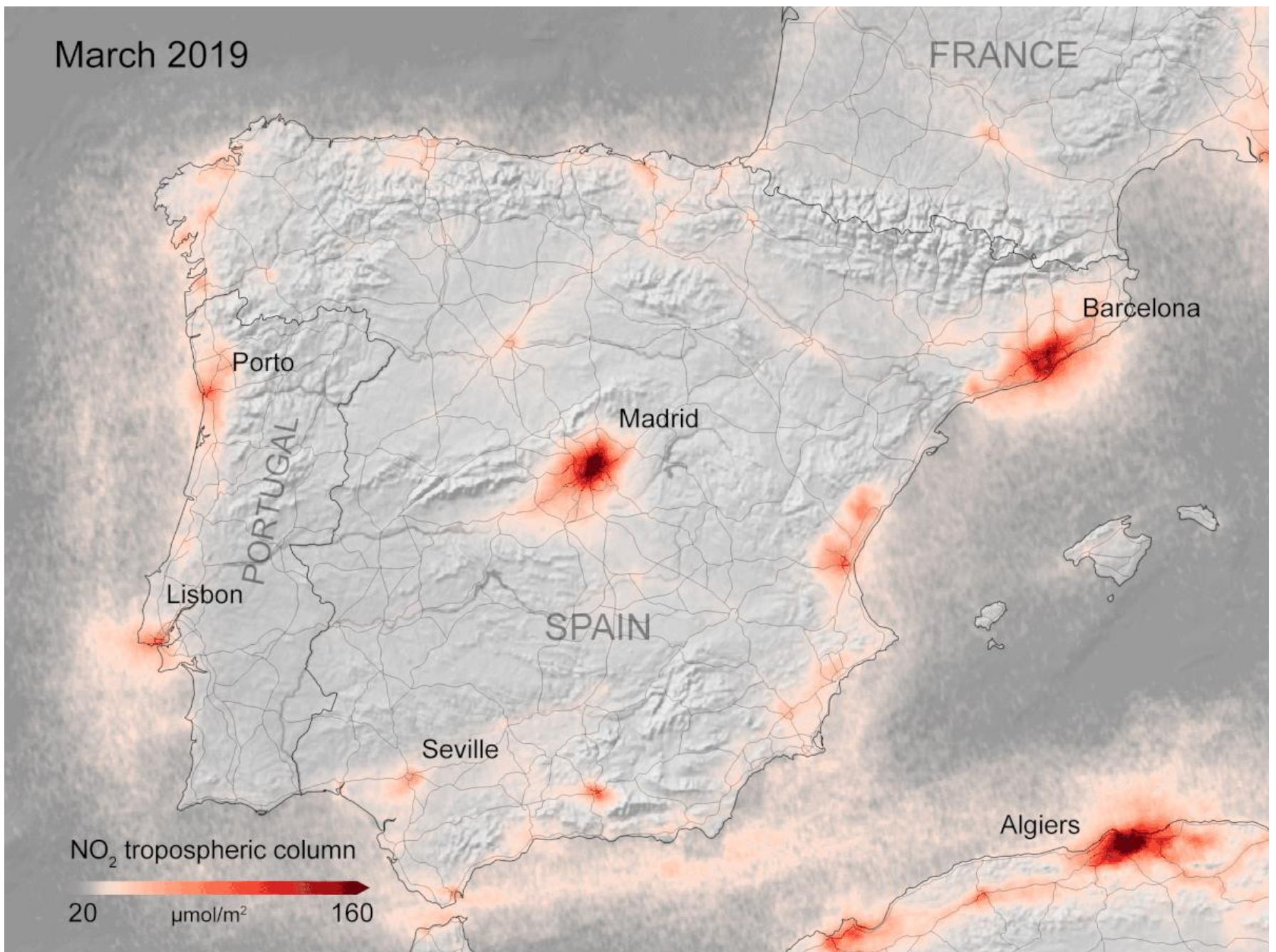


14-25 March 2020



March 2021

March 2019



The EUMETSAT
Network of
Satellite Application
Facilities

LSA SAF
Land Surface Analysis

LAND SURFACE ANALYSIS SATELLITE APPLICATIONS FACILITY

Guest

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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

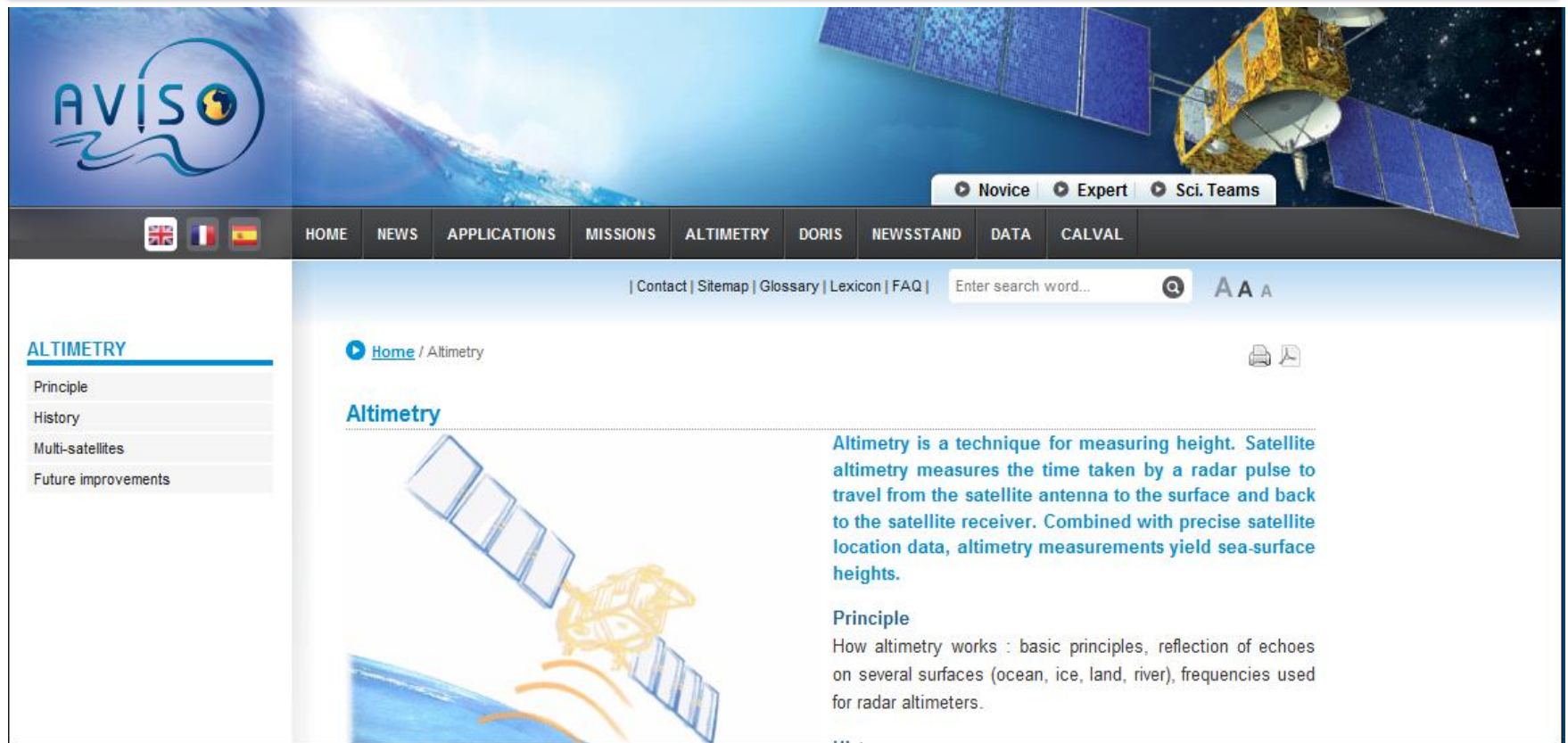
- Surface Albedo
- MSG Ten Day Surface Albedo

Land Surface Temperature

- Land Surface Temperature (15 mins)

Altimetria Espacial / Satellite Altimetry

Altimetria Espacial é uma técnica de medir a altitude. 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 interface. At the top left is the AVISO logo. Below it are flags for the UK, France, and Spain. A navigation menu includes HOME, NEWS, APPLICATIONS, MISSIONS, ALTIMETRY, DORIS, NEWSSTAND, DATA, and CALVAL. A search bar and language settings (AA) are also visible. The main content area is titled 'Altimetry' and includes a breadcrumb 'Home / Altimetry'. The text explains that altimetry measures height by timing radar pulses. A diagram shows a satellite emitting radar waves towards the Earth's surface. A sidebar on the left lists 'Principle', 'History', 'Multi-satellites', and 'Future improvements'.

ALTIMETRY

- Principle
- History
- Multi-satellites
- Future improvements

[Home](#) / Altimetry

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.

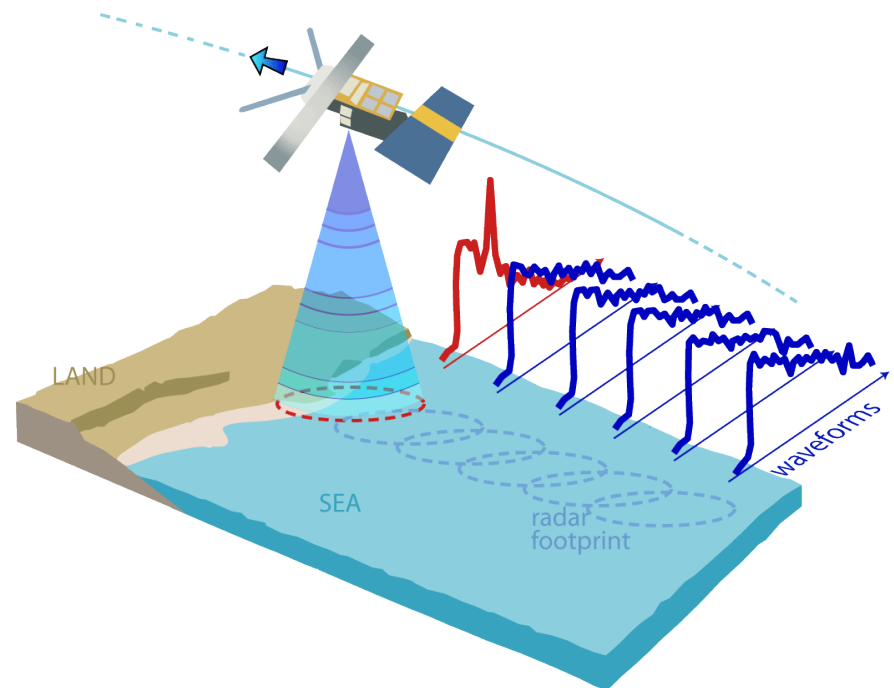
Principle

How altimetry works : basic principles, reflection of echoes on several surfaces (ocean, ice, land, river), frequencies used for radar altimeters.

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.

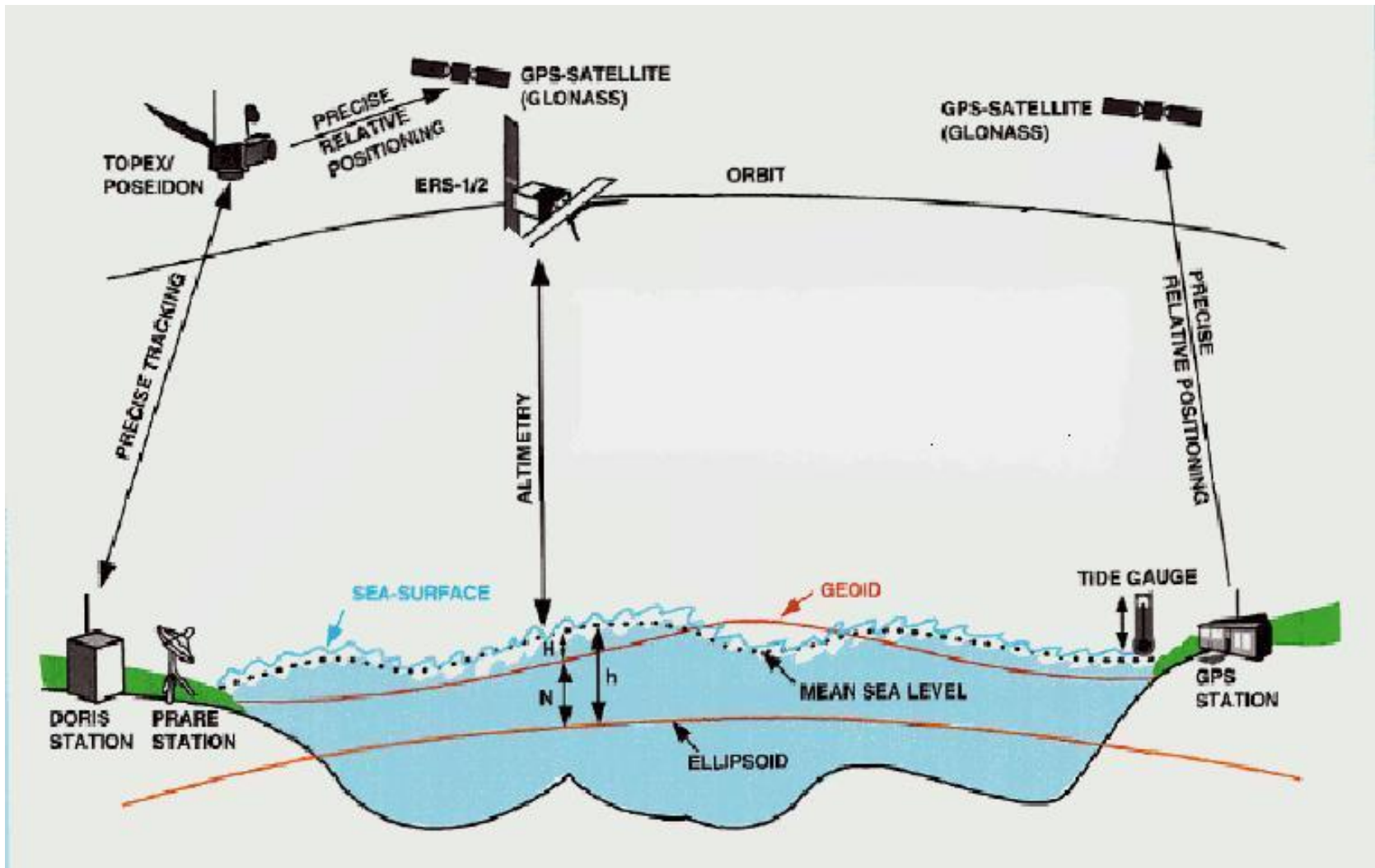


Altimetria Espacial



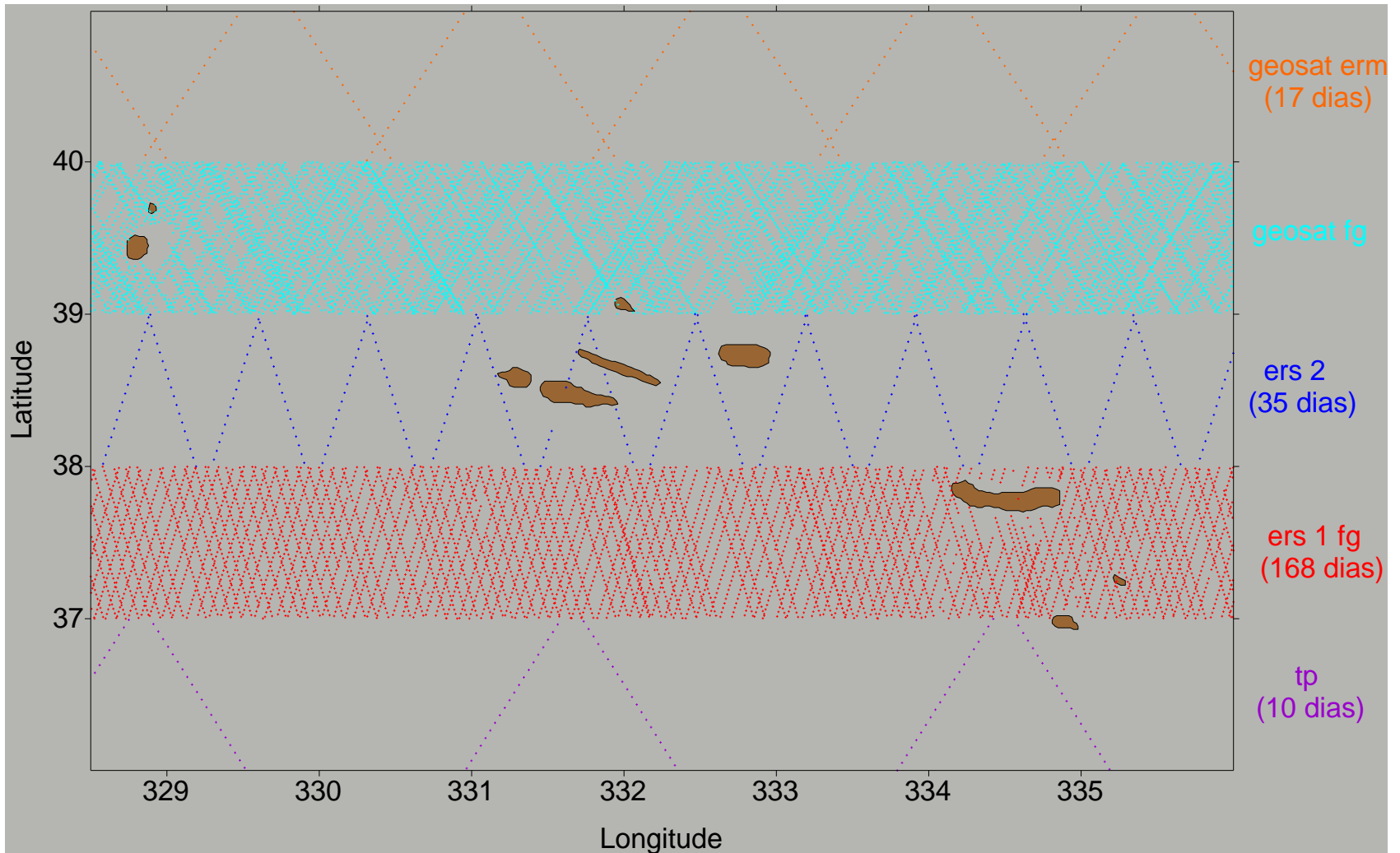
O resultado da Altimetria Espacial são as altitudes da superfície do mar, ou topografia do mar (Sea Surface Heights)

Altimetria Espacial

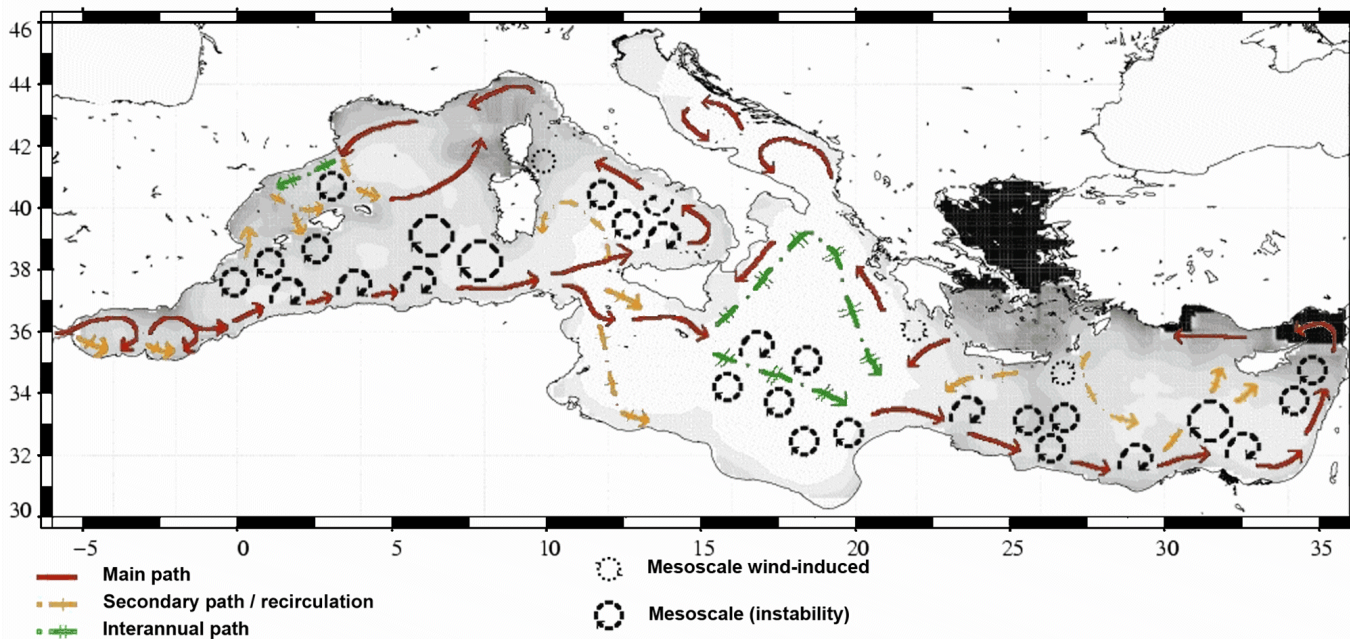
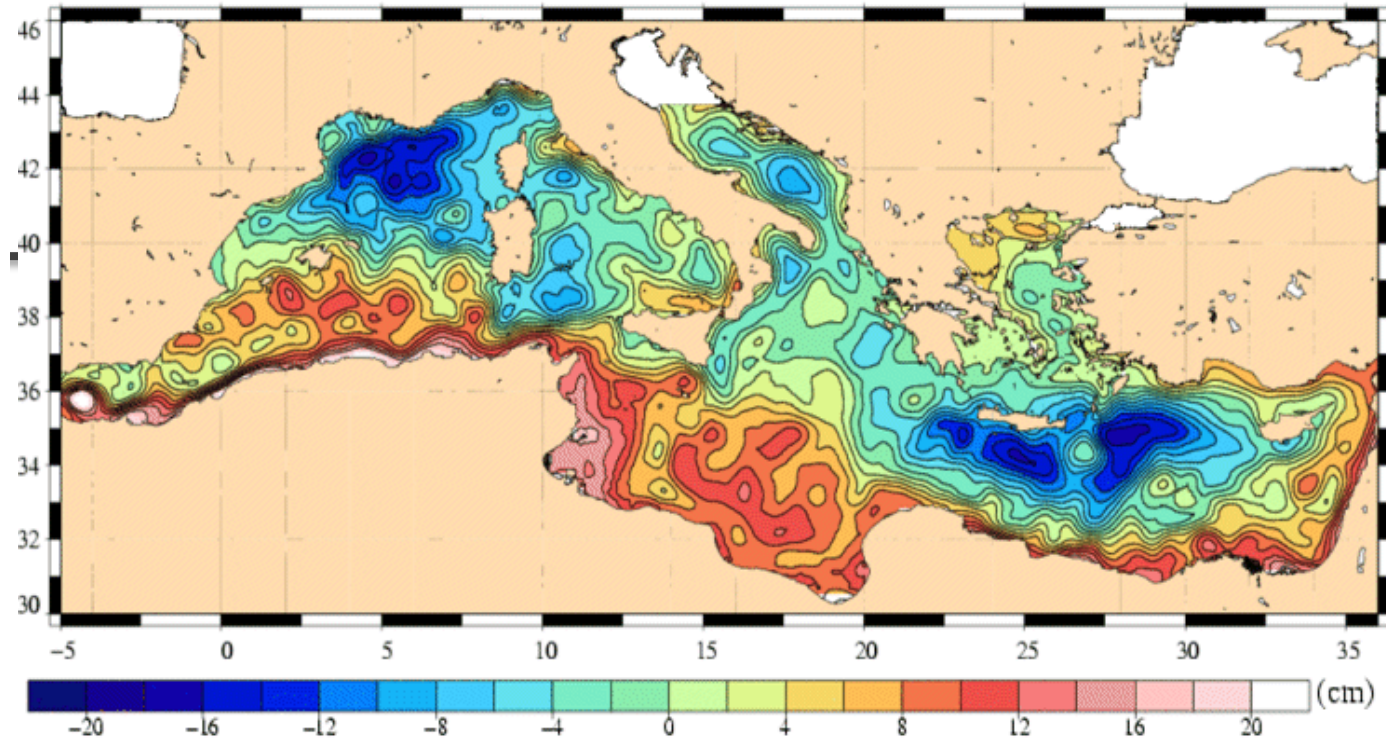




Altimetria Espacial

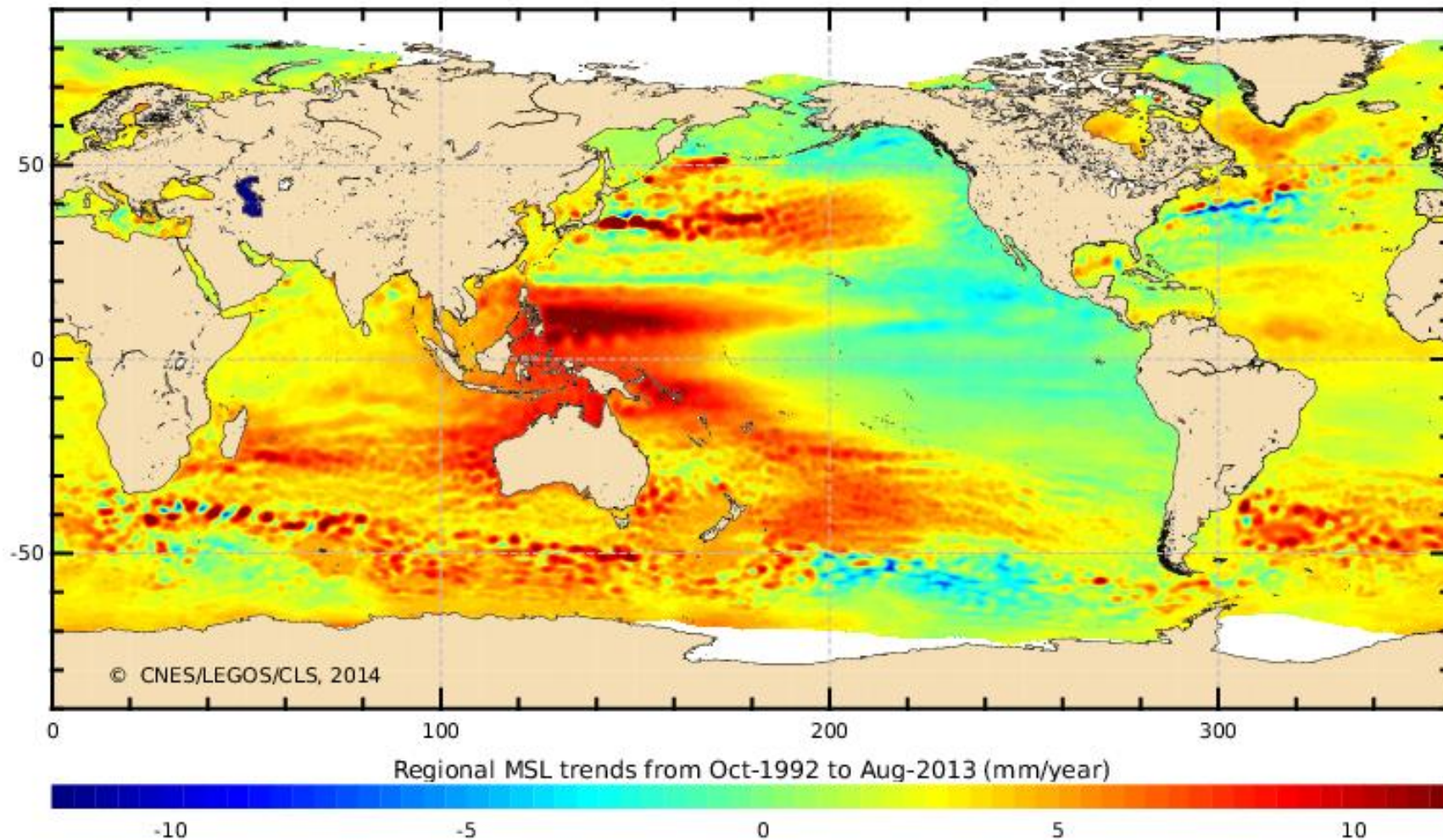


Topografia Dinâmica Média (1993-1999).
Calculada a partir de dados altimétricos, dados Grace e gravimetria de satélite.



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

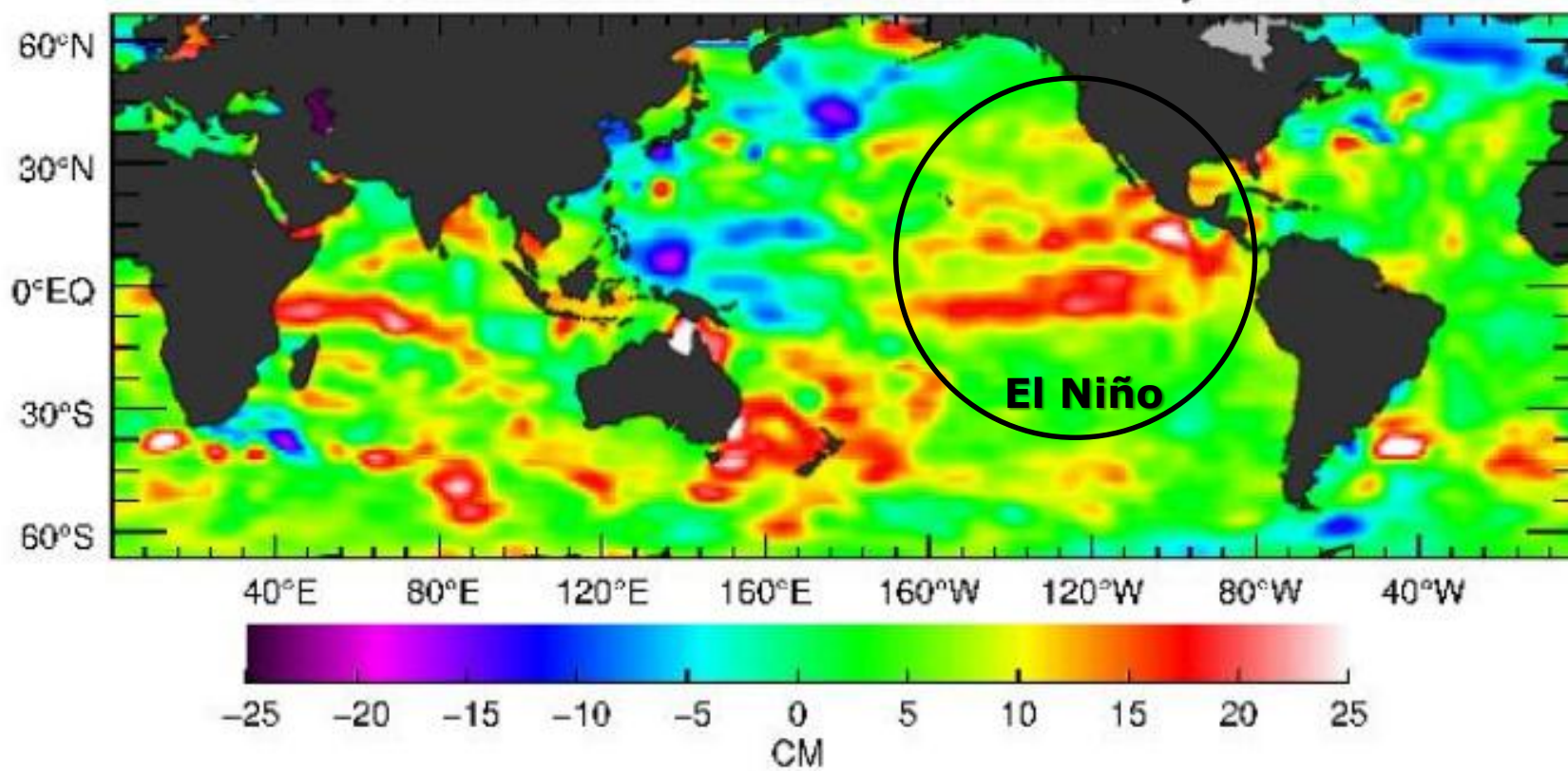
Altimetria Espacial



Satellite Altimetry

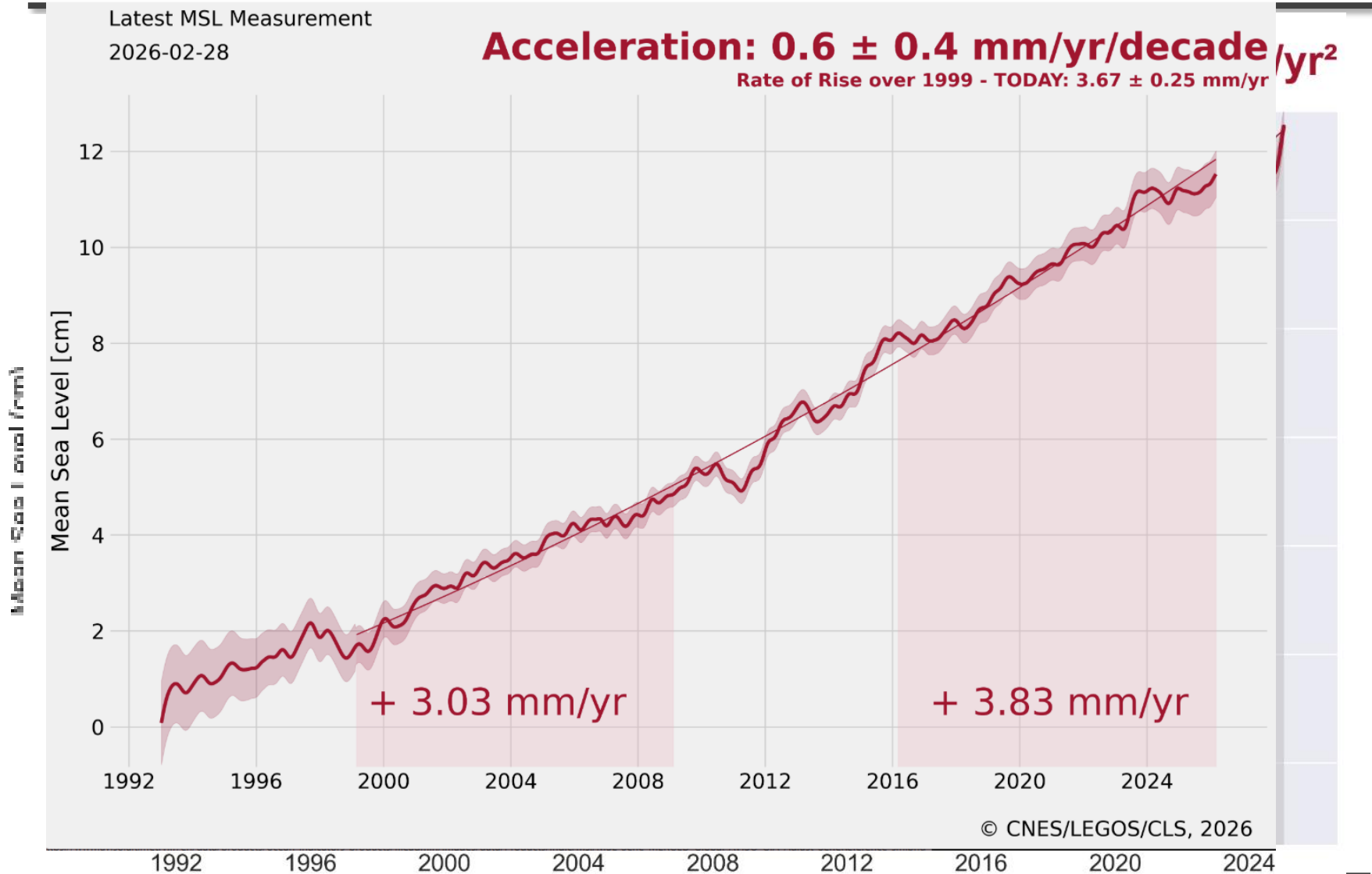


Jason-3 Sea Level Anomalies for February 12-22, 2016

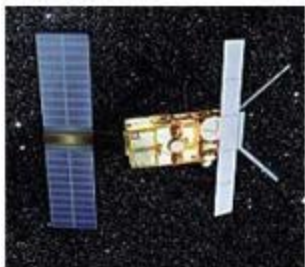




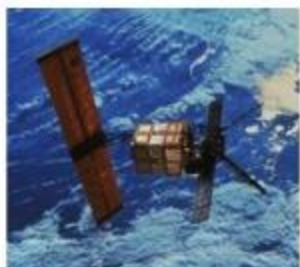
Altimetria Espacial



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.

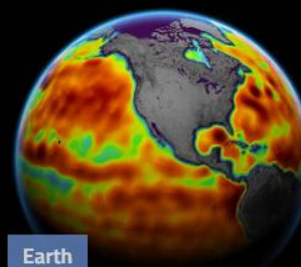
Sentinel-6 (NASA/ESA)

Sentinel-6 Michael Freilich

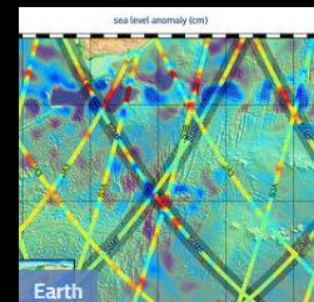
Sentinel-6 Overview Images Videos Media Resources

Related Topics

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



Major Ocean-Observing
Satellite Starts Providing...



NASA, US, European
Partner Satellite Returns...



Sentinel-6

The mission

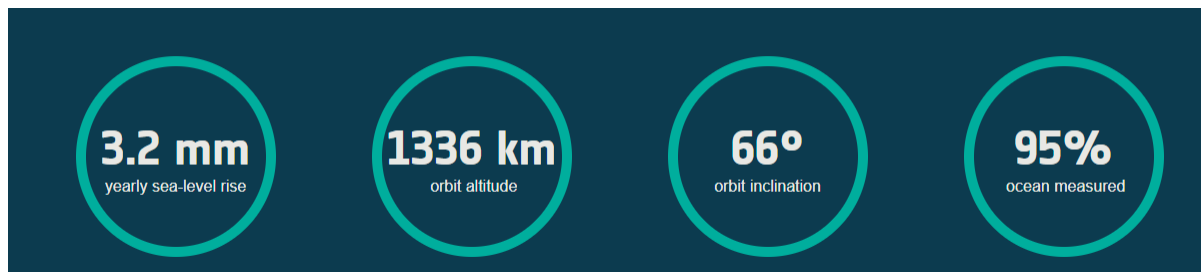
With global mean sea level rising because of climate change, Copernicus Sentinel-6 is the next radar altimetry reference mission to extend the legacy of sea-surface height measurements until at least 2030. The satellite carries a Poseidon-4 radar altimeter and a microwave radiometer.

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

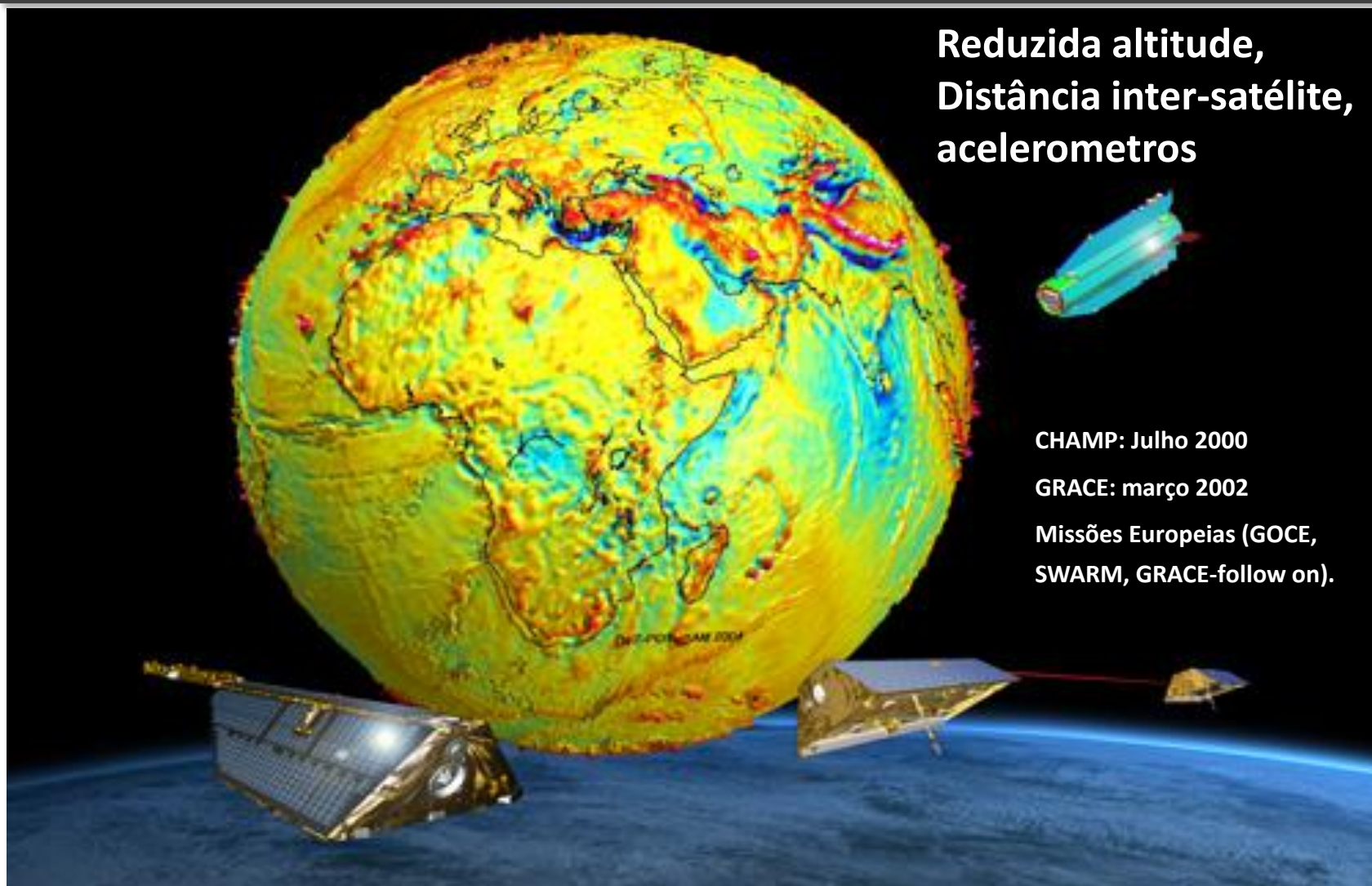
0.0 0.5 1.0 1.5 2.0 2.5 3.0 Meters

About the Tool Feedback

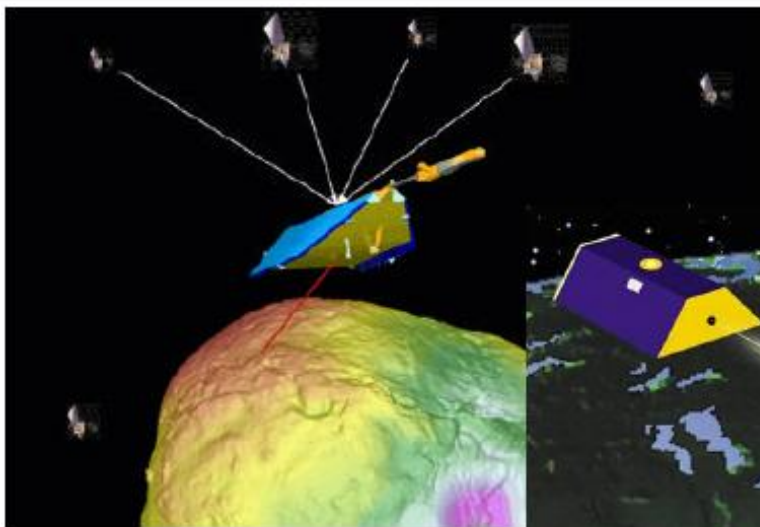
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<https://sealevel.nasa.gov/task-force-scenario-tool>

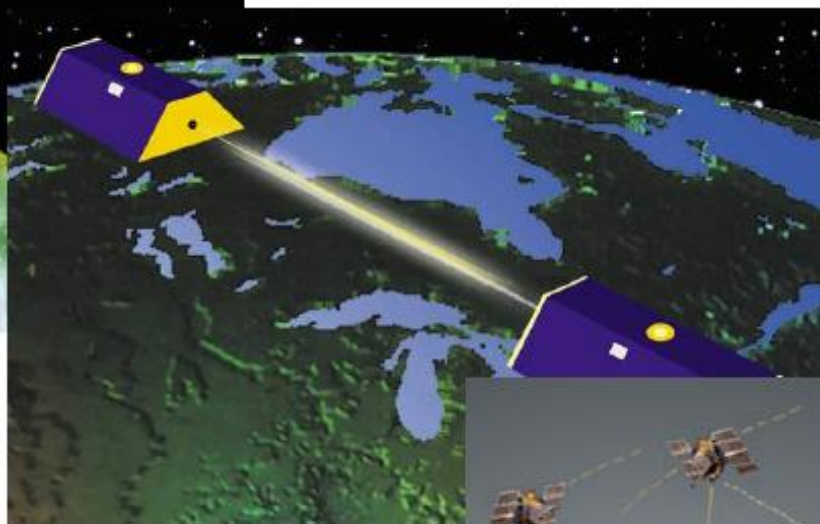
Missões Geopotenciais Espaciais



Missões Geopotenciais Espaciais



CHAMP



GRACE

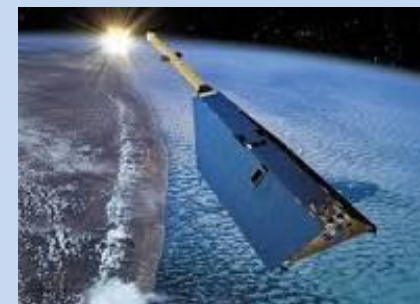


GOCE

Gravity Field Missions

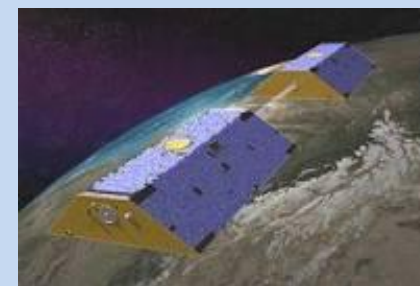
CHAMP

Magnetic field determination/
Temporal variations of the
gravity field



GRACE GRACE-FO (2017)

Improved knowledge of the
geoid estimates of time
variable components

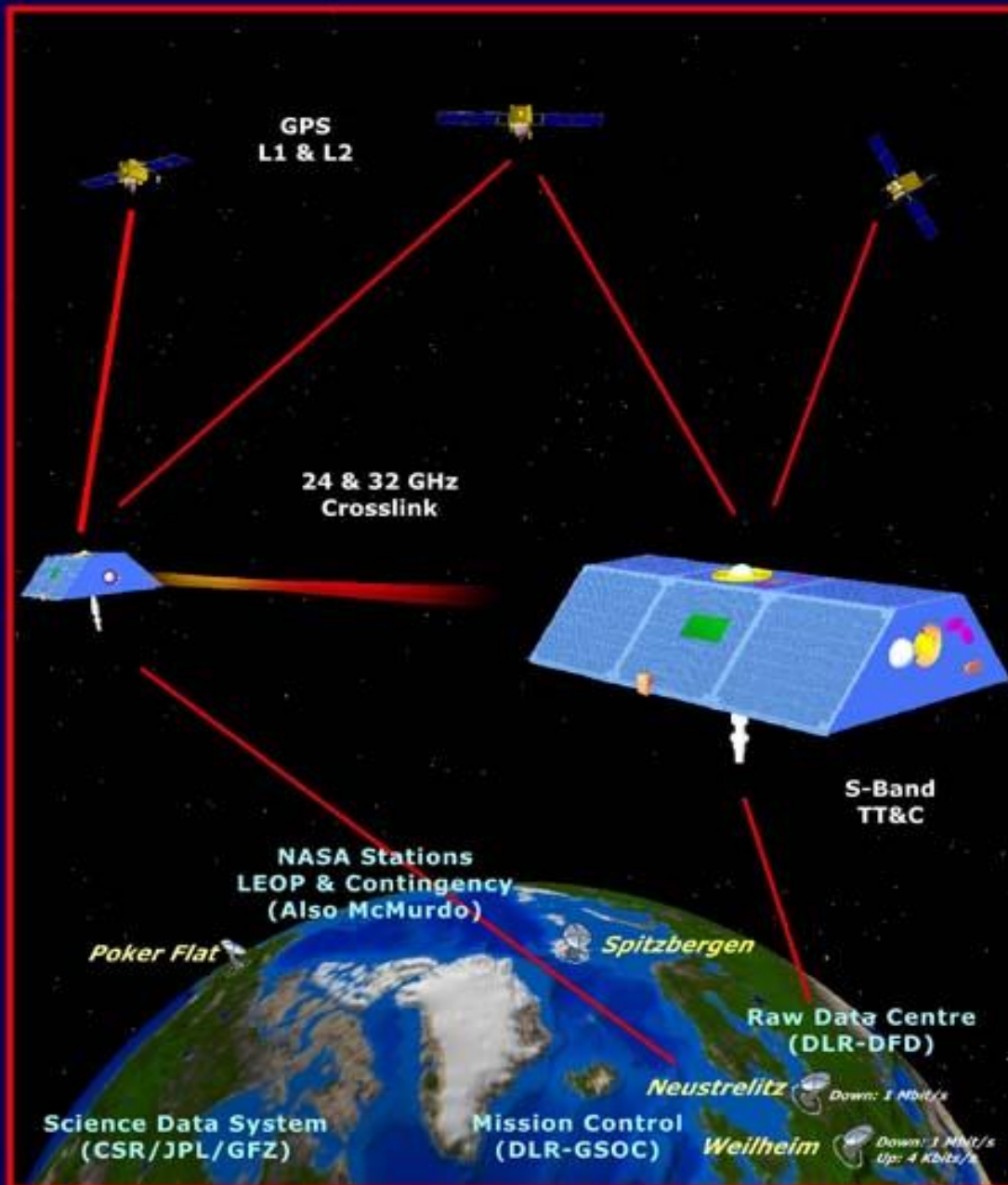


GOCE

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

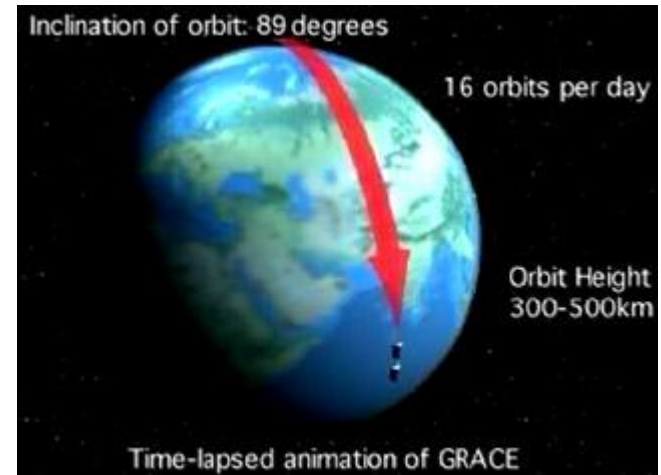
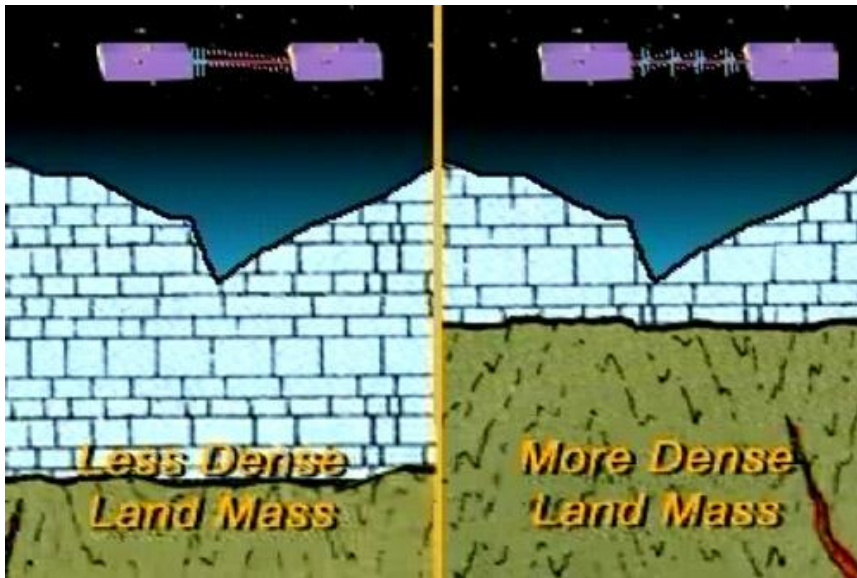
Eccentricity: ~0.001

Lifetime: 5 years

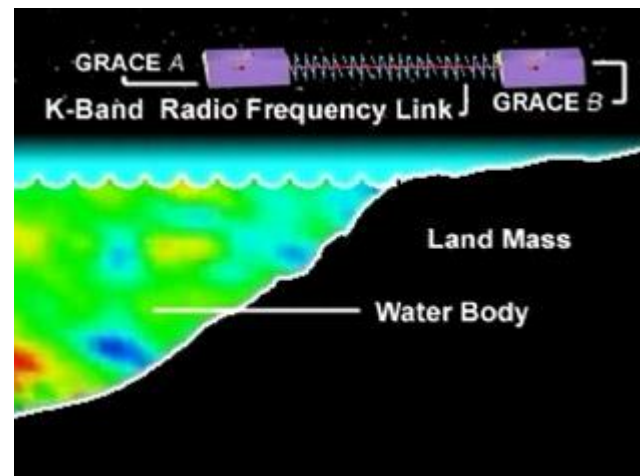
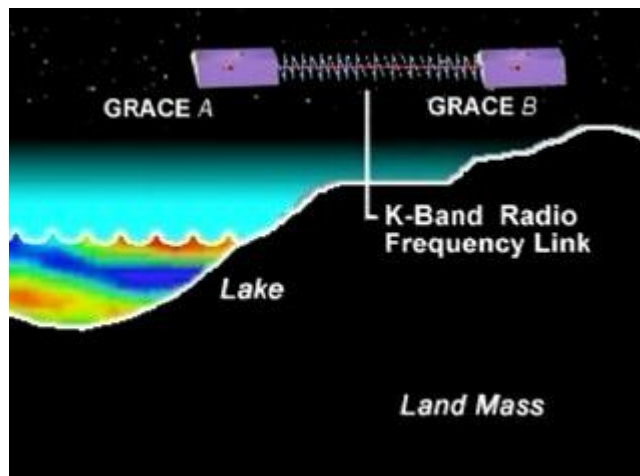
Non-Repeat Ground Track

Earth Pointed, 3-Axis Stable

GRACE

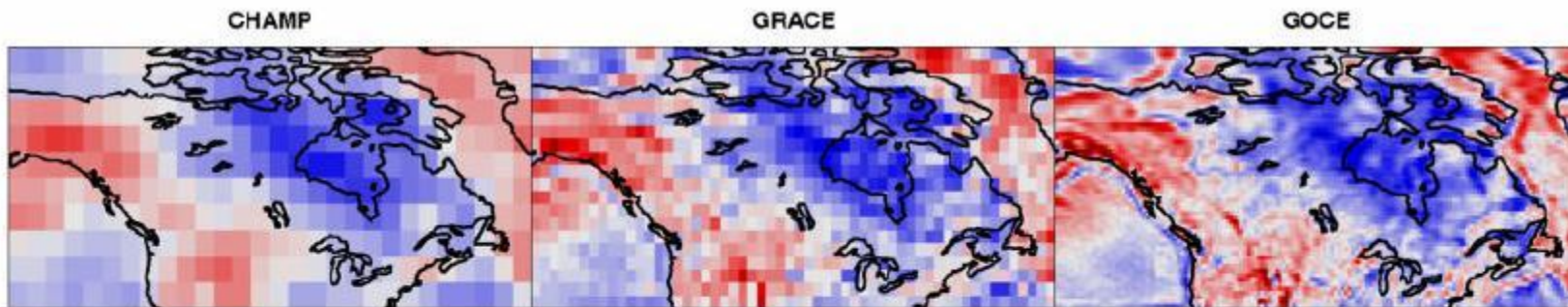


Distância = 220 km



Missões Geopotenciais Espaciais

Resolução Espacial



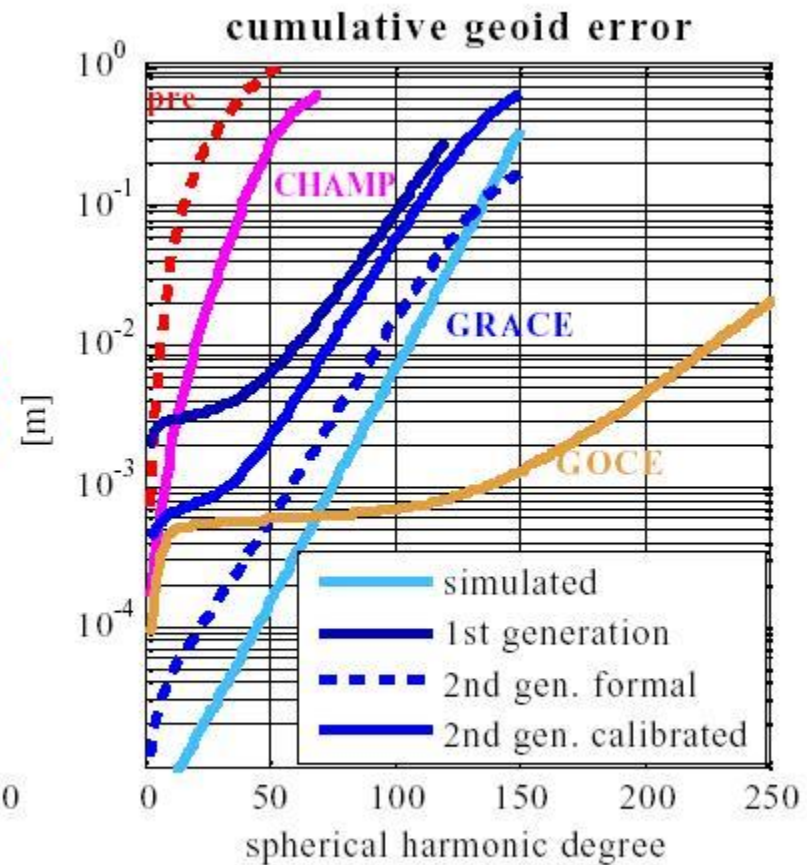
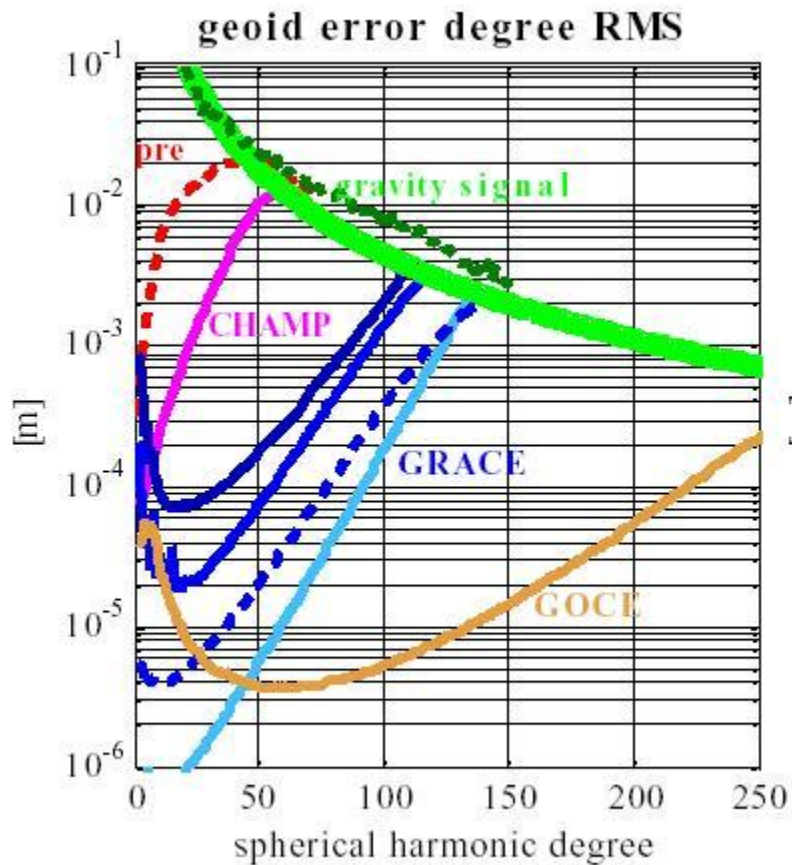
$L = 50$
 $\lambda / 2 = 400 \text{ km}$
 $\Delta T = 1 \text{ month}$

$L = 100$
 $\lambda / 2 = 200 \text{ km}$
 $\Delta T = 1 \text{ month}$

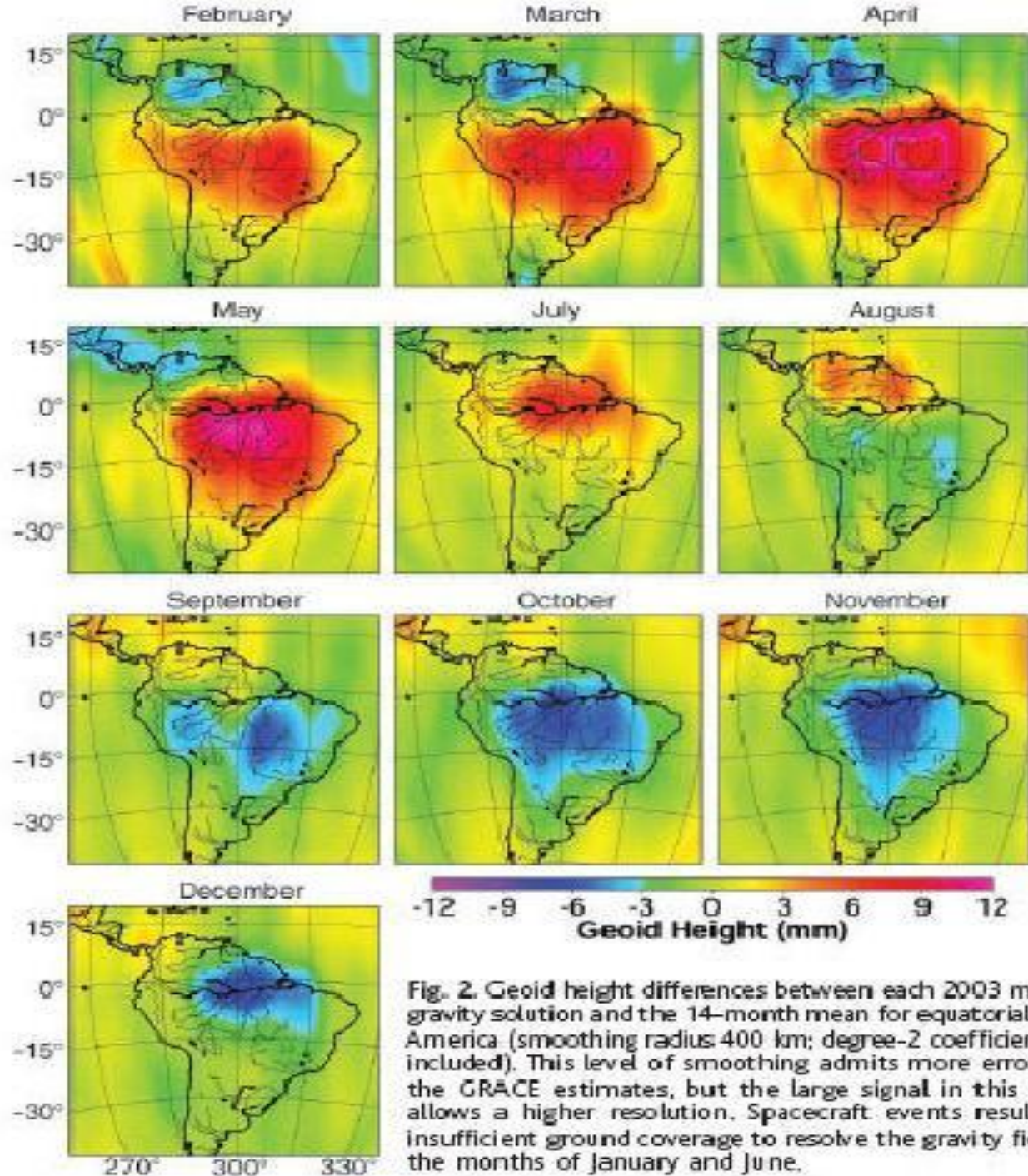
$L = 300$
 $\lambda / 2 = 70 \text{ km}$
 $\Delta T = \text{N/A}$

Missões Geopotenciais Espaciais

Resolução Espectral



GRACE



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

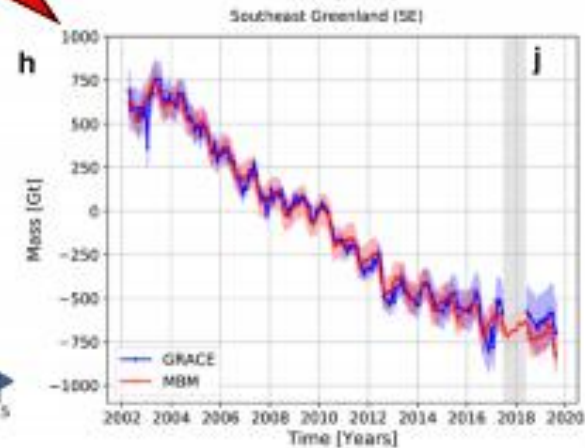
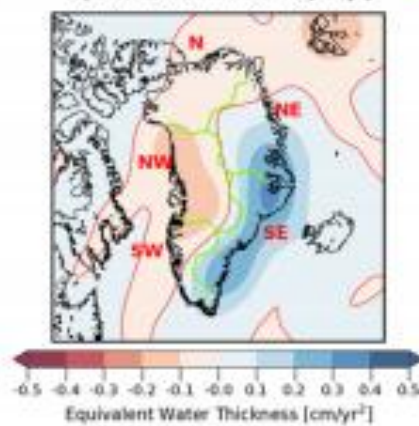
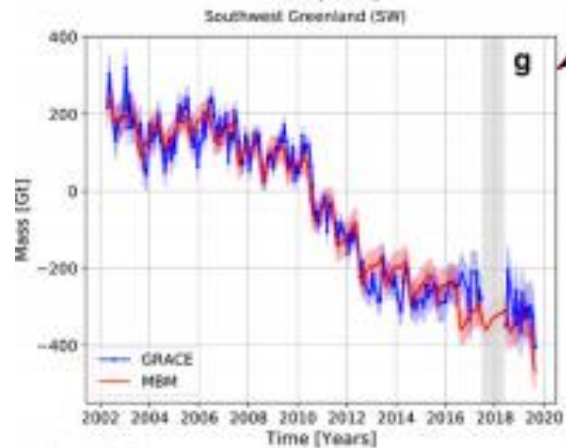
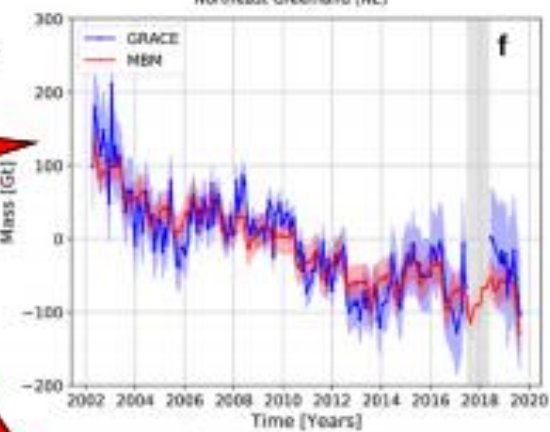
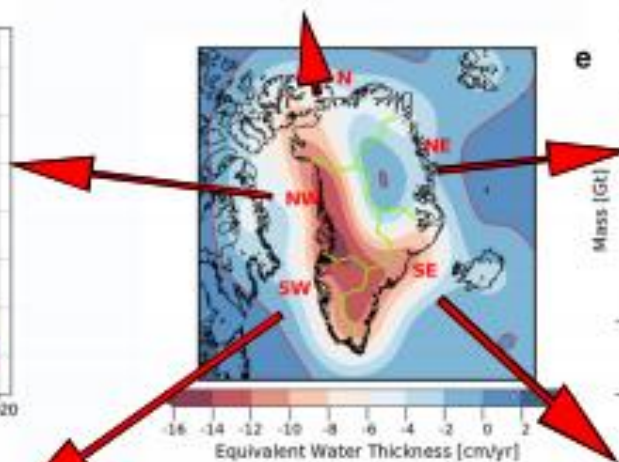
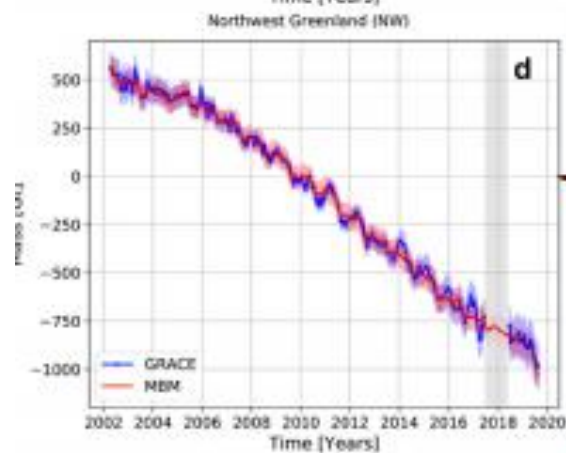
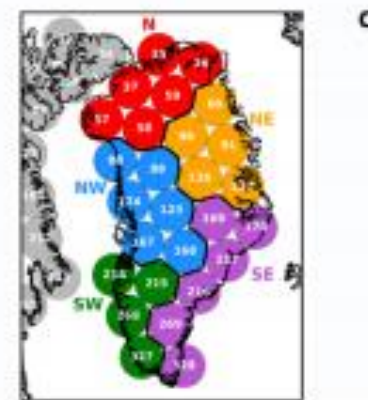
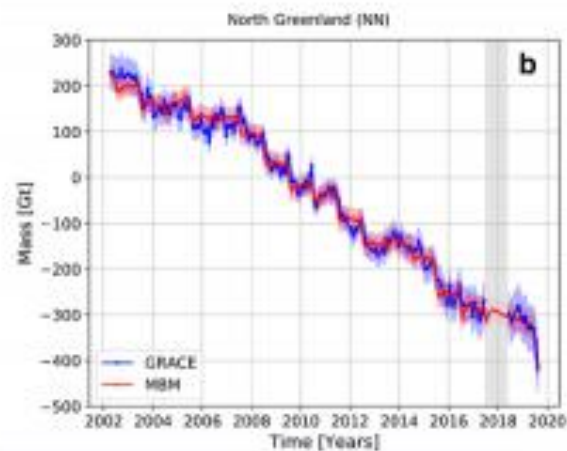
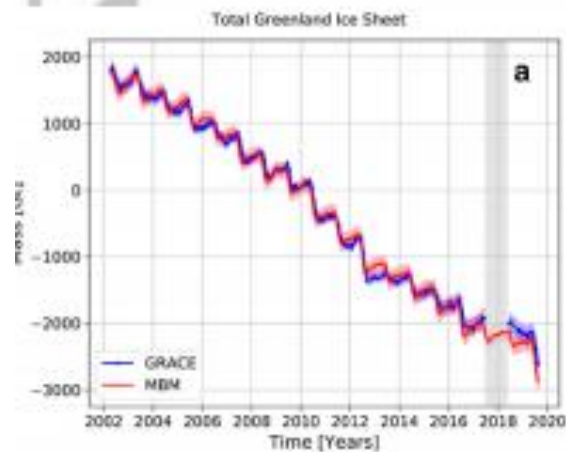
Fig. 2. Geoid height differences between each 2003 monthly gravity solution and the 14-month mean for equatorial South America (smoothing radius 400 km; degree-2 coefficients not included). This level of smoothing admits more error from the GRACE estimates, but the large signal in this region allows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

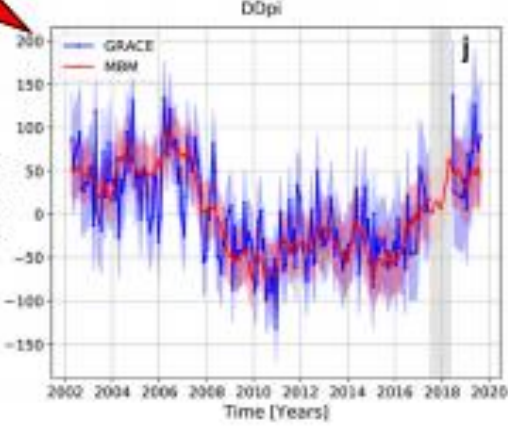
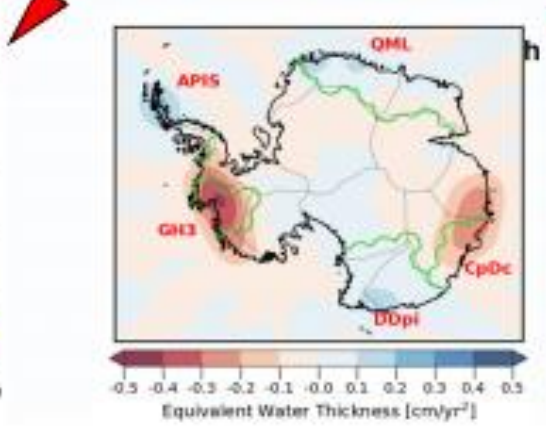
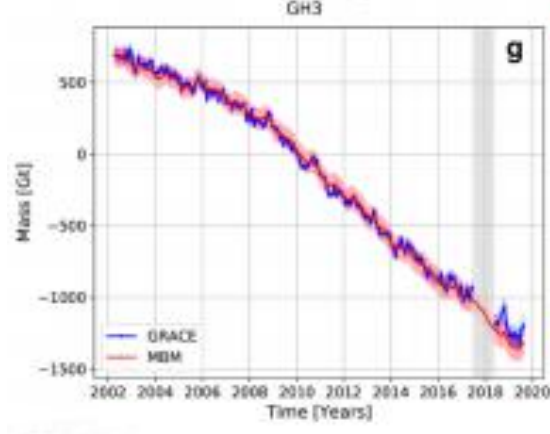
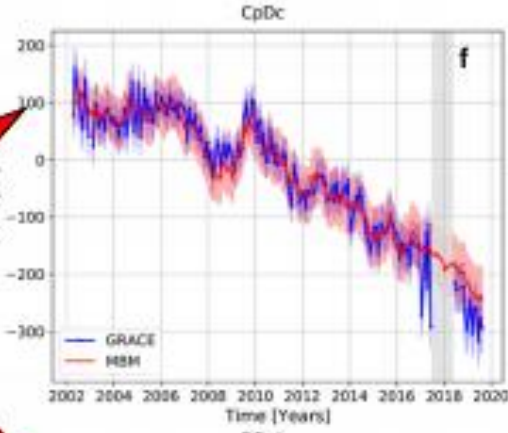
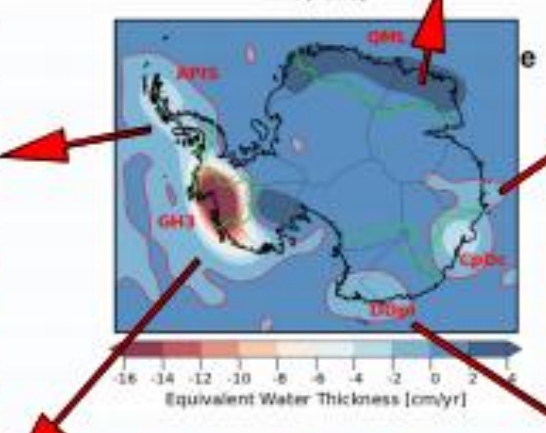
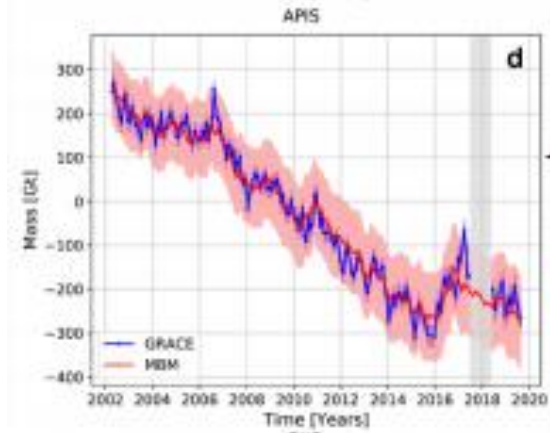
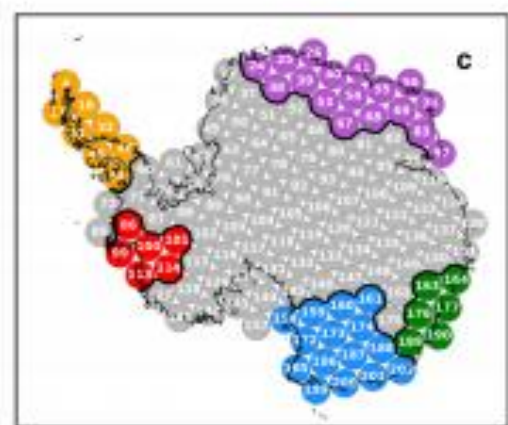
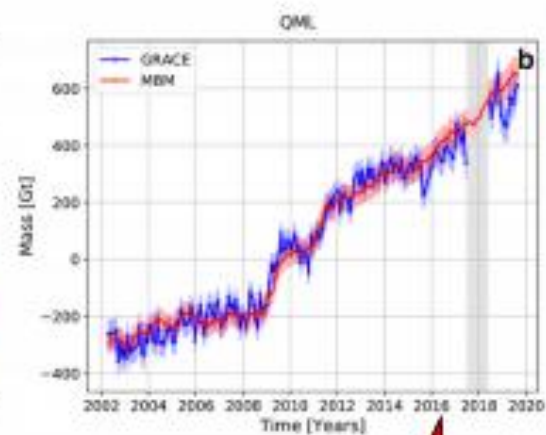
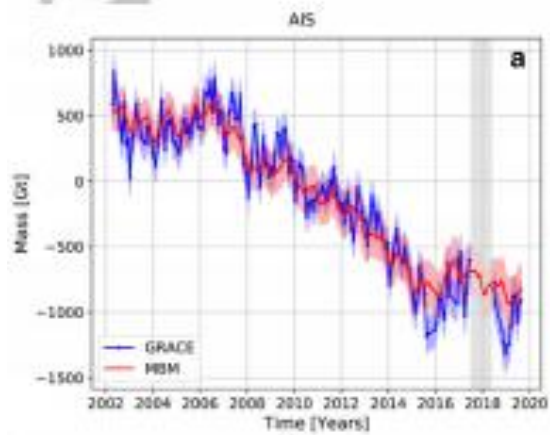
Abstract

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

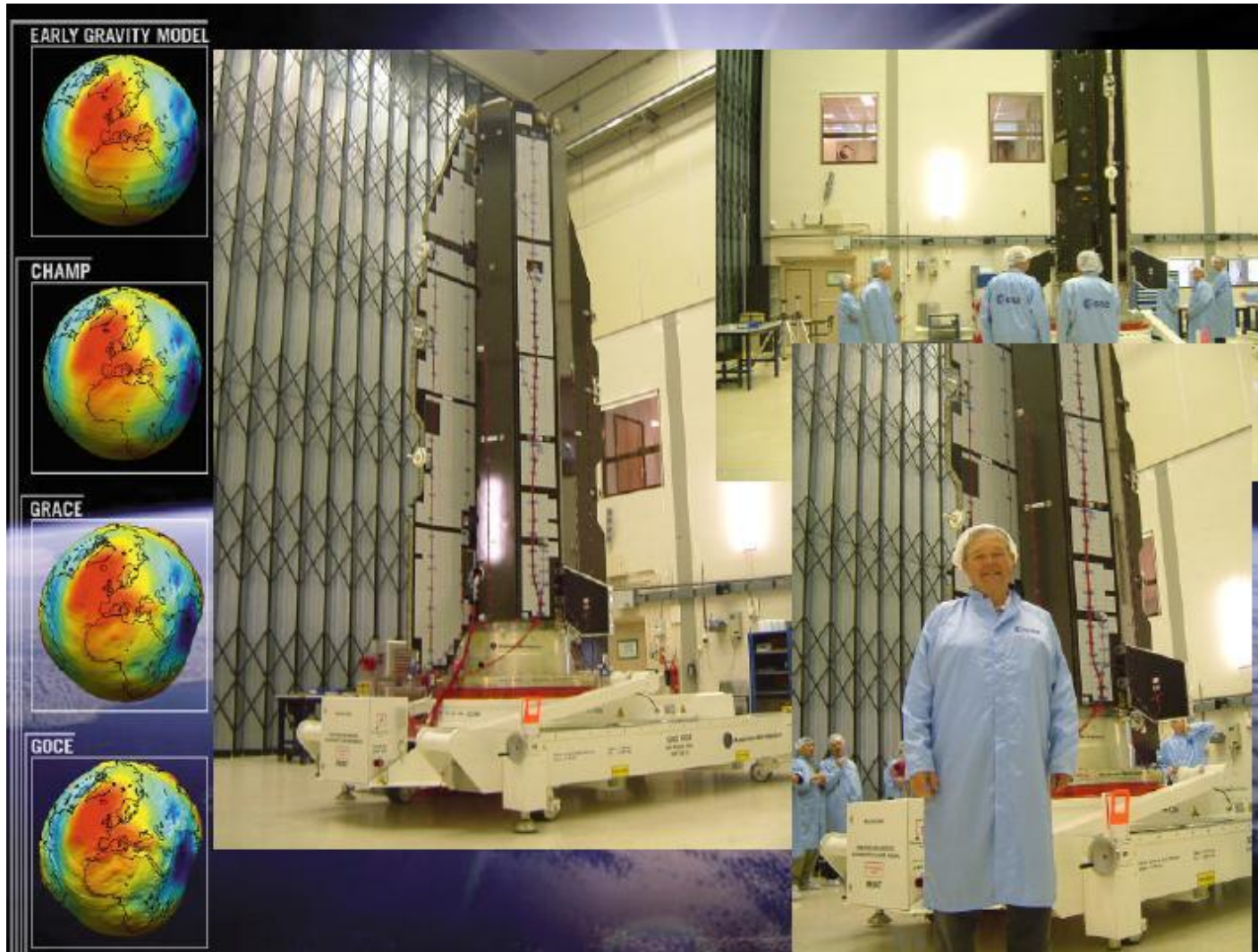
In Antarctica, ongoing high mass losses in the Amundsen Sea Embayment of West Antarctica, the Antarctic Peninsula, and Wilkes Land in East Antarctica cumulate to 2130, 560, and 370 Gigatonnes, respectively, since 2002.

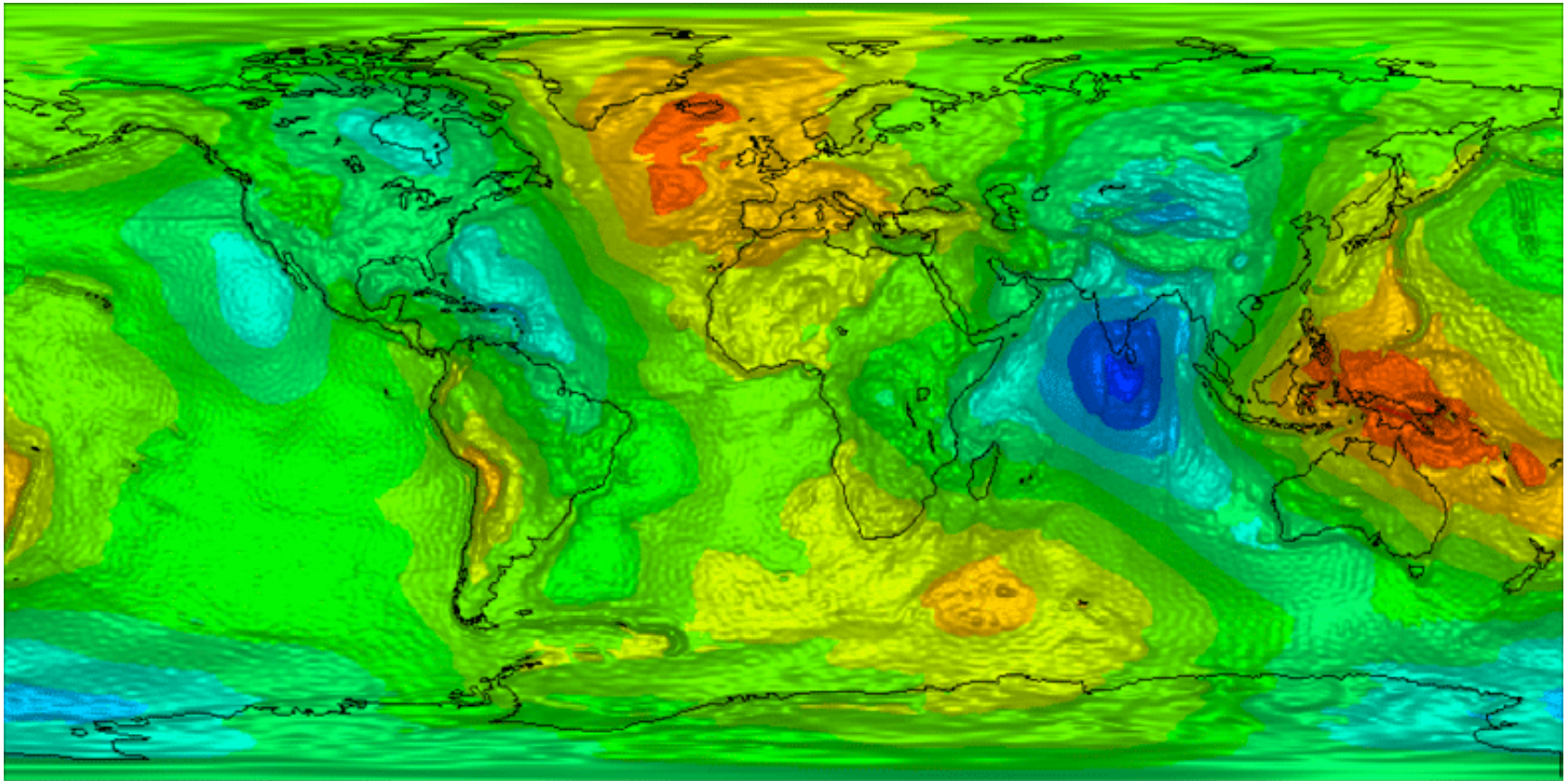
A cumulative mass gain of 980 Gigatonnes in Queen Maud Land since 2009, however, led to a pause in the acceleration in mass loss from Antarctica after 2016.





GOCE

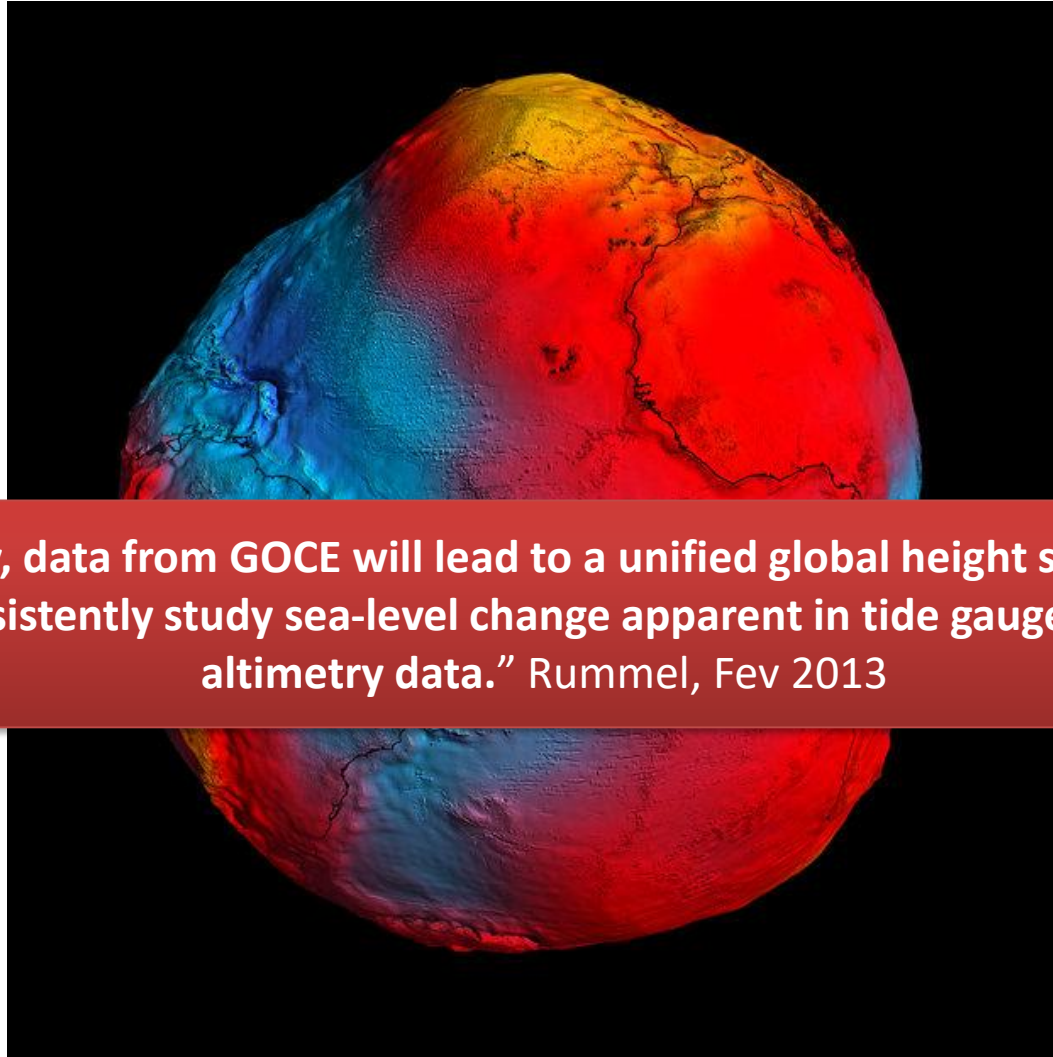




Global gravity model based on GOCE satellite data



GOCE - Geoid Model

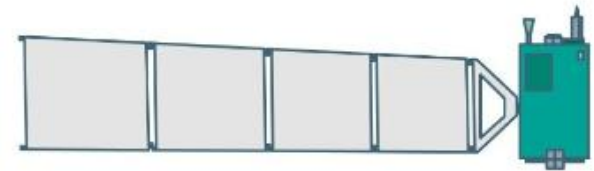


Importantly, data from GOCE will lead to a unified global height system so that we can consistently study sea-level change apparent in tide gauge and satellite altimetry data.” Rummel, Fev 2013

2013

The idea behind ESA's GENESIS mission is simple: a fixed framework is needed to chart the relative positions of locations across our planet, and satellites in orbit serve as the foundation of this framework. Fix a satellite's own position in space accurately enough and you can measure Earth beneath it much more precisely too.

To achieve this goal down to millimetre level, ESA's GENESIS satellite will combine and co-locate the four reference existing 'geodetic' – or Earth-measuring – techniques on a single platform for the first time. In so doing it will serve to identify and subtract inherent biases within each of these techniques, allowing, in turn, improvements in the accuracy and consistency of the reference frame that is used to organise much of the underlying functions of our civilisation. A new Invitation to Tender is giving European industry the chance to contribute to this groundbreaking mission.



— Preliminary GENESIS satellite design

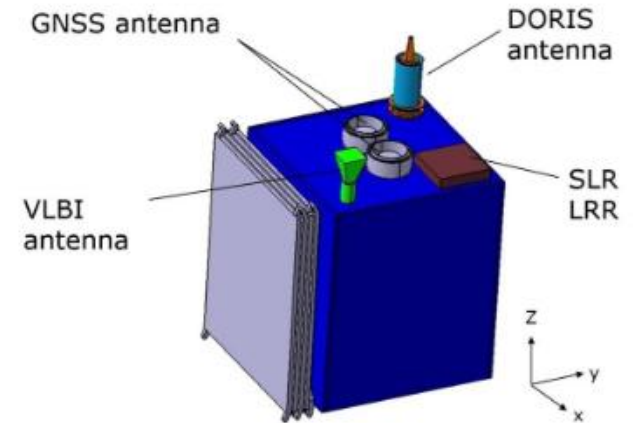


GENESIS is part of ESA's FutureNAV programme, approved at ESA's Council at Ministerial Level last November, seeking to respond to new satnav concepts and trends in an effective, agile way, bolstering European competitiveness in this vital sector.

Mapping planet Earth for better positioning

GENESIS will combine all four geodetic methods of fixing satellite positions in space: Very Long Baseline Interferometry, [VLBI](#), originally an astronomical technique that combines multiple radio observations from different sites to resolve a given object in high resolution; radio ranging (using France's [DORIS system](#)); [satellite navigation](#); and laser ranging (using the [International Laser Ranging Service](#)).

Each of these geodetic techniques have their own inherent biases, which affect the actual accuracy of the Terrestrial Reference Frame that we may achieve when combining them on Earth. By co-locating them together on the same satellite, with the instruments duly calibrated and synchronised, we may cross-check the results and remove these biases over time.



— Geodetic payloads on GENESIS satellite



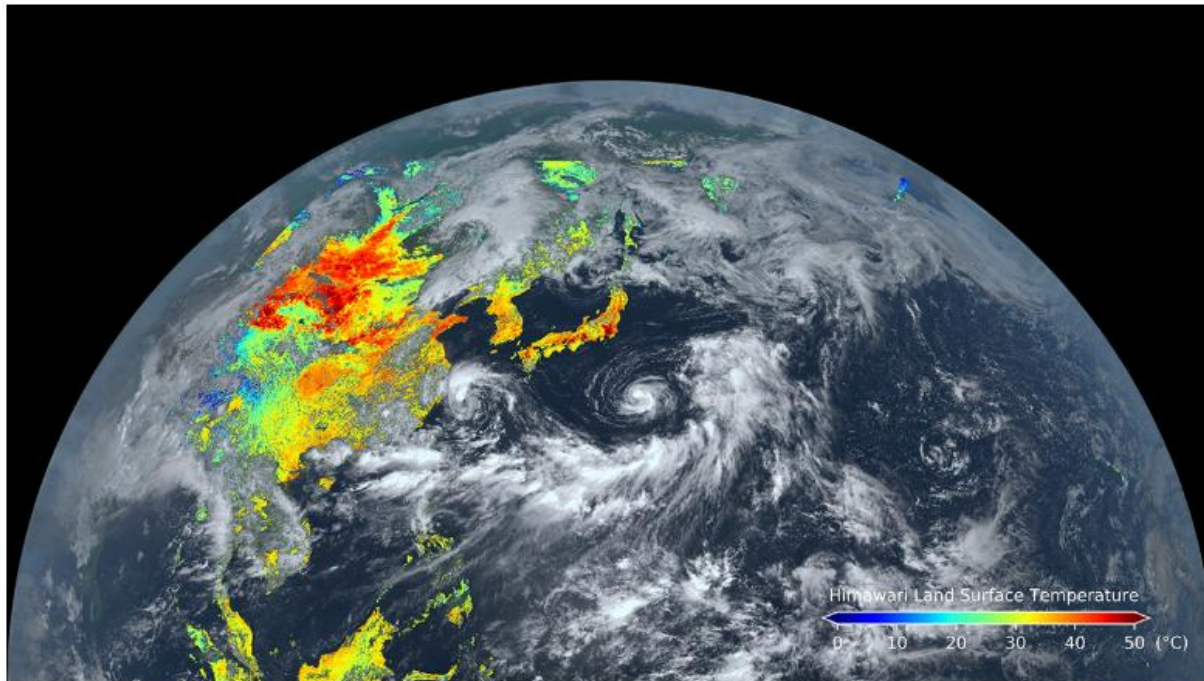
The final goal of the mission is to generate an updated more precise global model of Earth – the International Terrestrial Reference Frame, employed for everything from land surveying to measuring sea level rise – with an accuracy down to 1 mm, while tracking ground motion of just 0.1 mm per year. This improvement, at a stroke, will have a major impact in multiple navigation and Earth science applications, including enhancing the precision of the Galileo navigation system and by extension improving

Geostationary Satellite Applications Expand into Land Monitoring

Known for their weather-observing prowess, these satellites can also track land surface processes and disturbances over broad areas in near-real time.

Geostationary satellites can collect frequent measurements of temperatures and other characteristics of Earth's land surfaces, allowing them to detect rapid changes and disturbances. Land surface temperatures across parts of East Asia and Oceania recorded by the Himawari-8 and -9 satellites in July 2025 are shown here. Credit: Yuhei Yamamoto

By Xiangzhong Luo, N



 Sign up for **Eos Buzz**, Earth and space science news delivered to your inbox every Friday.



<https://eos.org/science-updates/geostationary-satellite-applications-expand-into-land-monitoring>



The primary role of geostationary satellites, which orbit in sync with Earth's rotation and remain in relatively fixed positions roughly 36,000 kilometers above the planet's surface, has traditionally been to [provide vital observations](#) for [weather forecasting](#). Now they are emerging as powerful tools for monitoring other conditions at Earth's land surface as well.

Satellites such as the Geostationary Operational Environmental Satellites–R ([GOES-R](#)) series, [Himawari-8 and -9](#), Fengyun-4 ([FY-4](#)), and the Geostationary Korea Multi-Purpose Satellite–2A ([GK-2A](#)) offer rare capabilities for near-real-time observations across large scales. By providing observations at intervals of 5–15 minutes, they offer a temporal resolution far superior to polar-orbiting or low-Earth-orbit satellite sensors like the Moderate Resolution Imaging Spectroradiometer ([MODIS](#)) and Sentinel-2's [Multispectral Imager](#). Those sensors typically capture infrequent snapshots of a given part of the land surface, one or two per day in the case of MODIS or once every 5 days in the case of Sentinel-2.

With this fine-grained coverage, they are uniquely powerful for high-frequency land surface monitoring, resolving diurnal and seasonal ecosystem dynamics, and enabling early warning and more effective tracking of rapid surface changes like wildfires, floods, frosts, and heat waves. They can also help support protection of tropical forests and inform carbon neutrality strategies, among other applications.

“

—————
With their fine-grained coverage, geostationary satellites are uniquely powerful for high-frequency land surface monitoring.

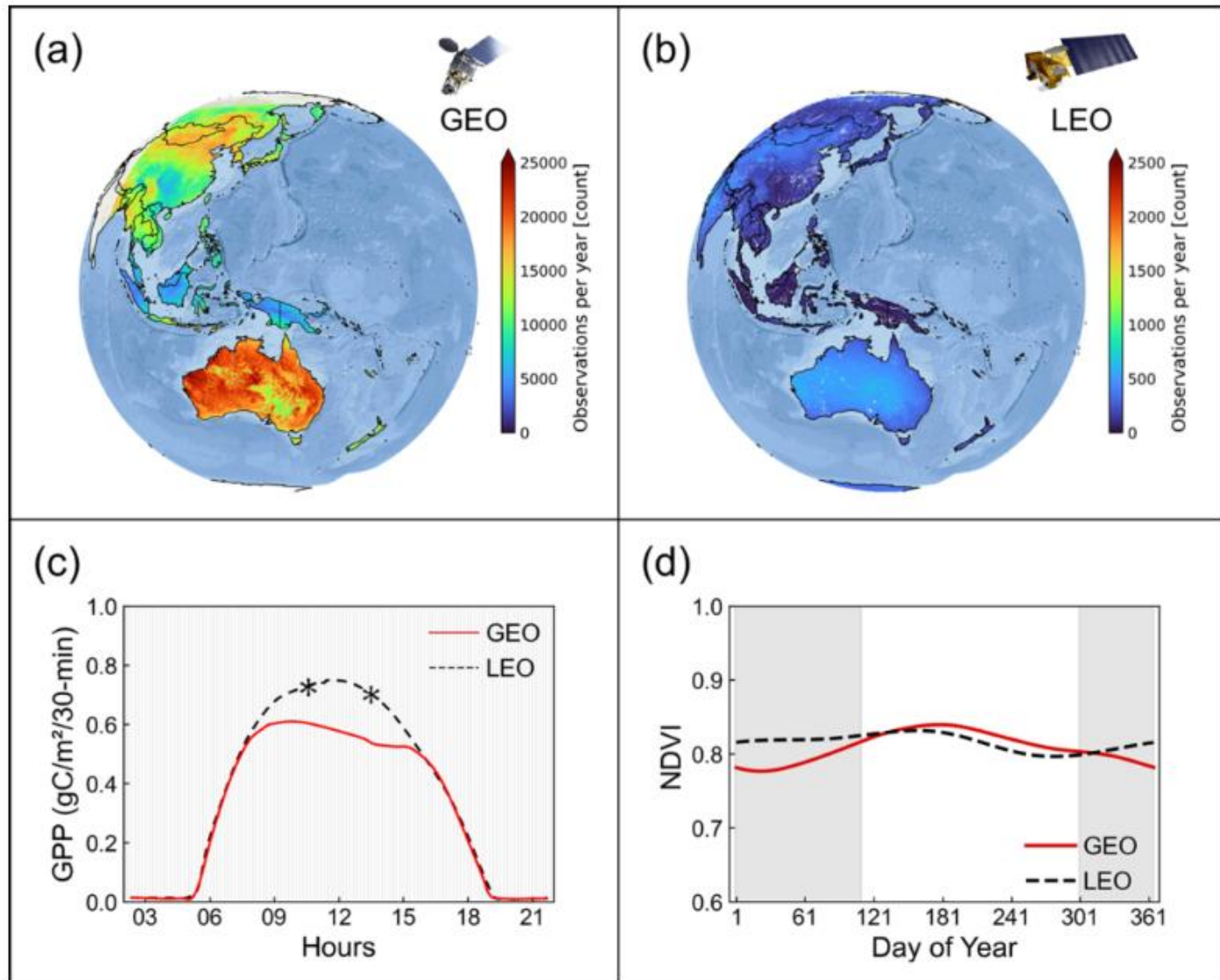


Fig. 1. Geostationary satellite (GEO) observations offer novel insights into ecosystem processes at high-resolution timescales. (a) Himawari-8, for example, collects far more clear-day observations per year than (b) polar-orbiting or low-Earth-orbit (LEO) satellite sensors such as the Moderate Resolution Imaging Spectroradiometer (MODIS). Note the different magnitudes of the scales. (c) GEO observations can also reveal a midday depression in photosynthesis (measured as gross primary productivity, GPP), as shown by the red curve for a forest site in Japan. The gray vertical lines indicate the timing of observations by Himawari-8 and -9, and the asterisks indicate the two daily snapshots taken by a MODIS sensor, which missed the depression signal. (d) The seasonalities of vegetation greenness (measured by the normalized difference vegetation index, NDVI) in a tropical Asian

The explanation for this suppression is not entirely clear, though it may relate to plants coping with higher vapor pressure deficits around midday; regardless of the reasons, it has profound implications for gross primary productivity. Together these results show how geostationary satellites complement polar-orbiting satellites by filling diurnal data gaps [[Xiao et al., 2021](#)] and how they sharpen our view of ecosystem processes under heat and moisture stress.

“

Geostationary satellites collect images many times per day, increasing the odds of cloud-free looks.

Geostationary satellite observations are also opening the tropics, which include the planet’s most carbon-dense and biodiverse land regions, to more frequent monitoring. Persistent cloud cover, especially in rainy seasons, has long hampered satellite views in the tropics; with their infrequent revisits, polar-orbiting sensors are more likely to return cloud-contaminated scenes. In

contrast, geostationary satellites collect images many times per day, increasing the odds of cloud-free looks. On average, for example, MODIS provides clear, cloud-free observations over tropical Asia on only 40% of the days, compared with 80% for Himawari-8 [[Tian et al., 2025](#)].

Leveraging this high-frequency cadence, recent studies using GOES-R and Himawari-8 and -9 have resolved seasonal dynamics of tropical forests in the Amazon and Southeast Asia [[Hashimoto et al., 2021](#); [Tian et al., 2025](#)]. For example, these studies have clearly observed the green-up of evergreen broadleaf forests in dry seasons, informing [long-running debates about whether and why](#) such green-ups occur (Figure 1d).

Also, geographic coverage and usage of geostationary satellite data are not evenly distributed. Each satellite views a fixed hemisphere, meaning applications of their data tend to be regional (Figure 3). Furthermore, differences in satellite sensors, viewing geometries, and data processing pipelines continue to complicate interoperability among different data products, although NASA's [GeoNEX](#) collaboration platform is an important step toward harmonization [[Wang et al.](#), 2020].

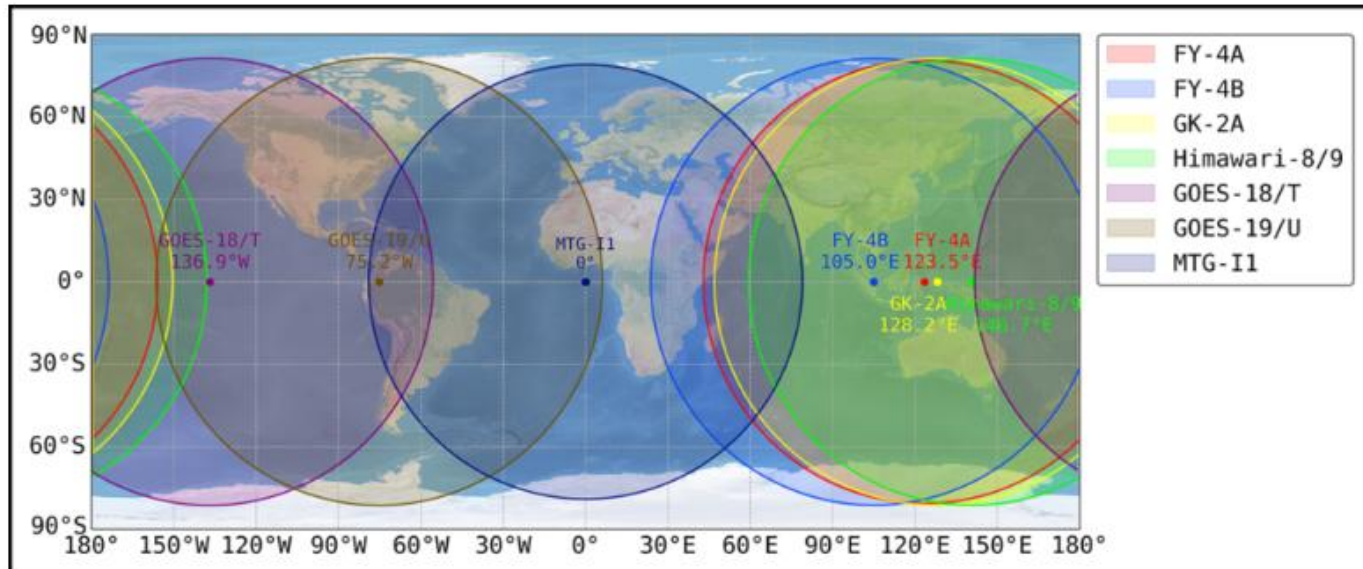


Fig. 3. Areas covered by various active geostationary satellites are shown here. The current constellation includes the Geostationary Operational Environmental Satellites–R (GOES-R) series (GOES-16, -17, -18, and -19; only GOES-18 and -19 are shown here) covering the Americas; the Meteosat Third Generation satellite (MTG-I1) covering Europe and Africa; and the Fengyun-4 (FY-4A and -4B), Geostationary Korea Multi-Purpose Satellite–2A (GK-2A), and Himawari-8 and -9 satellites covering Asia and Oceania. Credit: Adapted from [Deng and Ma](#) [2026], [CC BY-NC 4.0](#)

Compared with Africa, where the Meteosat Third Generation ([MTG](#)) satellite is the primary geostationary asset available, and the Americas, which rely chiefly on GOES-R, Asia has enjoyed more dense coverage from several geostationary satellites (Himawari-8 and -9, FY-4, GK-2A) in recent years, making it an ideal test bed for intersensor data comparison and harmonization.



Nvidia's space computing project will place AI data centres into orbit (Nvidia)

Leading AI chip maker [Nvidia](#) has announced plans to help build [artificial intelligence](#) data centres into [space](#).

The California-based company said that its new Space-1 Vera Rubin Module will be used by partners for orbital data centres and provide AI analysis for satellite constellations.

Nvidia CEO Jensen Huang said the initiative would “take intelligence where it’s never gone before” through space-based AI infrastructure.

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.

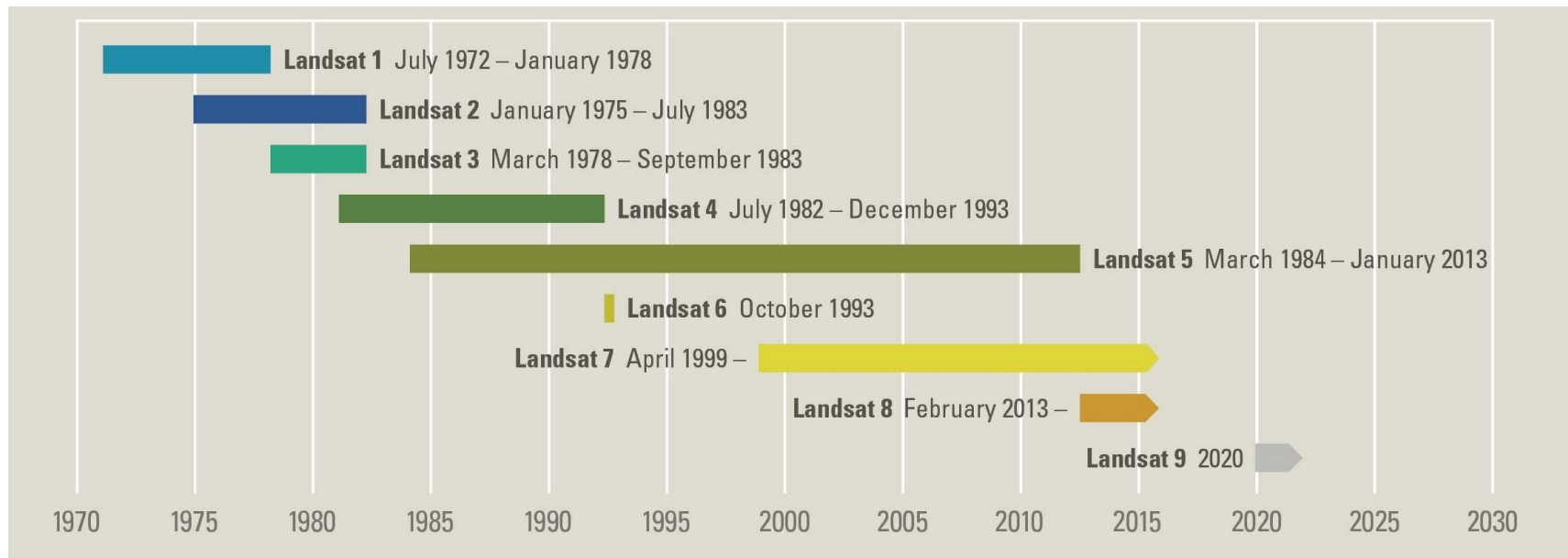
The launches of **Landsat-2**, **Landsat-3**, and **Landsat-4** followed in 1975, 1978, and 1982, respectively.



Earth Observation Satellites

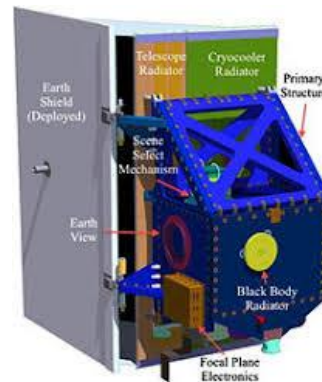
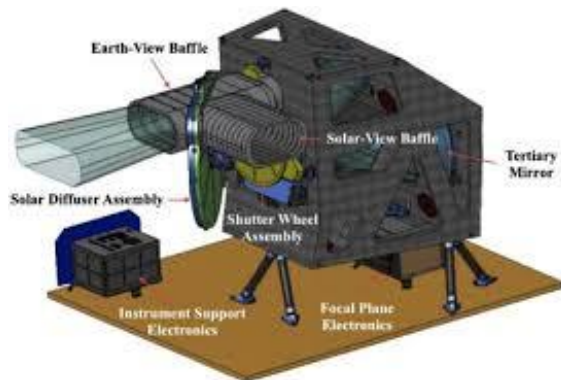
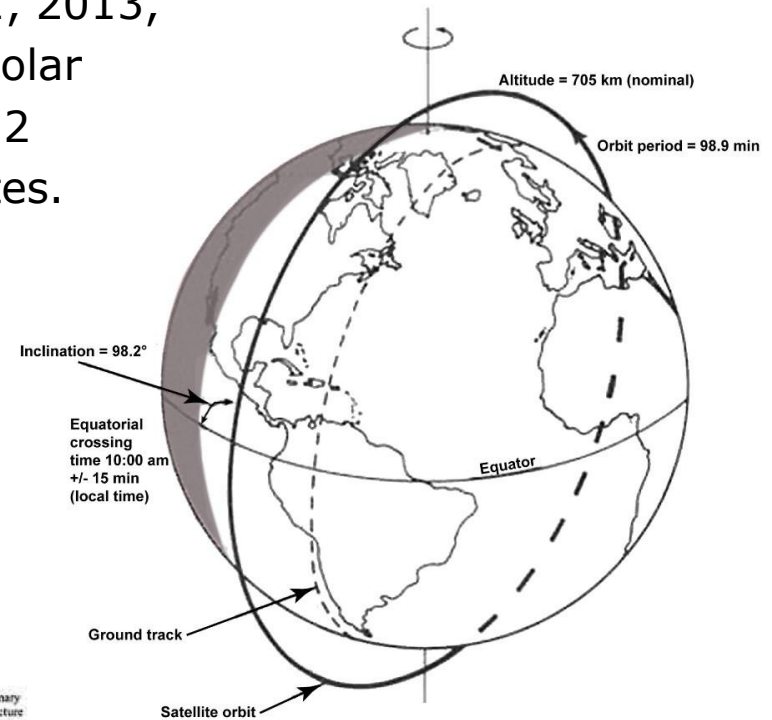
Landsat-5, launched in 1984, lasting 28 years and 10 months, officially setting a new Guinness World Record for "longest-operating Earth observation satellite."

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).

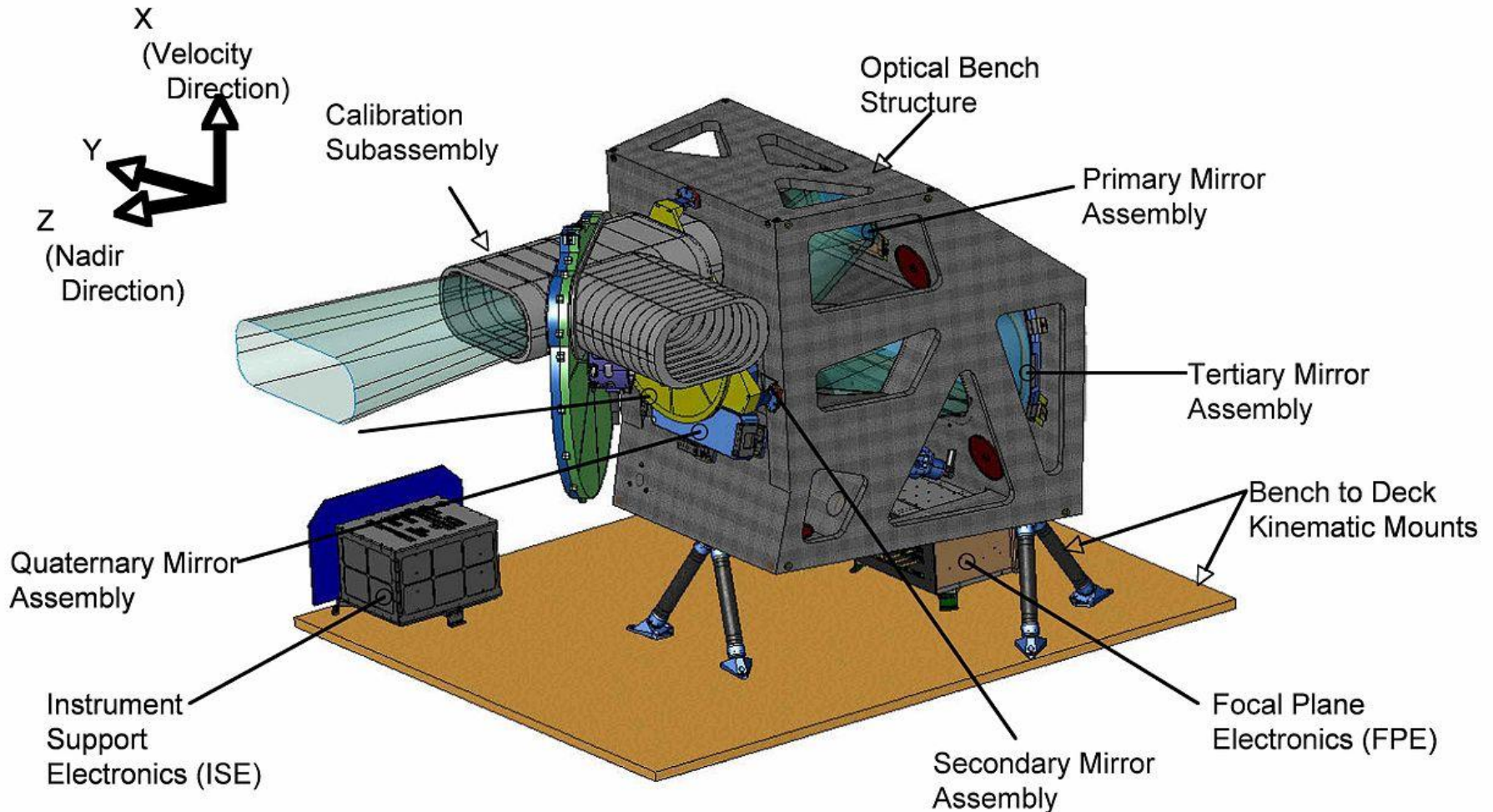


Landsat-8 satellite, launched on February 11, 2013, orbits the Earth in a sun-synchronous, near-polar orbit, at an altitude of 705 km, inclined at 98.2 degrees, and circles the Earth every 99 minutes.

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>)

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)

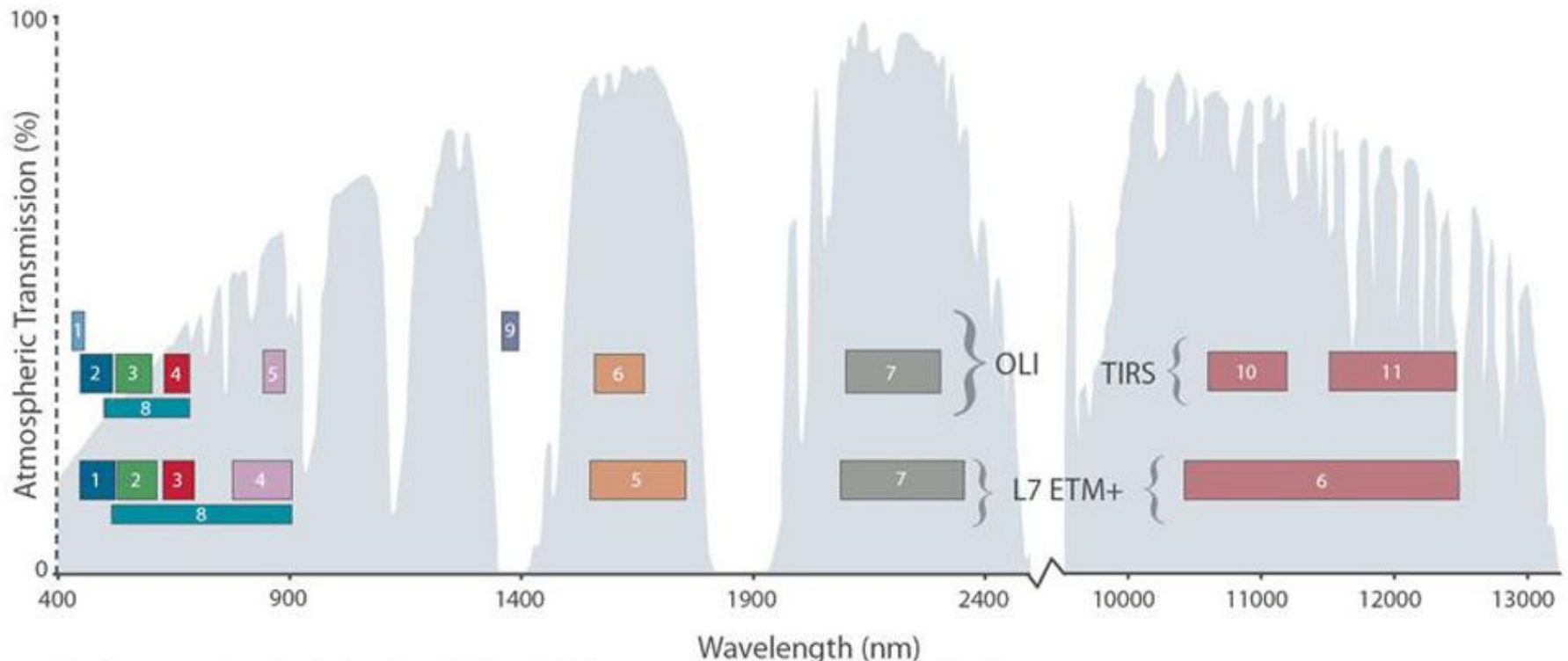


Earth Observation Satellites



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

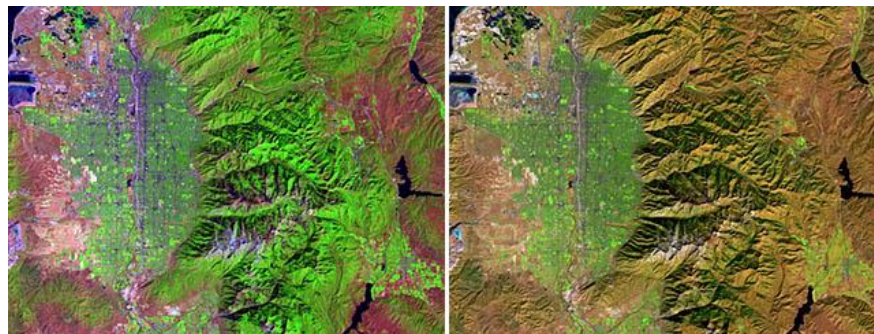
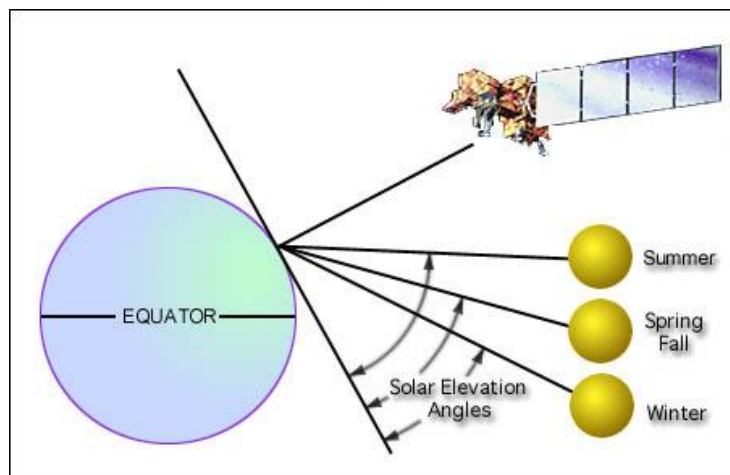
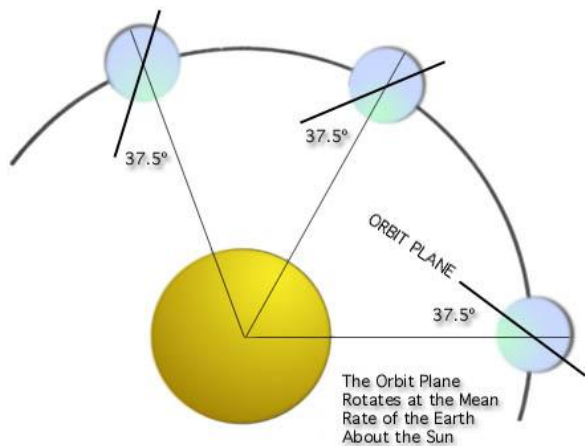
Note: atmospheric transmission values for this graphic were calculated using MODTRAN for a summertime mid-latitude hazy atmosphere (circa 5 km visibility).

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

Radiometric quantization (12-bits)

LANDSAT – sazonal effects

Nodo descendente às 10:00



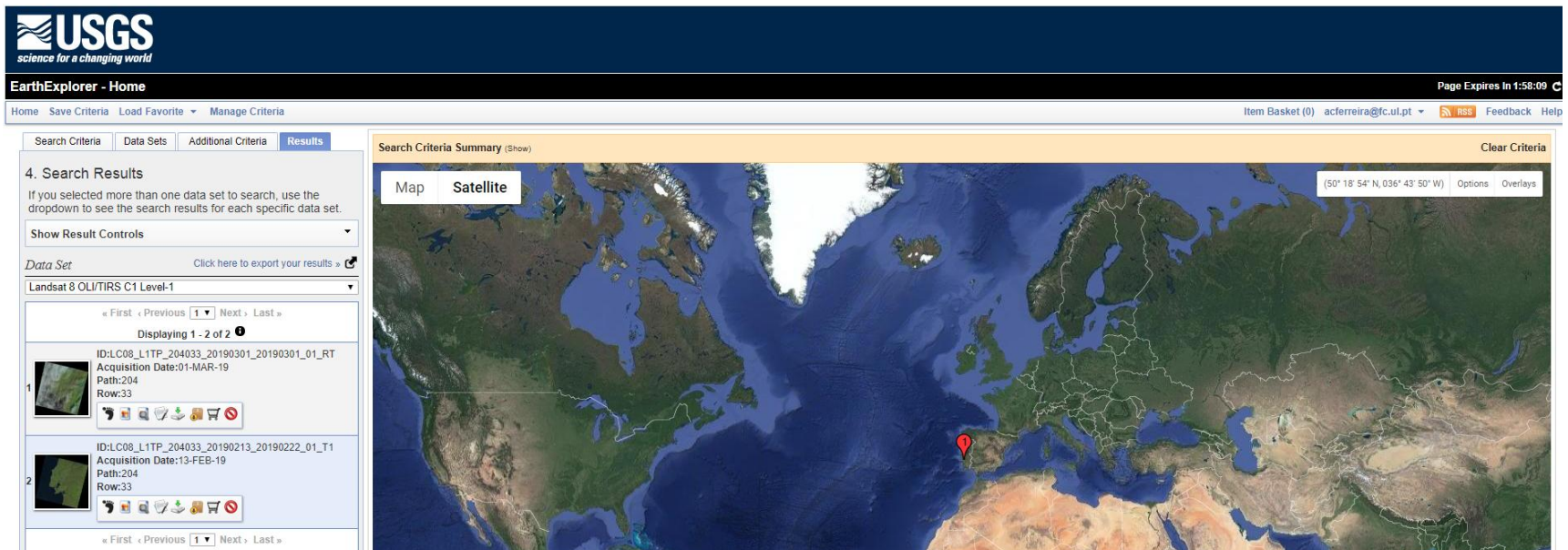
Effects of Seasonal Changes on Solar Elevation Angle



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).

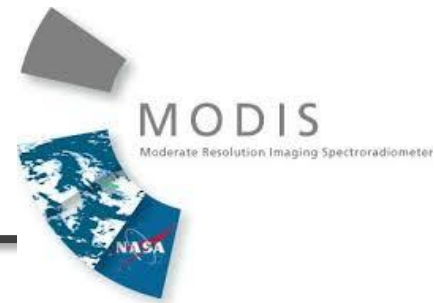


The screenshot shows the USGS Earth Explorer interface. The top navigation bar includes 'Home', 'Save Criteria', 'Load Favorite', and 'Manage Criteria'. The main content area is titled '4. Search Results' and displays two search results for Landsat 8 OLI/TIRS C1 Level-1 data. The first result is for ID: LC08_L1TP_204033_20190301_20190301_01_RT, acquired on 01-MAR-19. The second result is for ID: LC08_L1TP_204033_20190213_20190222_01_T1, acquired on 13-FEB-19. Both results show a thumbnail image and a list of icons for actions like download, share, and print. A map of the Atlantic Ocean region is visible on the right side of the interface, with a red pin indicating the location of the search results. The map shows the Atlantic Ocean, parts of North America, Europe, and Africa.

Earth Observation Satellites

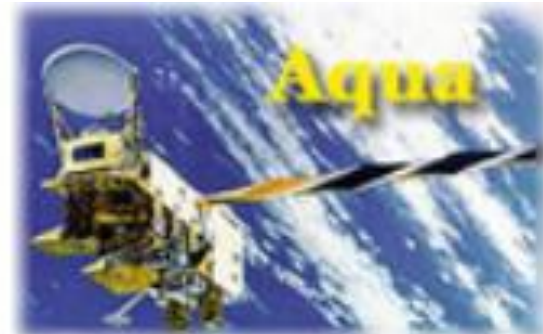


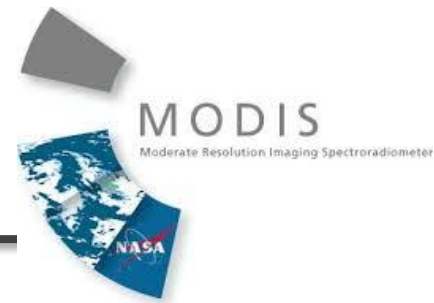
Landsat-8 (13.02.2019)



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.

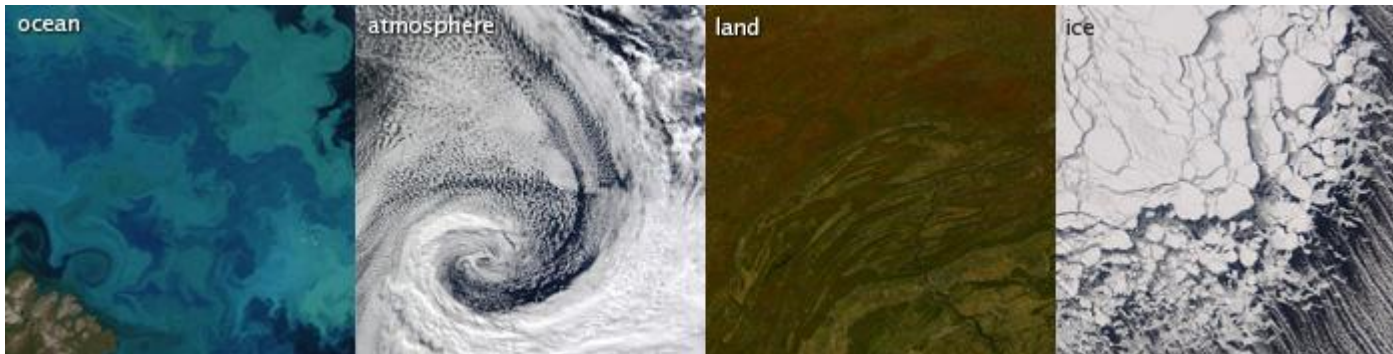
Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning (10:30 am), while **Aqua** passes south to north over the equator in the afternoon (01:30 pm).





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:

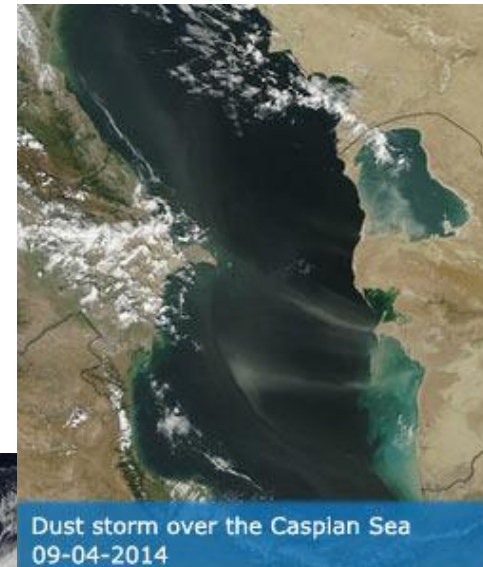
<https://lpdaac.usgs.gov/>

MODIS cryosphere products:

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

MODIS ocean color and sea surface temperature products:

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



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

185 km

146 km

117 km via
2 @ 60 km

11 km

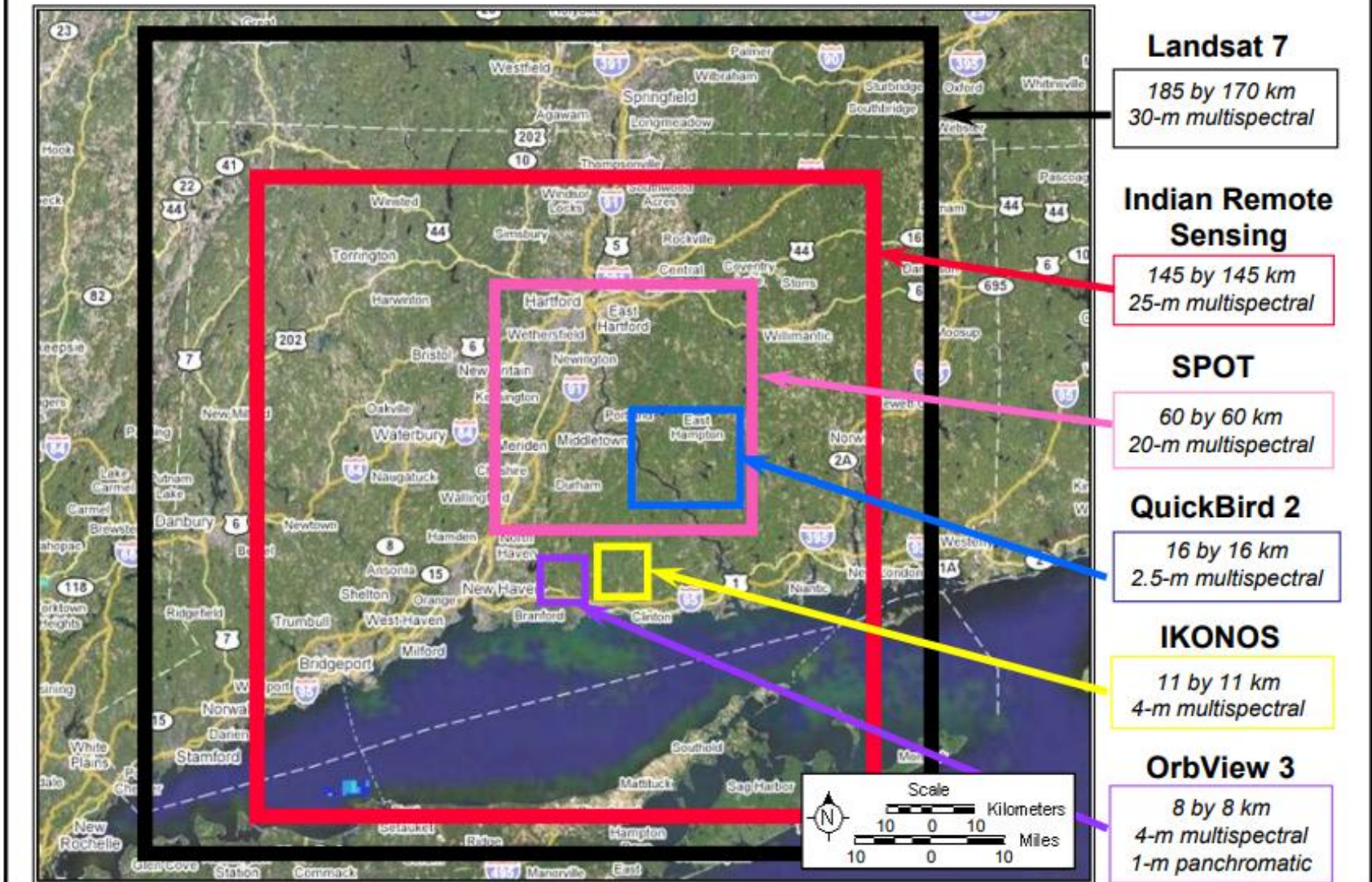
Looking More Closely at Resolution



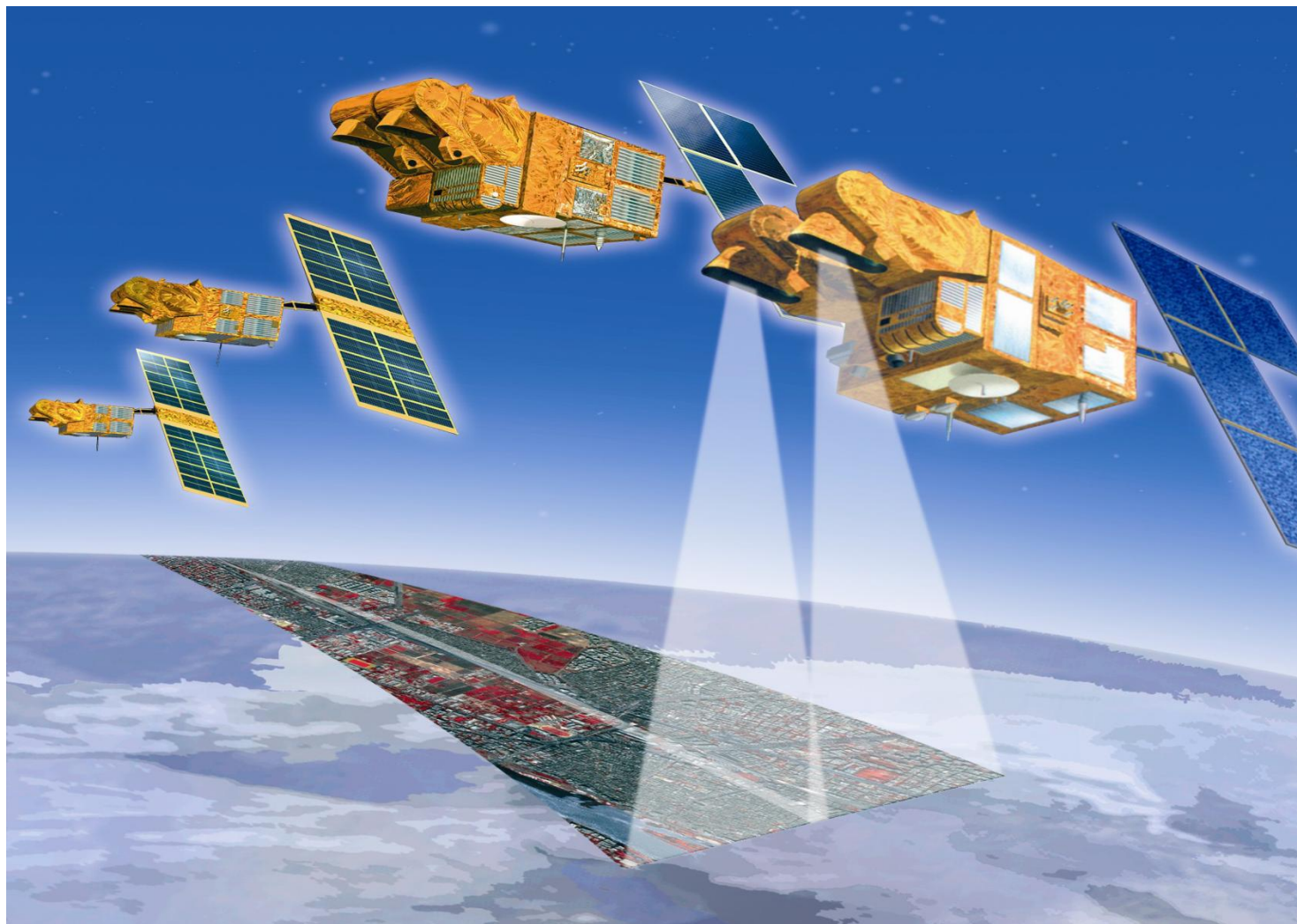
Looking More Closely at Resolution



Selected Satellite Footprints

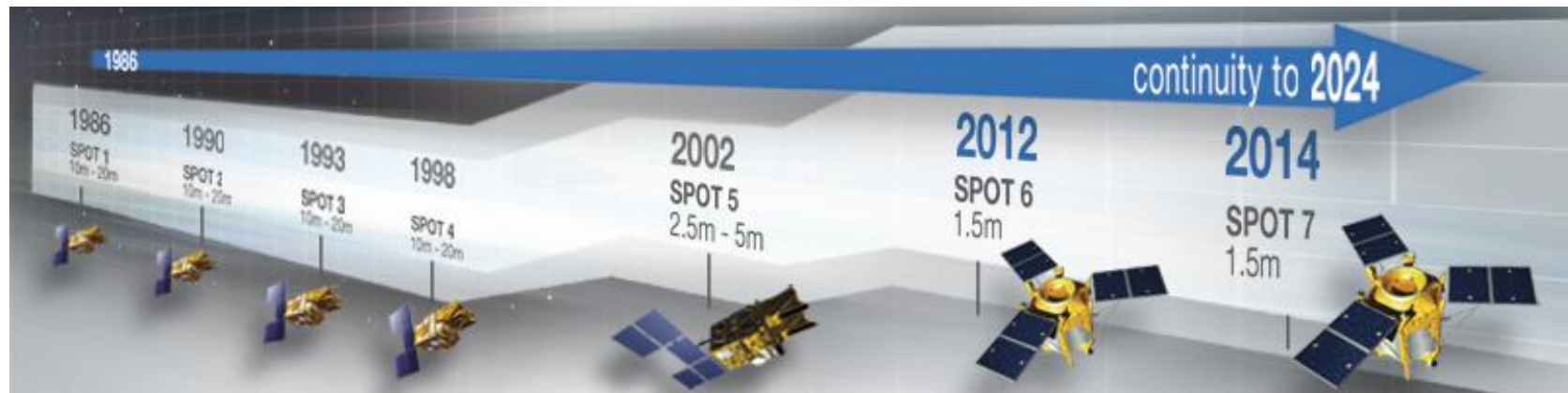


SPOT (Système Pour l'Observation de la Terre)



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 Spetrum

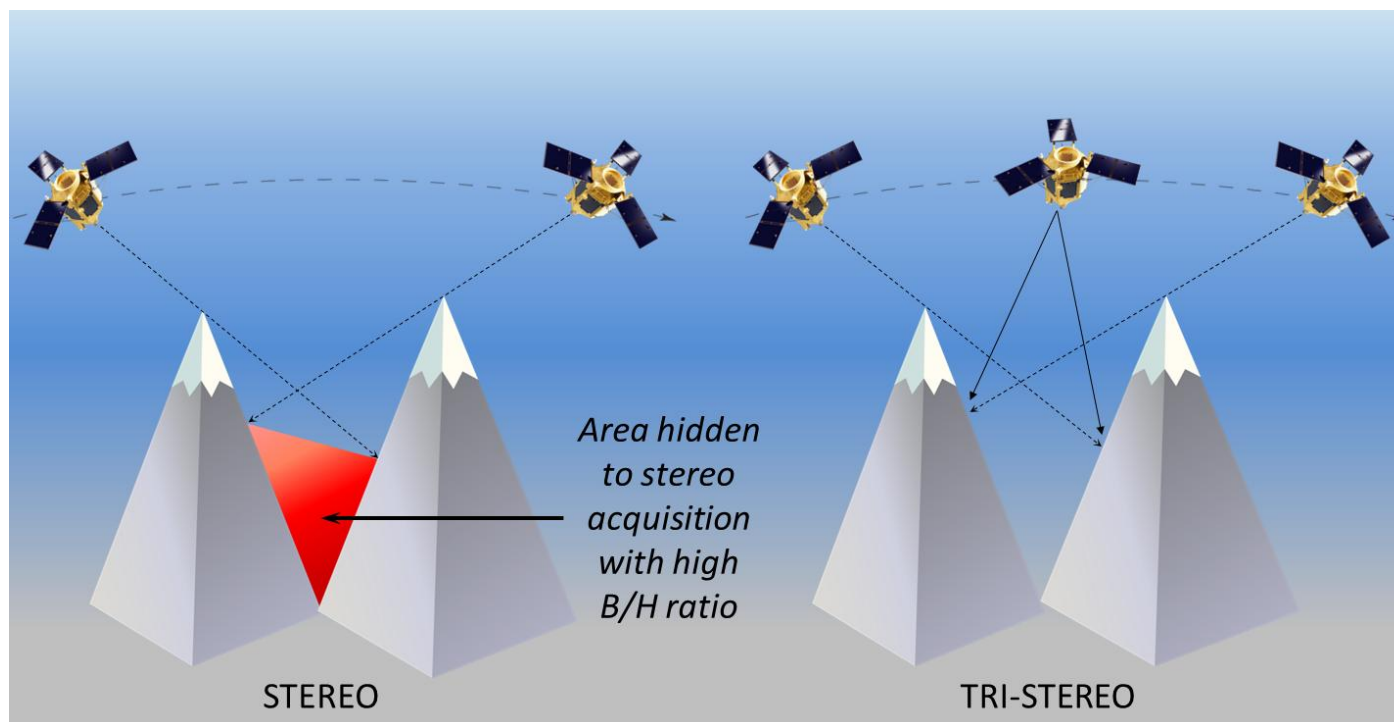
Sensors	Electromagnetic Spectrum	Pixels Size	Spectral bands
SPOT 5	Panchromatic	2.5 m or 5 m	0.48 - 0.71 μm
	B1 : green	10 m	0.50 - 0.59 μm
	B2 : red	10 m	0.61 - 0.68 μm
	B3 : near-infra-red	10 m	0.78 - 0.89 μm
	B4 : short-wave infrared (SWIR)	20 m	1.58 - 1.75 μm
SPOT 4	Monospectral	10 m	0.61 - 0.68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

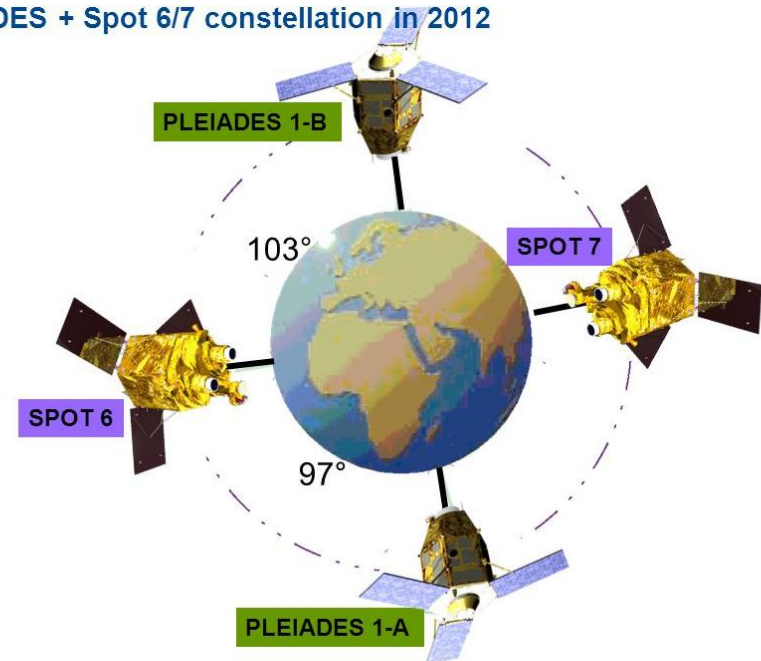
Both SPOT and Pleiades have **stereoscopic image acquisition capability** along the track (forward/backward): along-track stereo pairs and stereo triplets.



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



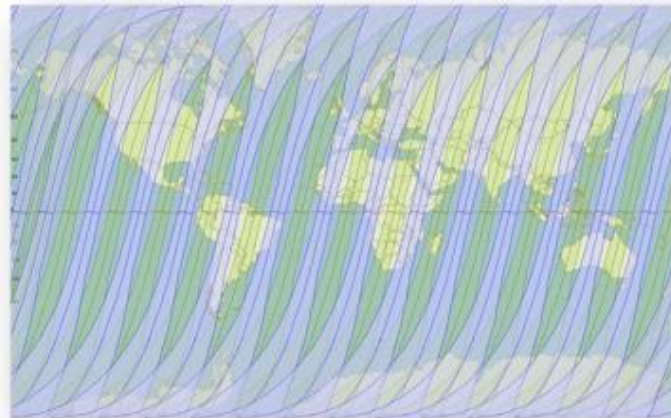
	SPOT-6/7	Pleiades-1A/1B
Spectral Resolution	5 spectral bands, including a panchromatic band	5 spectral bands, including a panchromatic band
Spatial Resolution	1.5 m - panchromatic band 6 m - 4 multispectral bands (B,G,R,NIR)	0.5 m - panchromatic band 2 m - 4 multispectral bands (B,G,R,NIR)
Radiometric 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

Orbital Characteristics and Viewing Capability

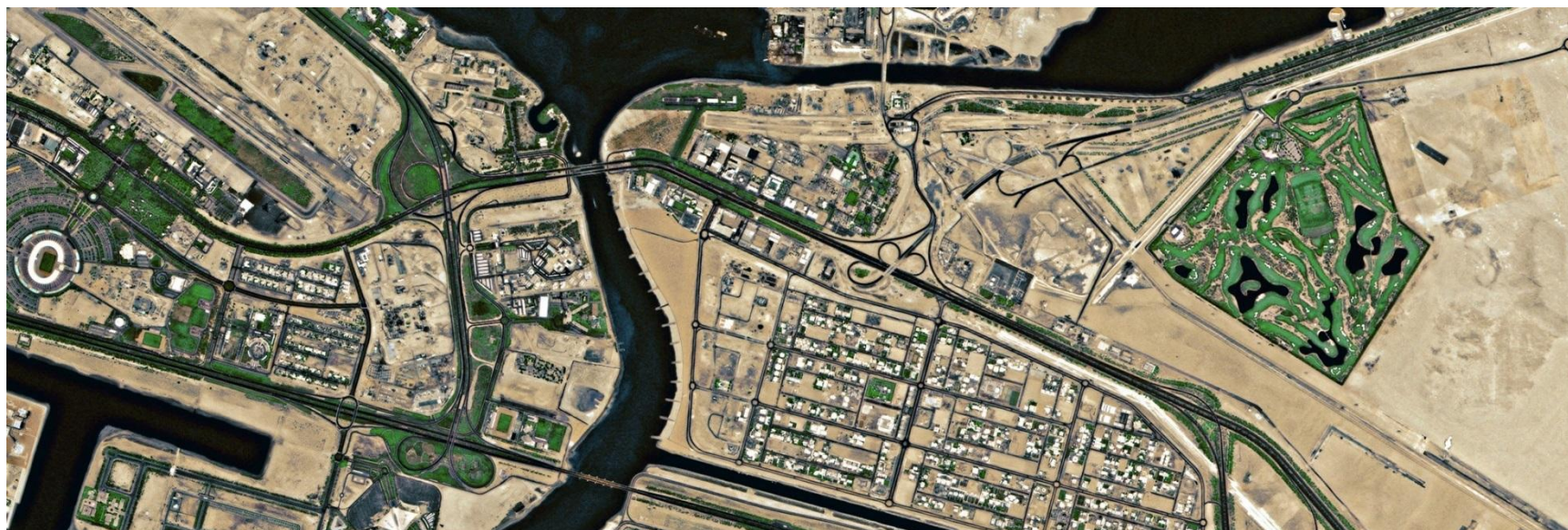
The SPOT 6 and SPOT 7 missions are designed to provide large area coverage and detailed information on individual targets. This is possible thanks to the superior agility of the satellite.

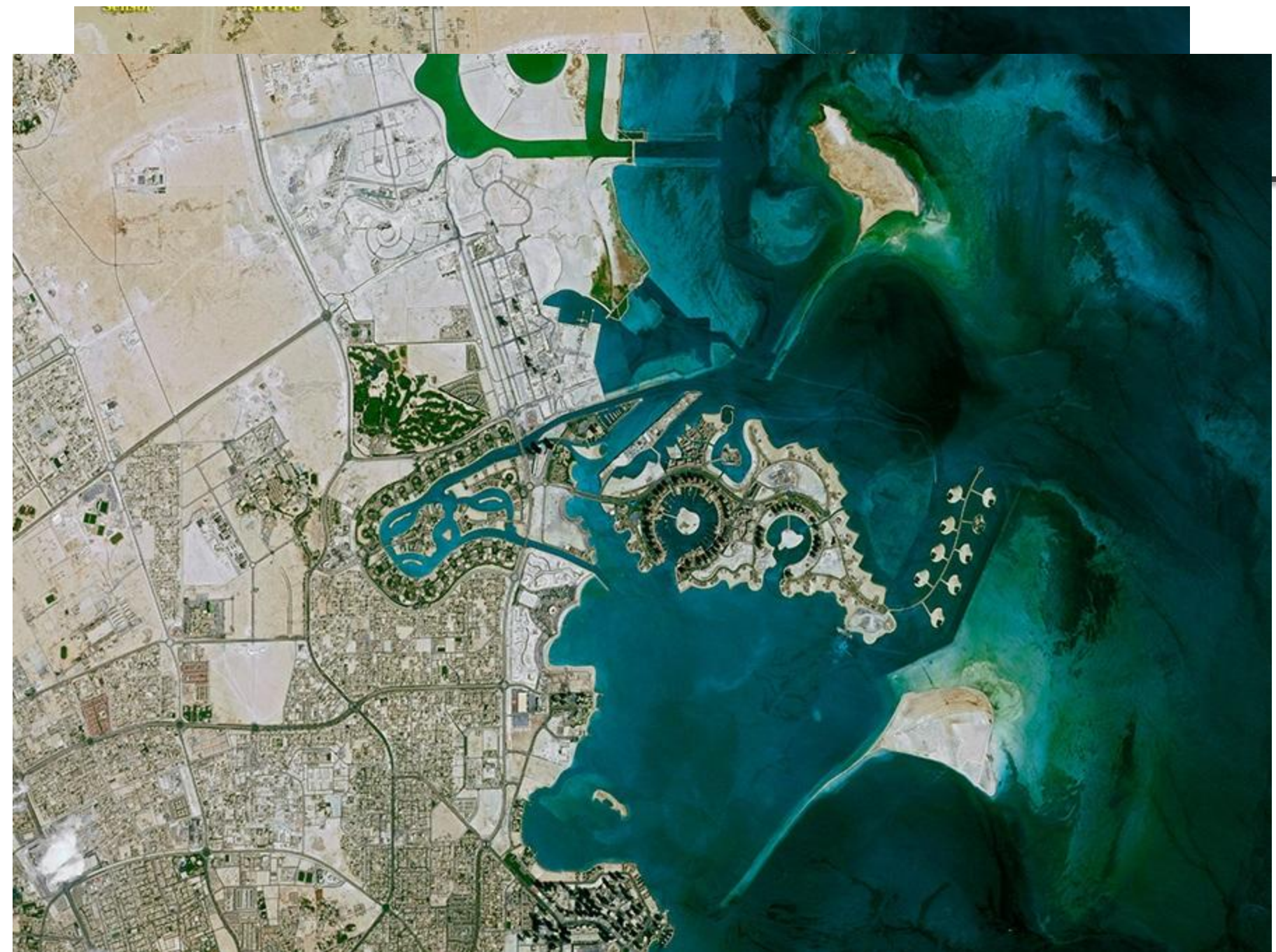
Orbit	Sun-synchronous; 10:00 AM local time at descending node
Period	98.79 minutes
Cycle	26 days
Viewing Angle	Standard: +/- 30° in roll Extended: +/- 45° in roll
Revisit	<ul style="list-style-type: none"> ▪ 1 day with SPOT 6 and SPOT 7 operating simultaneously ▪ Between 1 and 3 days with only one satellite in operation¹
Pointing Agility	Control Moment Gyroscopes allow quick maneuvers in all directions for targeting several areas of interest on the same pass (30° in 14 seconds, including stabilization time)
Acquisition Capacity	Up to 6 million km ² daily with SPOT 6 and SPOT 7 when operating simultaneously
Nominal Imaging Mode	<ul style="list-style-type: none"> ▪ 60-km swath strips oriented along North-South axis ▪ Up to 600km length
Stereo Capability	Single pass stereo and tri-stereo (fore, nadir and aft mode)



Daily revisit for the SPOT 6 and SPOT 7 constellation:

SPOT 5 – Imagem 2.5 m

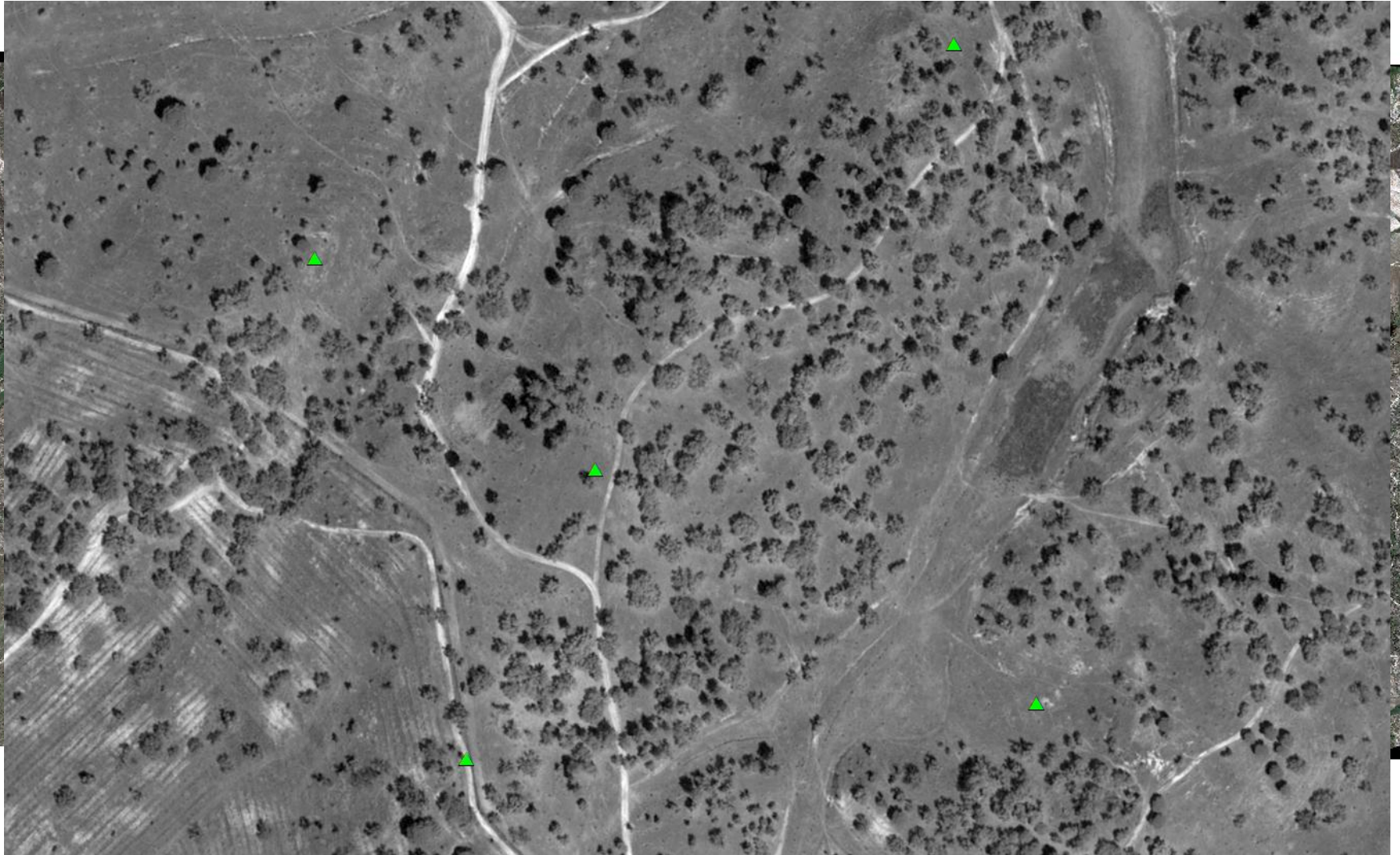




SPOT – Imagem 5 m



Pleiades – Pan, resolução 0.5 m





Pleiades – resolução 2 m

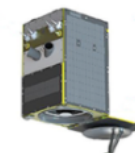
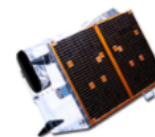
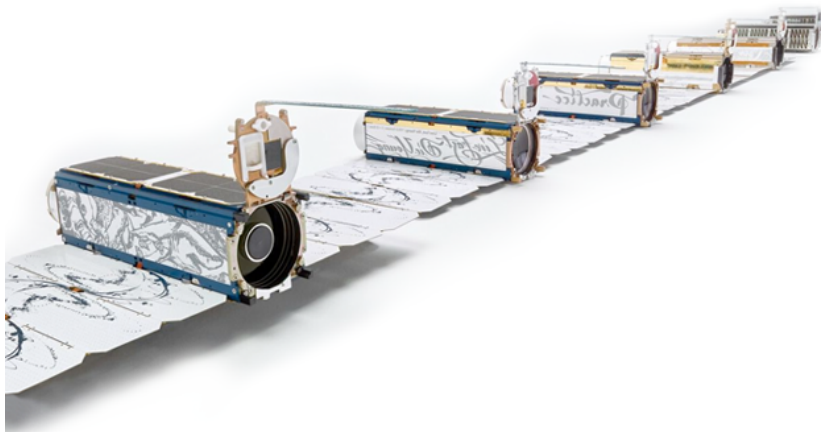


Our constellations

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

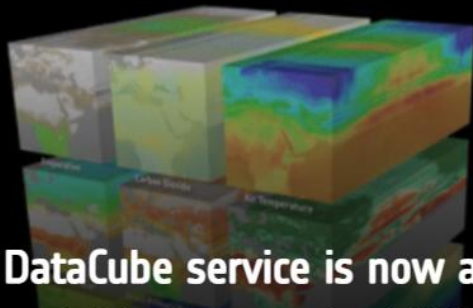
400K km²/day

PLANETSCOPE INSTRUMENTS

Explore instruments used in PlanetScope mission.

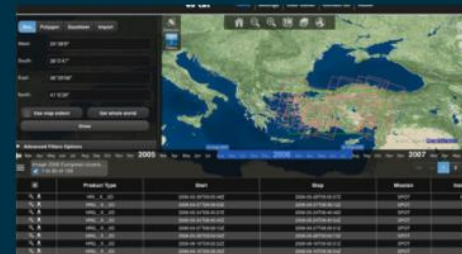
EXPLORE INSTRUMENTS

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 Green Red RedEdge NIR	455 – 515 nm 500 – 590 nm 590 – 670 nm 733 – 748 nm 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



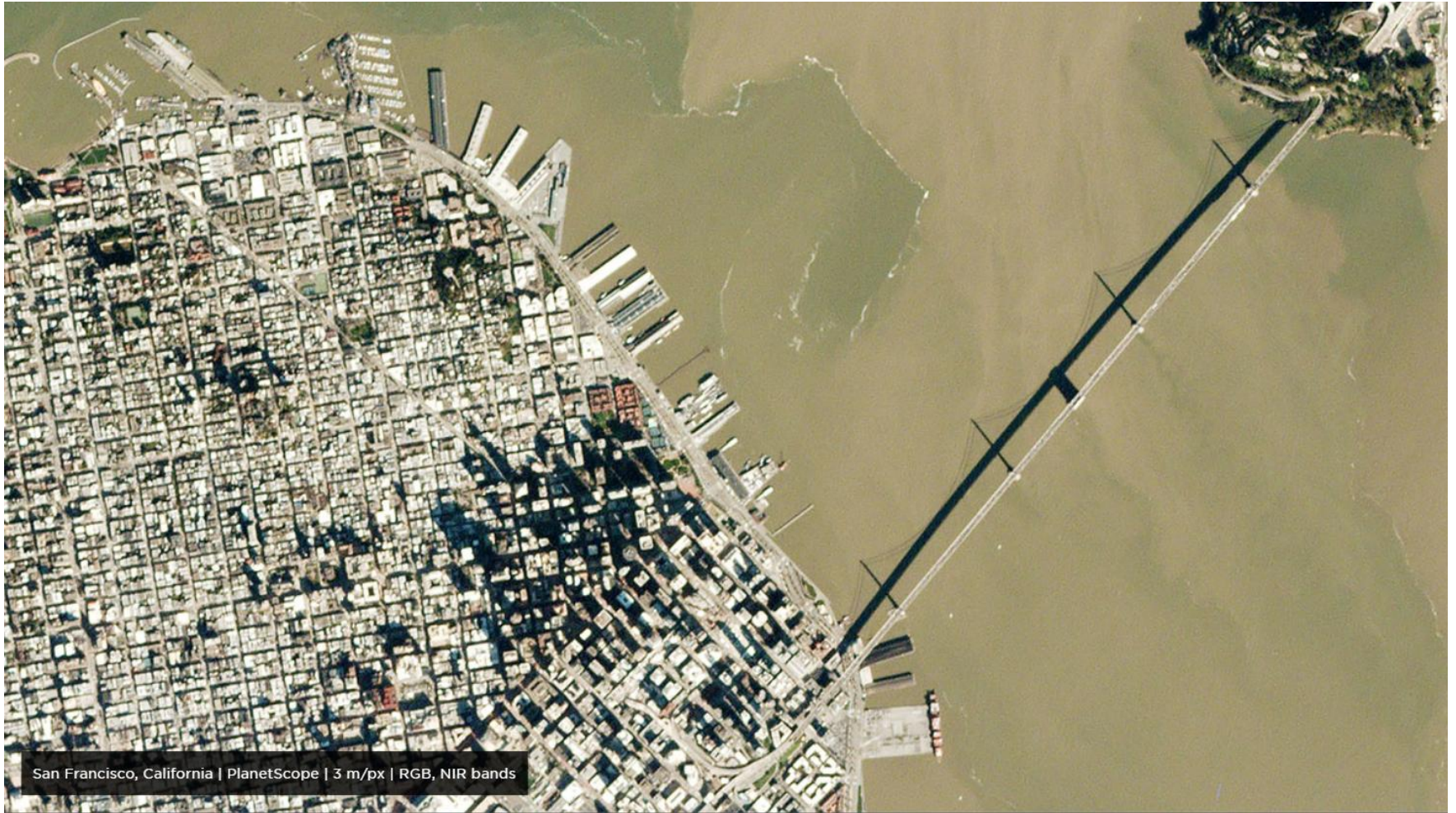
SKYSAT

	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

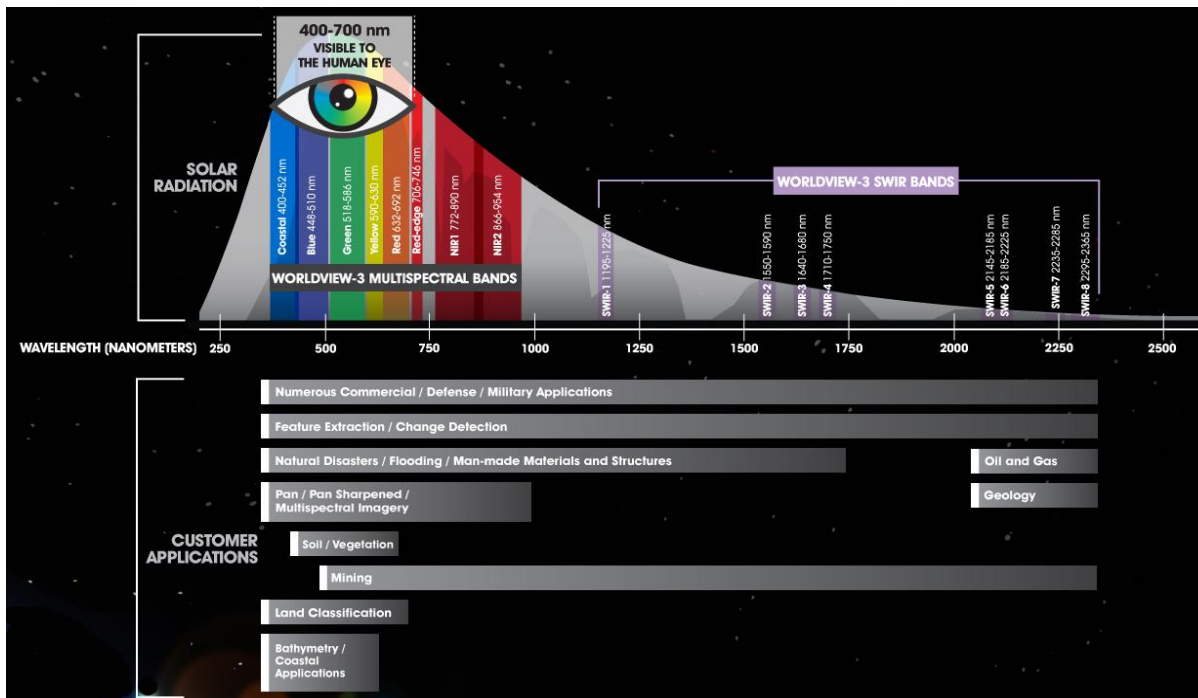


Other Systems

<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

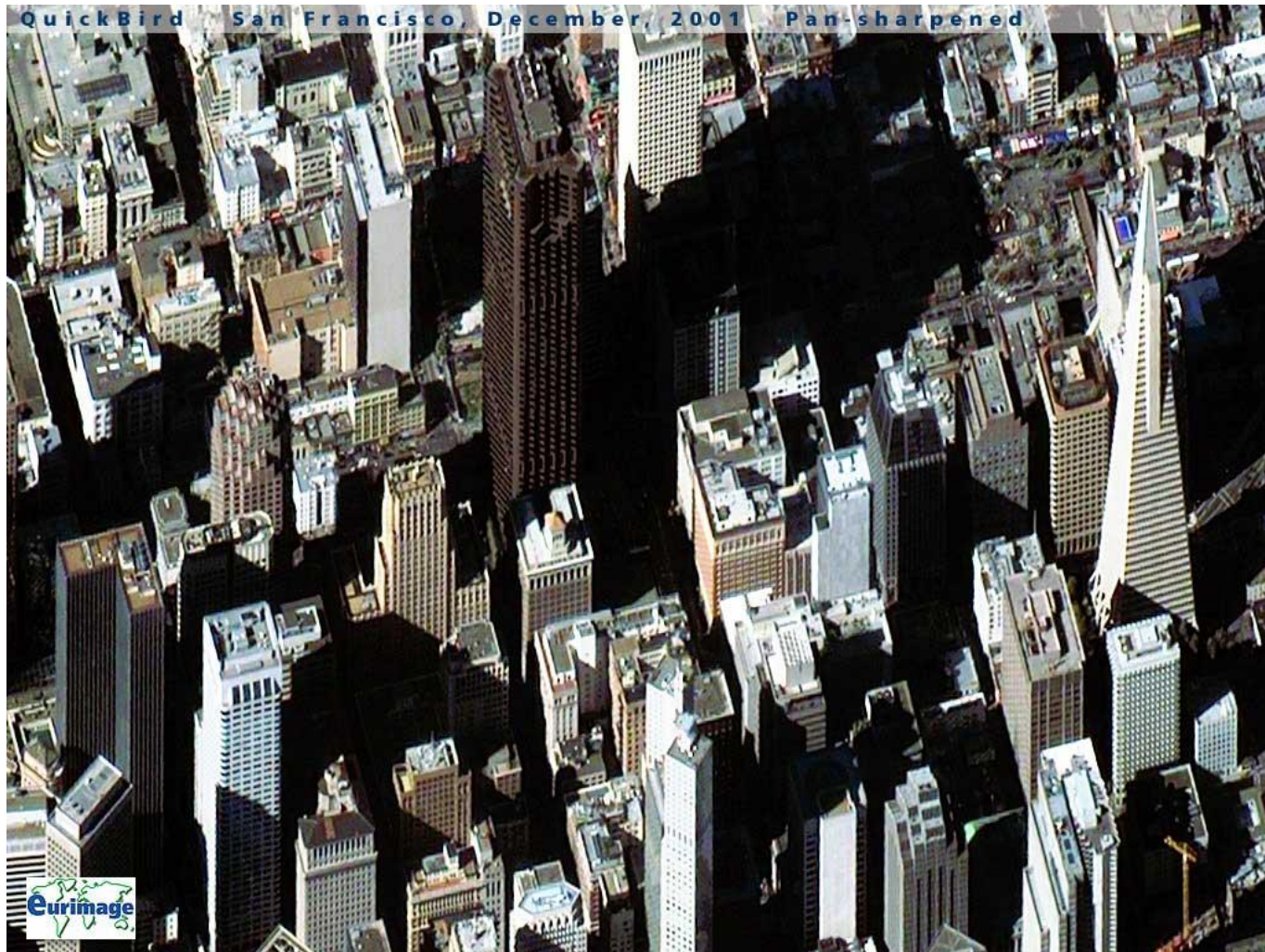
QUICKBIRD





Ciências
ULisboa

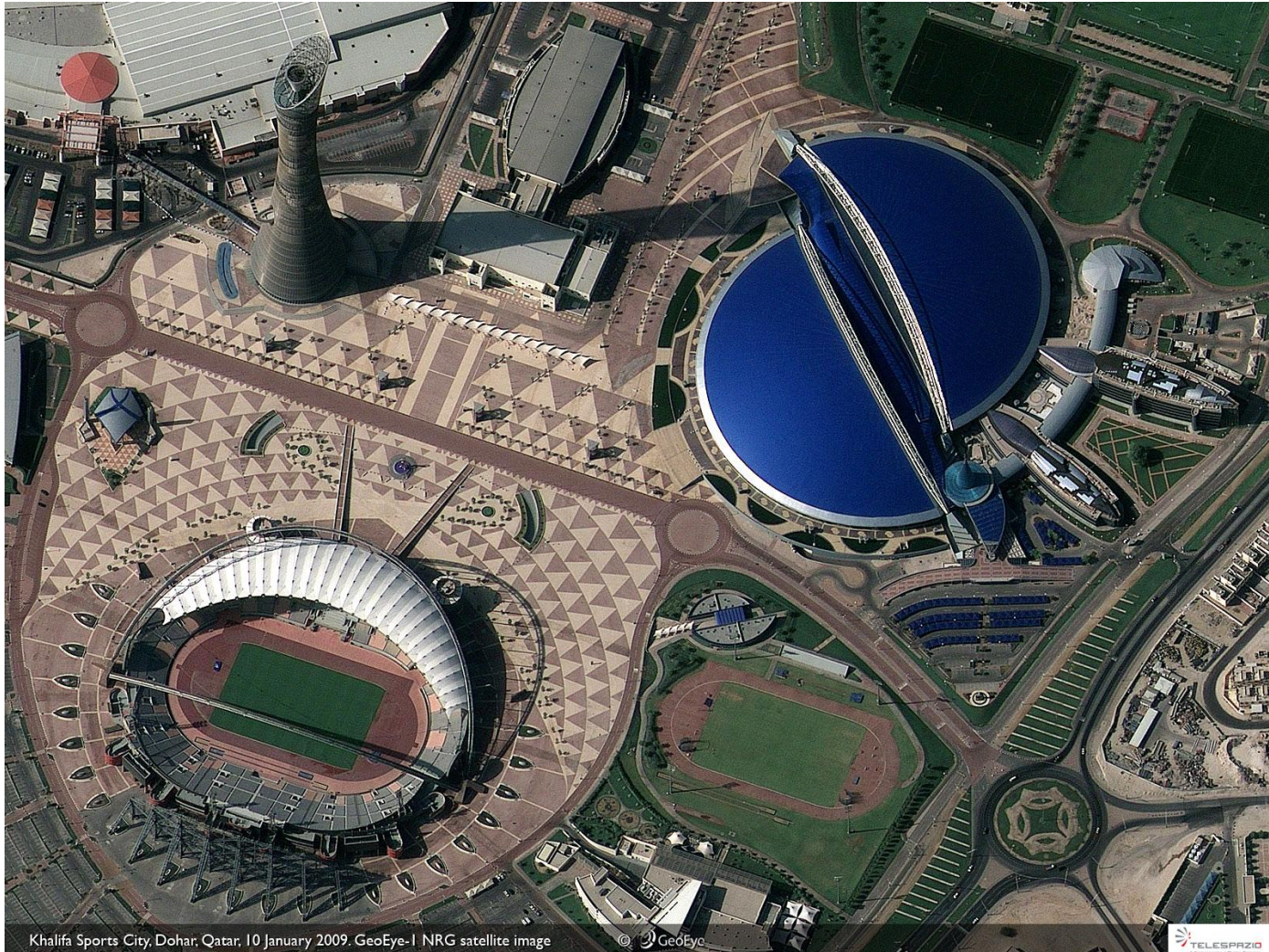
QUICKBIRD





Ciências
ULisboa

GeoEye

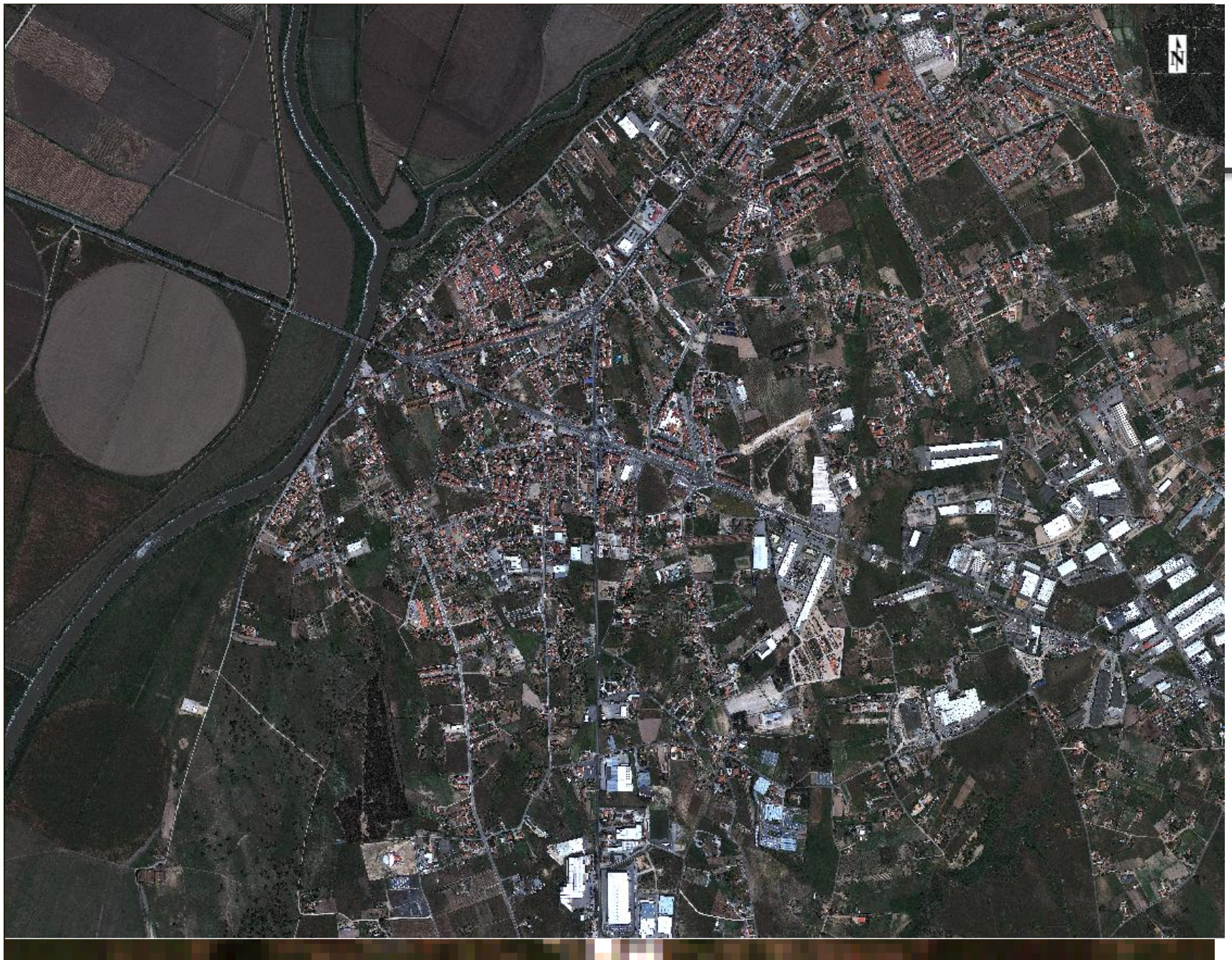


Khalifa Sports City, Dohar, Qatar, 10 January 2009. GeoEye-1 NRG satellite image

© GeoEye





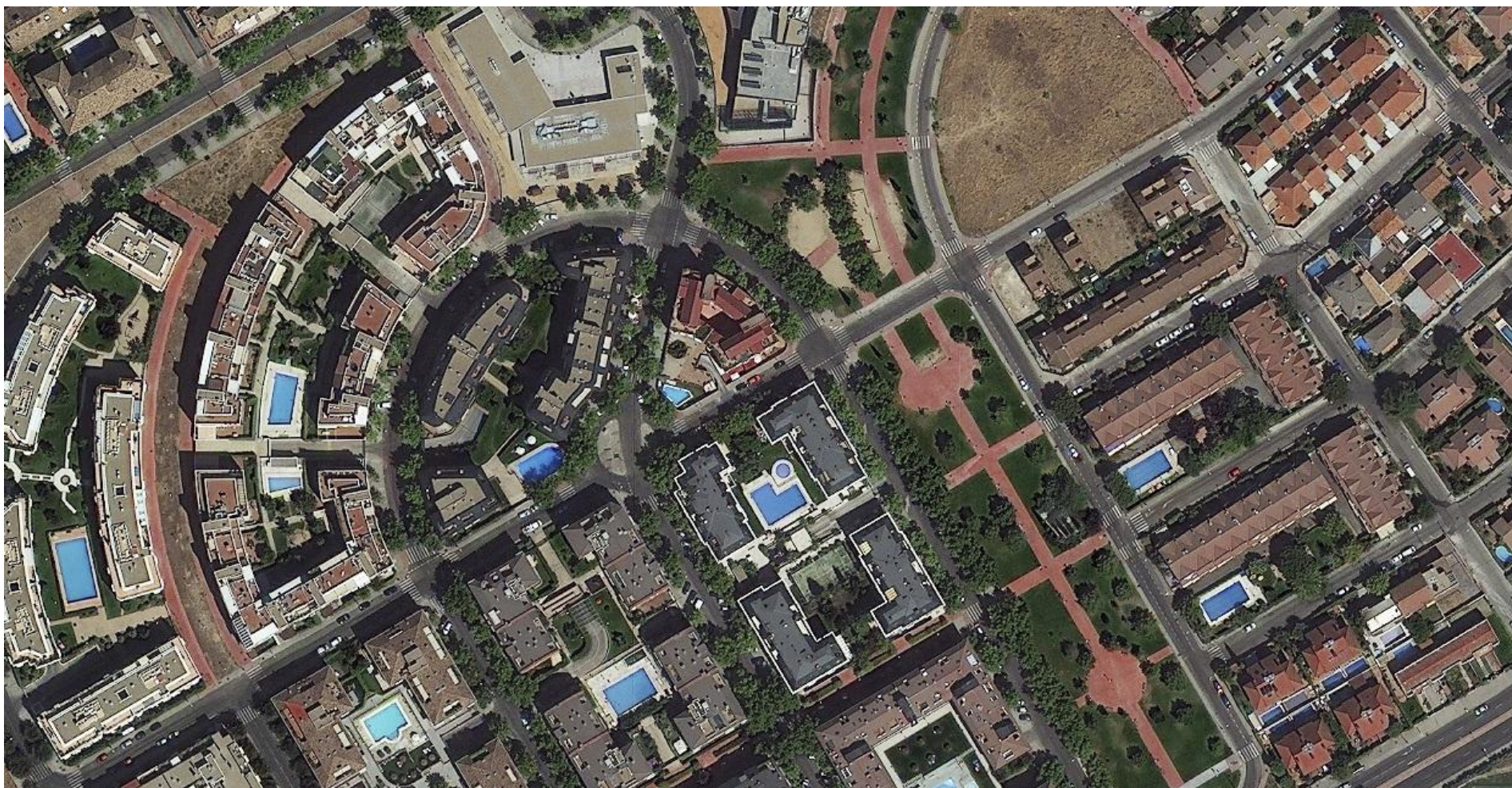




Ciências
ULisboa

Worldview

8 bandas, 0.31 / 1.24 m





Worldview
2m





Disponibilização da OrtoSat2023

Cobertura de imagens de satélite de 30 cm para Portugal Continental

/ 07 06 2024 /



OrtoSat2023 (30 cm)



Ortofoto 2018 (25 cm)

Esta cobertura de imagens, designada OrtoSat2023, foi obtida com imagens de satélite Pléiades Neo adquiridas durante o ano de 2023 sobre o território de Portugal continental. A cobertura é composta por um mosaico equalizado e ininterrupto de imagens ortorretificadas com uma resolução espacial de 30 cm.

Orto Sat vs Ortoimagem





ESA Missions

EO Missions handled by EOP

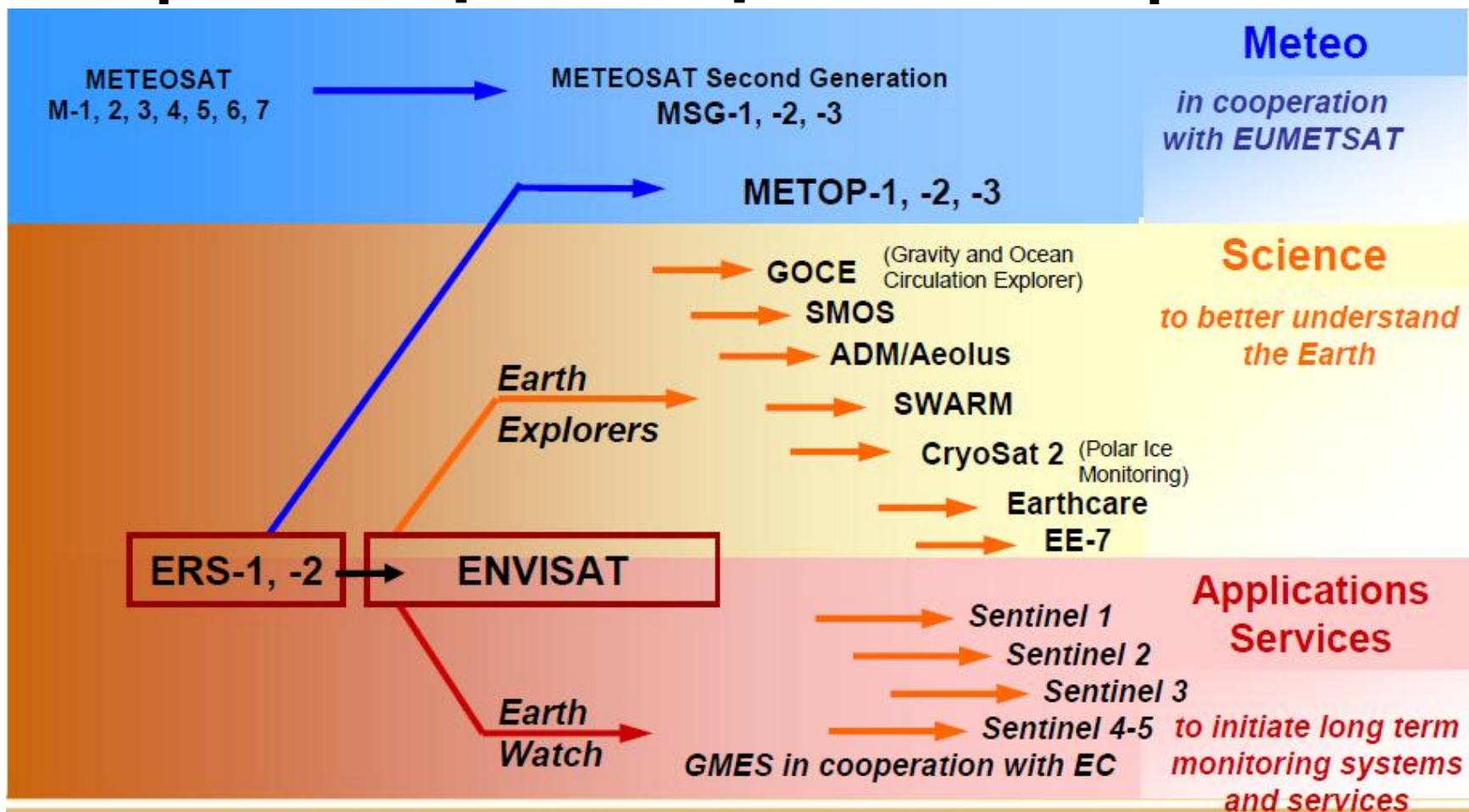
Since
1977

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

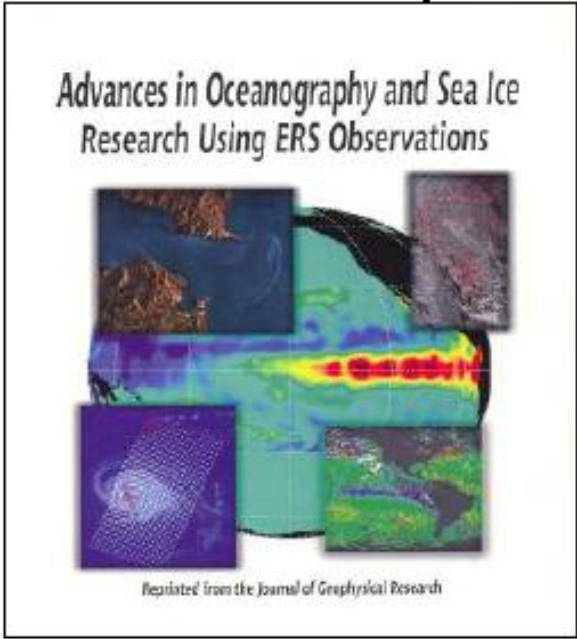
- ❑ **Largest European satellite & largest worldwide EO satellite:**
 - unique combination of 10 instruments addressing land, ocean, ice and atmosphere studies,
 - instruments working nominally, except MIPAS instrument
- ❑ **Satellite OK with long-term operations capabilities:**
 - 65 % of fuel available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



Oceanography and sea Ice

ERS and Volcanic activities



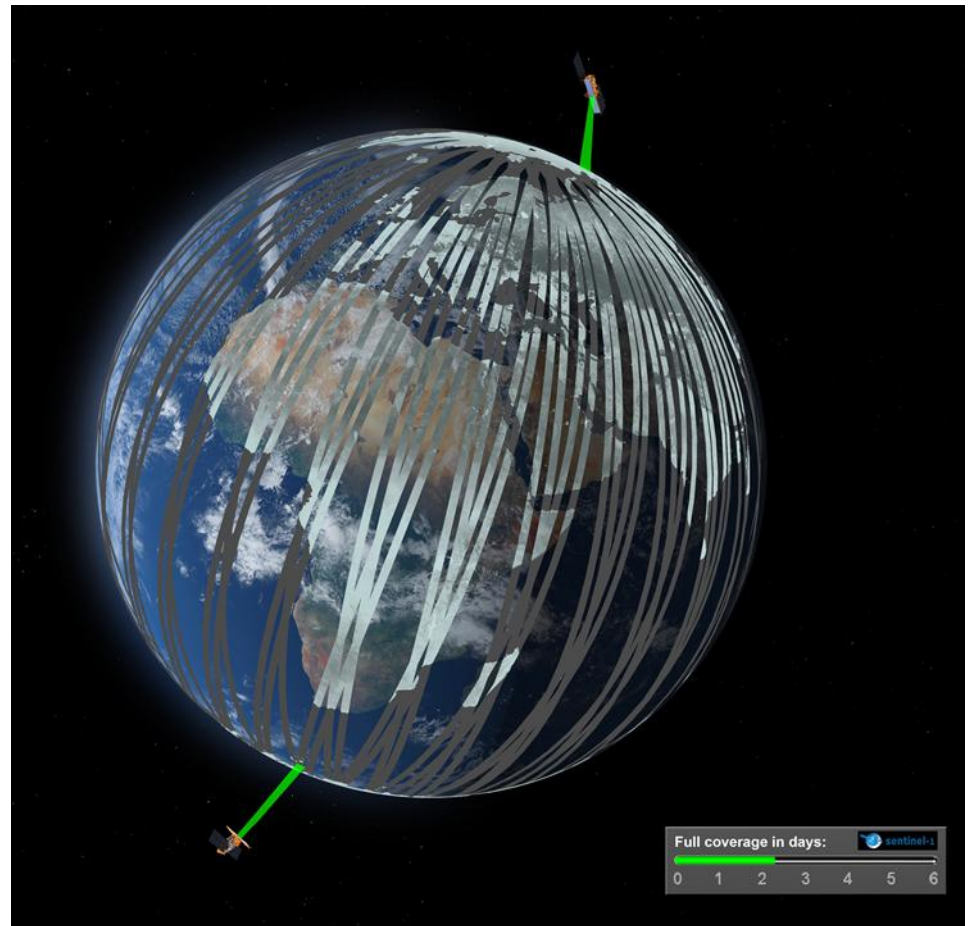
ERS and SAR Interferometry



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.



Global Monitoring for Environment and Security (GMES)

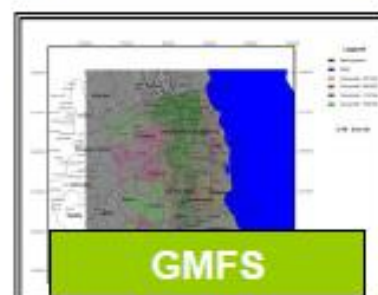
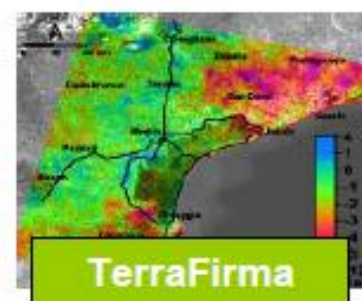
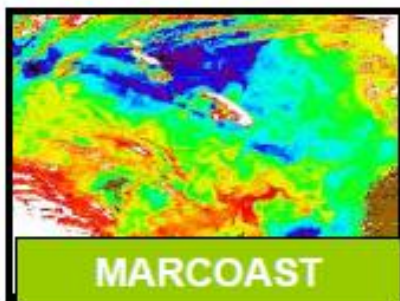


European autonomy in data sources for environment
and security monitoring

and

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

GMES - Services

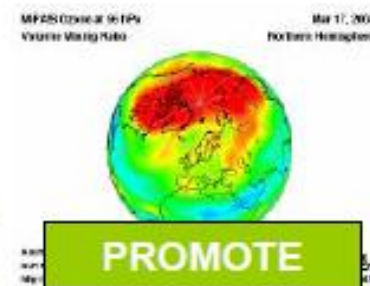


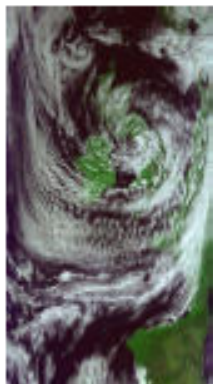
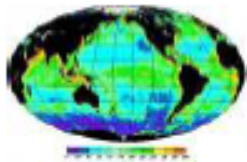
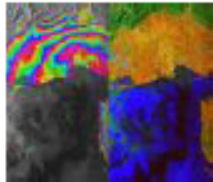
**100 M€ by ESA
MS**

**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-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.

<https://sentiwiki.copernicus.eu/web/s2-mission>

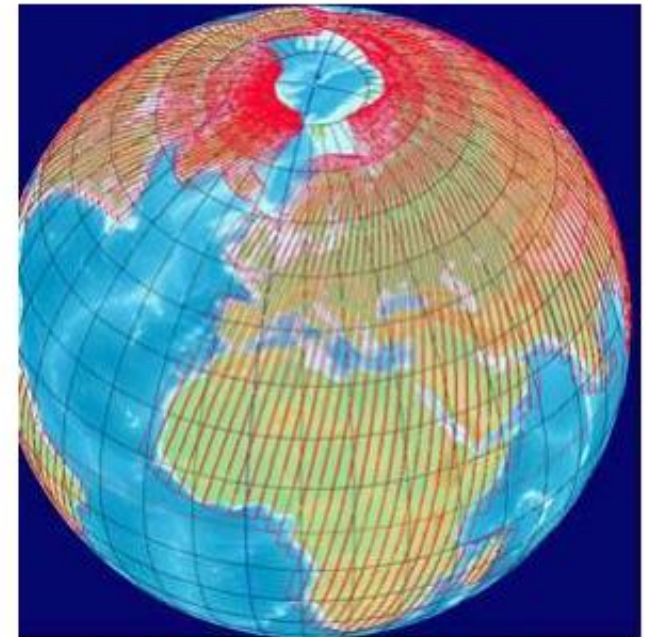
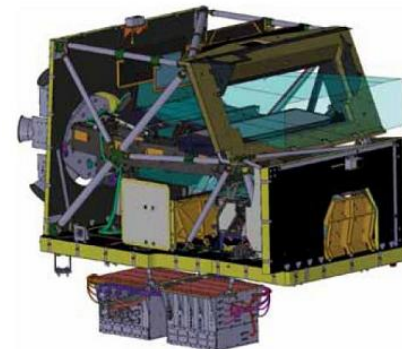
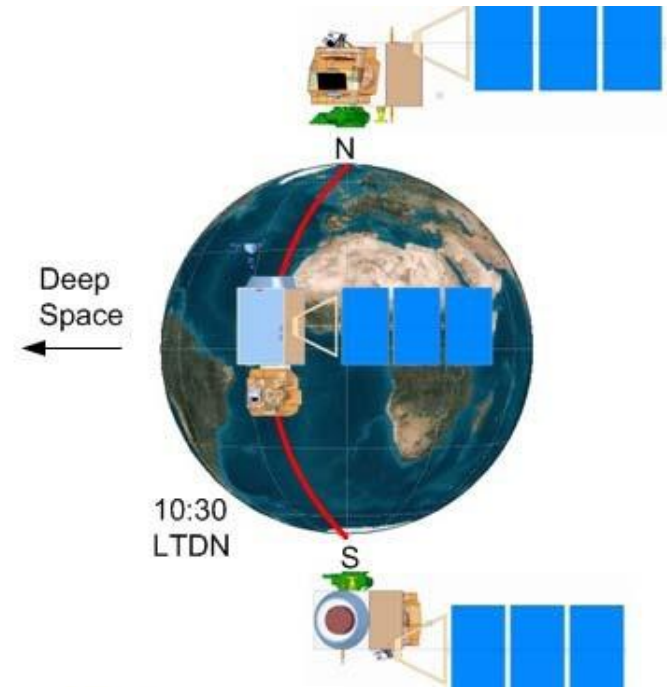


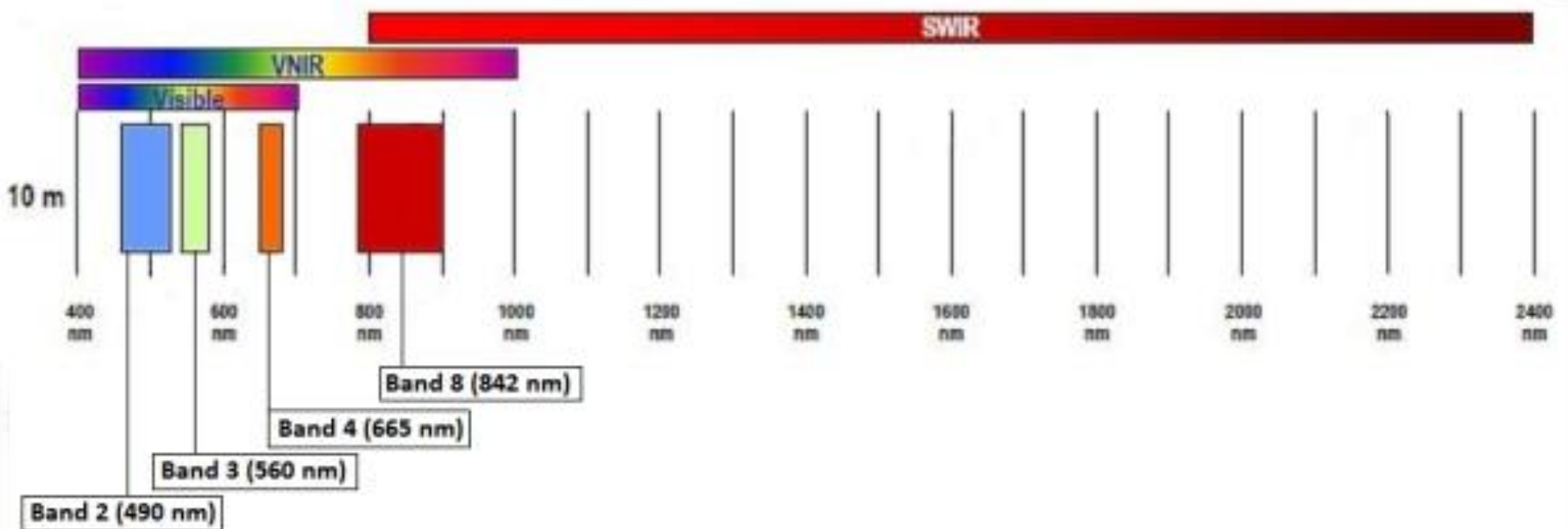
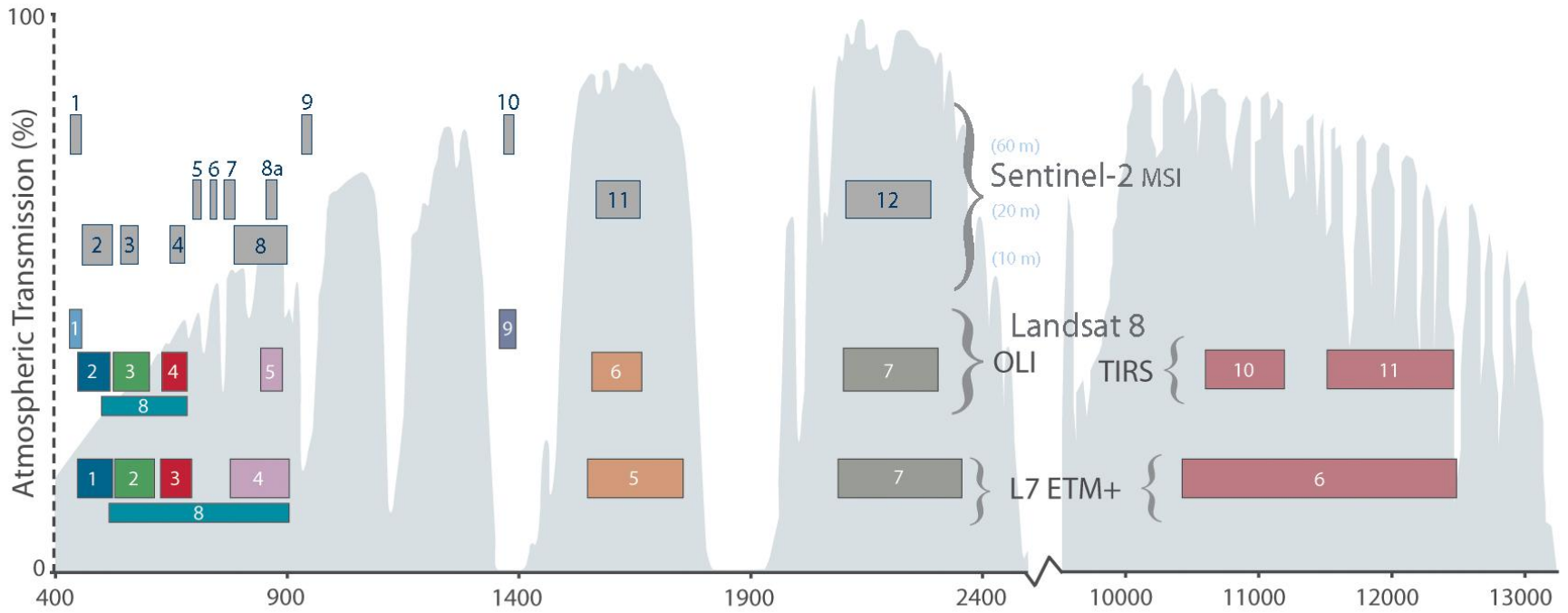
Figure 22: Modelled Sentinel-2 Coverage

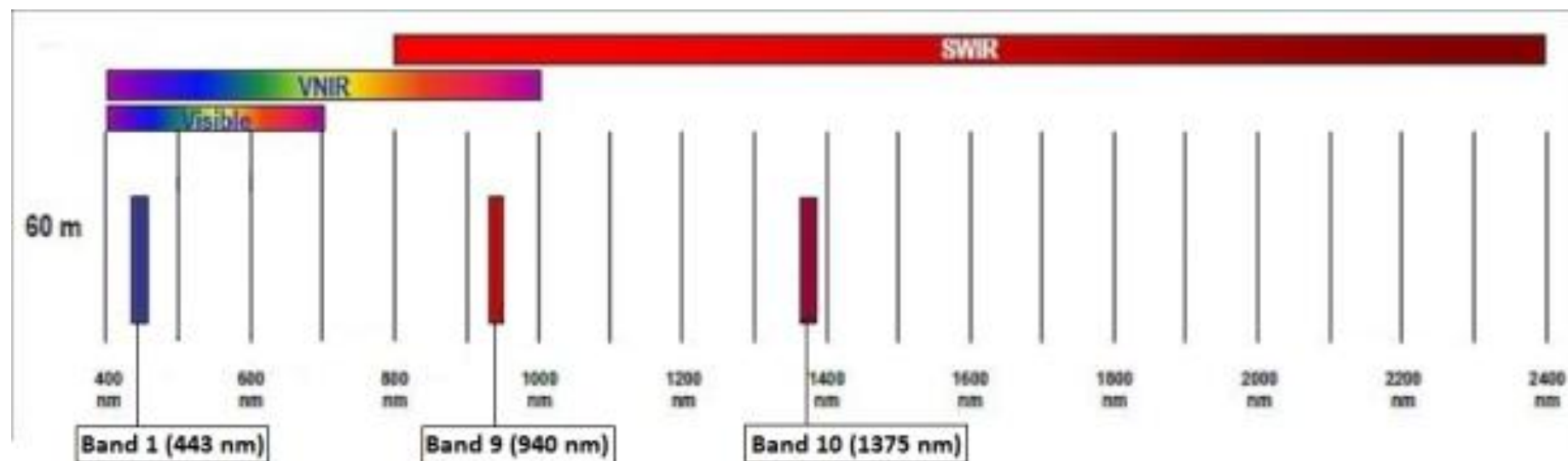
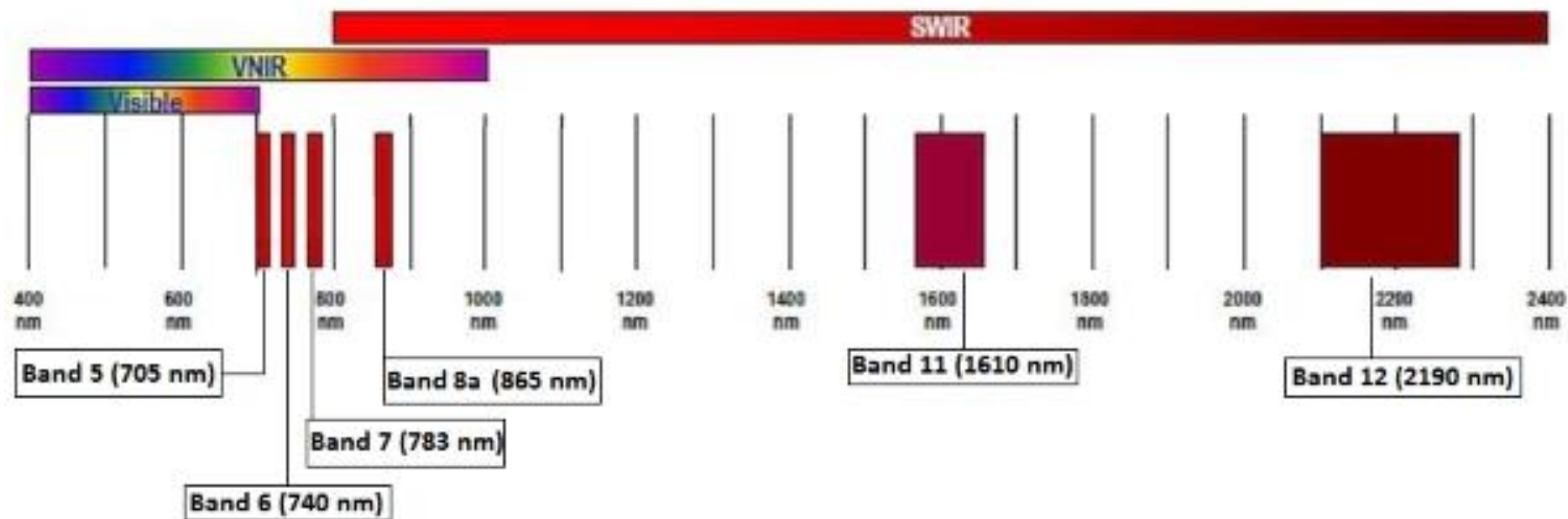
The **Sentinel-2** satellites are placed in the same sun-synchronous orbit, phased at 180° to each other, at an altitude of 786 km and an inclination of 98.5 degrees for 14.3 revolutions per day and a 10:30 Local Time of **Descending Node** that has been chosen to minimize cloud cover and ensure a good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







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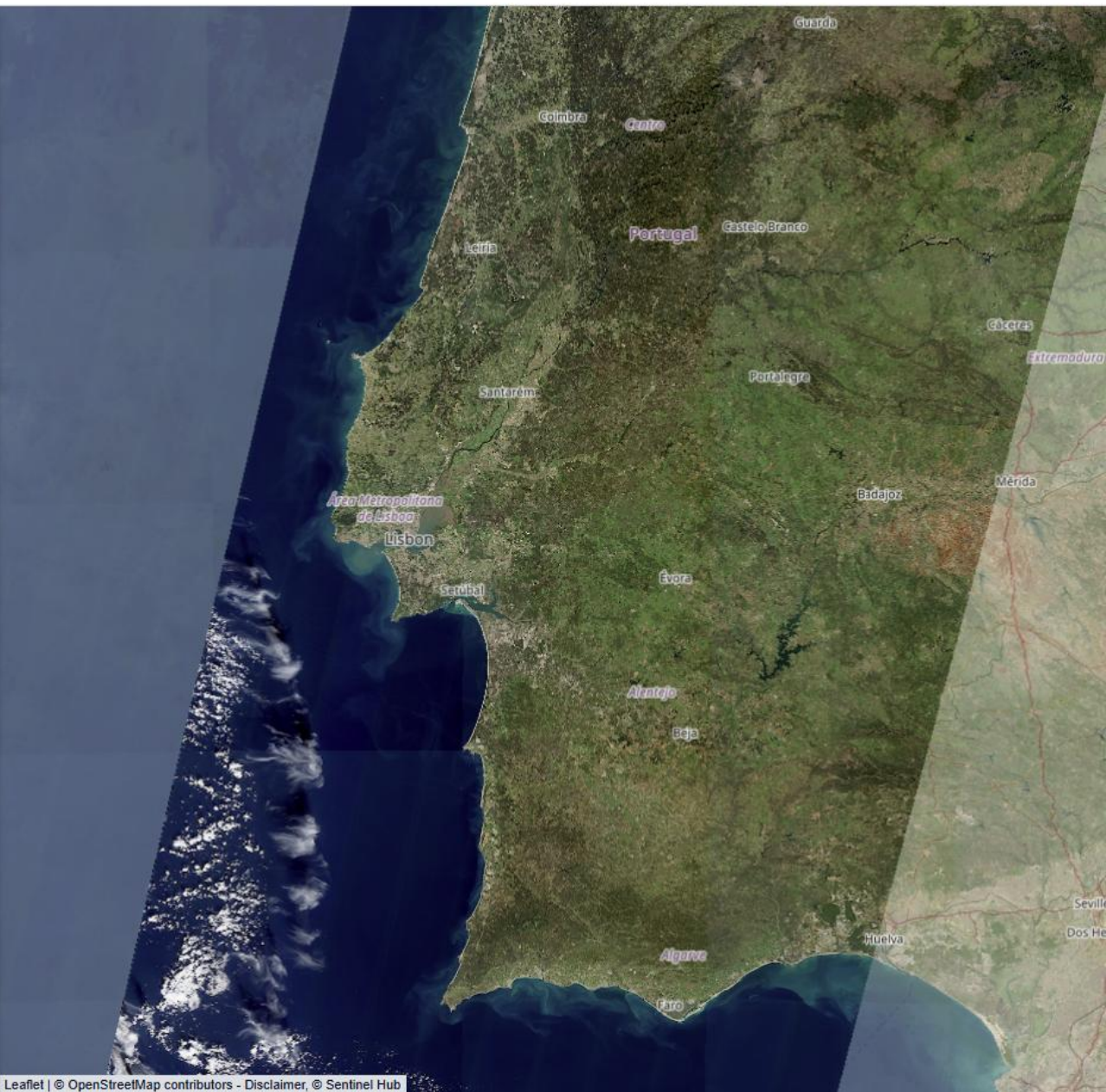
Default

Sentinel-2 L2A

LAYERS:

- True color**
Based on bands B4, B3, B2
- False color**
Based on bands B8, B4, B3
- Highlight Optimized Natural Color**
Enhanced natural color visualisation
- NDVI**
Based on a combination of bands $(B8 - B4)/(B8 + B4)$
- False color (urban)**
Based on bands B12, B11, B4
- Moisture index**
Based on a combination of bands $(B8A - B11)/(B8A + B11)$
- SWIR**
Based on bands B12, B8A, B4
- NDWI**
Based on a combination of bands $(B3 - B8)/(B3 + B8)$

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Default Sentinel-2 L2A

LAYERS:

- True color Based on bands B4, B3, B2
- False color Based on bands B8, B4, B3
- Highlight Optimized Natural Color Enhanced natural color visualisation
- NDVI Based on a combination of bands (B8 - B4)/(B8 + B4)
- False color (urban) Based on bands B12, B11, B4
- Moisture index Based on a combination of bands (B8A - B... + Add to </>
- SWIR Based on bands B12, B8A, B4
- NDWI Based on a combination of bands (B3 - B8)/(B3 + B8)

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