Deteção Remota Multiespetral

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- Missões SAR
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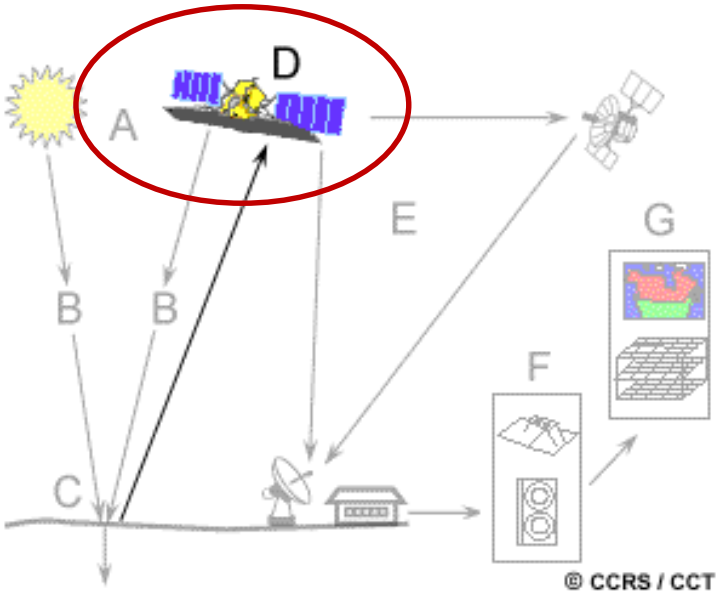
  - LANSAT, SPOT, IRS, IKONOS, QuickBird, GeoEye-1

Missões de Observação da Terra



Meteorológicas

Geopotenciais

Altimetria de Satélite

Observação da Terra

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Stitching together multiple images from #Sentinel2, Austrian company @eox_a gives us an unobstructed view of Europ... t.co/IooiHVET8f
06 Mar 2017 12:54:09

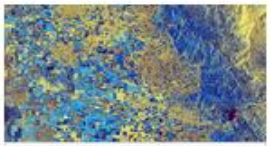
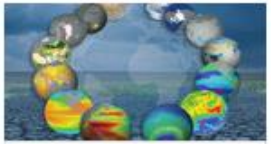


Image of the week archive


Earth from Space on ESA Web-TV



Satélites / Sensores Meteorológicos

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

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

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

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

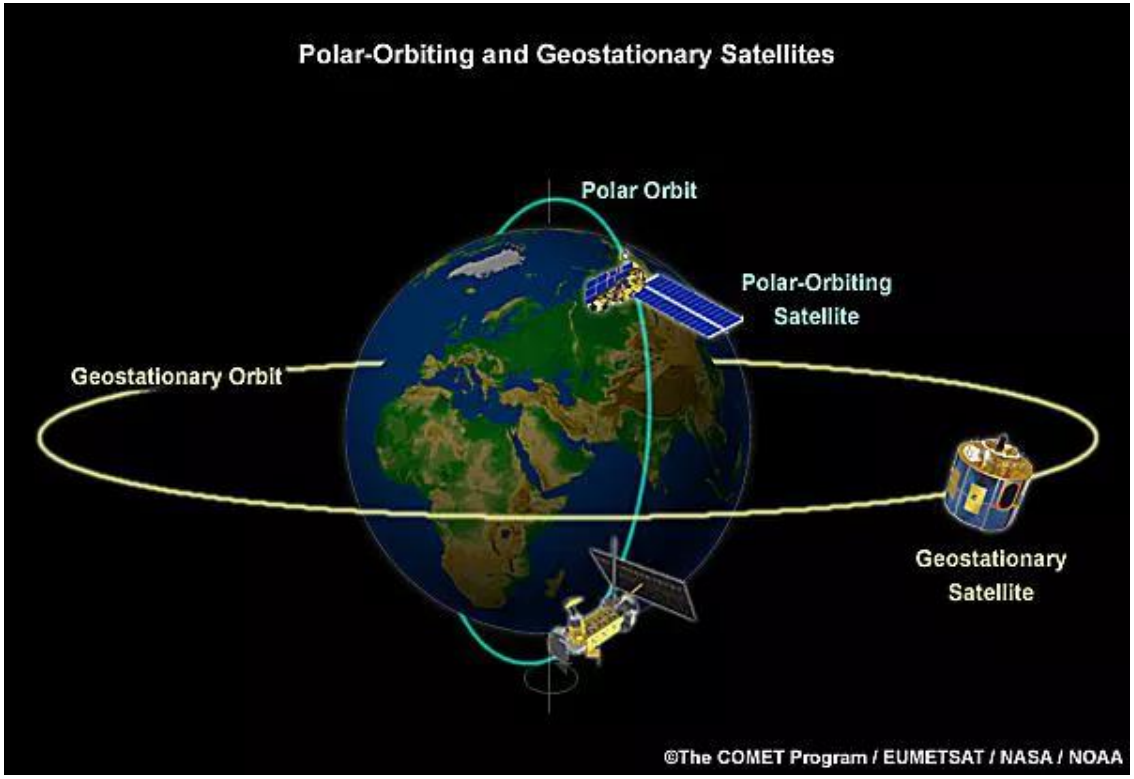
Weather Satellites

Some current operational weather satellites

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

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)

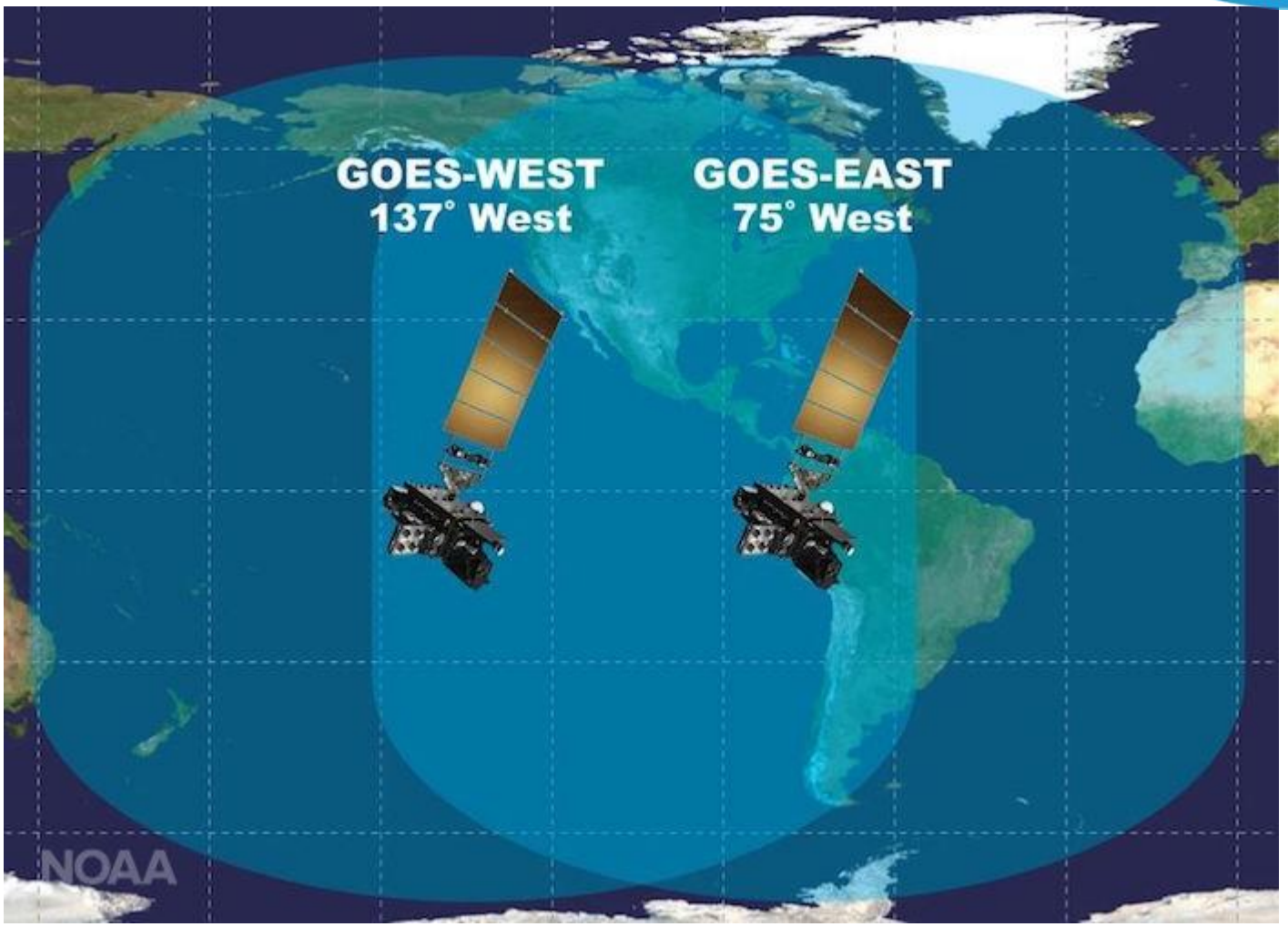
Imagem de um furacão EUA, Setembro de 1996

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 70º em longitude que fornecem uma cobertura permanente da Terra.

Weather Satellites



GOES

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

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

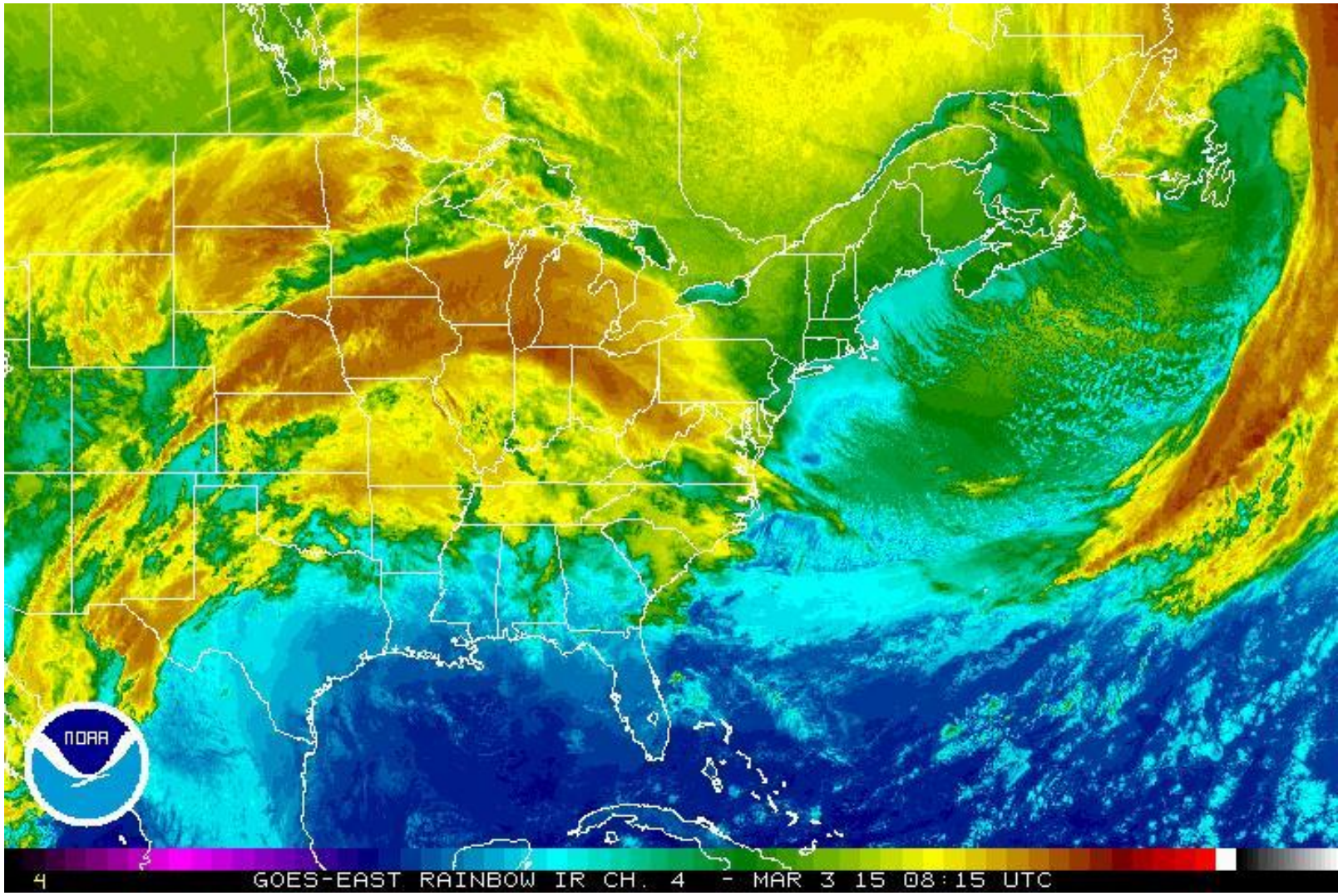
Foram lançadas duas gerações dos satélites GOES ambas medindo a radiação emitida e reflectida a partir da qual se pode determinar:

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

GOES - 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

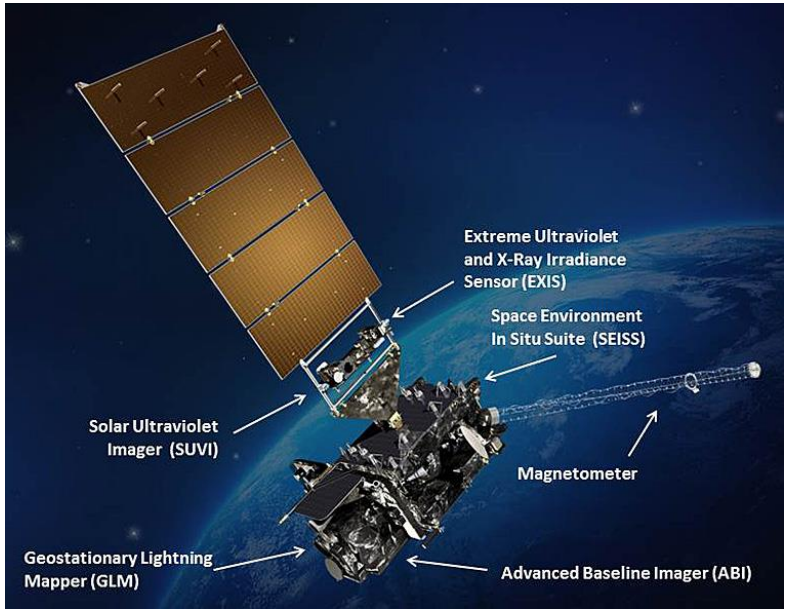
GOES



Weather Satellites

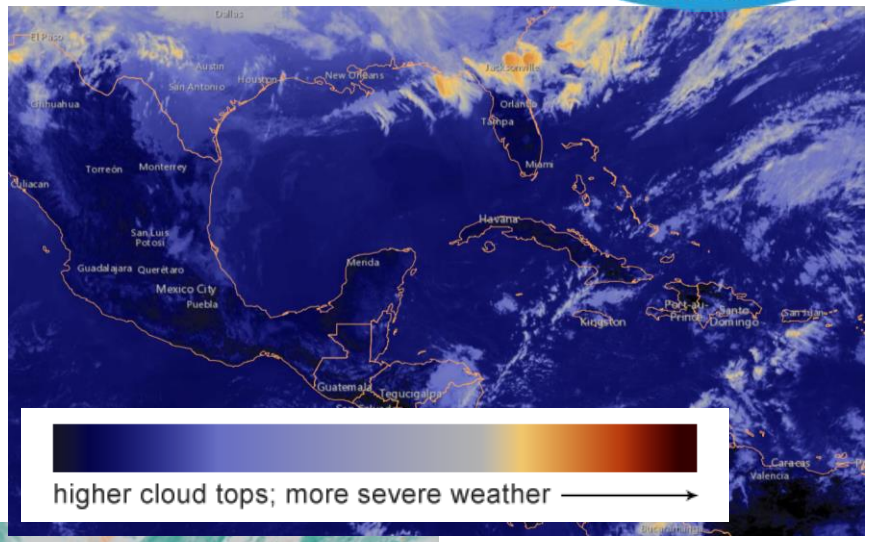
The **Advanced Baseline Imager (ABI)** is the primary instrument on the GOES–R Series spacecraft for imaging Earth's weather, oceans and environment.

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, and five times faster coverage than previous GOES.

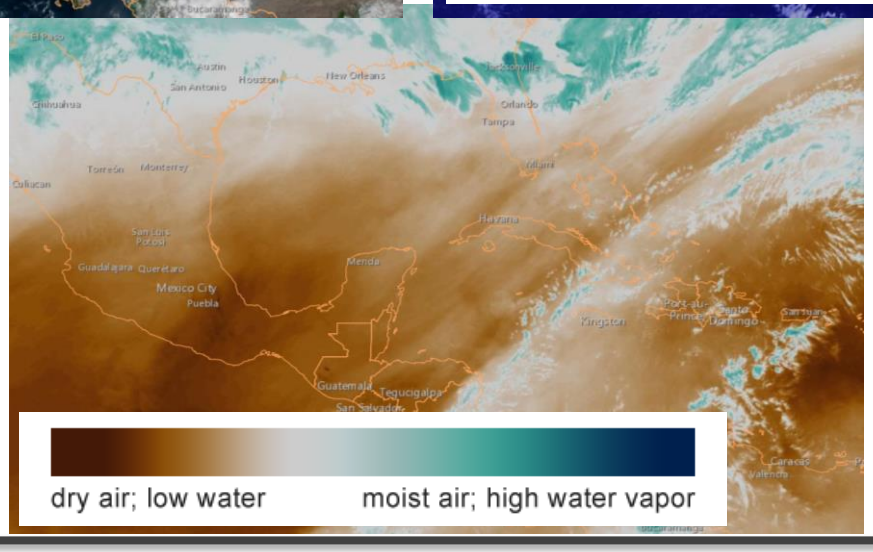


Weather Satellites

Geocolor Map



Infrared Map



Water vapor Map

NOAA AVHRR

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)

NOAA AVHRR

BANDAS

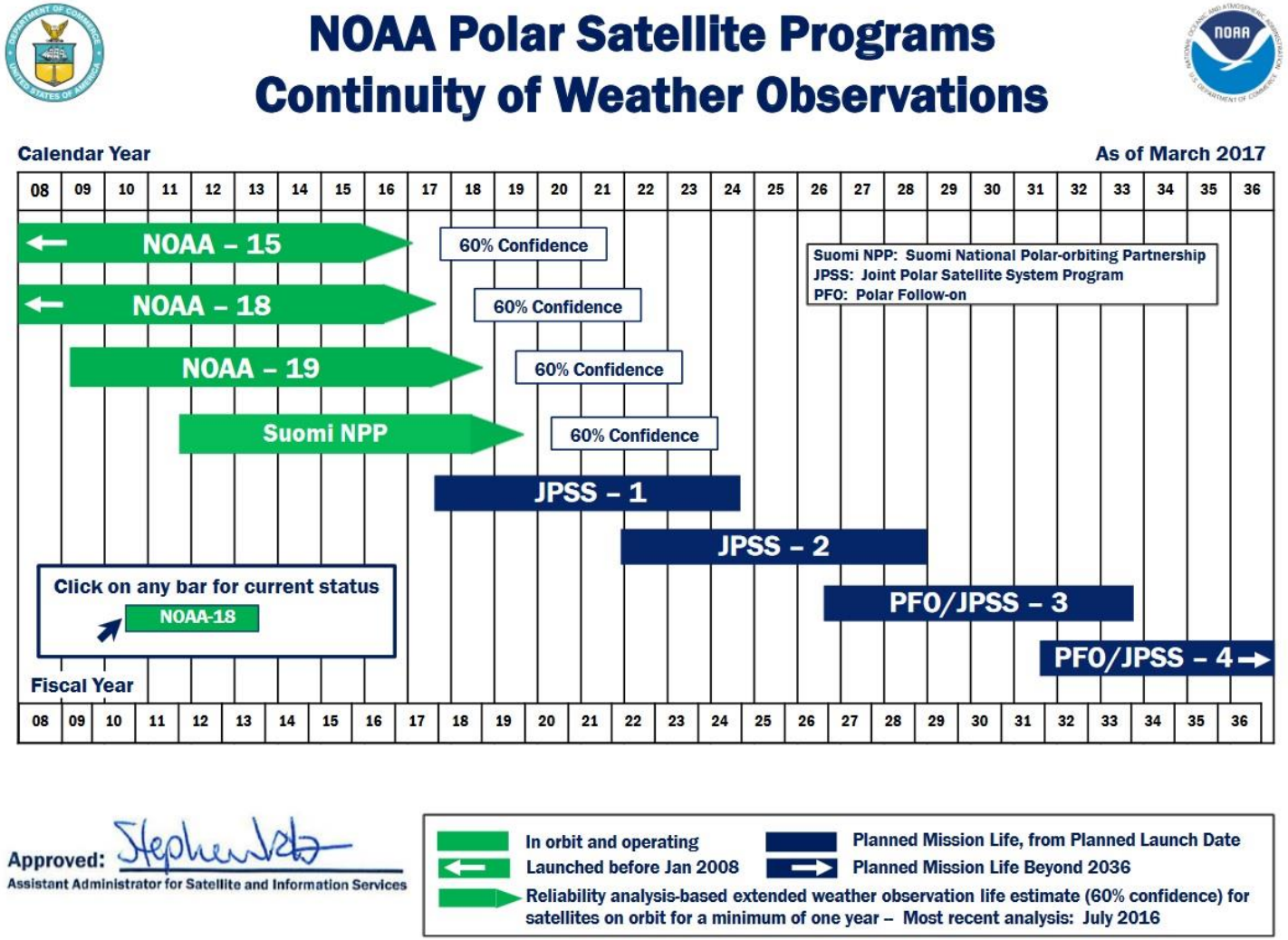
Table 3.1.2.1-1. Summary of AVHRR/3

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

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

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

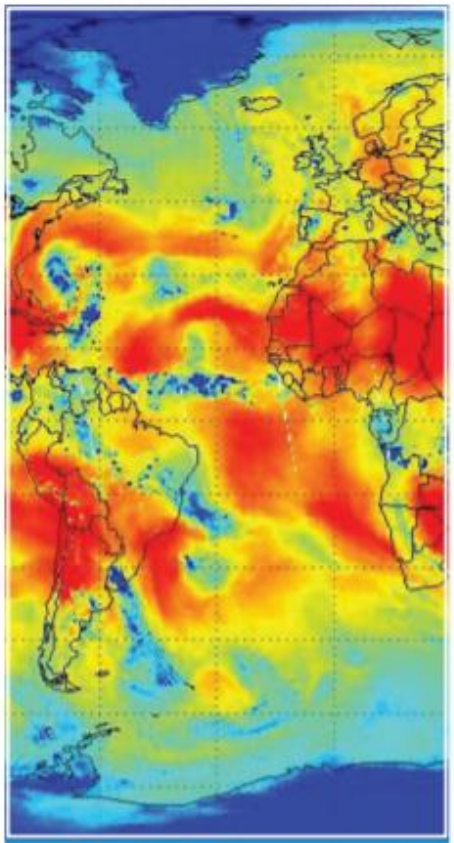
Weather Satellites



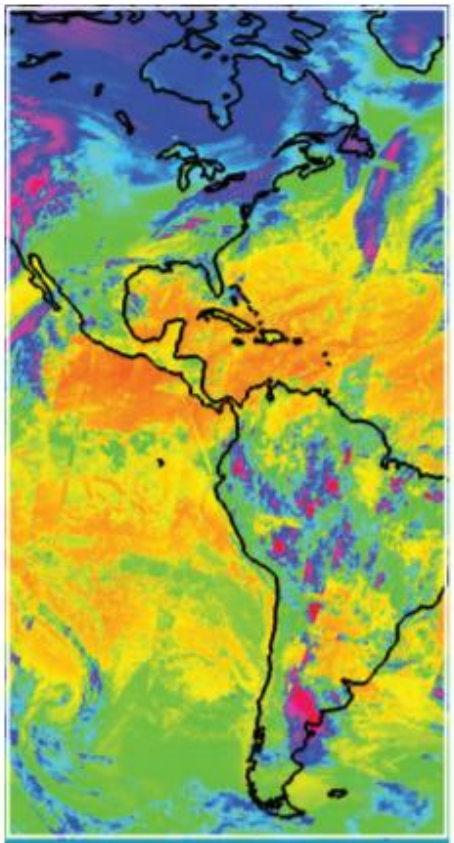
Weather Satellites

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 diameter 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

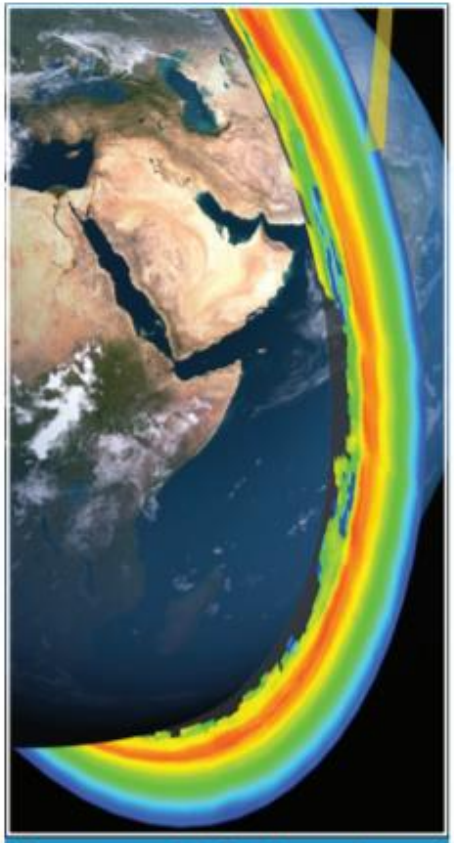


ATMS channel 18-microwave antenna temperature at 183.3 GHz. 11/08/2011



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

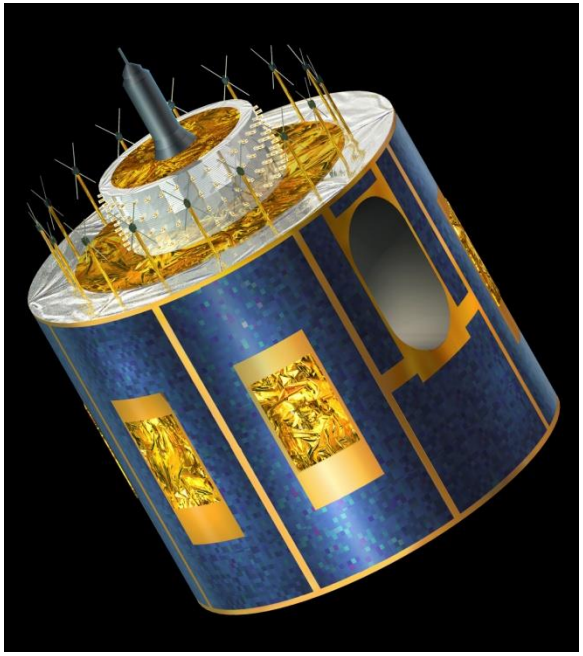
Tropical Cyclone Chapala as seen by Suomi NPP's VIIRS instrument on 11/1/2015 Credit: NOAA/NASA



Cross-section of the Earth's ozone layer as measured by the OMPS - 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 estará operacional até 2020.



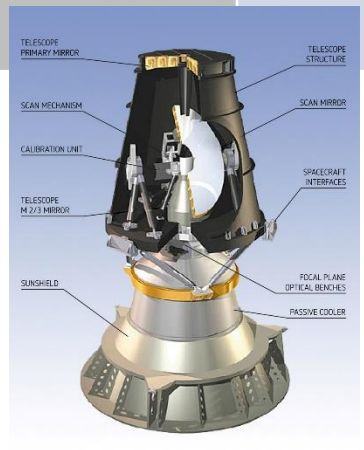
Estes satélites têm dois instrumentos:

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

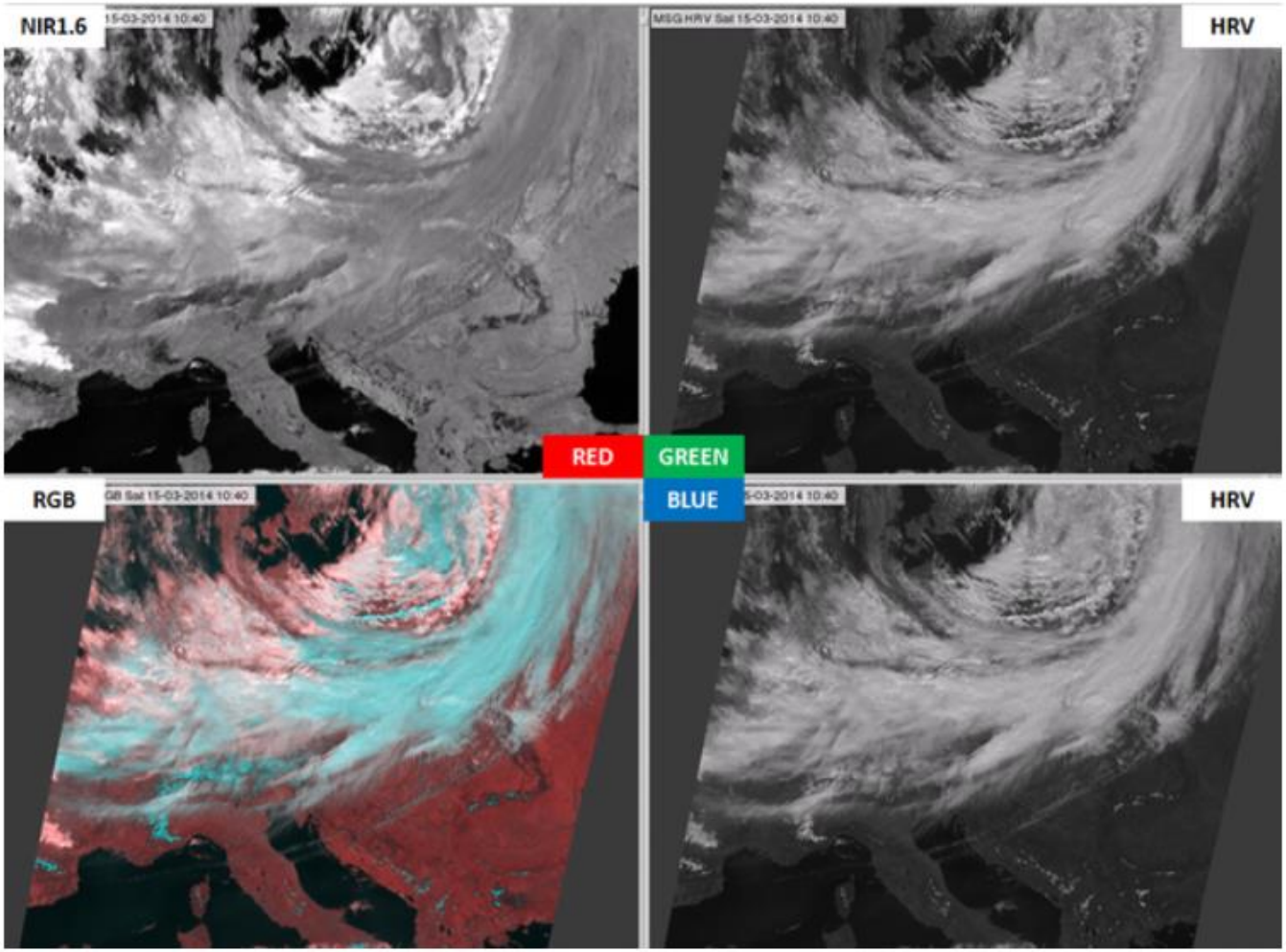
GERB (Geostationary Earth Radiation Budget) que suporta estudos climáticos

Weather Satellites

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



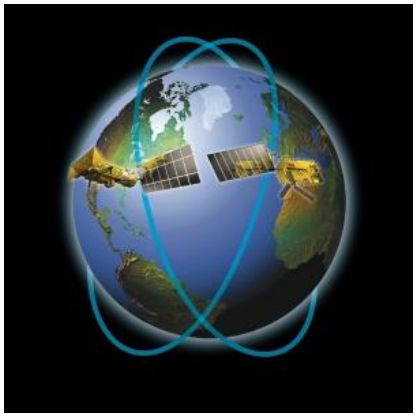
NIR1.6 (upper left), HRV (upper and bottom right) and HRV Fog RGB image (bottom left) for 15 March 2014

MetOp

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

MetOp

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 (3.8-15μm), one visible channel.

MetOp

Instrument	
GOME-2 Global Ozone Monitoring Experiment-2	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
AVHRR Advanced Very High Resolution Radiometer/3	Visible/infrared imaging radiometer for global measurement of cloud cover, sea surface temperature, ice, snow and vegetation cover and characteristics, six channels.
ASCAT Advanced Scatterometer	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.
GRAS Global Navigation Satellite System Receiver for Atmospheric Sounding	Radio occultation receiver for atmosphere sounding of temperature and humidity profiles.

MetOp

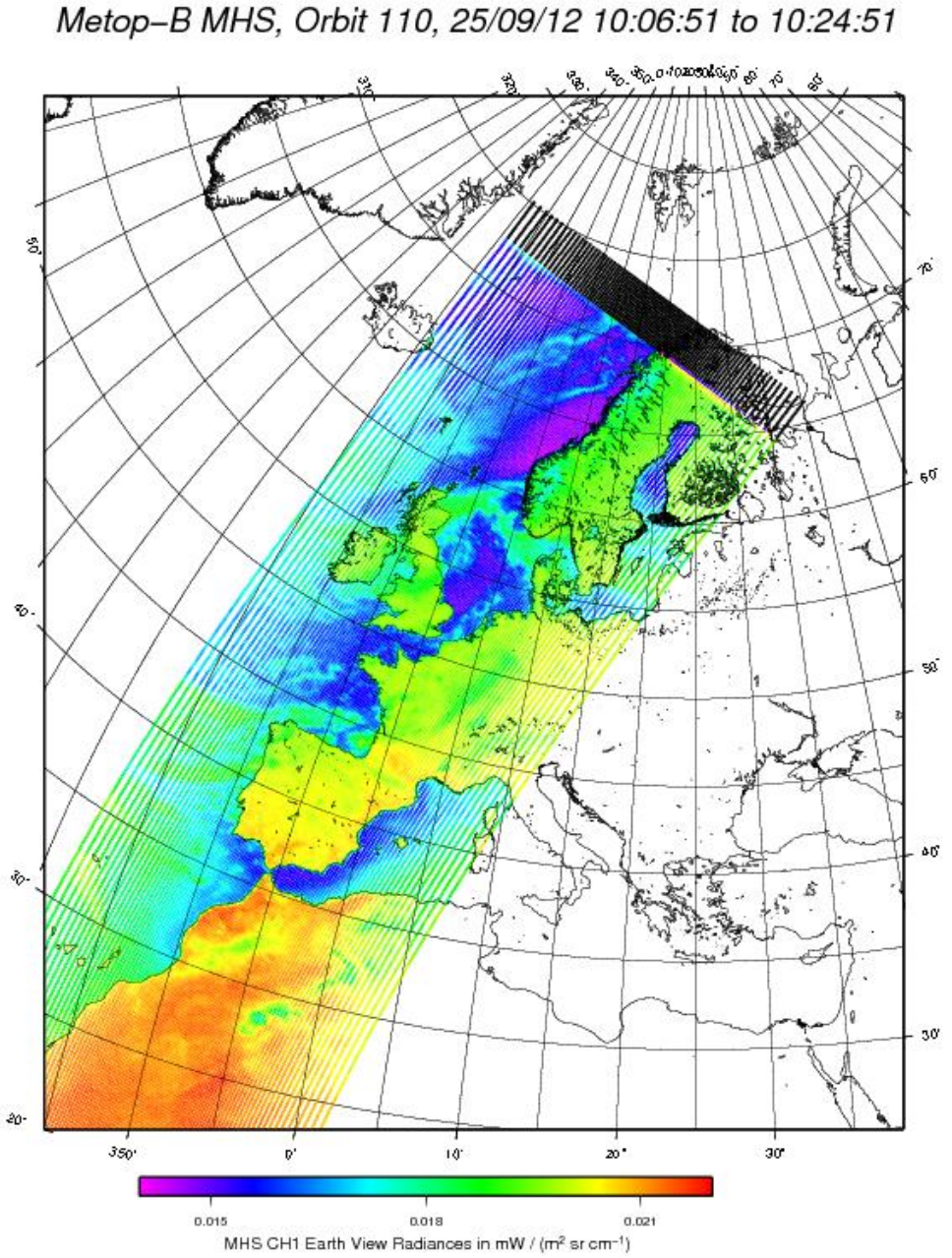
28 September 2012

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

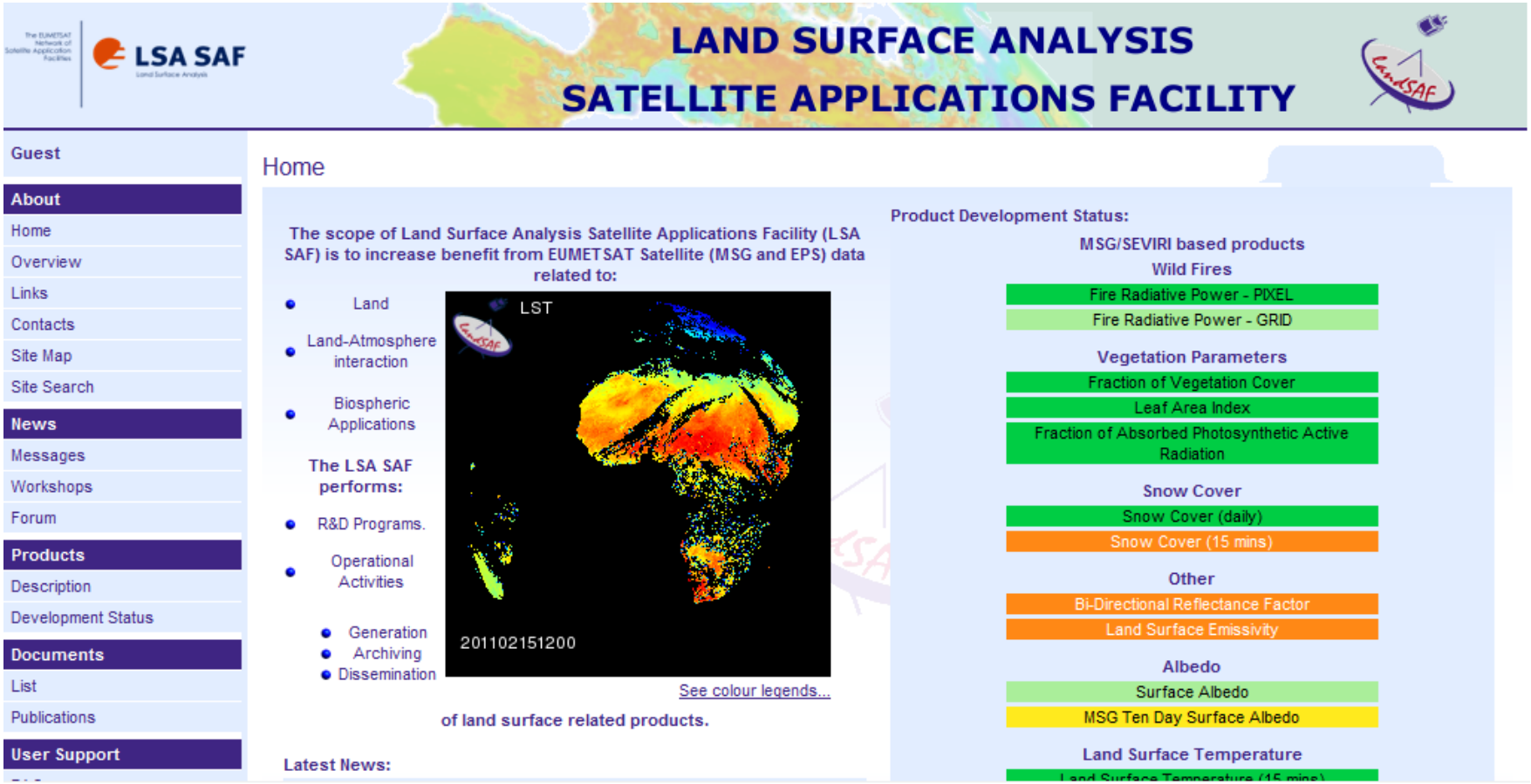
The Microwave Humidity Sounder (MHS) delivers information on atmospheric humidity in all weather conditions.

Funciona em tandem com o Metop-A

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

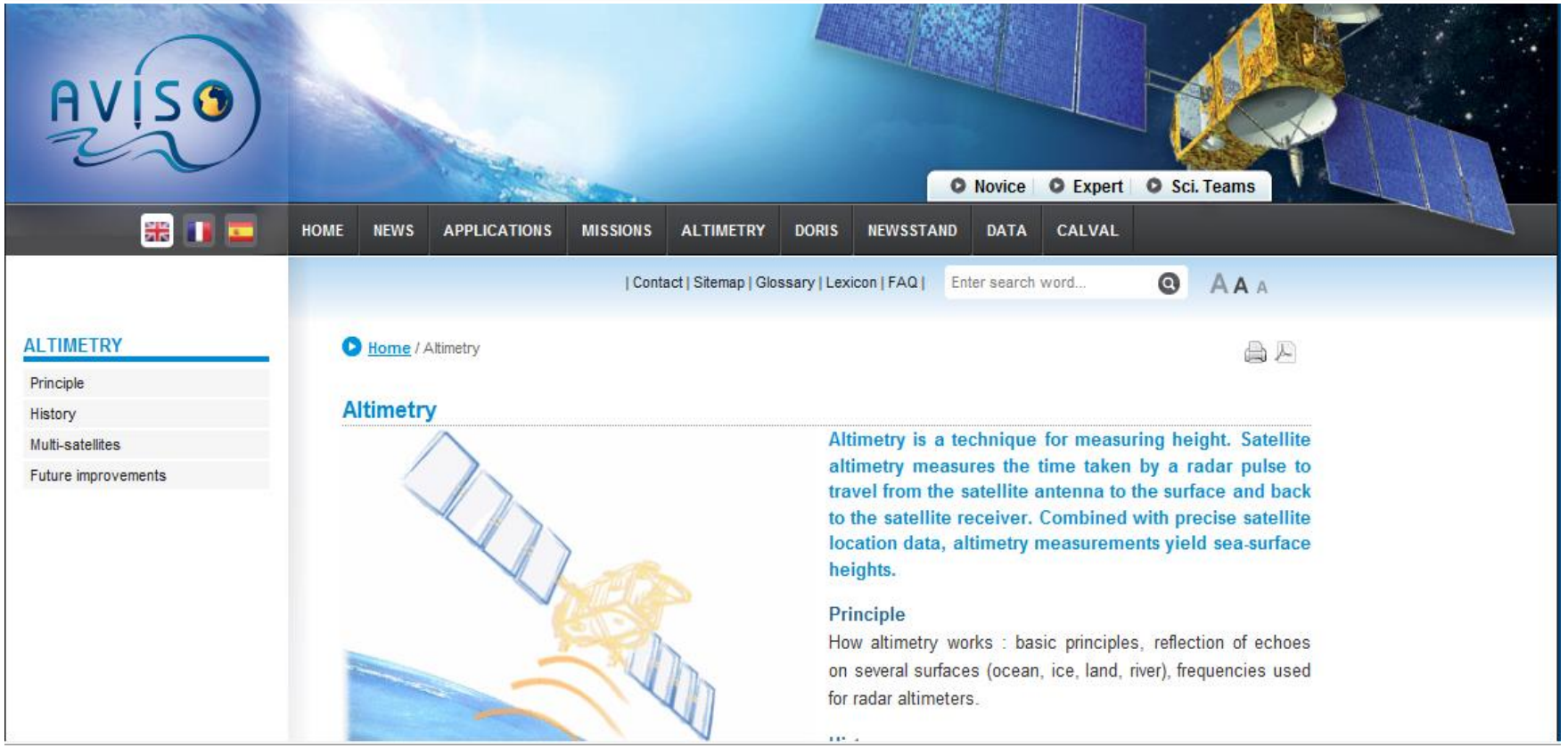


LANDSAF (http.//landsaf.meteo.pt)



Altimetria Espacial

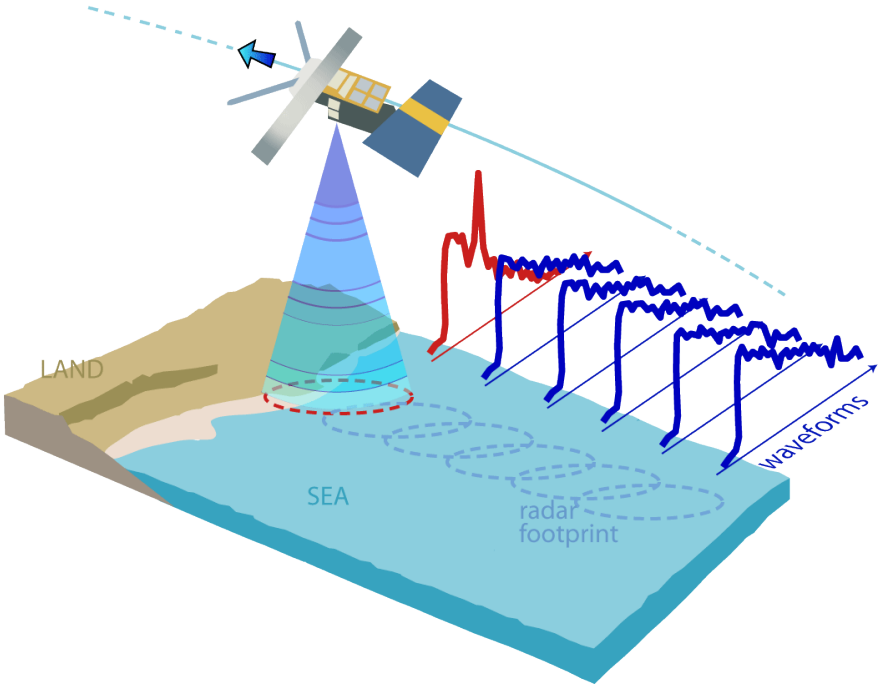
Altimetria Espacial é a técnica de medir altitudes. É medido o tempo que leva um pulso radar a viajar do satélite à superfície e regressar ao satélite.



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**.

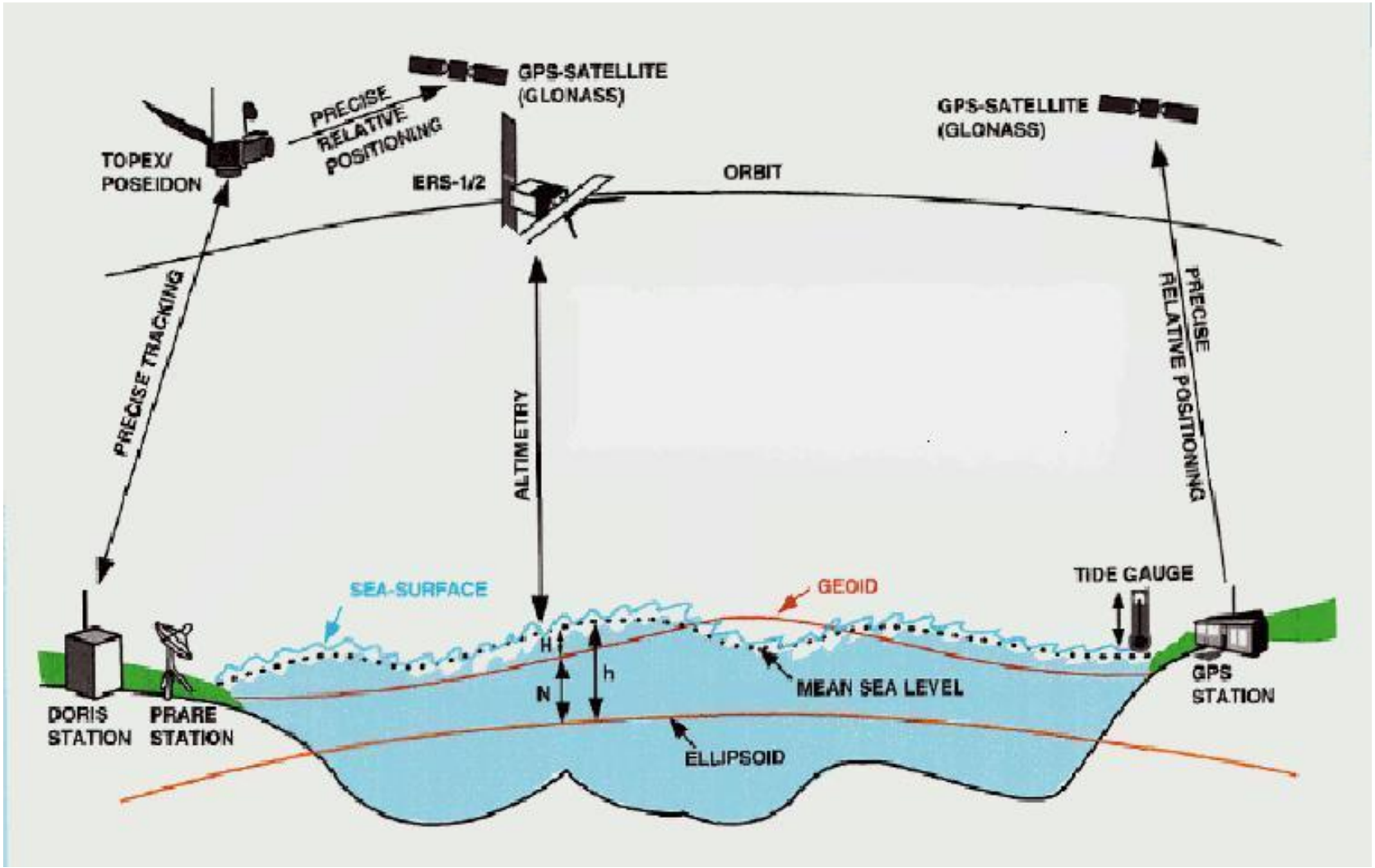
The magnitude and shape of the echoes (or waveforms) also contain information about the characteristics of the surface which caused the reflection. The best results are obtained over the **ocean**, which is spatially homogeneous.



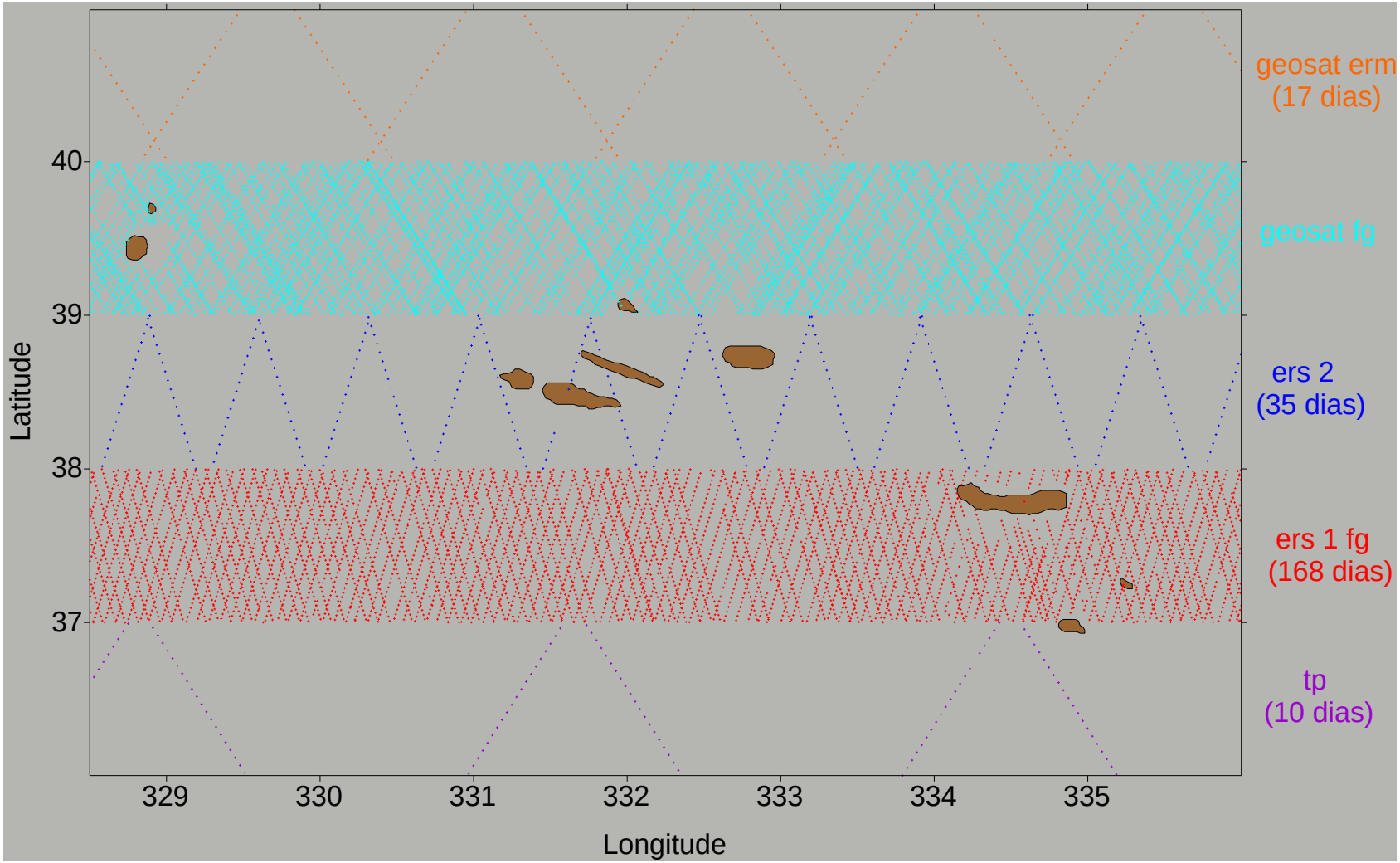
Altimetria Espacial

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

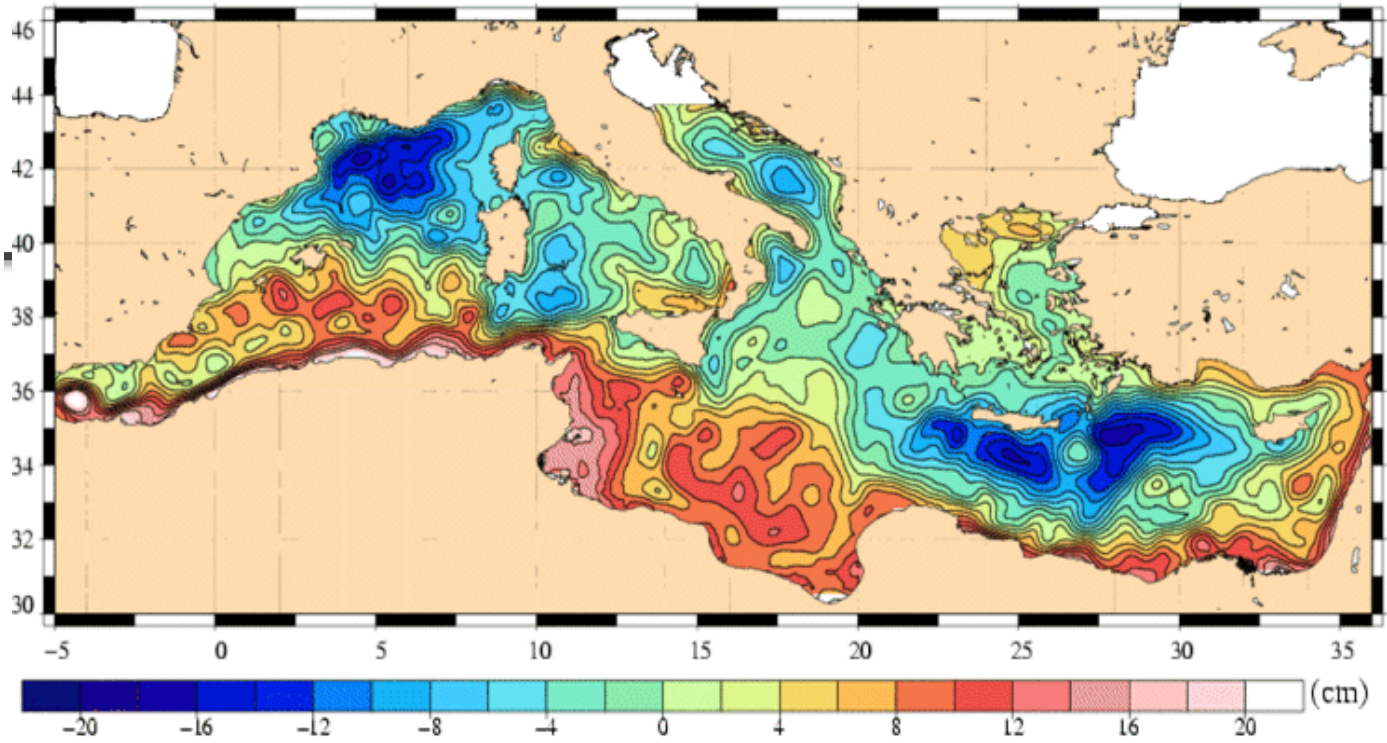
Altimetria Espacial

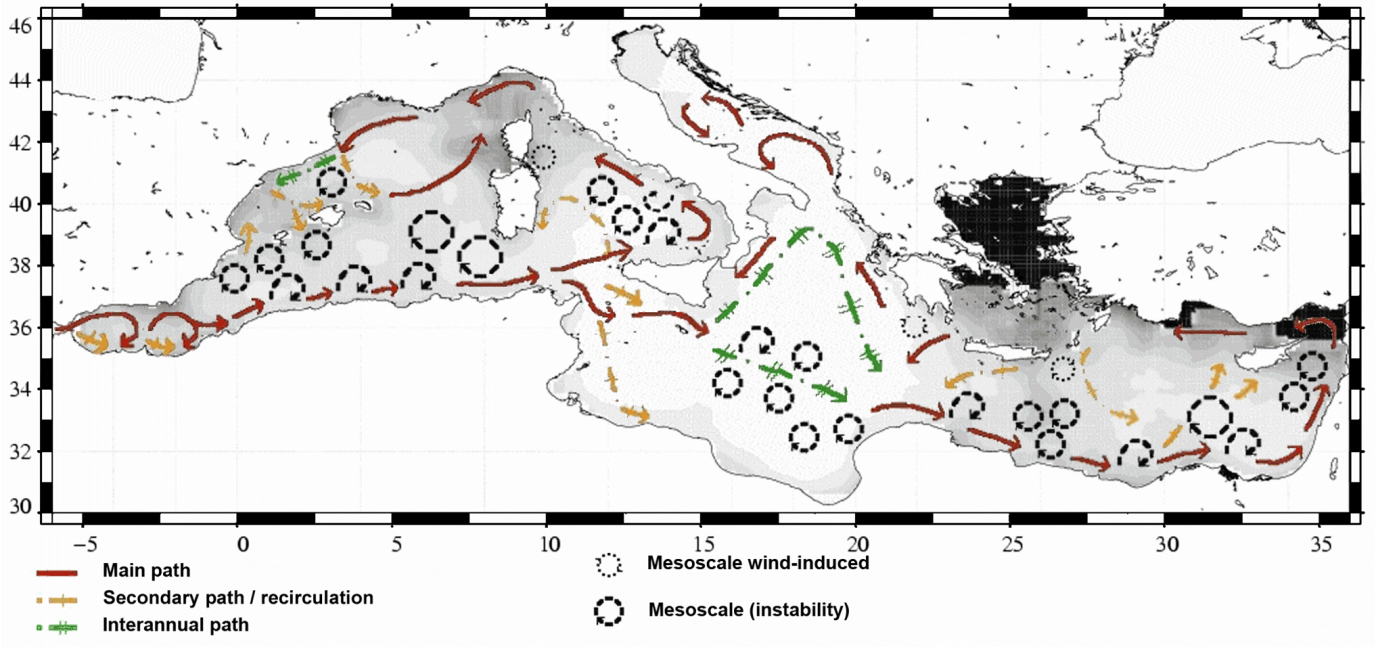


Altimetria Espacial



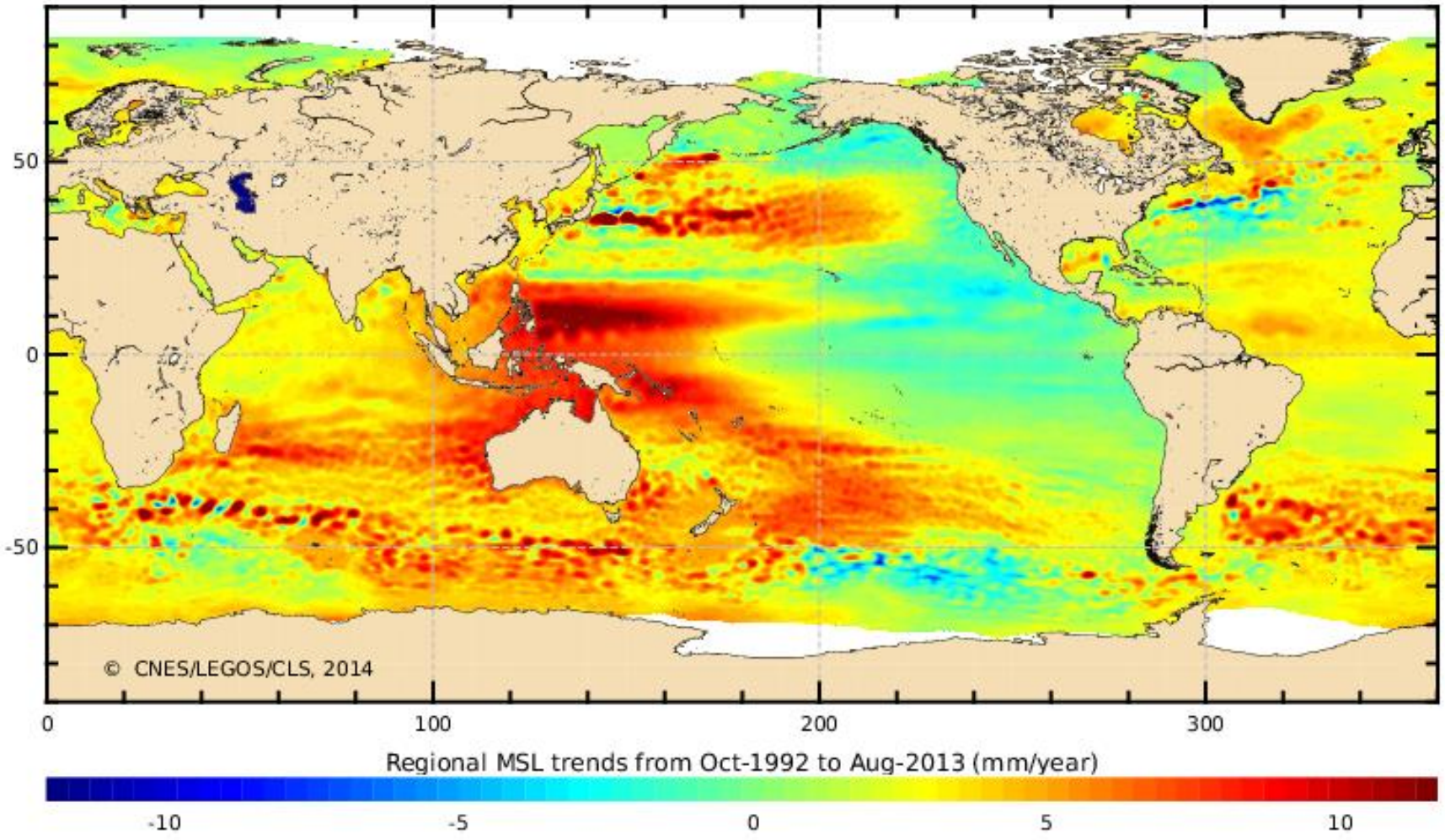
Topografia Dinâmica Média (1993-1999). Calculada a partir de dados altimétricos, dados Grace e gravimetria de satélite.



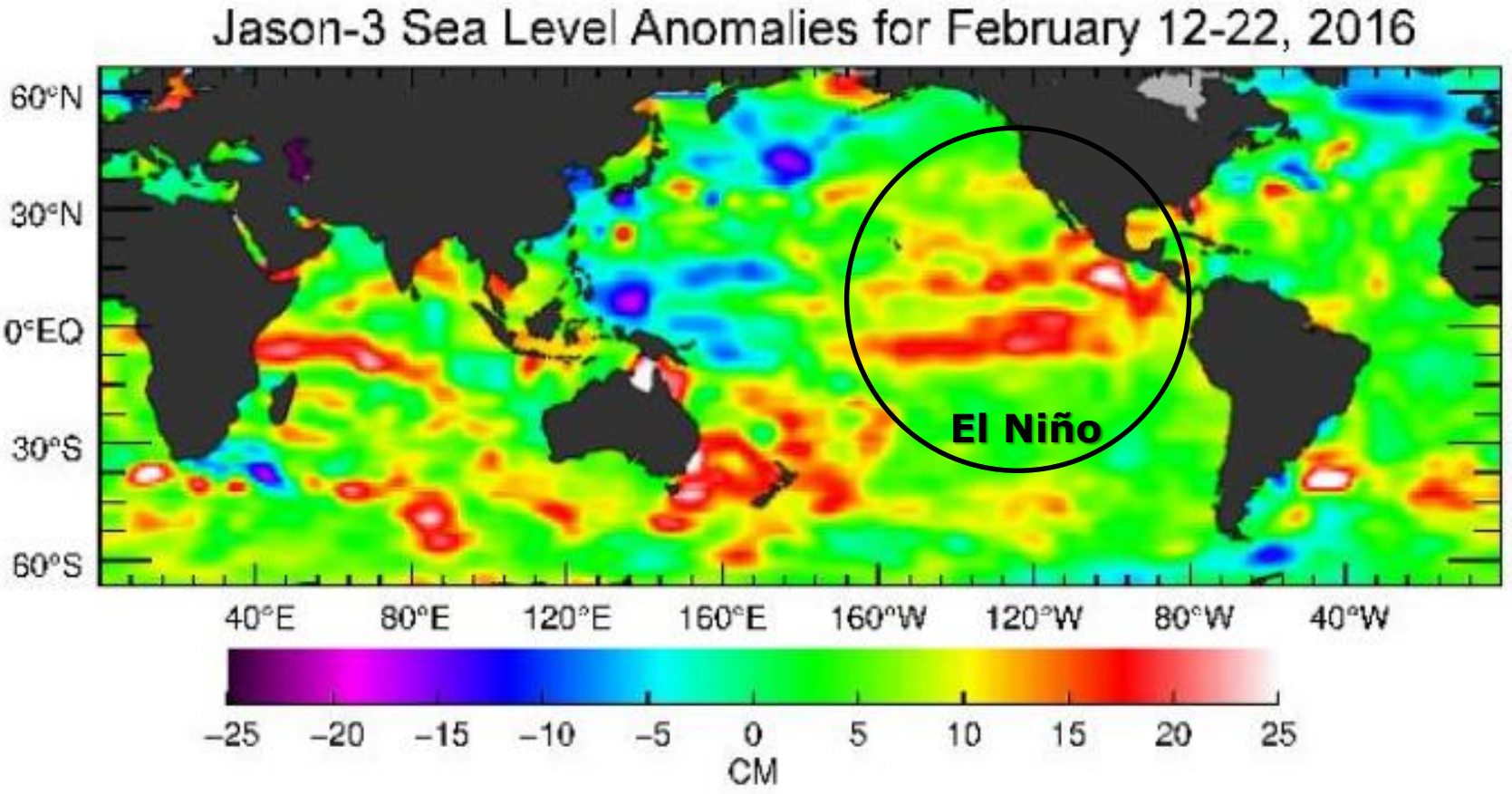


Circulação deduzida da topografia dinâmica e da altimetria de 1993-2004

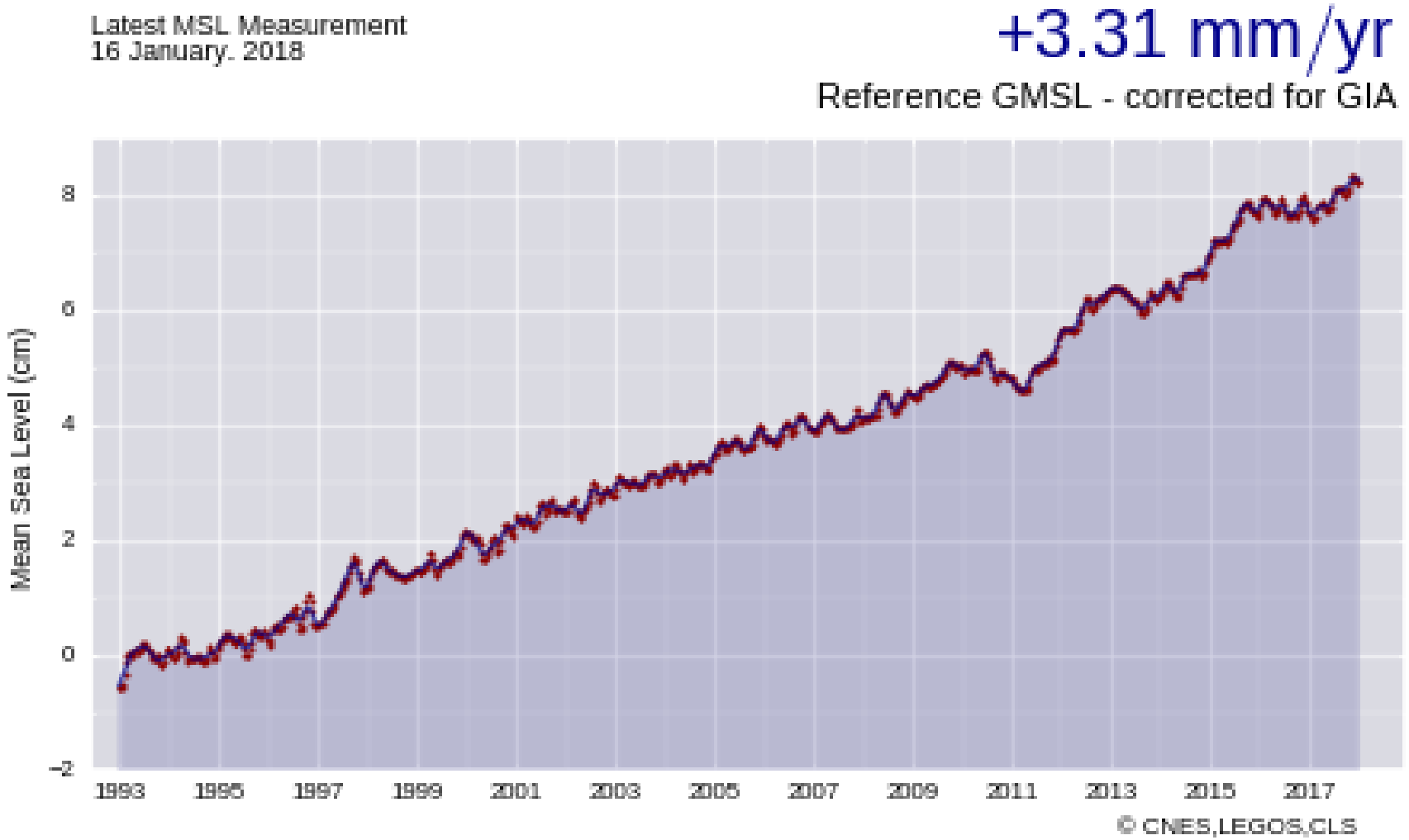
Altimetria Espacial



Satellite Altimetry



Altimetria Espacial



Satellite Altimetry

ESA Altimetry Missions

ERS1 → ERS2 → ENVISAT → CryoSat → Sentinel-3

esa

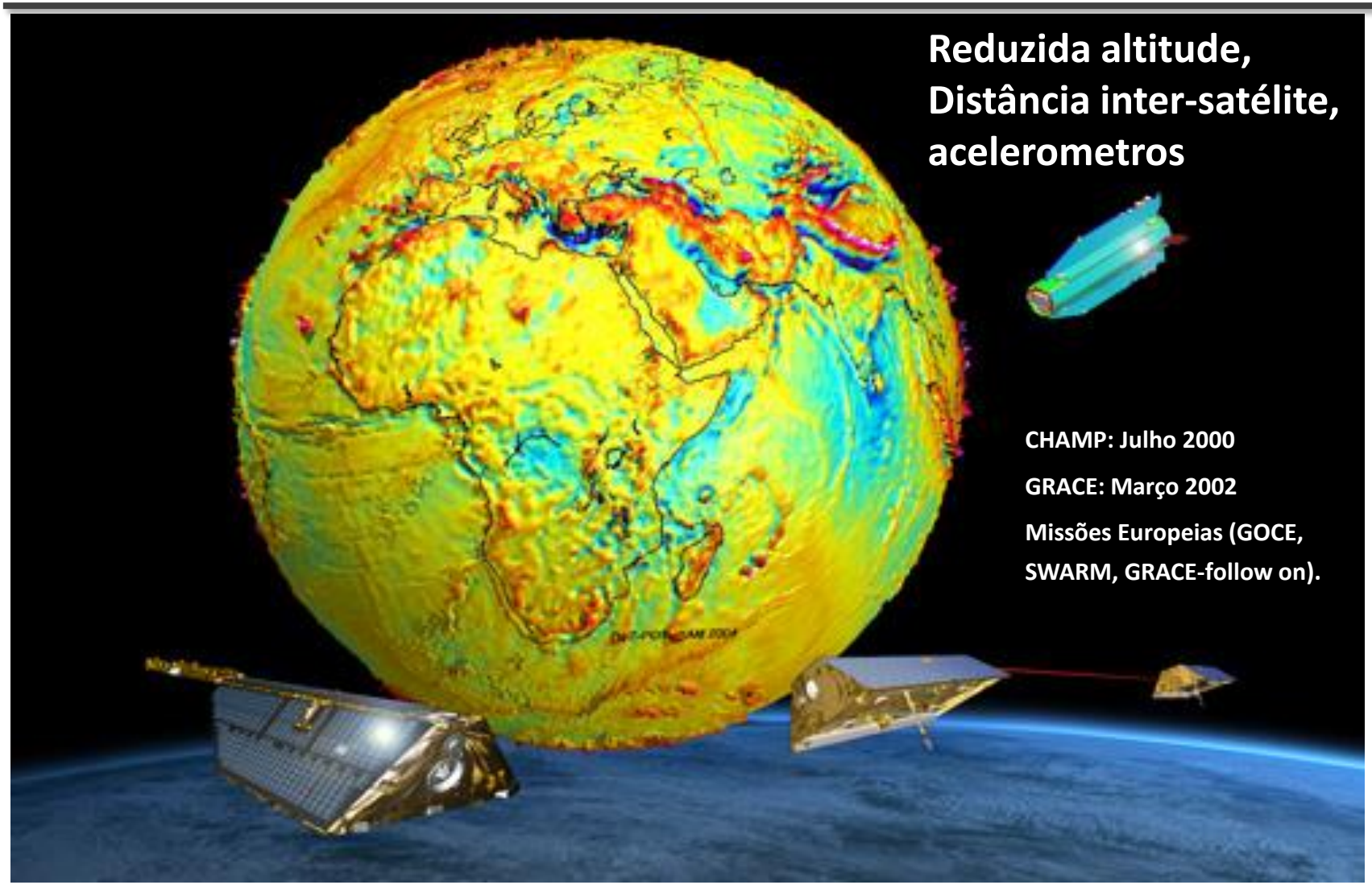
European Space Agency

Satellite Altimetry

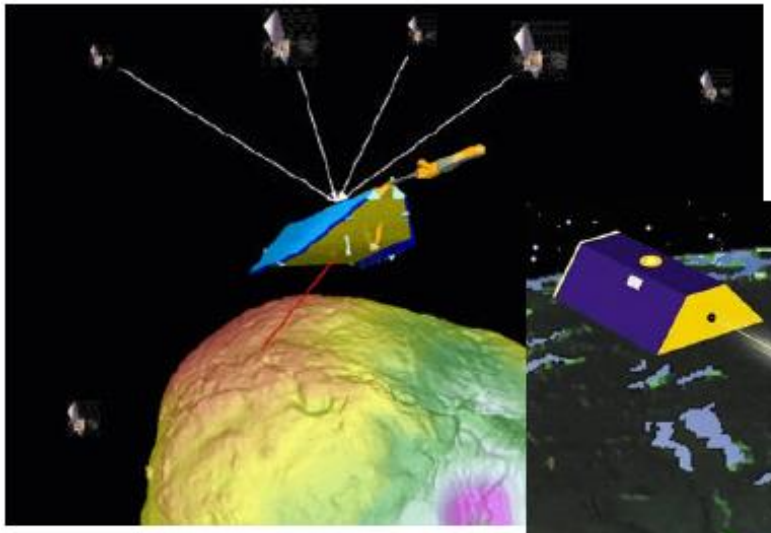
Sentinel-3 is primarily an **ocean mission**, however, the mission is also able to provide atmospheric and land applications. The **Sentinel-3** mission continues the monitoring of the sea state, wind speed, sea-ice and ice thickness as started by the ERS-1 (1991), ERS-2 (1995), Envisat (2002) and CryoSat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

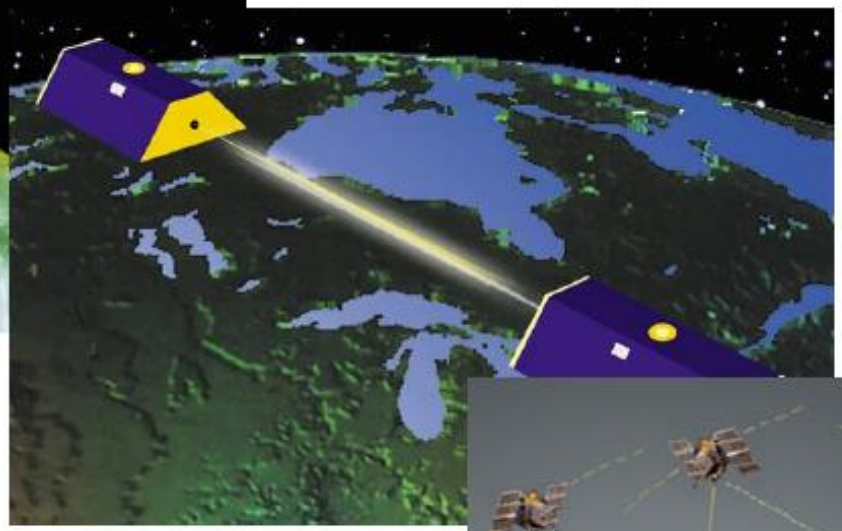
Missões Geopotenciais Espaciais



Missões Geopotenciais Espaciais



CHAMP

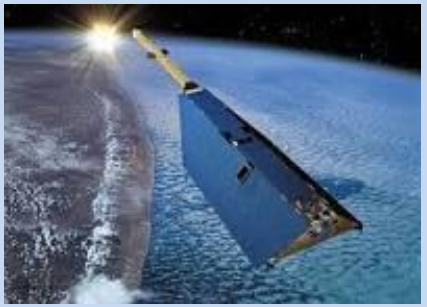


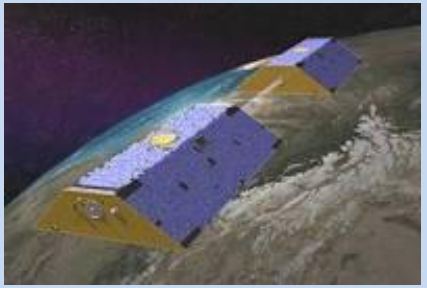
GRACE

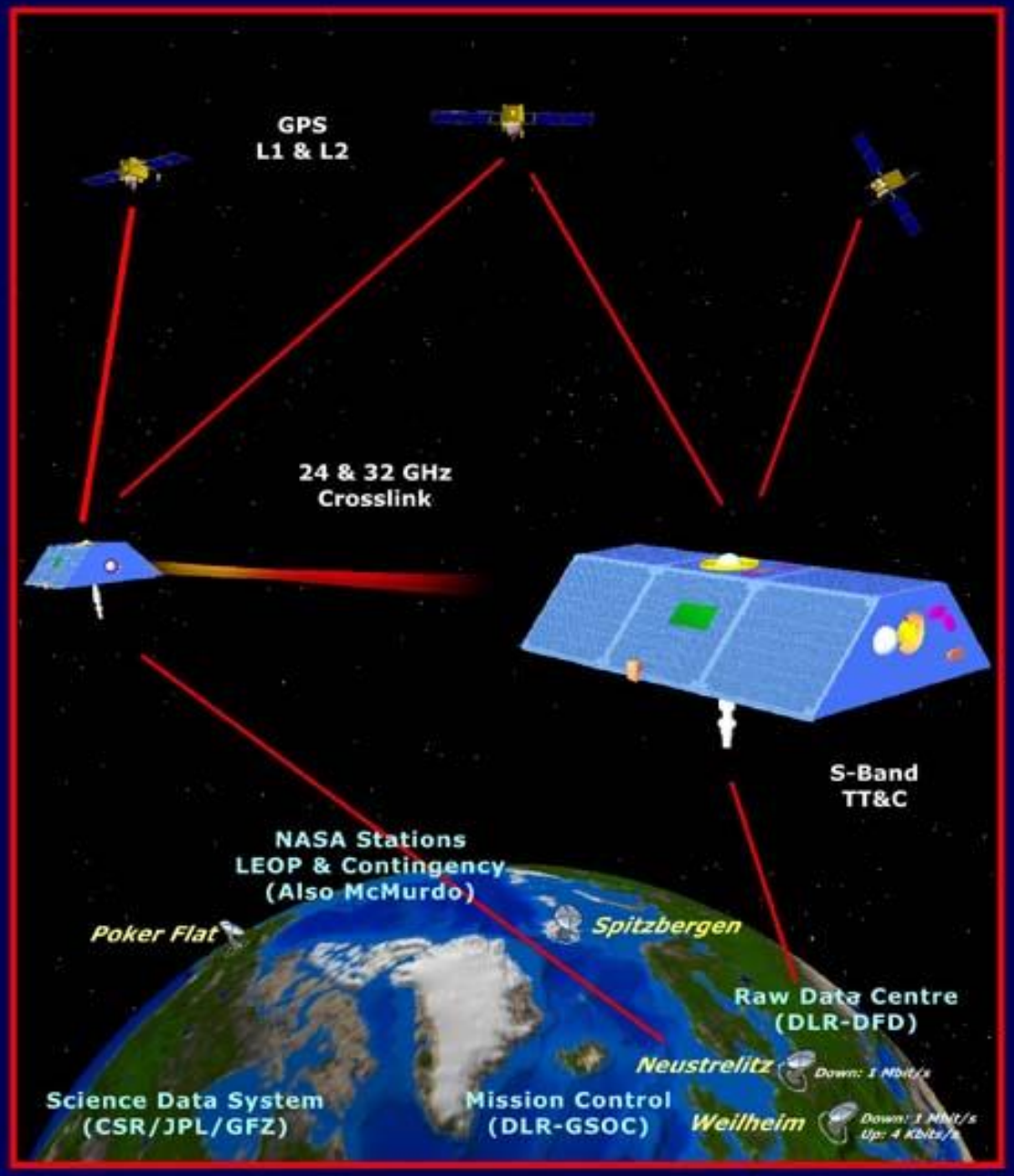
GOCE

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

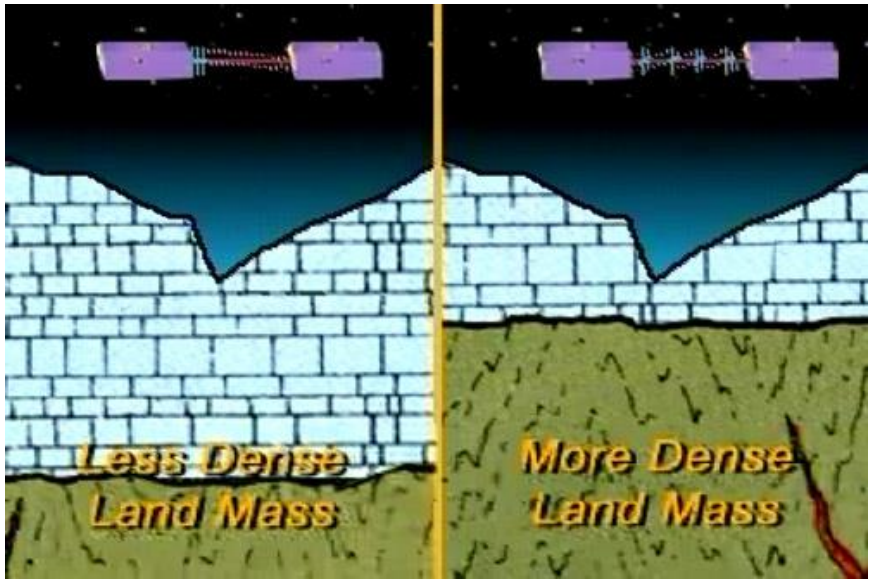
- KBR (JPL/SSL)
- ACC (ONERA)
- SCA (DTU)
- GPS (JPL)

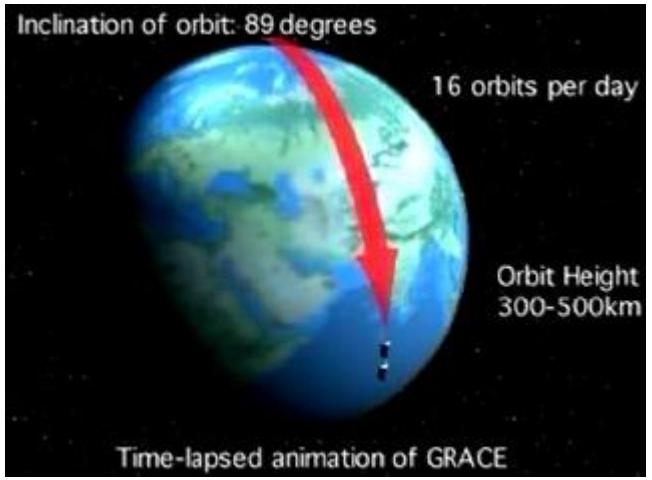
Satellite (JPL/DSS)
Launcher (DLR/Eurockot)
Operations (DLR/GSOC)
Science (CSR/JPL/GFZ)

Orbit

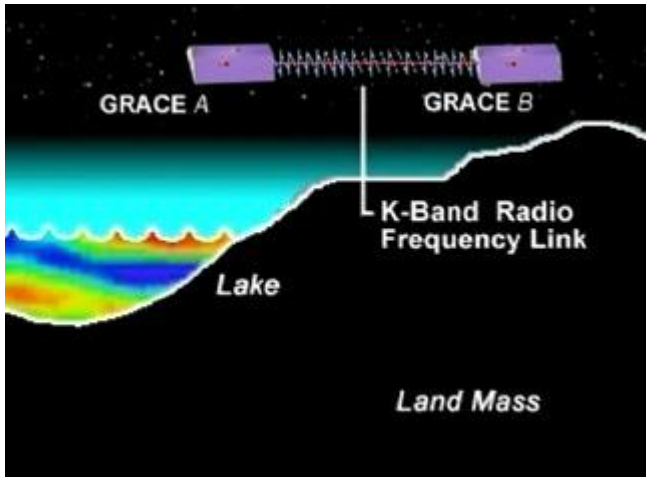
Launch: March 2002
Altitude: 485 km
Inclination : 89 deg
Eccentricity: ~0.001
Lifetime: 5 years
Non-Repeat Ground Track
Earth Pointed, 3-Axis Stable

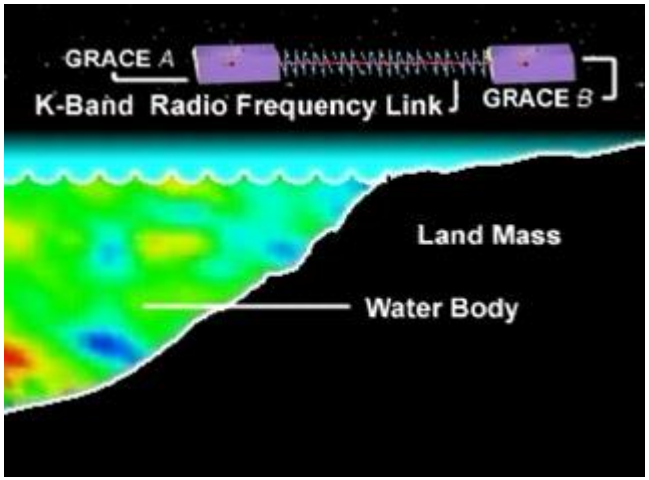
GRACE





Distância = 220 km





GRACE

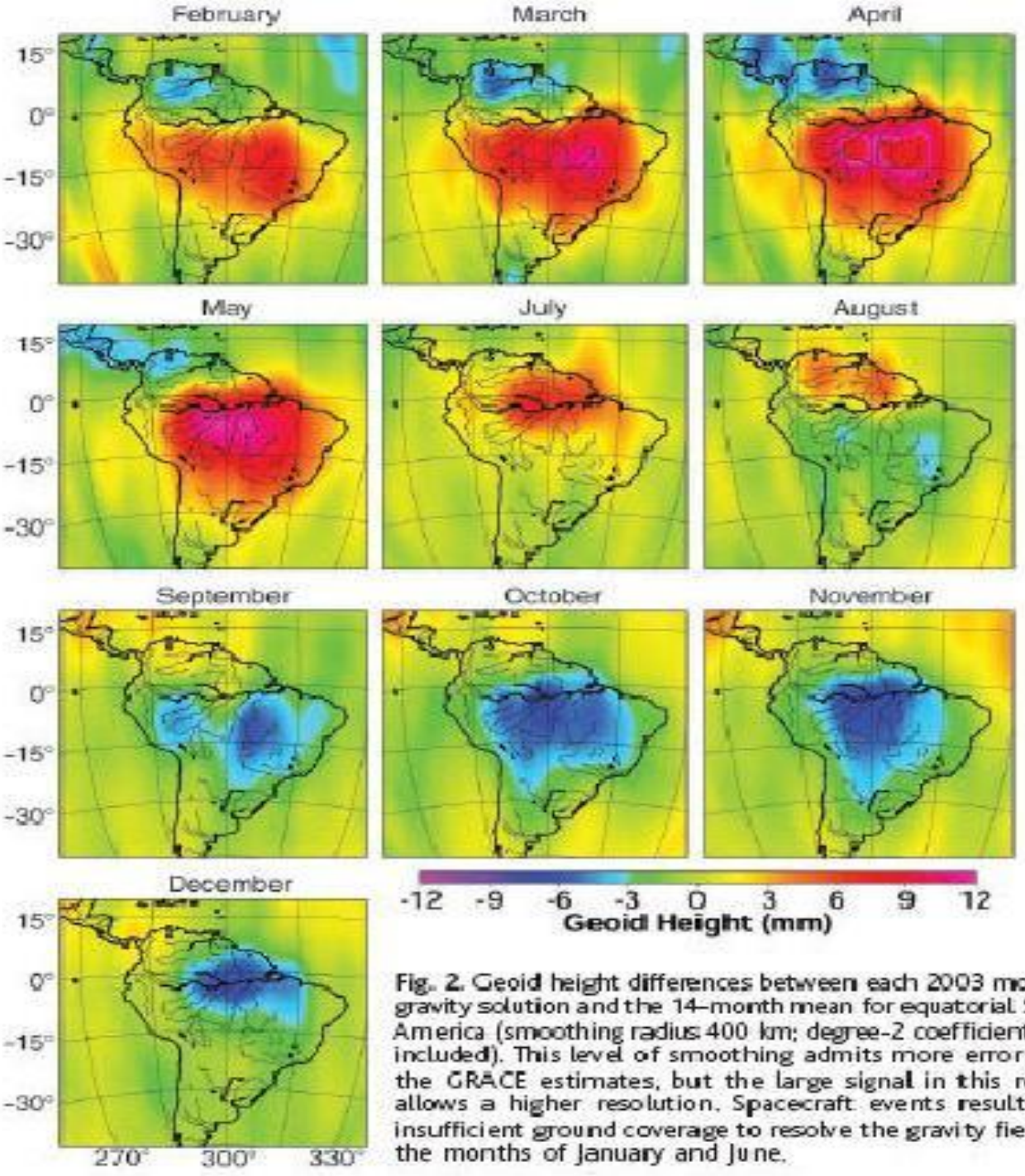


Fig. 2. Geoid height differences between each 2003 monthly gravity solution and the 14-month mean for equatorial South America (smoothing radius 400 km; degree-2 coefficients not included). This level of smoothing admits more error from the GRACE estimates, but the large signal in this region allows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

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

Ciências ULisboa

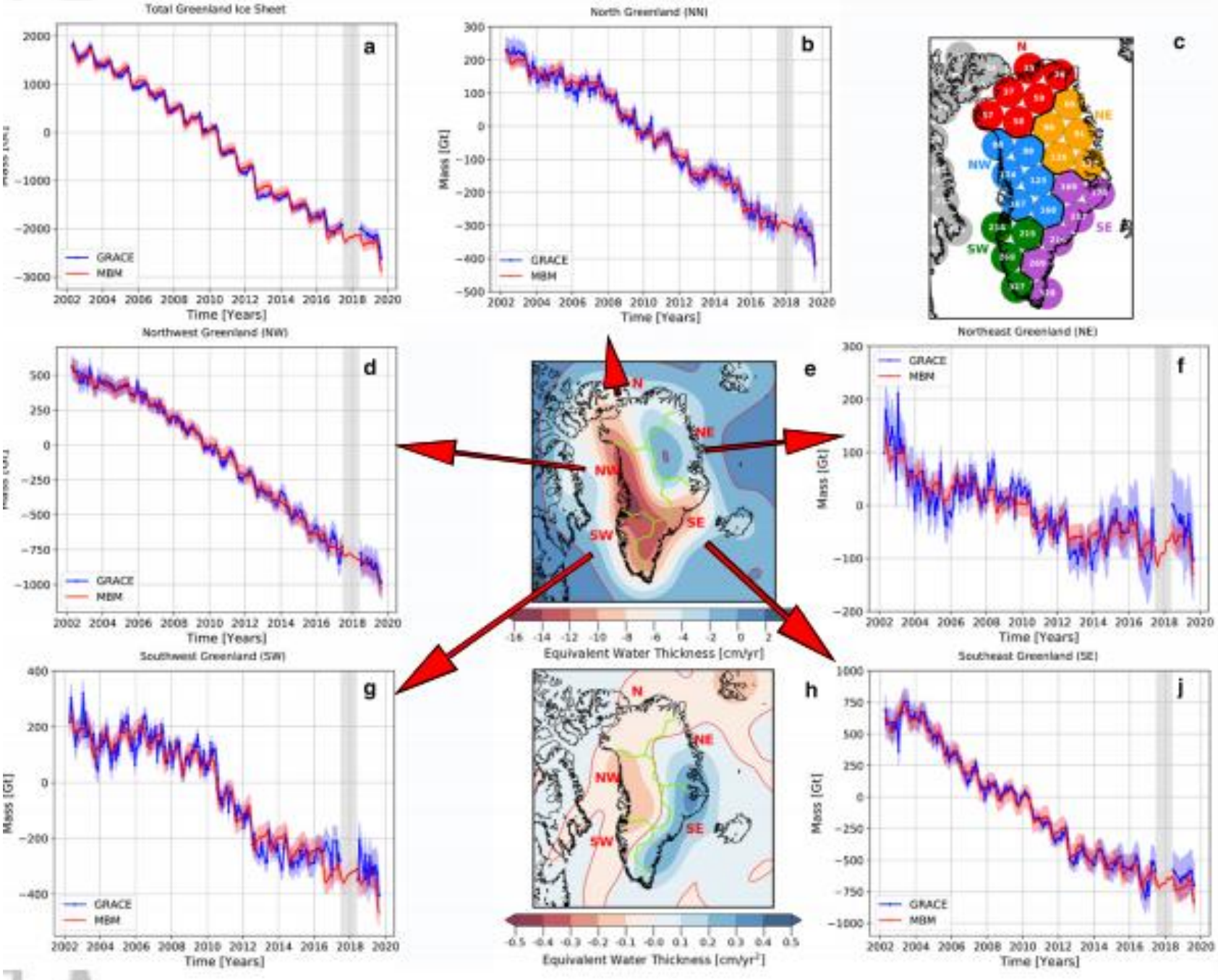
Continuity of ice sheet mass loss in Greenland and Antarctica from the GRACE and GRACE Follow-On missions. Isabella Velicogna et al., GRL, April 2020

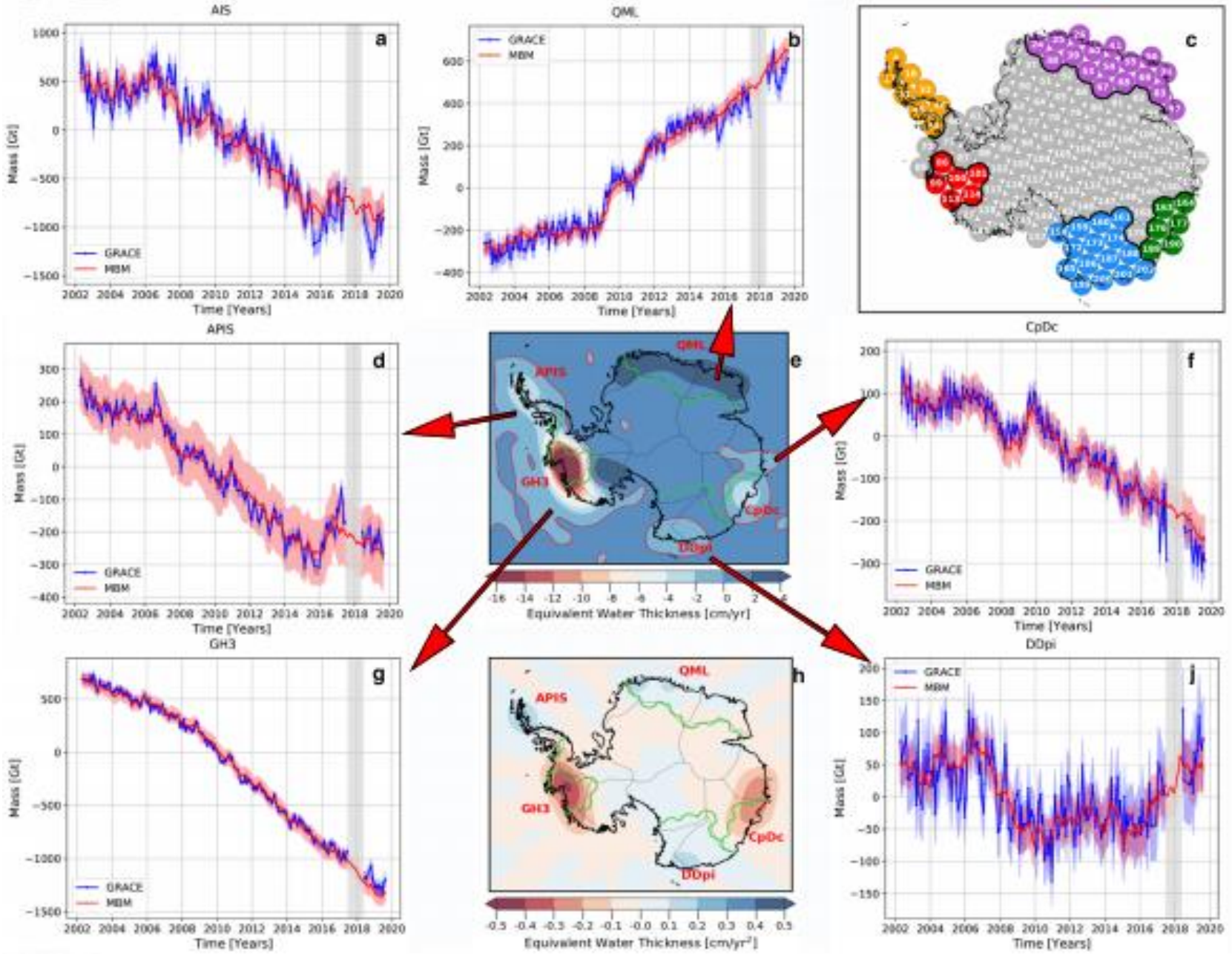
Abstract

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.


Total Greenland Ice Sheet
a
GRACE
MBM
Time [Years]
North Greenland (NN)
b
Mass [Gt]
GRACE
MBM
Time [Years]
c
N
NE
NW
SE
SW
Northwest Greenland (NW)
d
GRACE
MBM
Time [Years]
N
NE
NW
SE
SW
Equivalent Water Thickness [cm/yr]
Northeast Greenland (NE)
e
f
GRACE
MBM
Mass [Gt]
Time [Years]
Southwest Greenland (SW)
g
GRACE
MBM
Mass [Gt]
Time [Years]
N
NE
NW
SE
SW
Equivalent Water Thickness [cm/yr²]
Southeast Greenland (SE)
h
j
GRACE
MBM
Mass [Gt]
Time [Years]

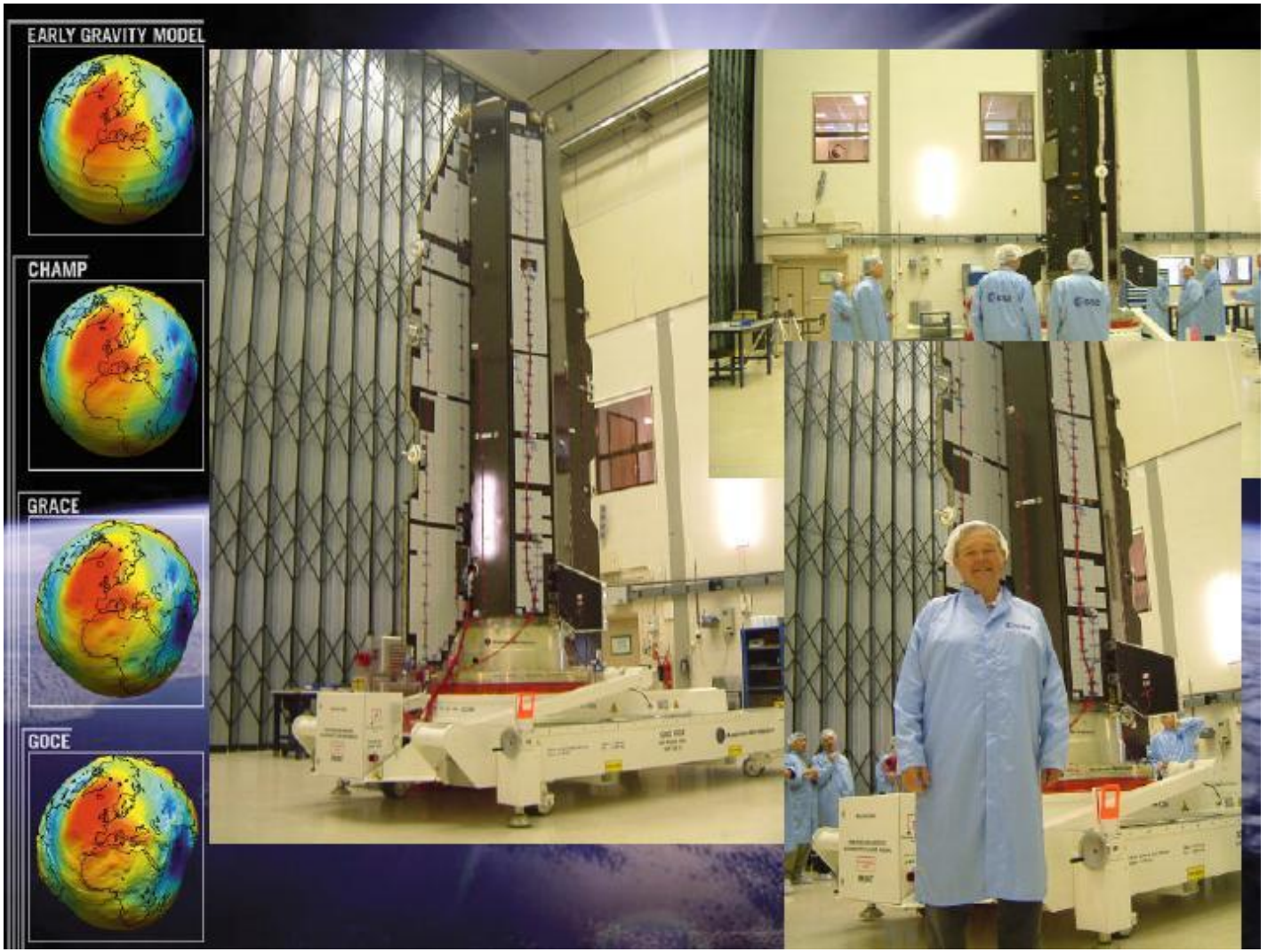

AIS
a
GRACE
MBM
Mass [Gt]
Time [Years]
QML
b
GRACE
MBM
Mass [Gt]
Time [Years]
c
APIS
d
GRACE
MBM
Mass [Gt]
Time [Years]
e
QML
APIS
GH3
CpDc
DDpi
Equivalent Water Thickness [cm/yr]
CpDc
f
GRACE
MBM
Mass [Gt]
Time [Years]
GH3
g
GRACE
MBM
Mass [Gt]
Time [Years]
h
QML
APIS
GH3
CpDc
DDpi
Equivalent Water Thickness [cm/yr²]
DDpi
j
GRACE
MBM
Mass [Gt]
Time [Years]

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

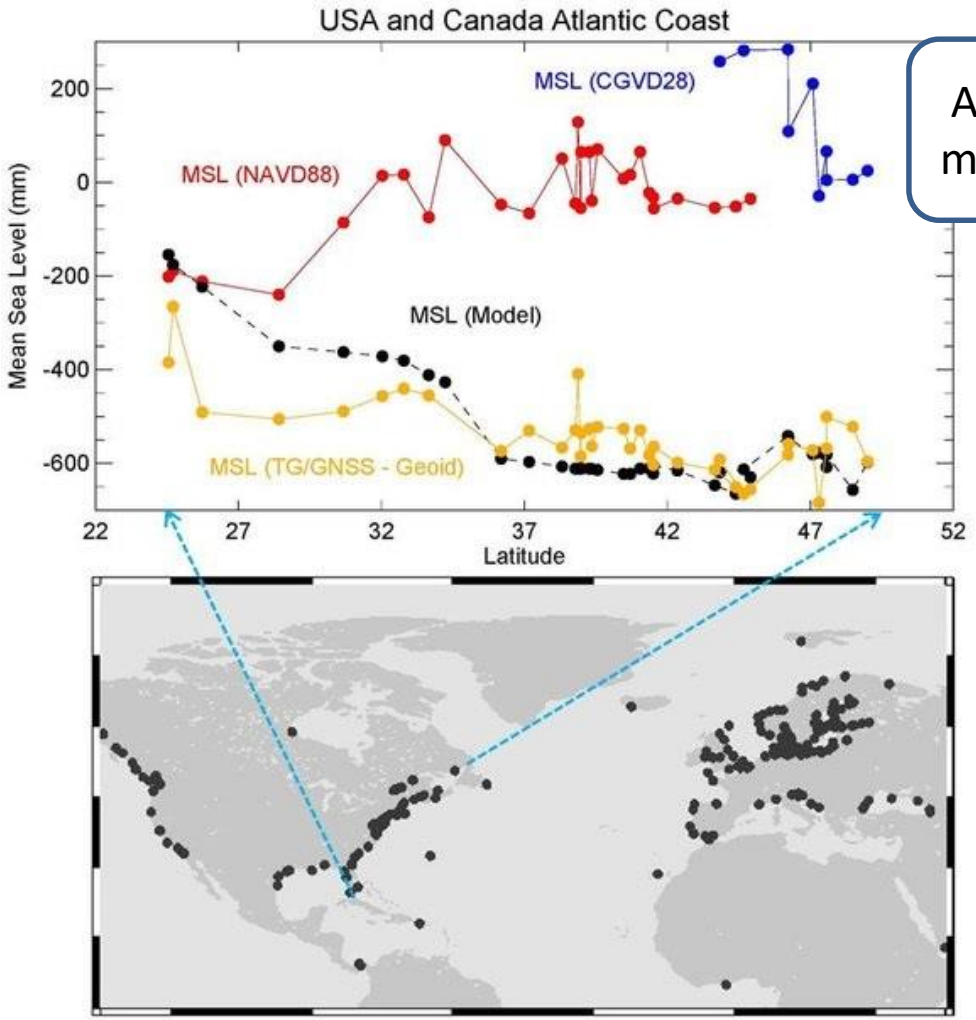


Mean Sea Level

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

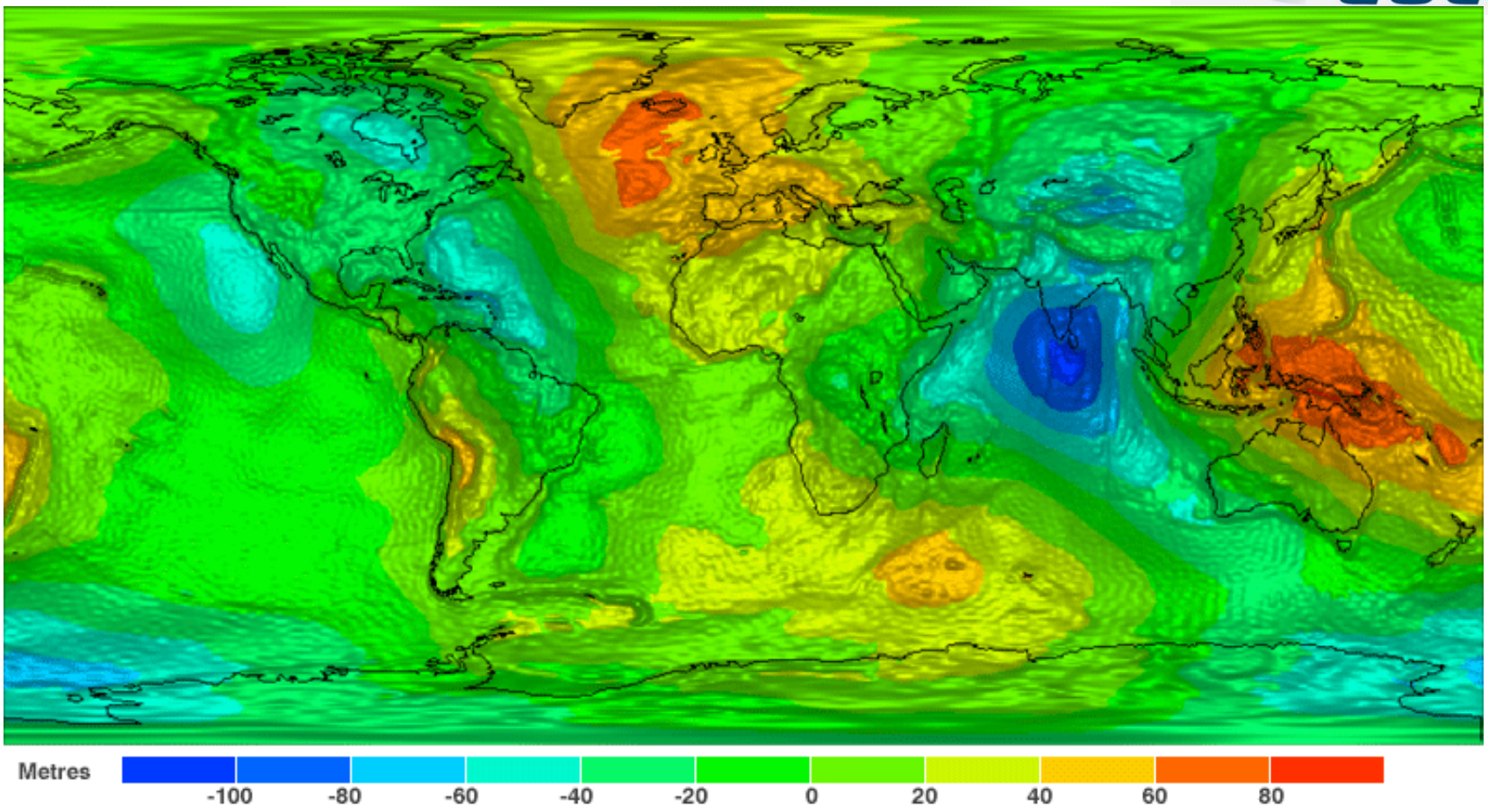
"The results prove conclusively **that sea level decreases** going north along the North American Atlantic coastline, in agreement with the ocean models."

Fev. 2103



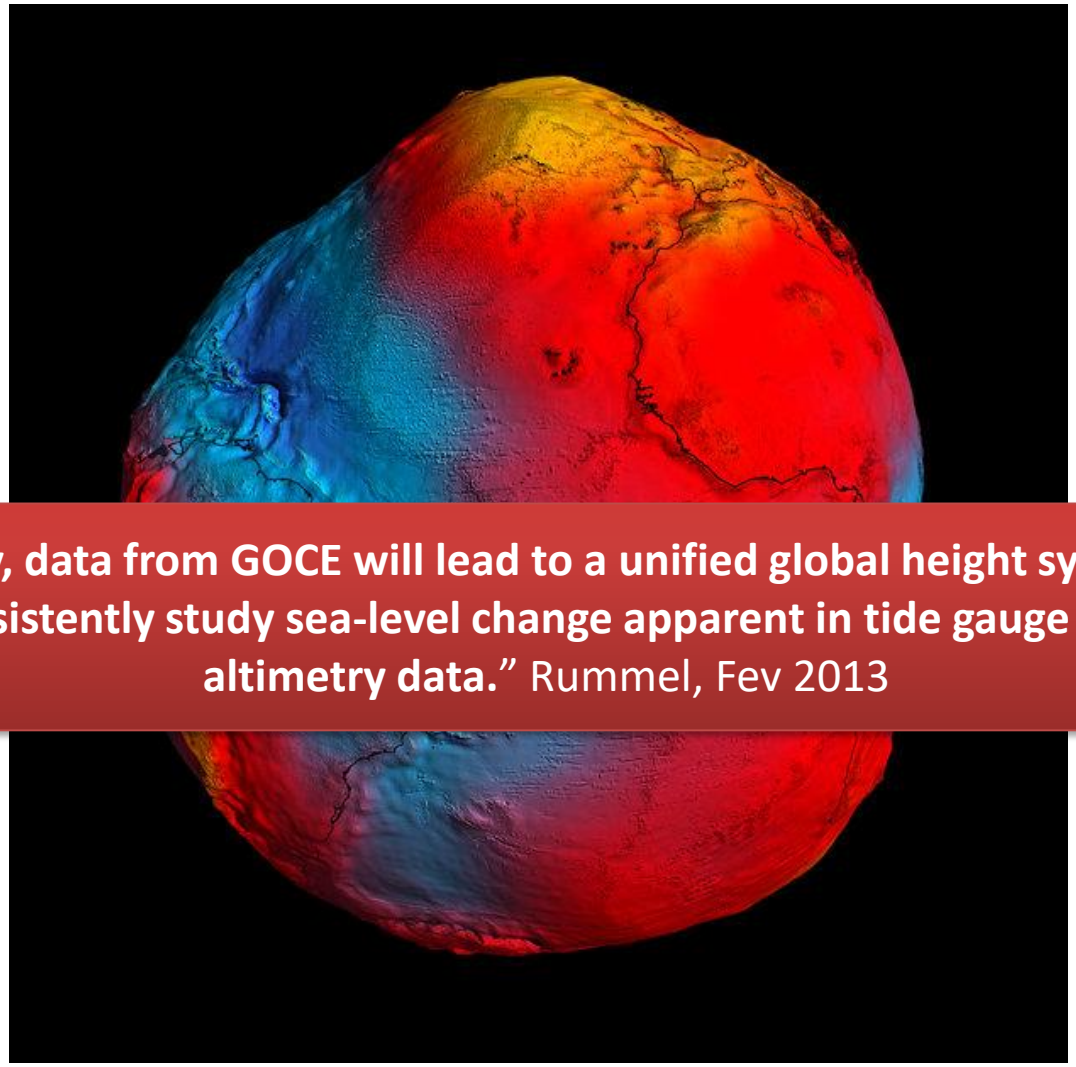
Antigo modelo

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

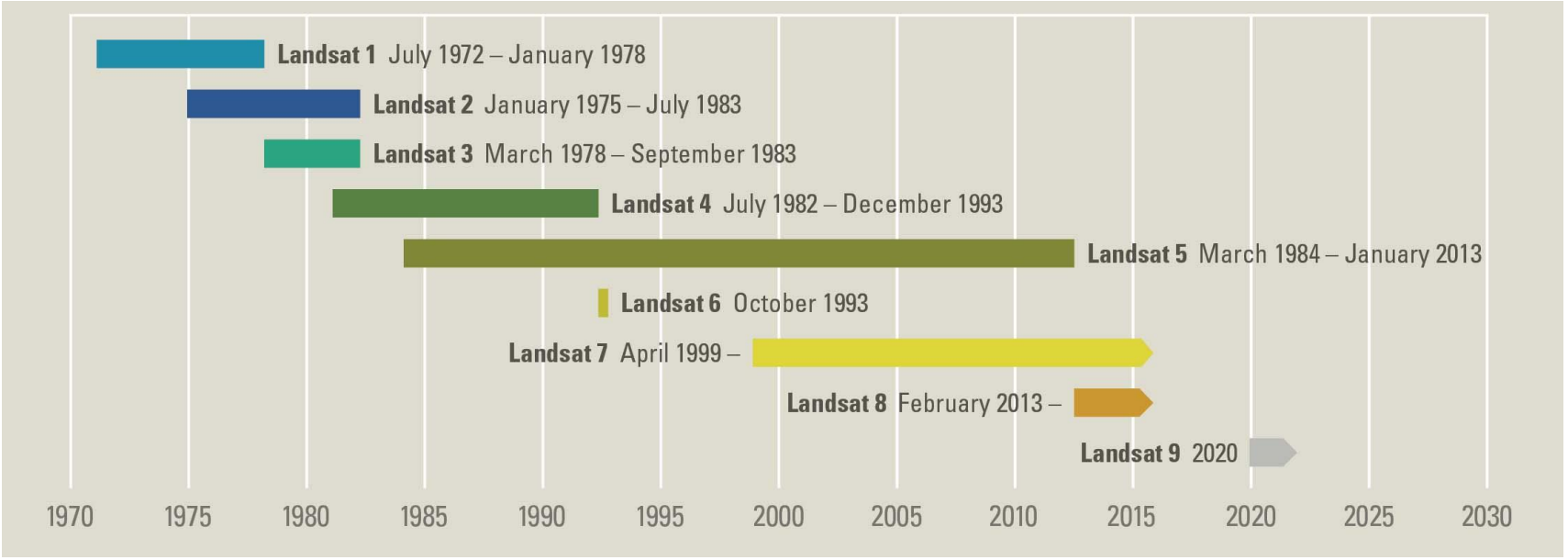
Earth Resources Technology Satellite (ERTS-1), later renamed **Landsat-1**, was launched on July 23, 1972.

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."

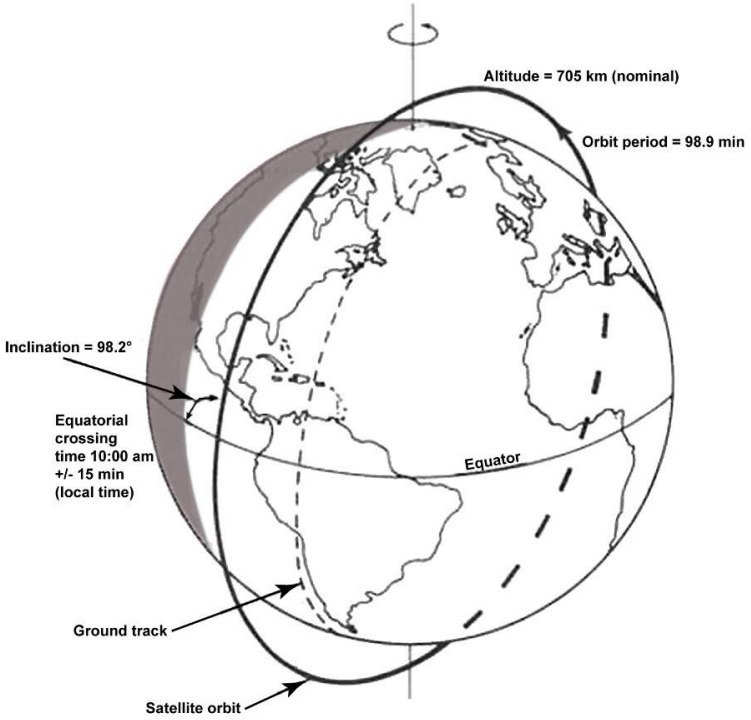
Landsat-7 successfully launched in 1999 and, along with **Landsat-8**, launched in 2013, continues to provide daily global data. **Landsat-9** has a launch readiness date of December 2020.

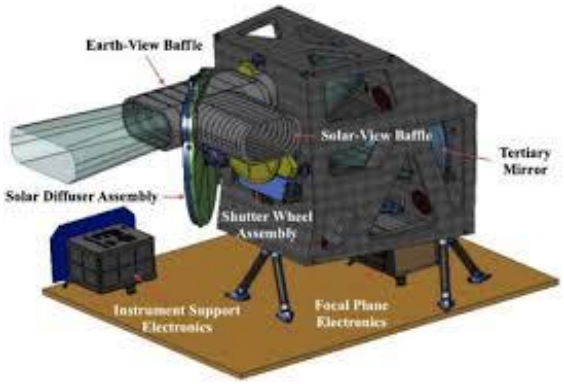


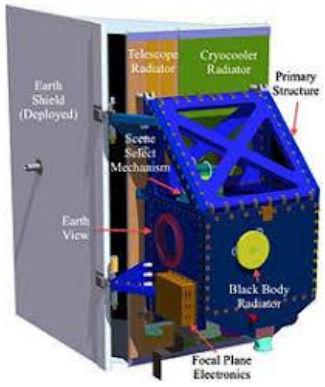
Earth Observation Satellites

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.

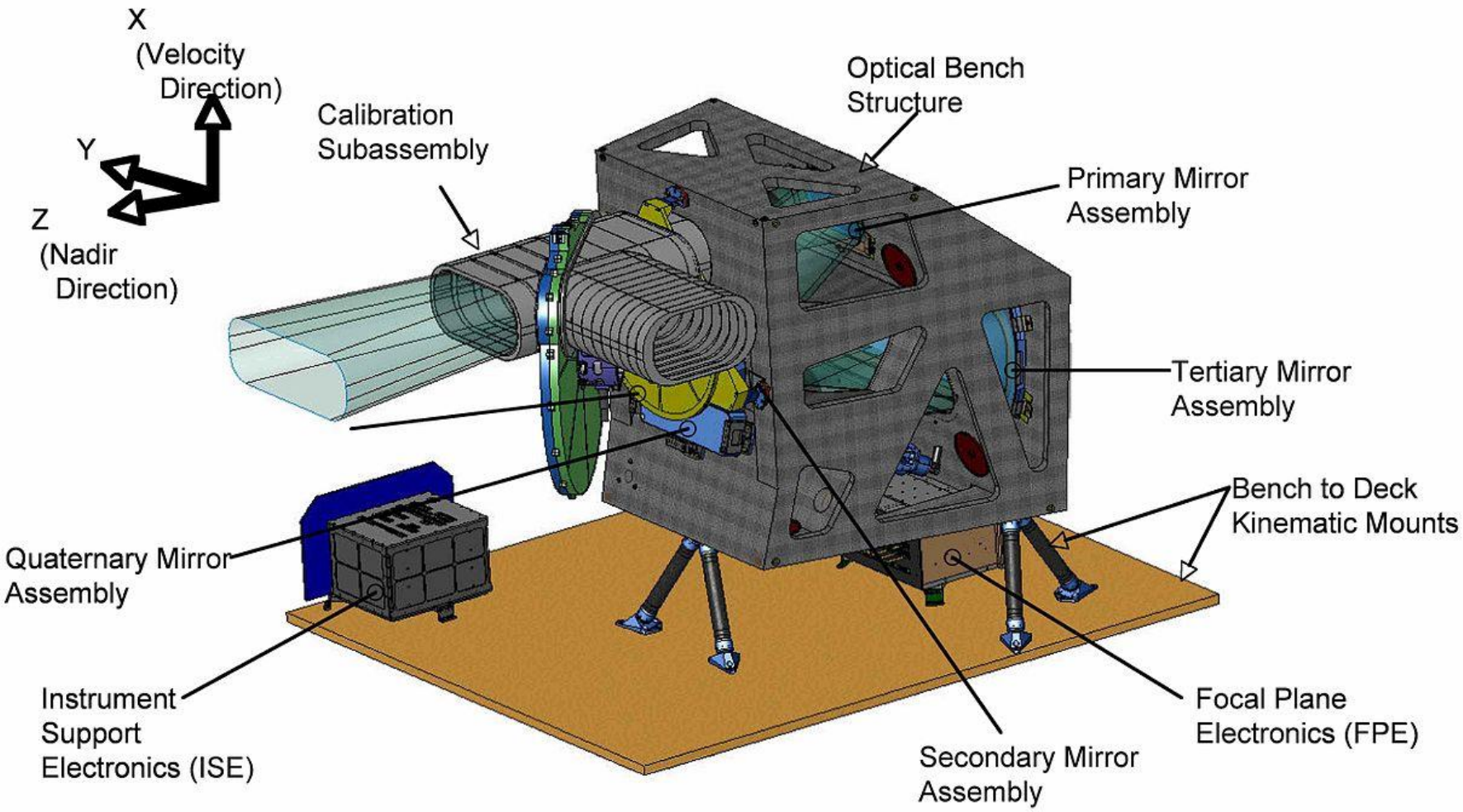
Landsat-8 carries two pushbroom instruments: the **Operational Land Imager (OLI)** and the **Thermal Infrared Sensor (TIRS)**.







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)

1

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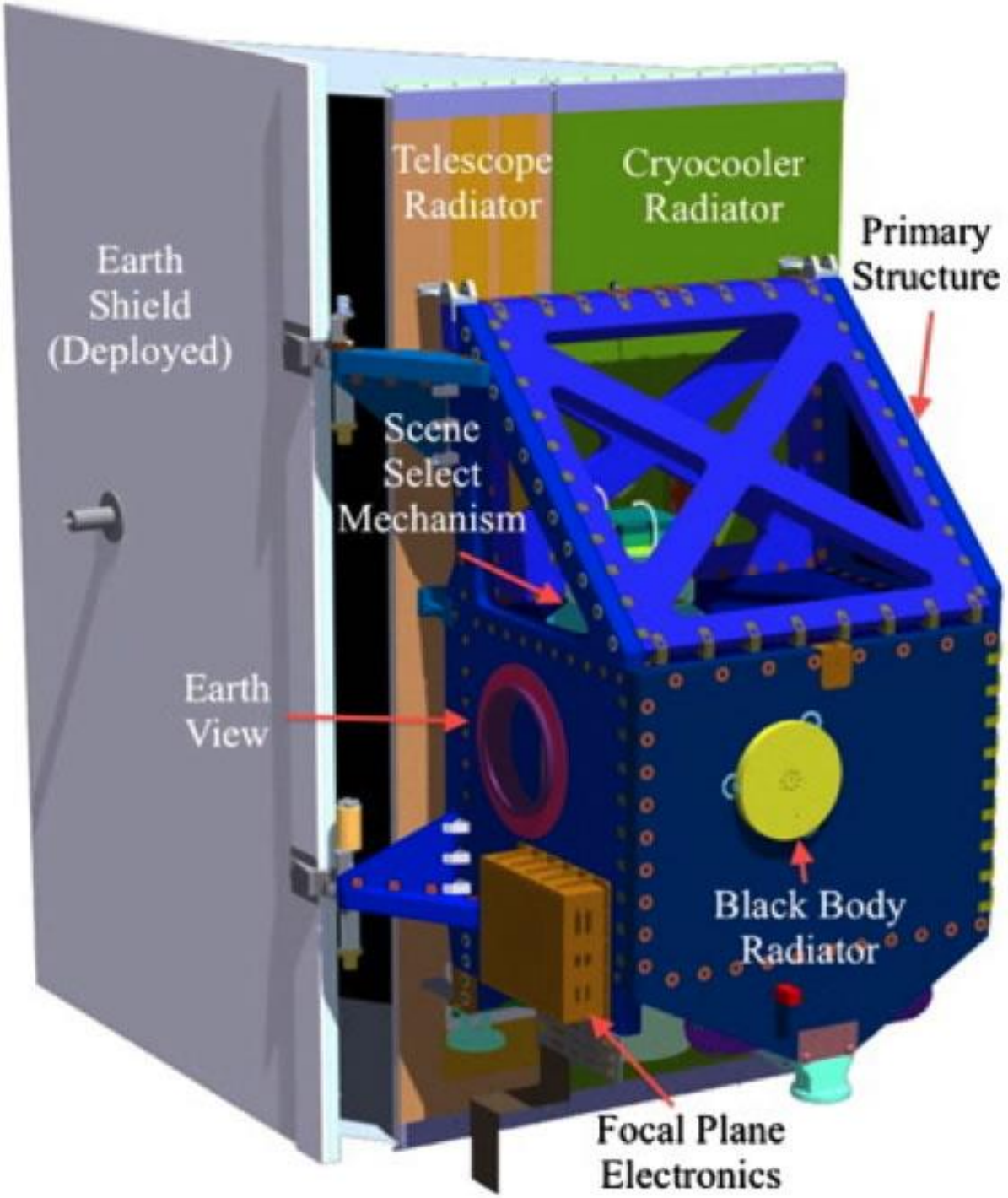
Thermal InfraRed Sensor (TIRS)



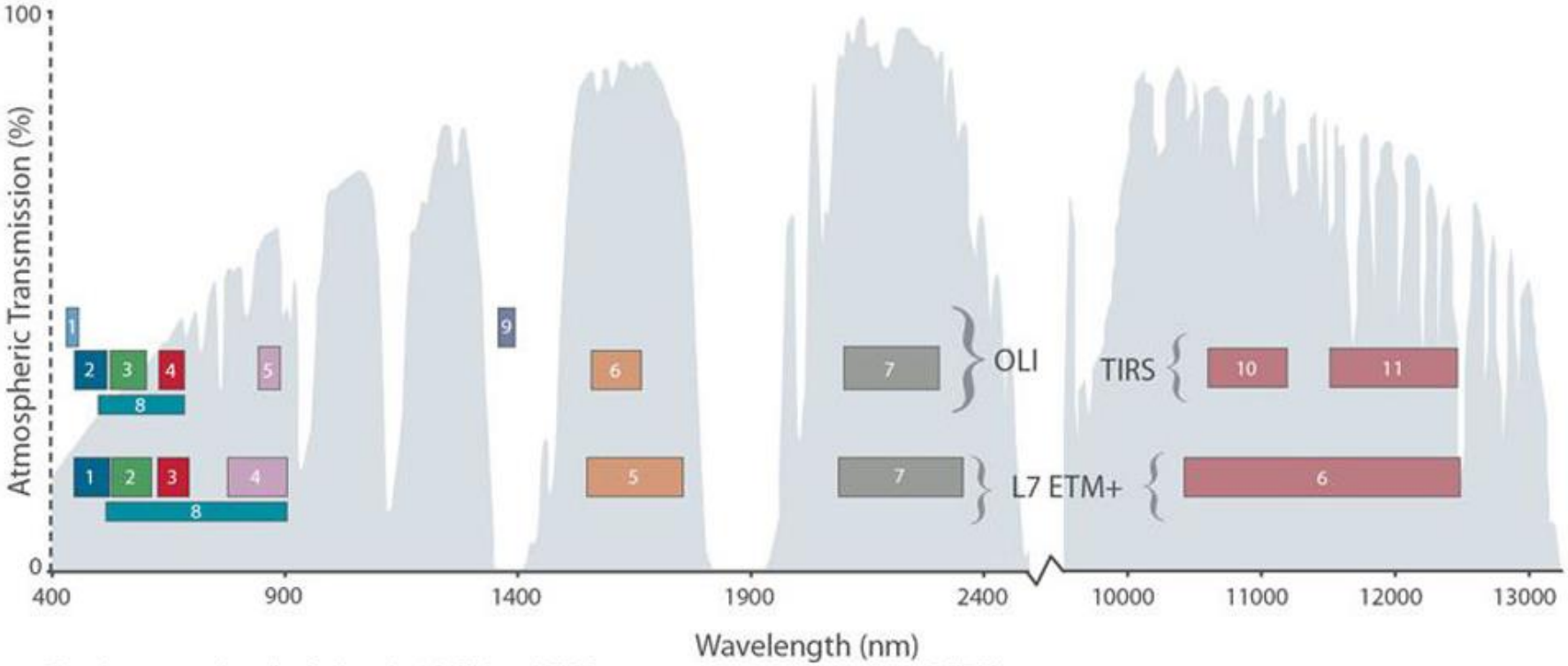
Earth Observation Satellites

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



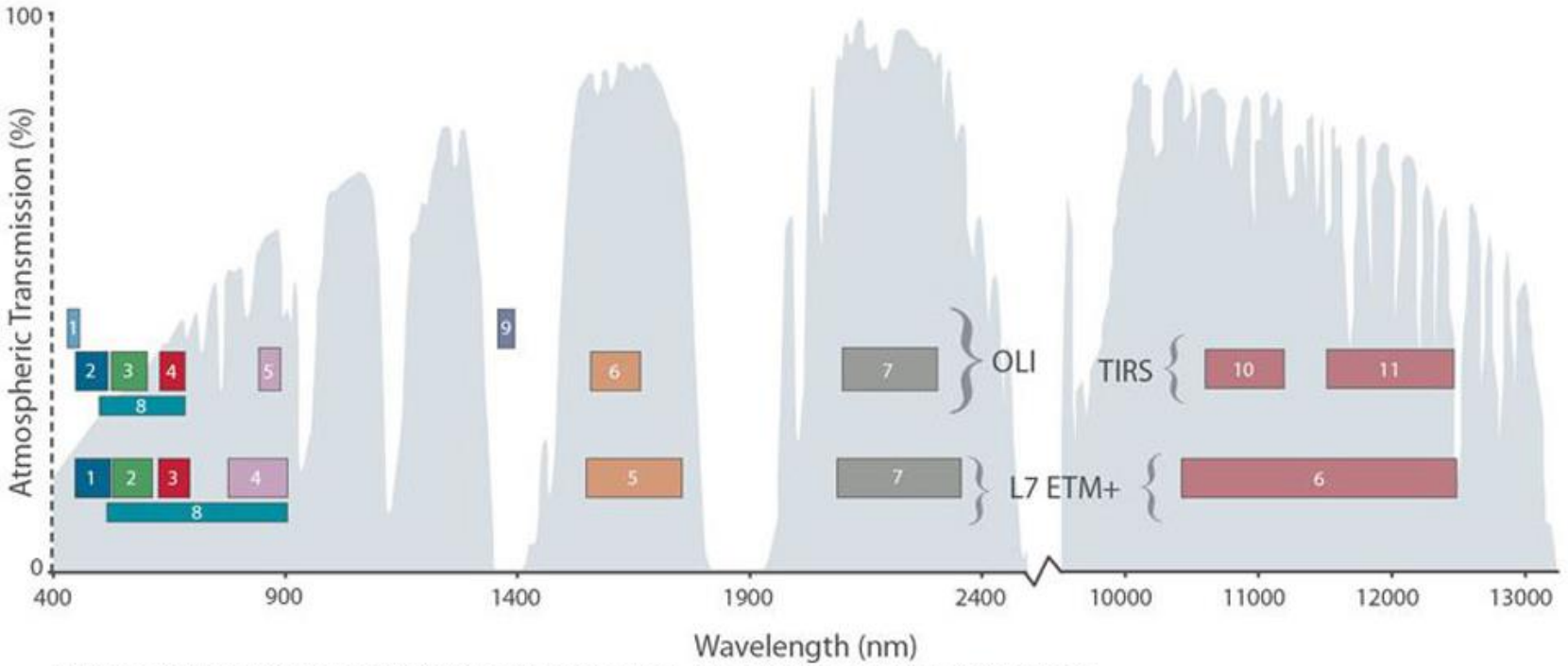
Bandpass wavelengths for Landsat 8 OLI and TIRS sensor, compared to Landsat 7 ETM+ sensor

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)

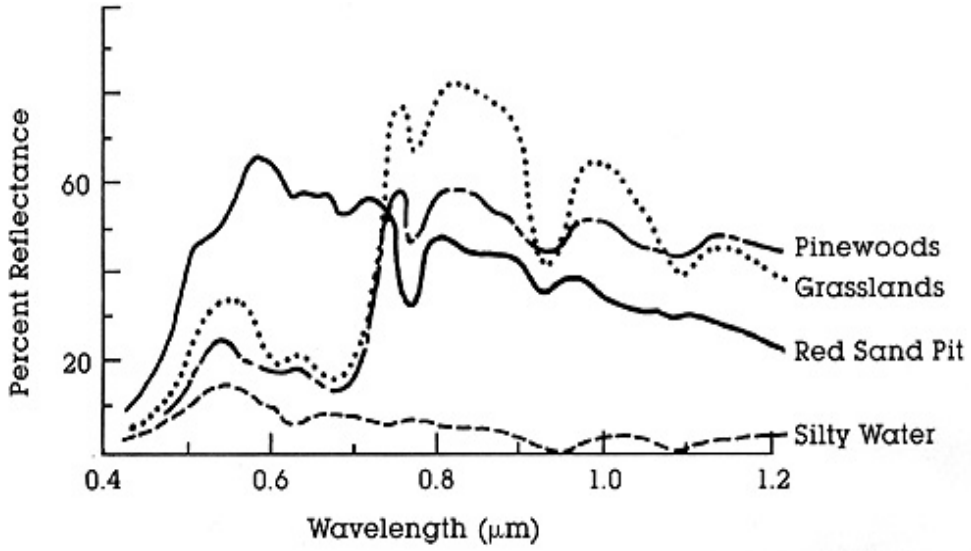
Earth Observation Satellites

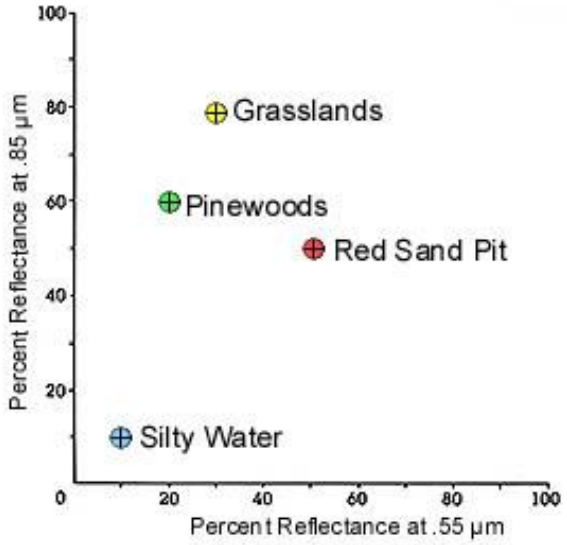


Bandpass wavelengths for Landsat 8 OLI and TIRS sensor, compared to Landsat 7 ETM+ sensor

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

LANDSAT – Spectral bands



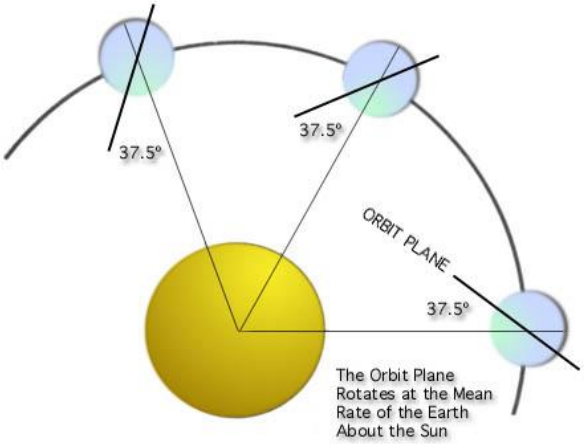


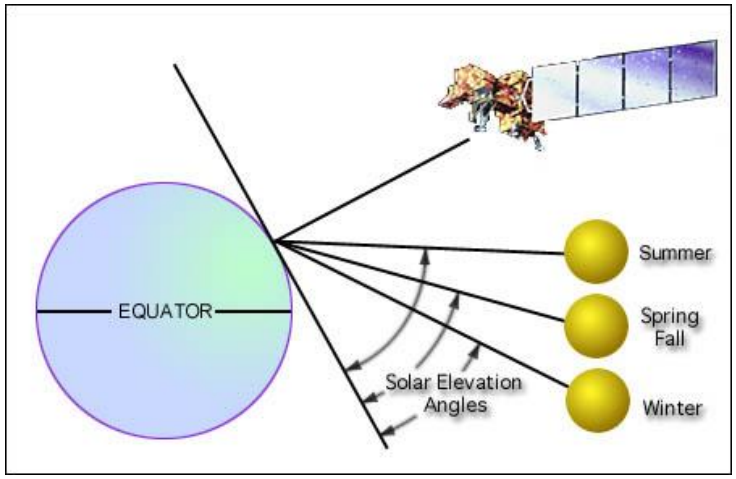
For any given material, the amount of emitted and reflected radiation varies by wavelength. These variations are used to establish the signature reflectance fingerprint for that material.

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

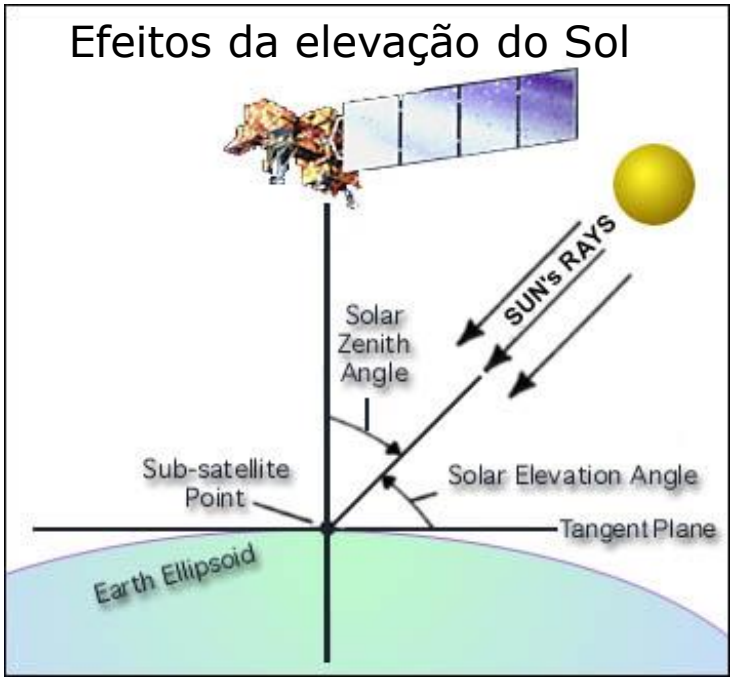
LANDSAT – seazonal effects

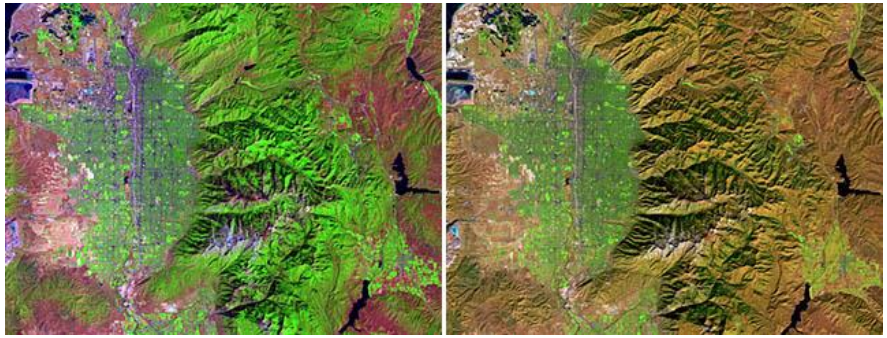
Nodo ascendente Às 10:00





Efeitos da elevação do Sol





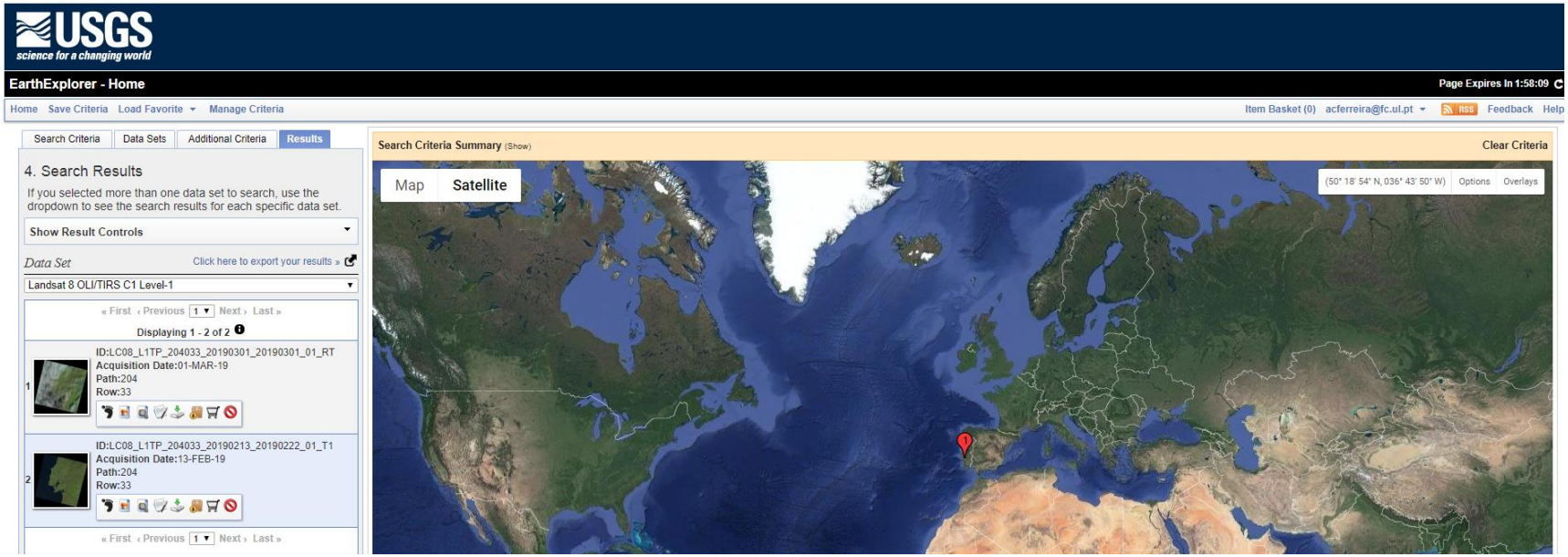
Effects of Seasonal Changes on Solar Elevation Angle

Earth Observation Satellites

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).



Earth Observation Satellites

Landsat Level-1 standard data products are processed to standard parameters, and distributed as scaled and calibrated digital numbers (DN). The DN's can be scaled to absolutely calibrated radiance or reflectance values using metadata which are distributed with the product (see conversion algorithms for Landsat 1-8 Level-1 data).

Landsat Level-1 Processing Levels	
Processing Level	**Description**
Standard Terrain Correction L1TP	Radiometrically calibrated and orthorectified using ground control points and digital elevation model (DEM) data to correct for relief displacement. These are the highest quality Level-1 products suitable for pixel-level time series analysis.
Systematic Terrain Correction L1GT	Radiometrically calibrated and with systematic geometric corrections applied using the spacecraft ephemeris data and DEM data to correct for relief displacement.
Systematic Correction L1GS	Radiometrically calibrated and with only systematic geometric corrections applied using the spacecraft ephemeris data.

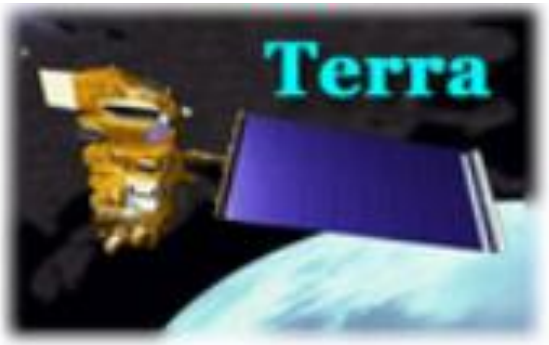
Earth Observation Satellites

Landsat-8 (13.02.2019)

Earth Observation Satellites

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.

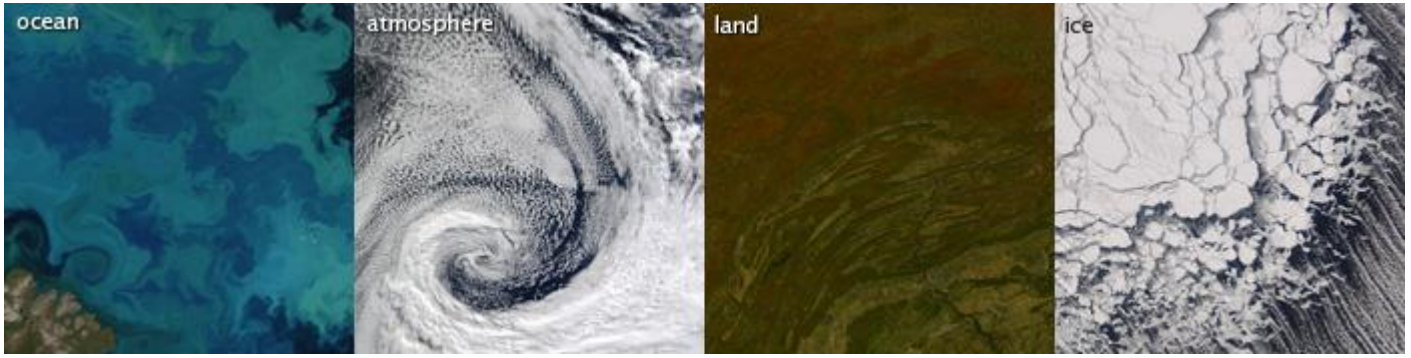
Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning (10:30 am), while **Aqua** passes south to north over the equator in the afternoon (01:30 pm).



Earth Observation Satellites

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.



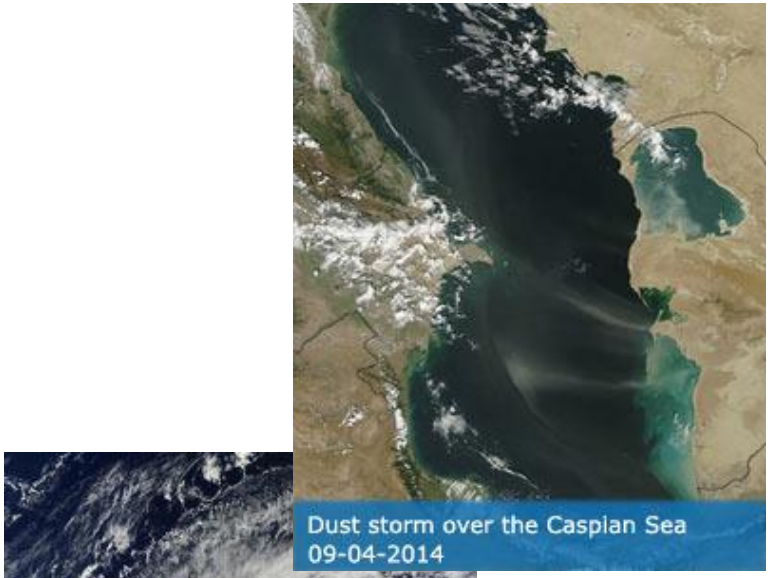
Earth Observation Satellites

MODIS level 1 data, geolocation, cloud mask, and atmosphere products:
http://ladsweb.nascom.nasa.gov/

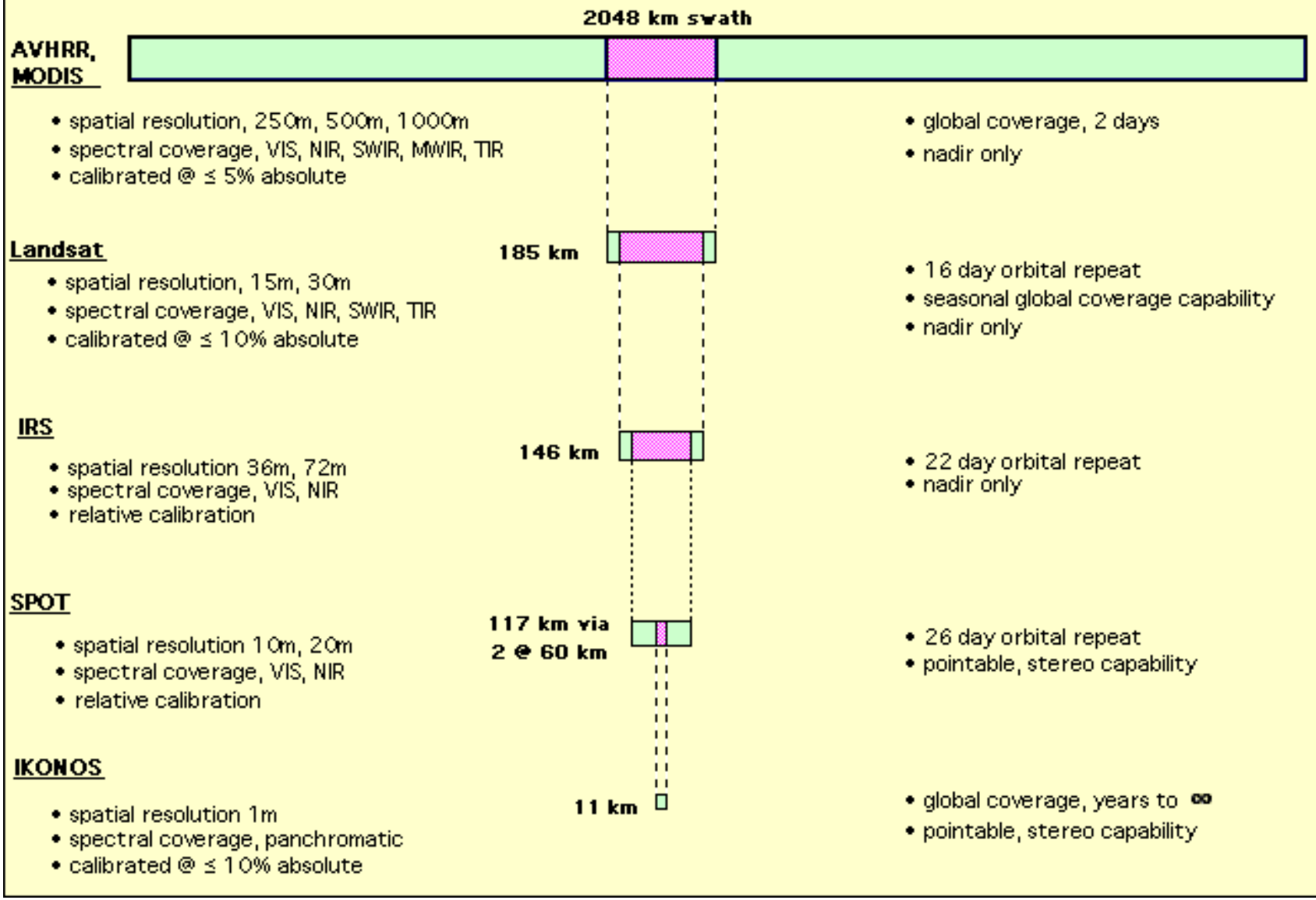
MODIS land products:
https://lpdaac.usgs.gov/

MODIS cryosphere products:
http://nsidc.org/daac/modis/index.html

MODIS ocean color and sea surface temperature products:
http://oceancolor.gsfc.nasa.gov/



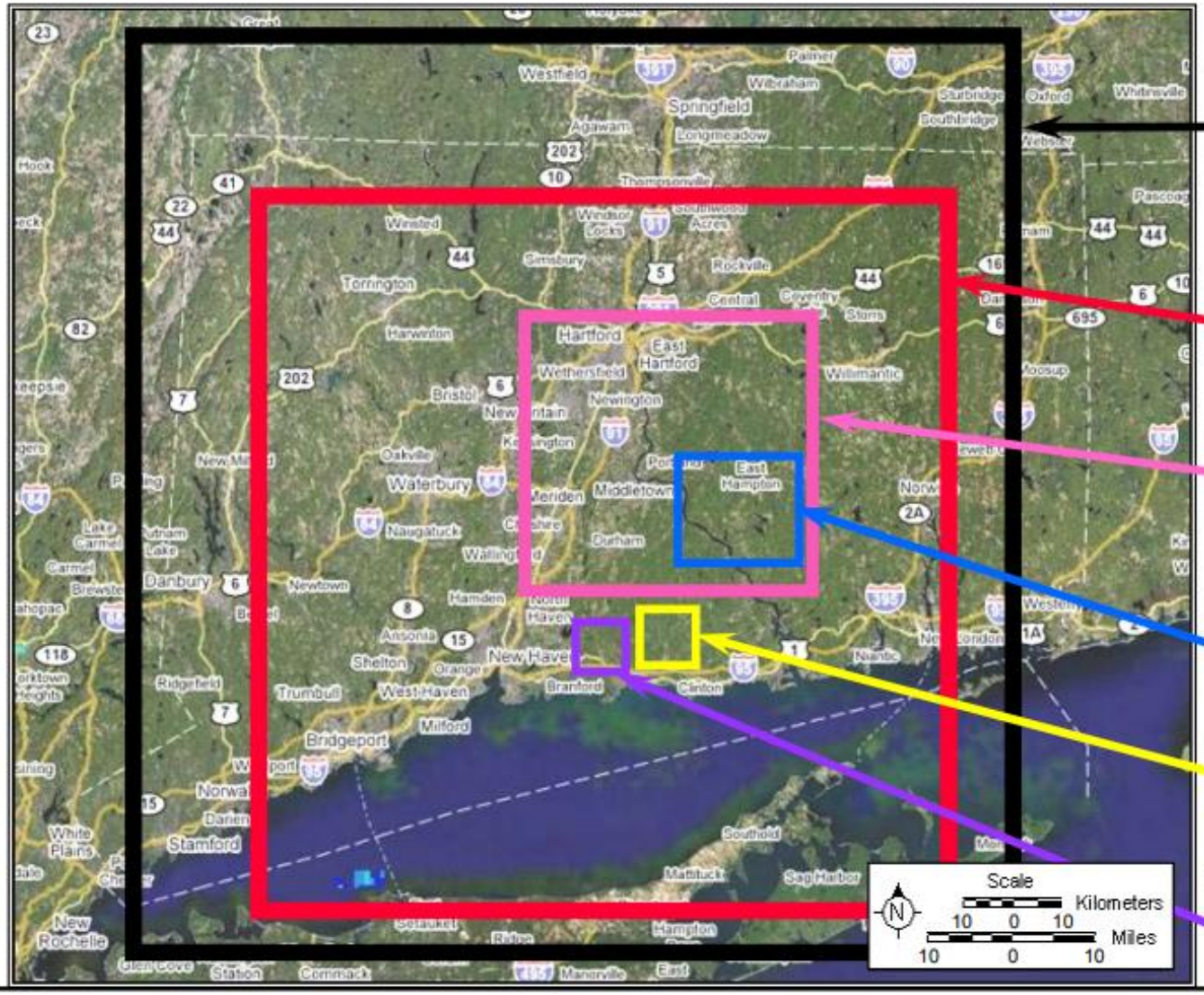
Landsat's Unique Niche Leads to a High Resolution Global Seasonal Archive Capability



Looking More Closely at Resolution

Looking More Closely at Resolution

Selected Satellite Footprints



Landsat 7

185 by 170 km
30-m multispectral

Indian Remote Sensing

145 by 145 km
25-m multispectral

SPOT

60 by 60 km
20-m multispectral

QuickBird 2

16 by 16 km
2.5-m multispectral

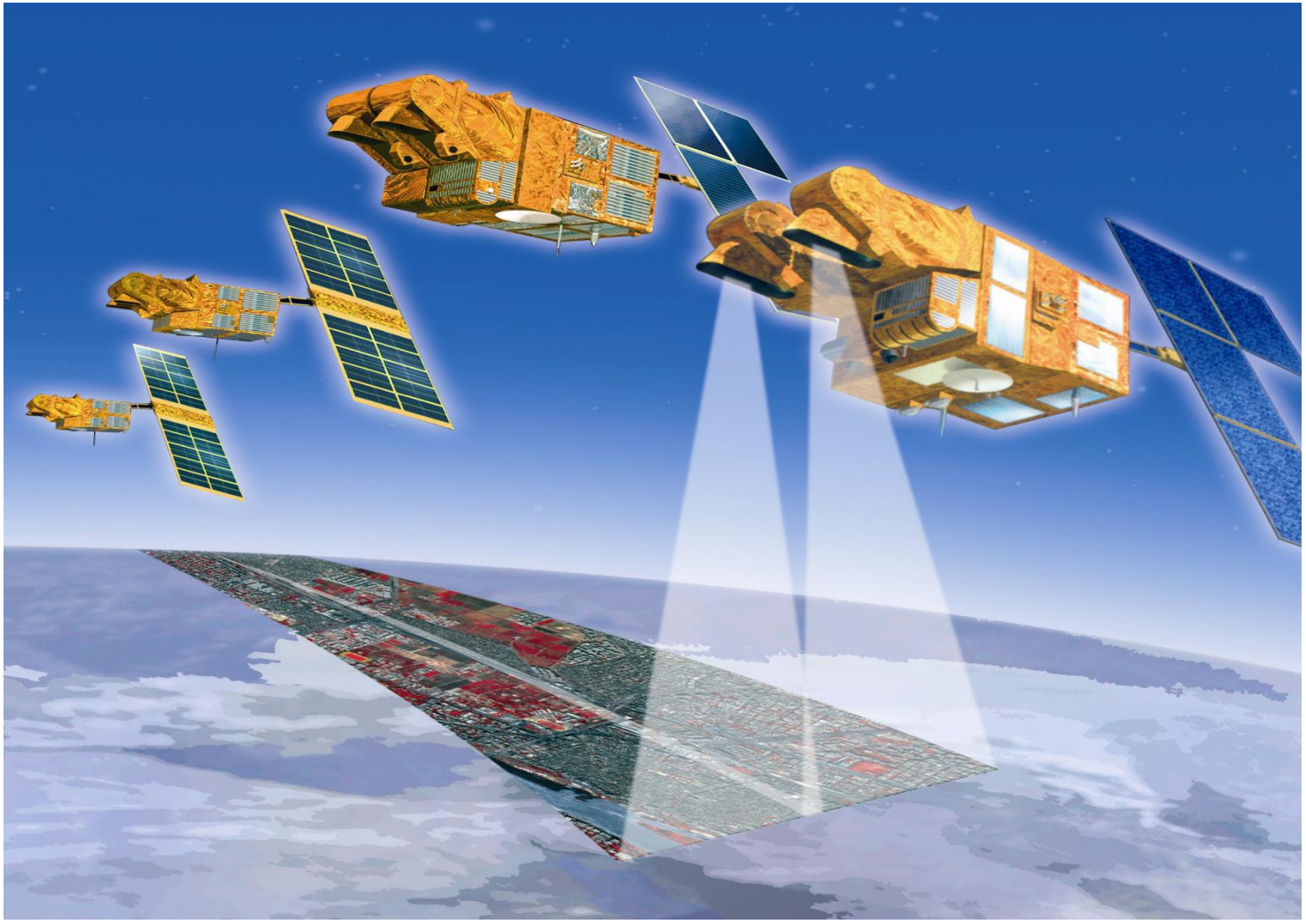
IKONOS

11 by 11 km
4-m multispectral

OrbView 3

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

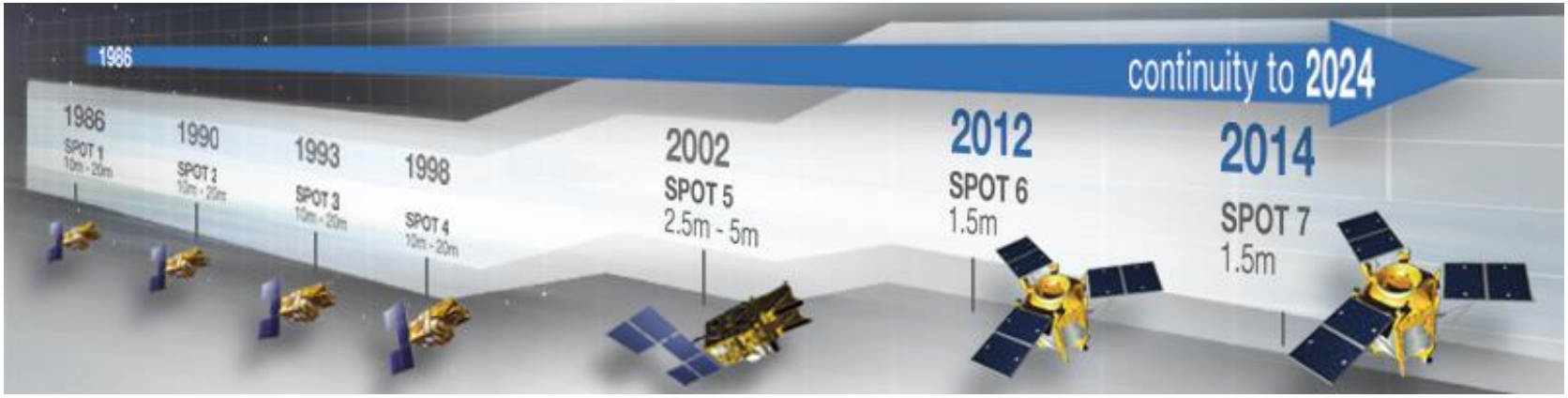
SPOT (Système Pour l'Observation de la Terre)



Earth Observation Satellites

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

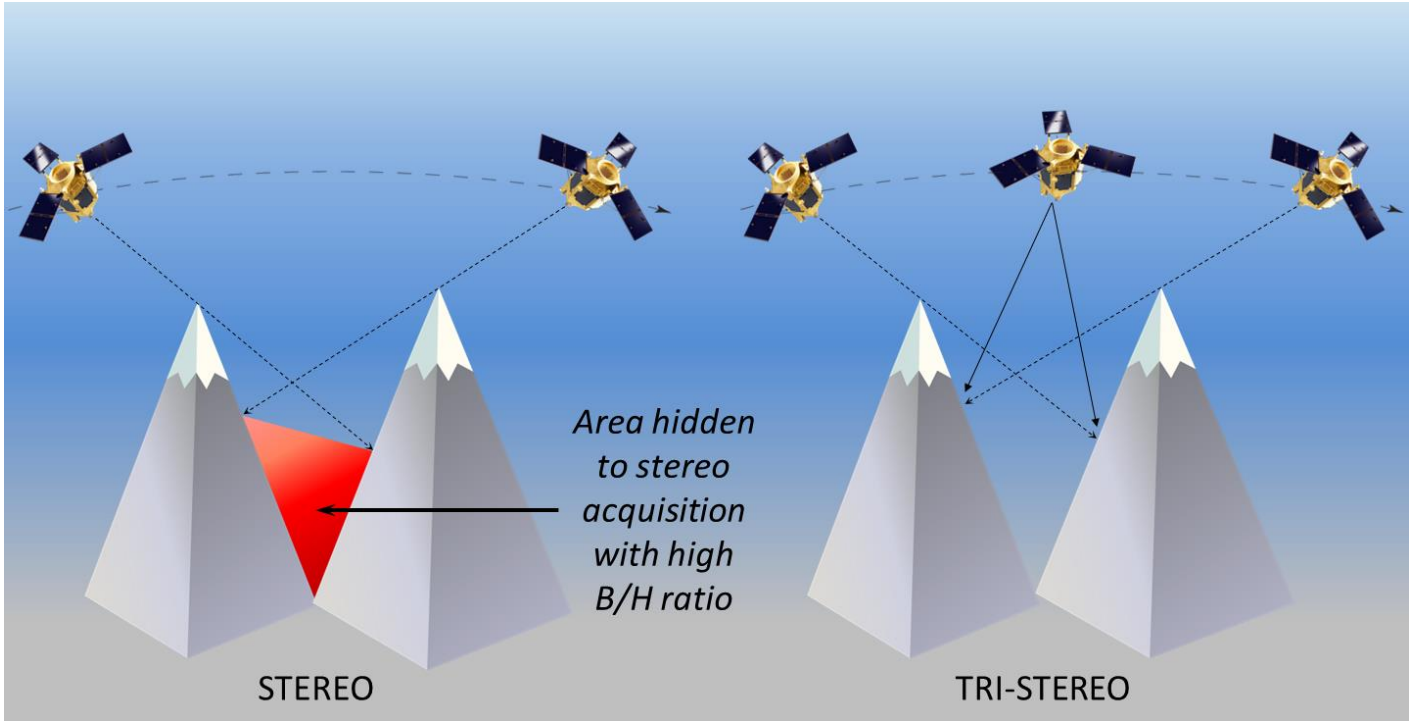
SPOT – Stereoscopy

	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 (± 20°)		
Absolute location accuracy (no ground control points, flat terrain)	10 m (1 σ)*	30 m (1 σ)*	350 m

HRS (High-Resolution Stereoscopic imaging instrument)

Multispectral Missions

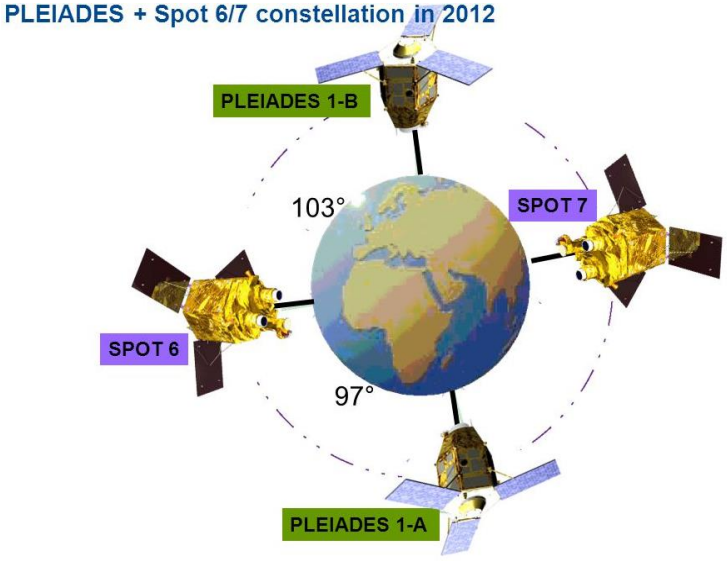
Both SPOT and Pleaides have **stereoscopic image acquisition capability** along the track (forward/backward): along-track stereo pairs and stereo triplets.



Earth Observation Satellites

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



Earth Observation Satellites

	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

SPOT 6

SPOT-6 Satellite Sensor Specifications

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

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

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

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

6 tasking plans per day

Several weather forecasts per day to optimize tasking

Each tasking plan covers 24 hours

Up to 750 scenes per day per satellite

SPOT 6 & 7

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

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

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

- Daily revisits everywhere

SPOT 5 – Imagem 2.5 m


SPOT 6 Satellite Image - Doha, Qatar © 2012 Astrium Services/Spot Image, Distribution Astrium Services/Spot Image, France, all rights reserved.
www.satimagingcorp.com

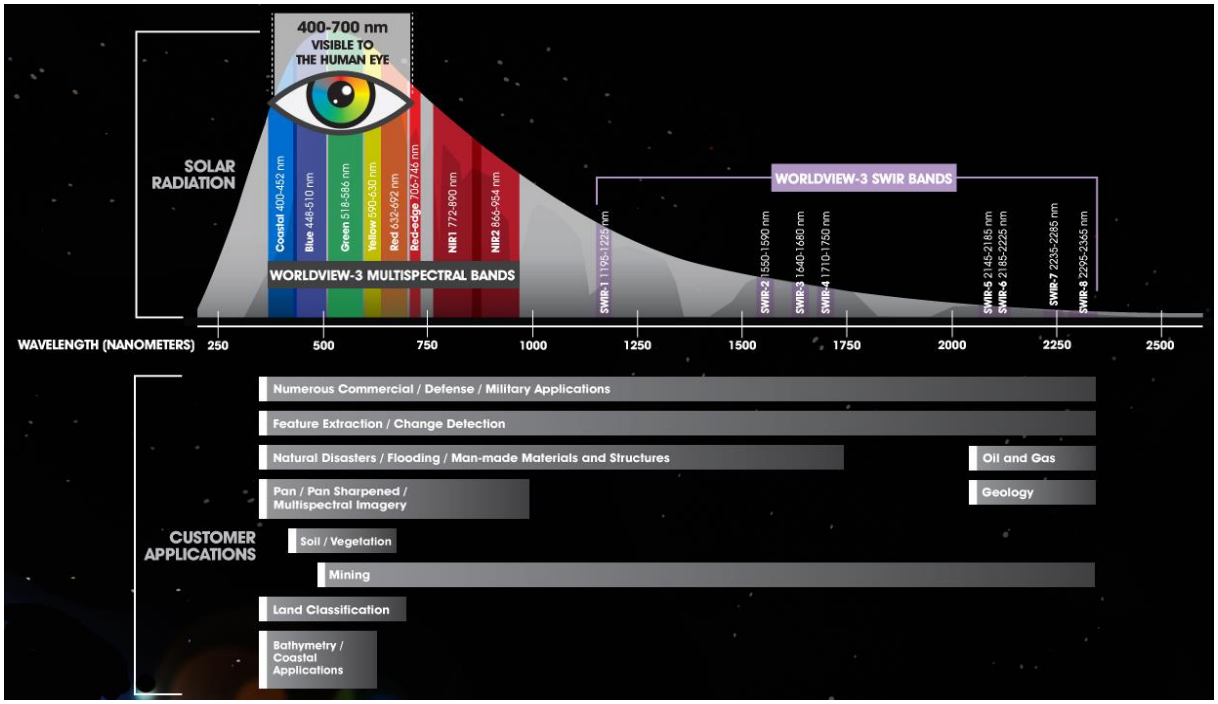
SPOT – Imagem 5 m

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.

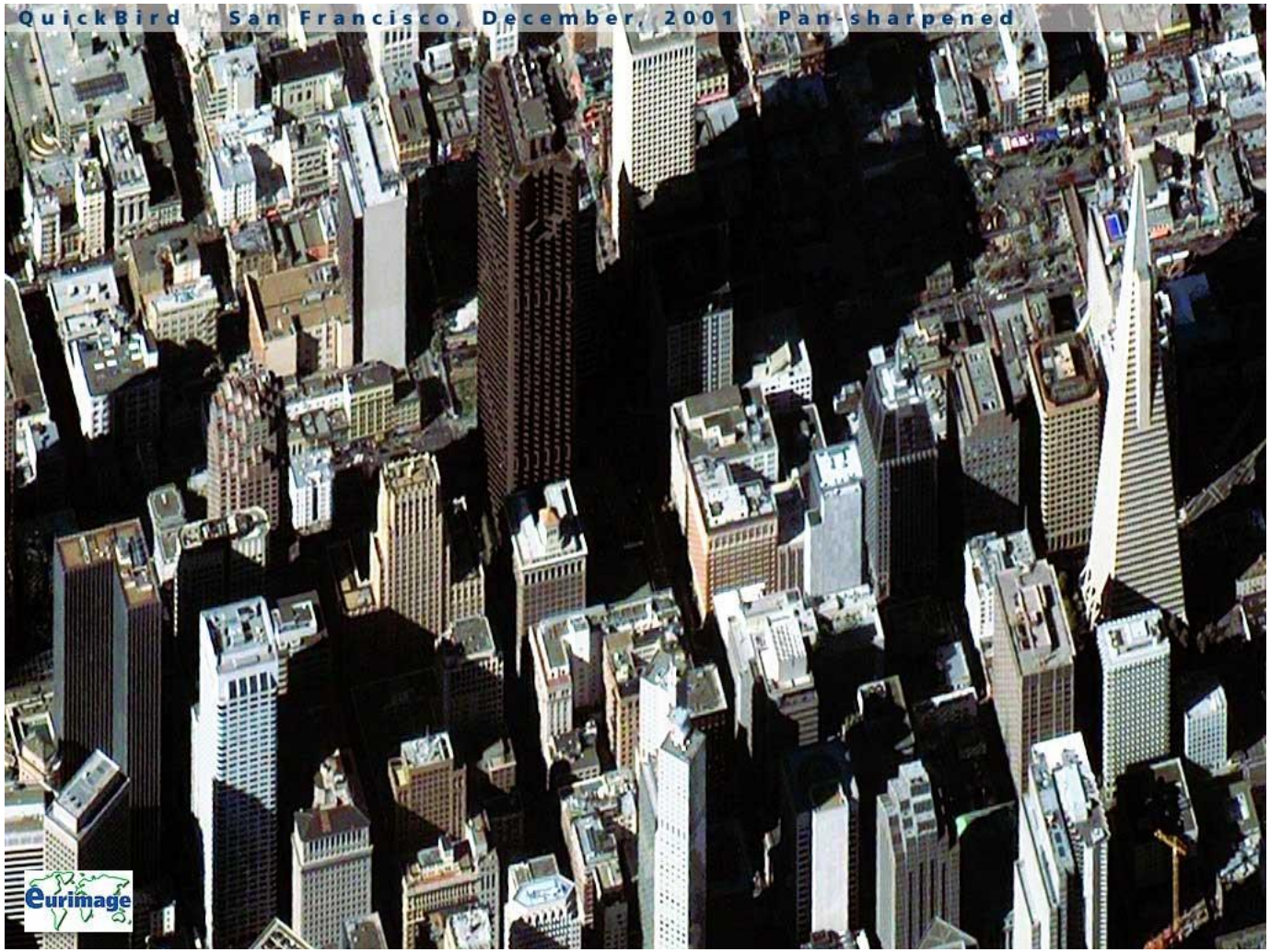


- GeoEye-1 (0.46m)
- GeoEye-2 (0.34m)
- WorldView-1 (0.46m)
- WorldView-2 (0.46m)
- WorldView-3 (0.31m)
- Pleiades-1A (0.5m)
- Pleiades-1B (0.5m)
- KOMPSAT-3A (0.55m)
- KOMPSAT-3 (0.7M)
- QuickBird (0.65m)
- IKONOS (0.82m)
- SkySat-1 (0.9m)
- SkySat-2 (0.9m)
- TripleSat (1m)
- TerraSAR-X
- SPOT-6 (1.5m)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

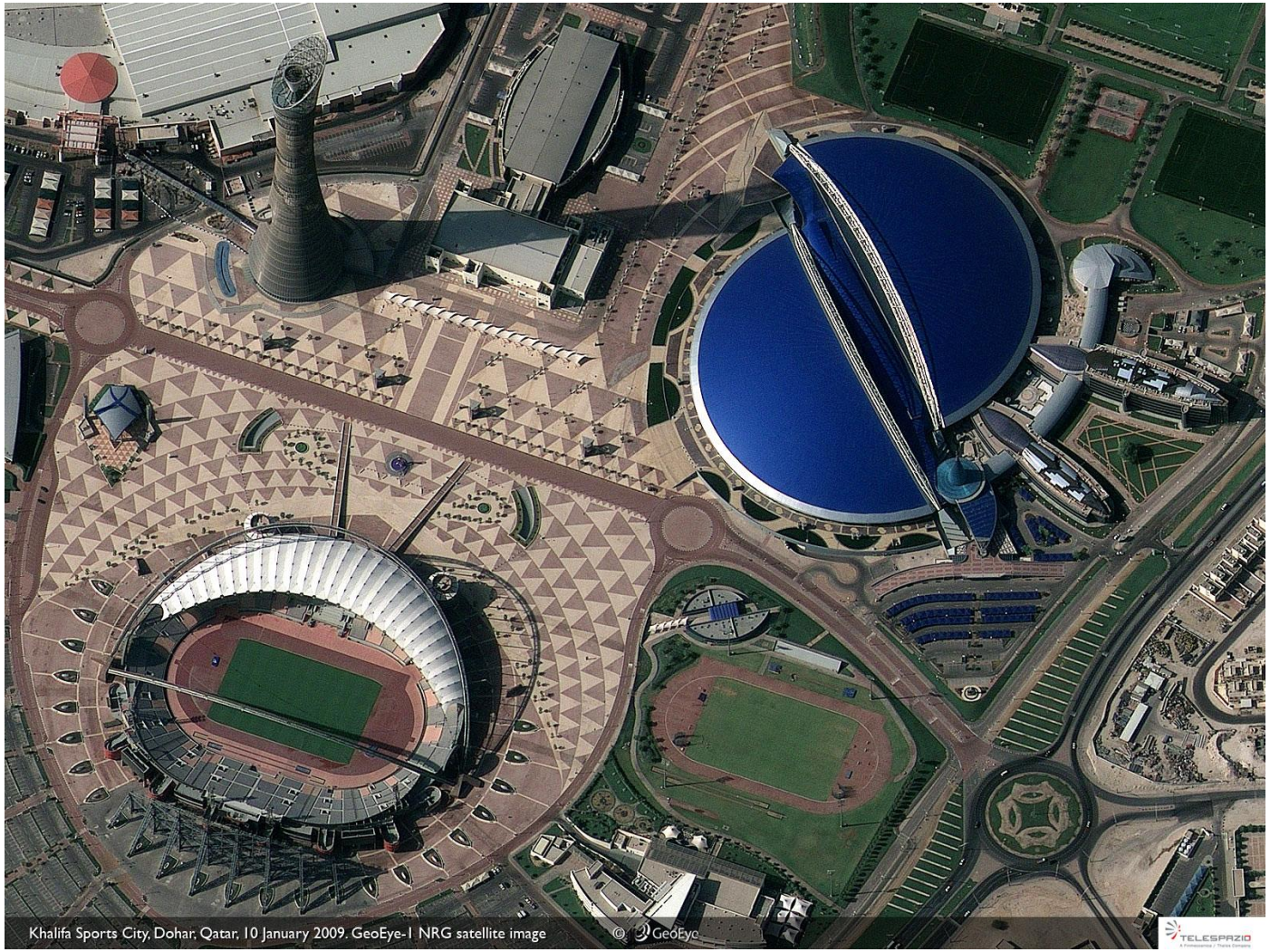
Ciências
ULisboa

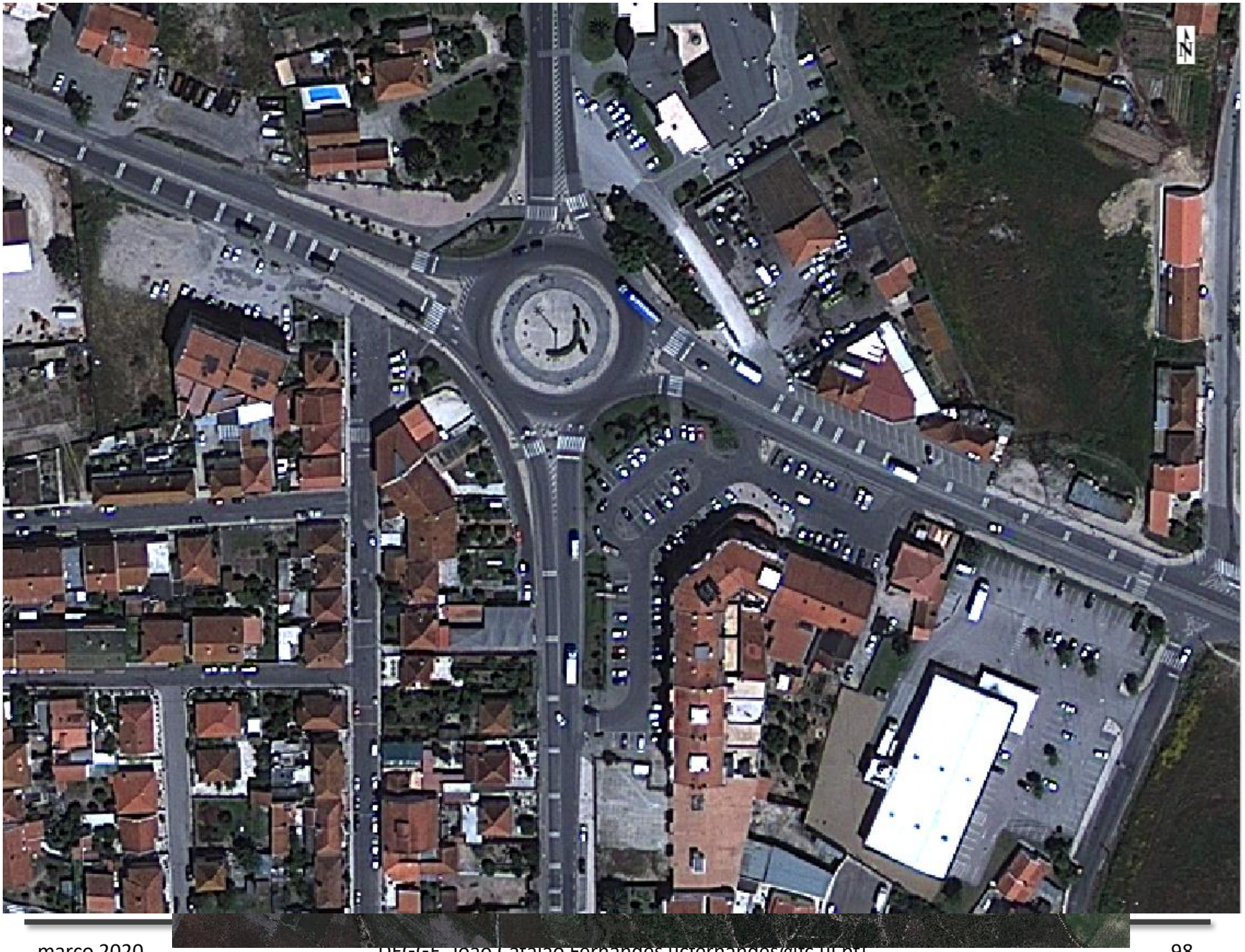
QUICKBIRD

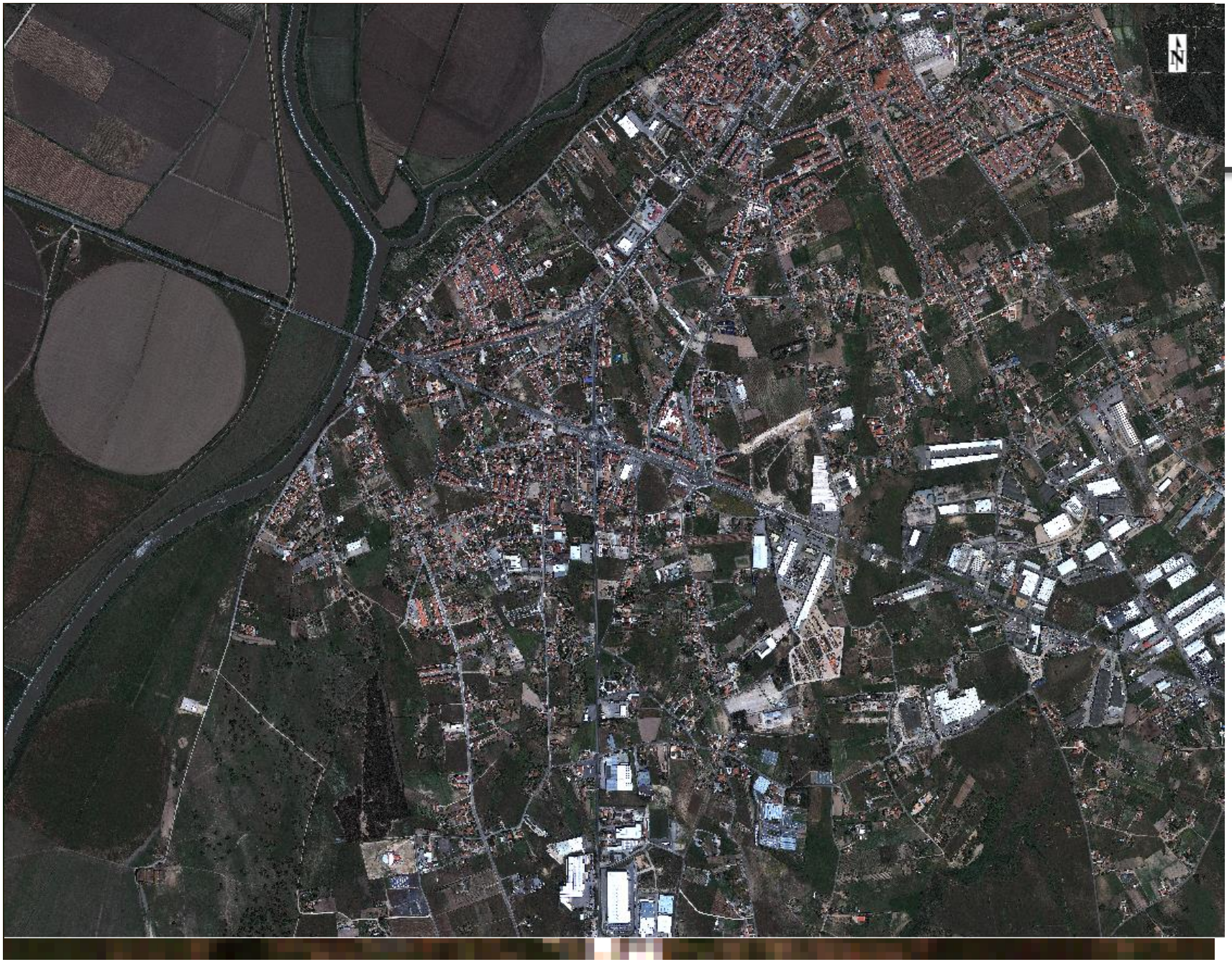
QUICKBIRD


QuickBird San Francisco, December, 2001 Pan-sharpened
Eurimage

GeoEye


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

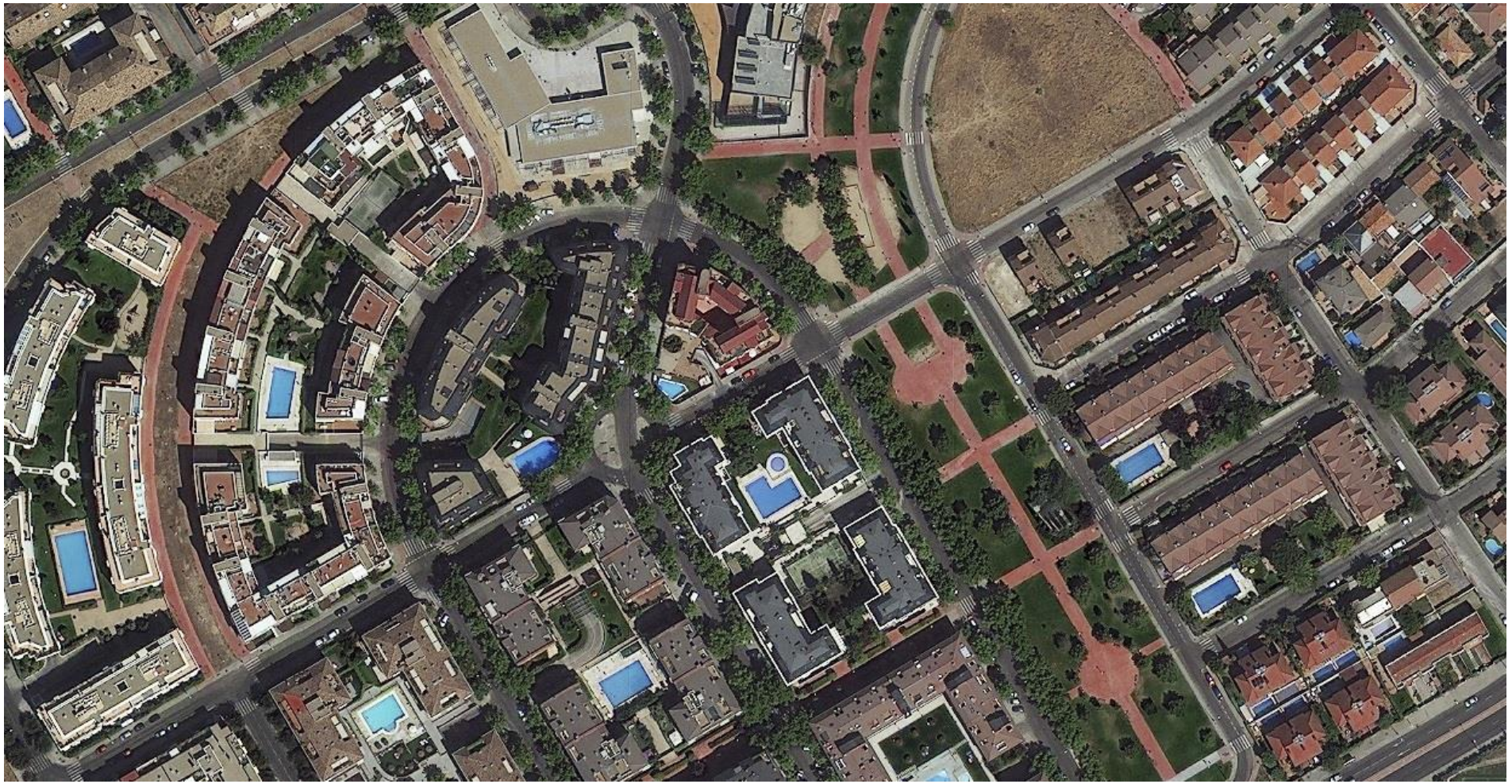




Ciências ULisboa

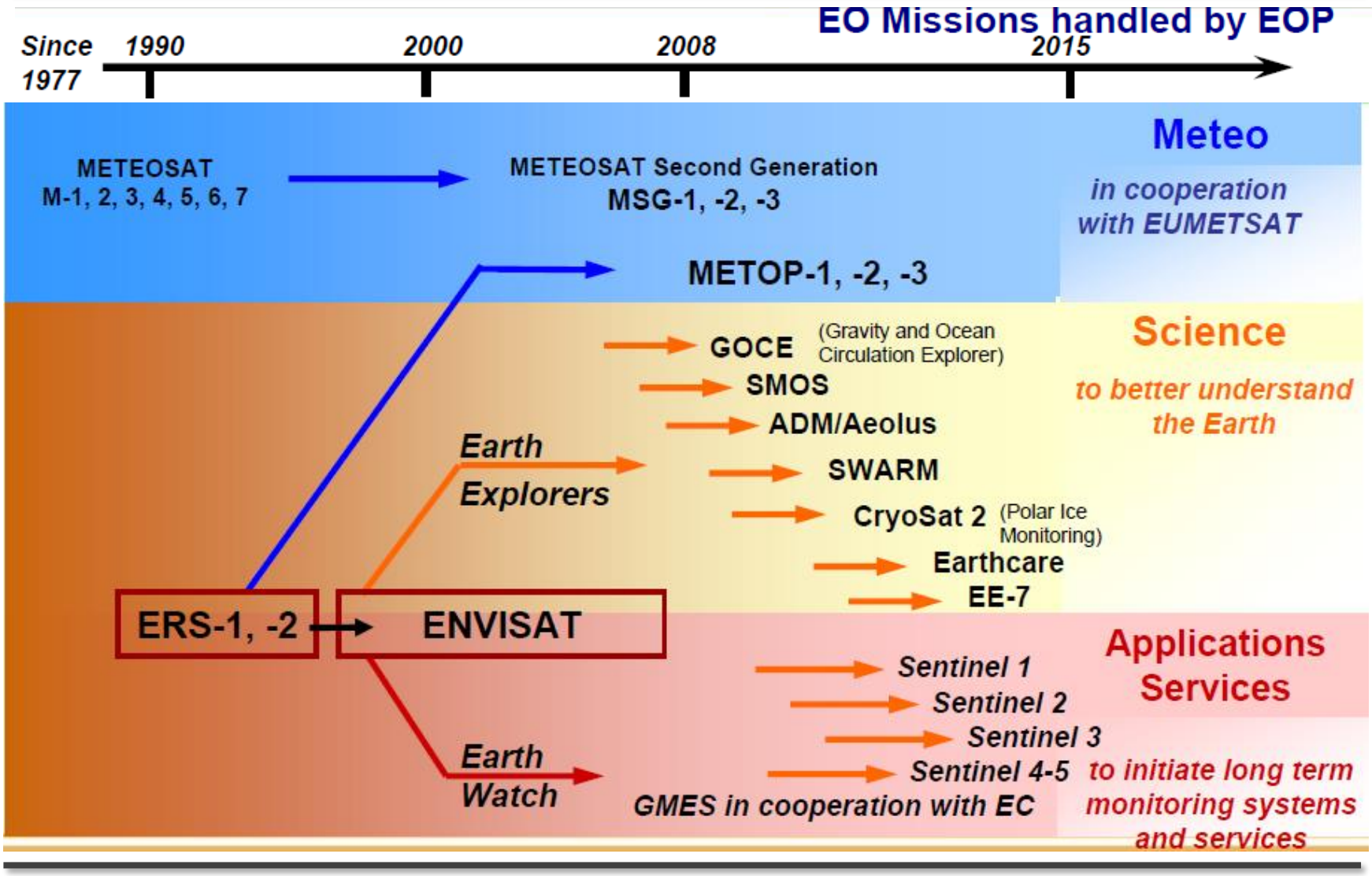
Worldview

8 bandas, 0.31 / 1.24 m

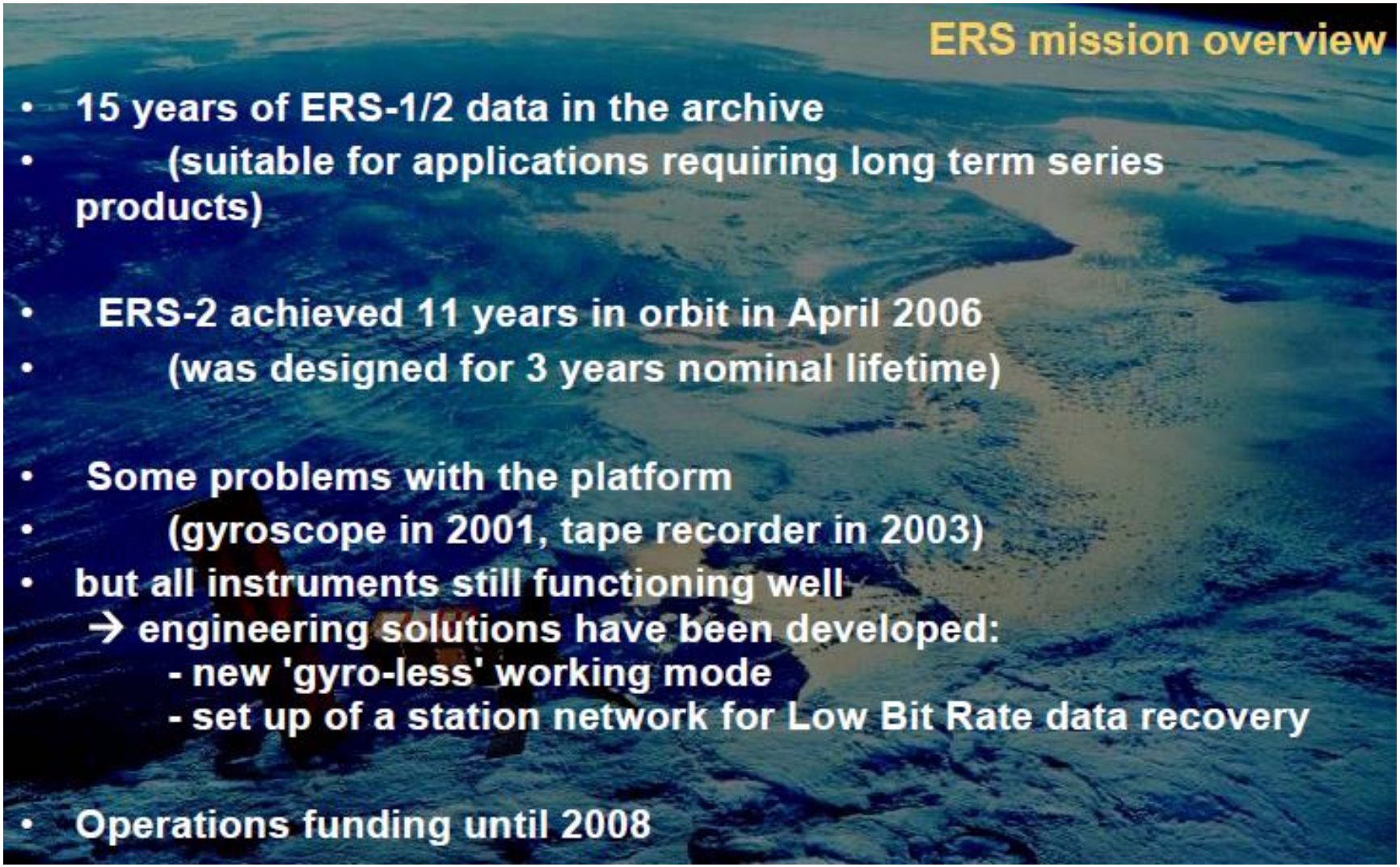



Worldview
2m
N

ESA Missions



ERS mission (European Remote Sensing)

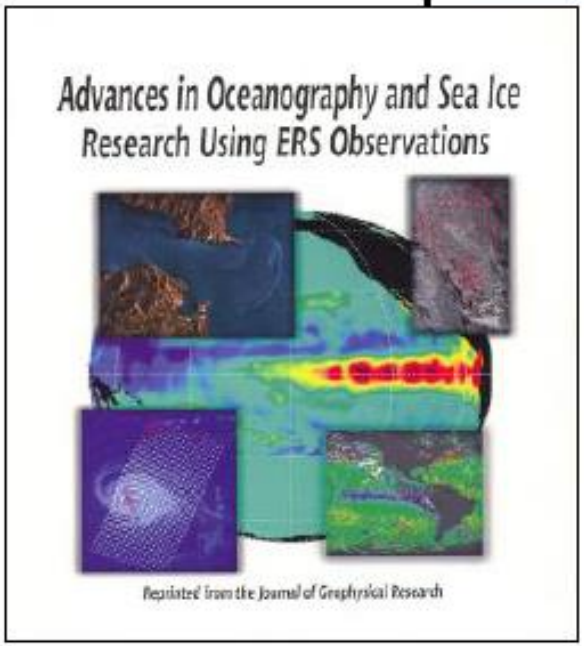


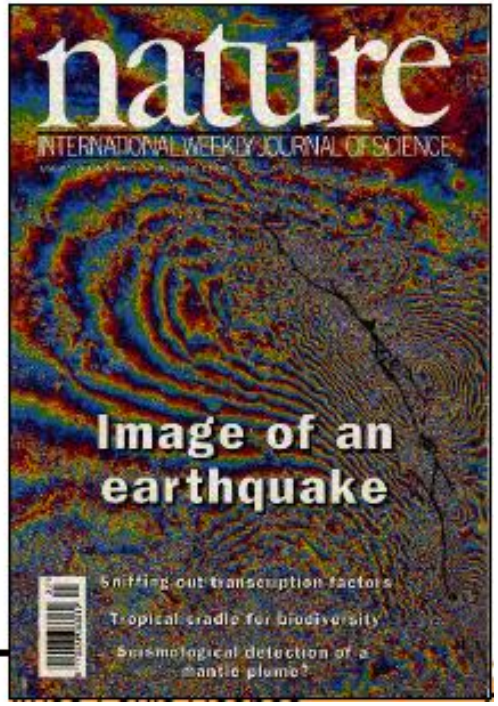
ENVISAT Mission

ERS missions - Science

ERS and Volcanic activities

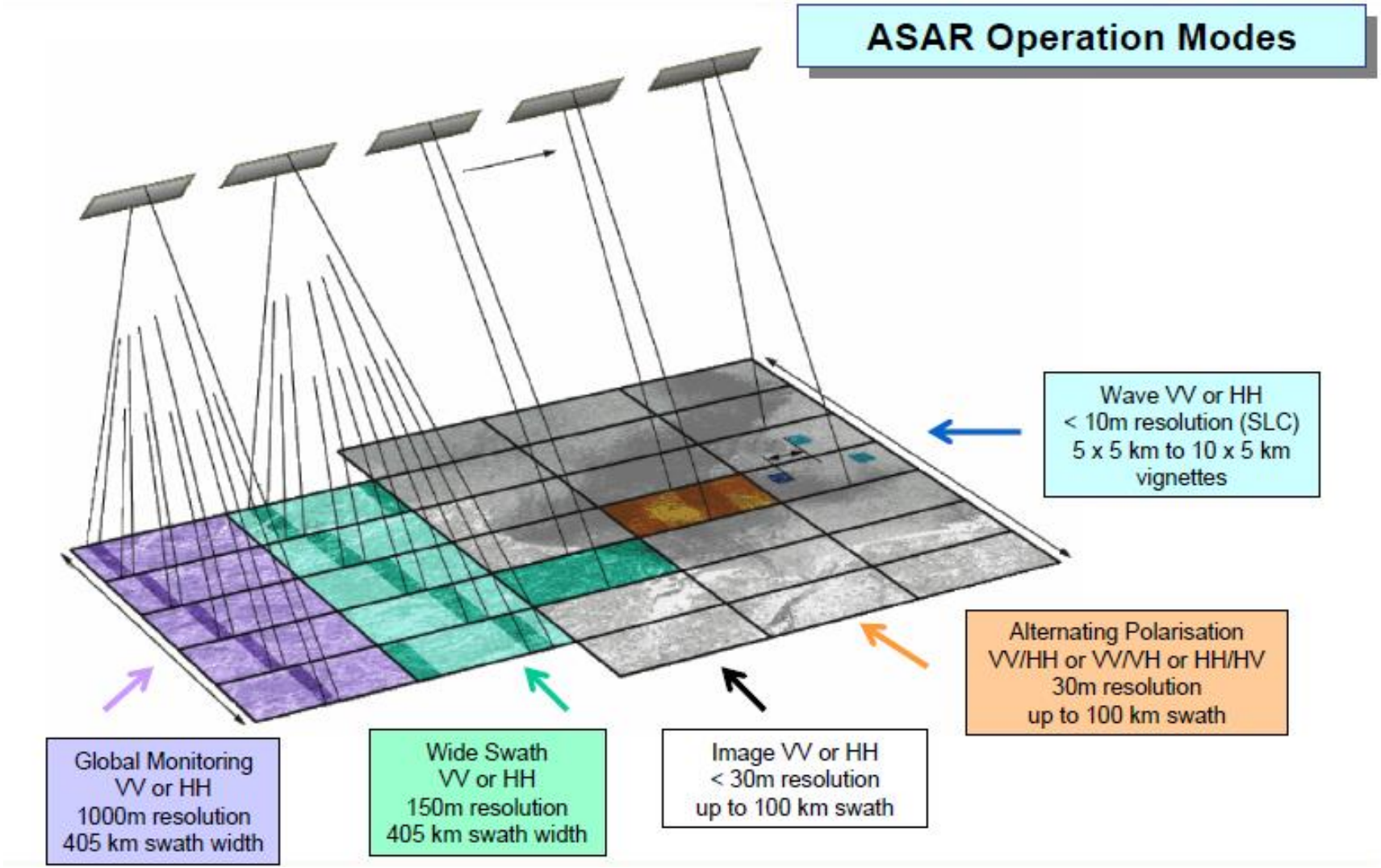
Oceanography and sea Ice





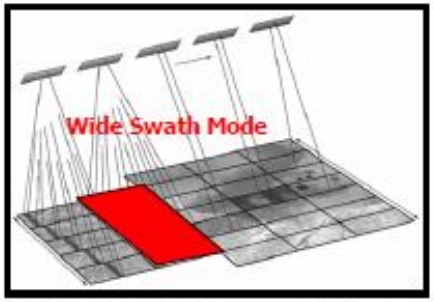
ERS and SAR Interferometry

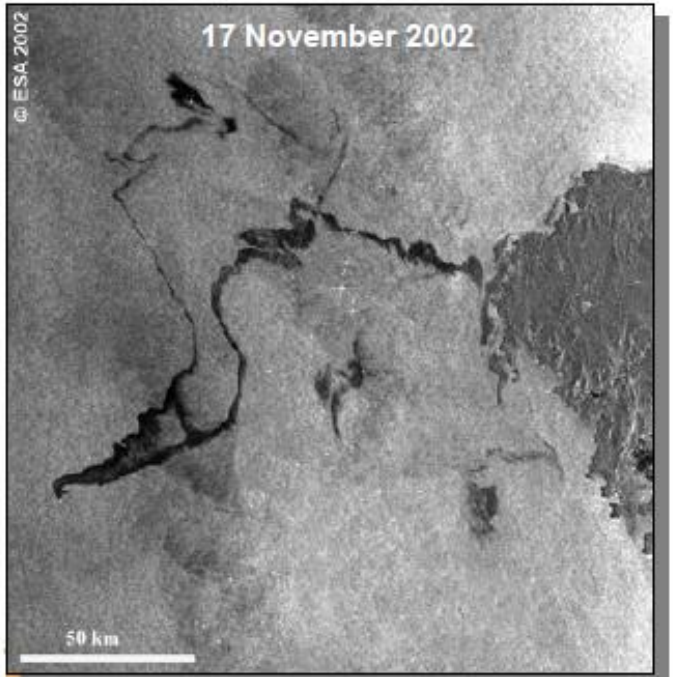
ENVISAT - ASAR



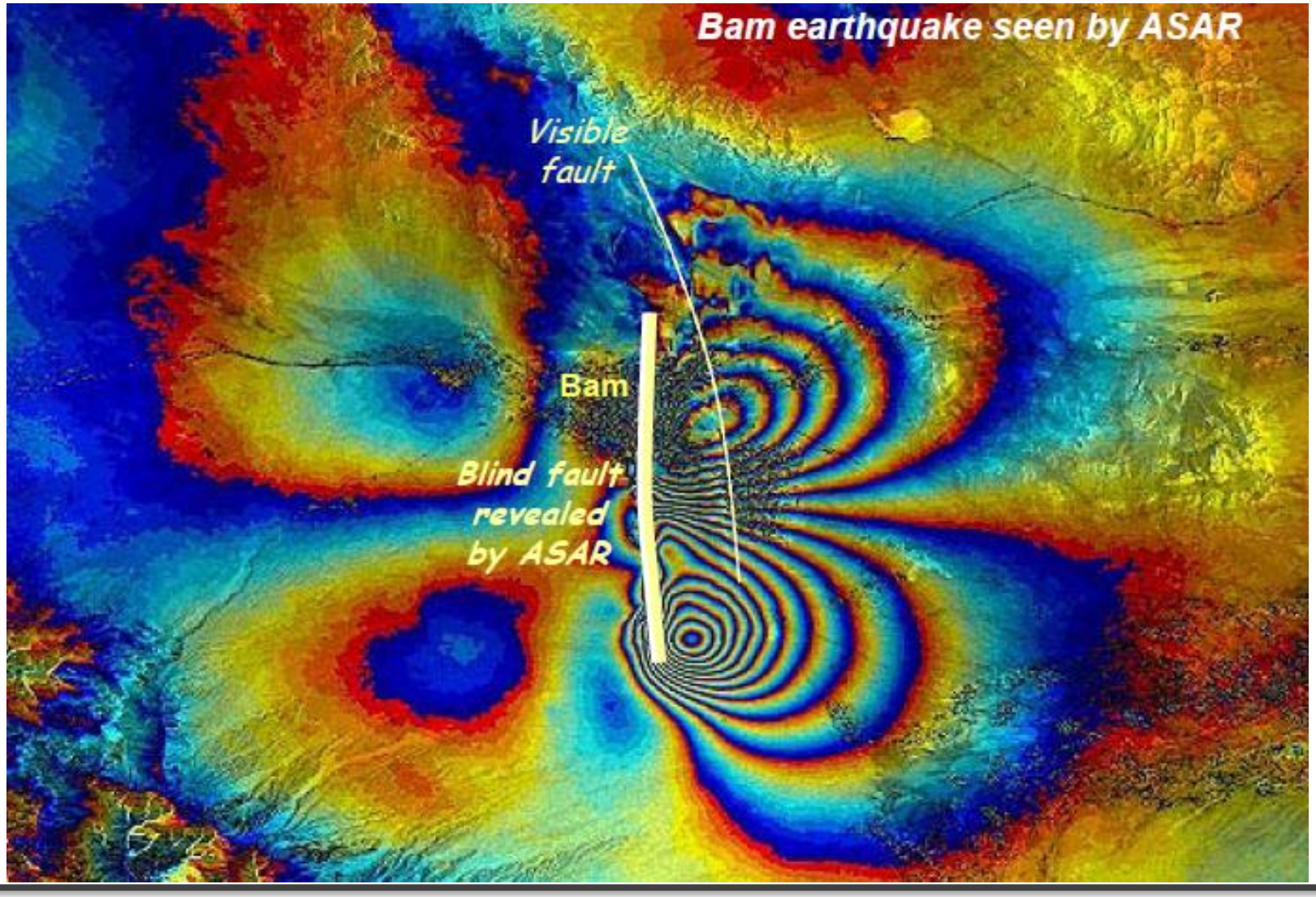
ENVISAT - ASAR

ENVISAT Imaging Radar





ENVISAT - ASAR



ESA – Earth Explorers

Earth Explorers – Core Missions

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

GOCE

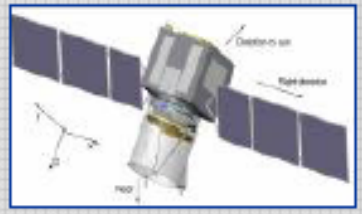
Earth gravity field and Geoid measurements

Launch: 2007

ADM-Aeolus

Windspeed vectors measurements

Launch: 2009



EarthCARE

Clouds, Aerosols & radiation measurements

Launch: 2012+

ESA – Earth Explorers

Earth Explorers – Opportunity Missions

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

SMOS

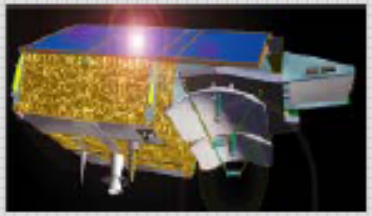
Soil moisture and ocean salinity measurements

Launch: 2008

Cryosat-2

Ice elevation and ice thickness measurements

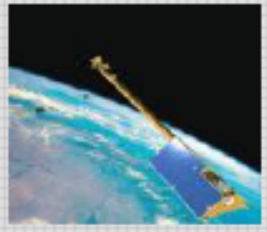
Launch: 2009



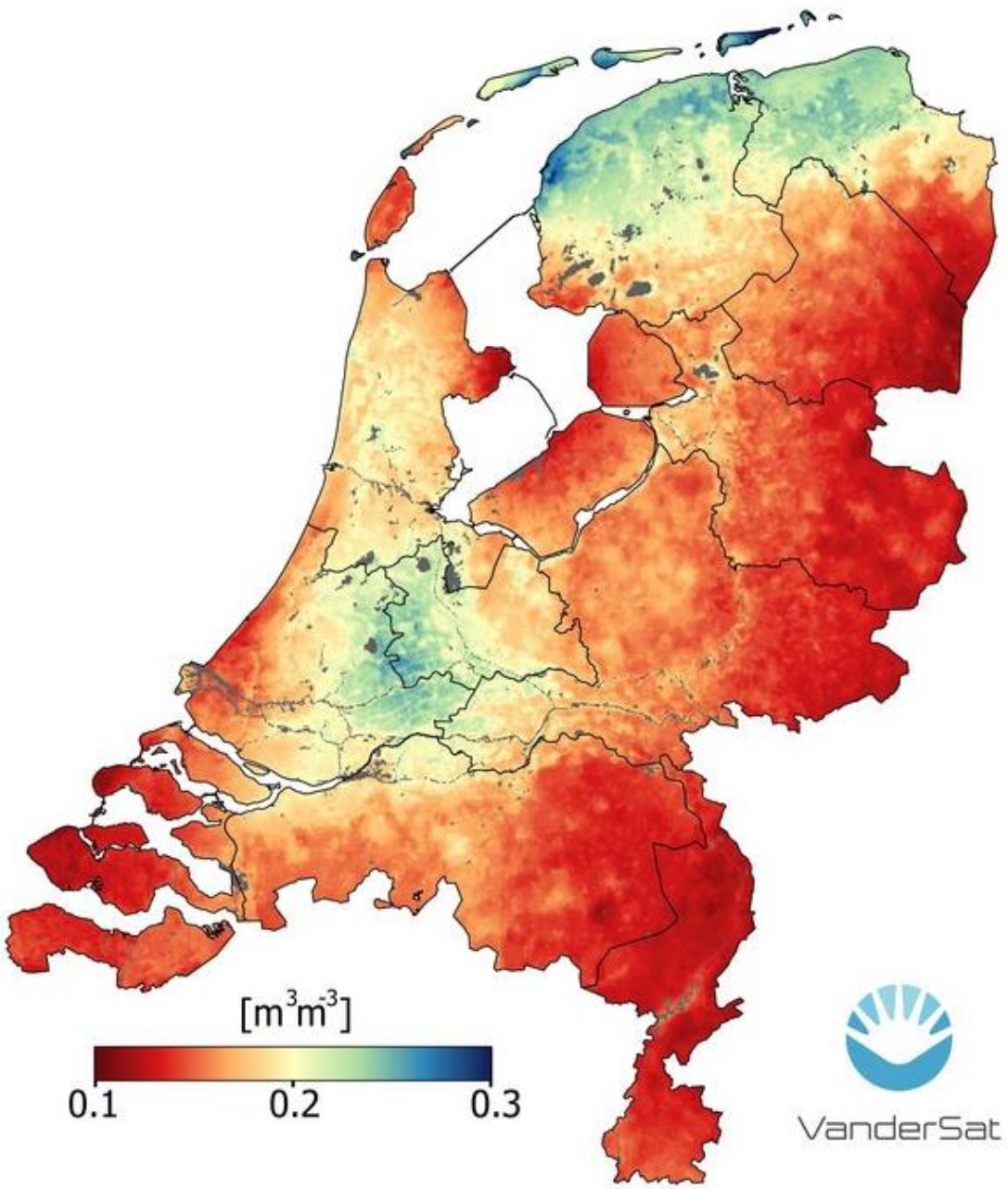
SWARM

Earth magnetic field & Earth core dynamics meas.

Launch: 2009+



Ciências ULisboa



re the
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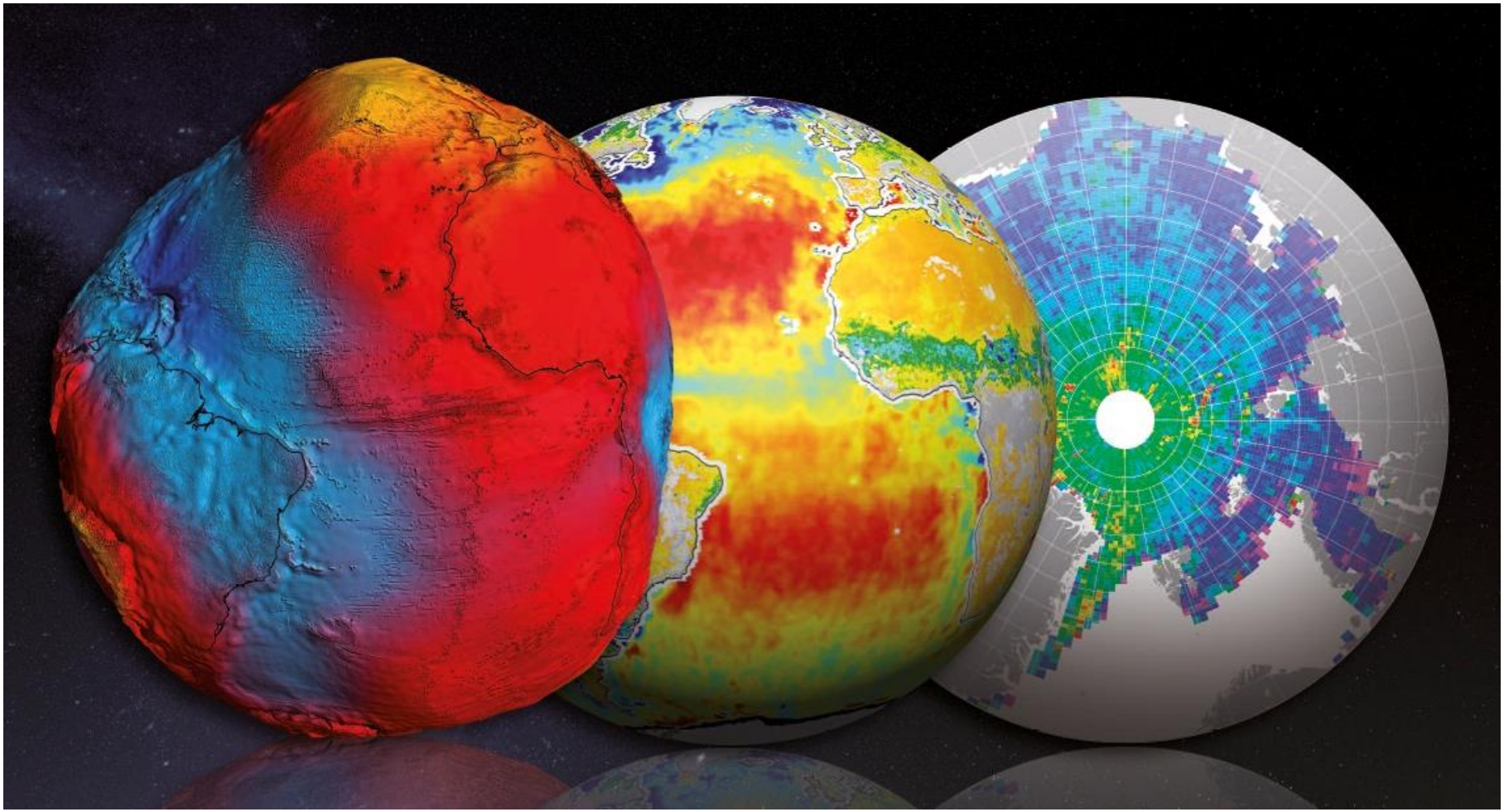
Earth Explorers (ESA)



GOCE SMOS CryoSAT

GMES

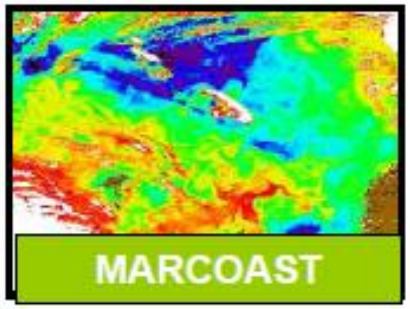
Global Monitoring for Environment and Security (GMES)

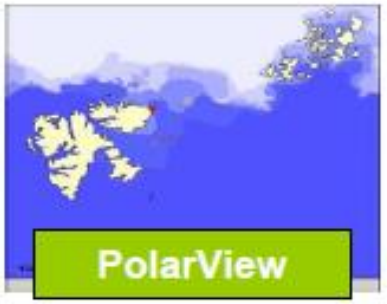
European autonomy in data sources for environment and security monitoring

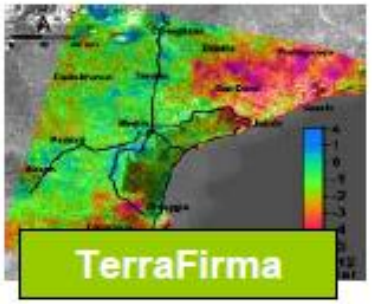
and

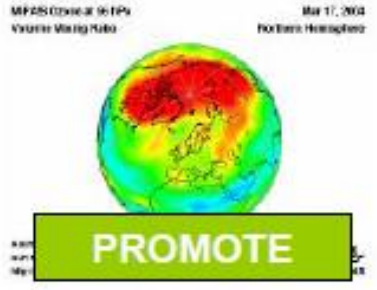
The European contribution to the Global Earth Observation System of Systems (GEOSS)

GMES - Services









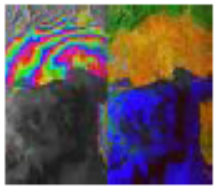
100 M€ by ESA MS

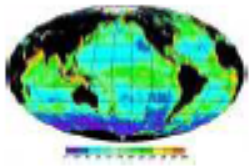
Period 2003-2008 (2009)

300+ user organisations

EC has invested another 100 M€

GMES – Componente Espacial



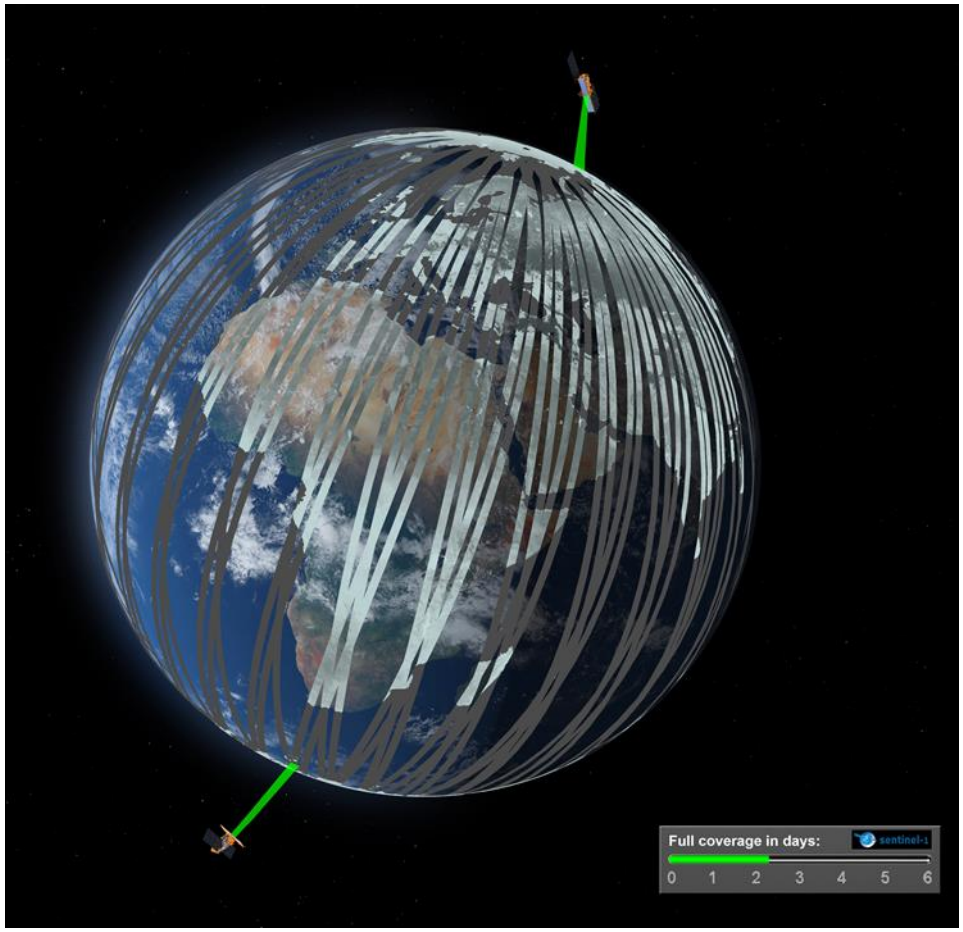


- **Sentinel 1 – SAR imaging**
  - All weather, day/night applications, interferometry, ocean/ice/land
- **Sentinel 2 – Superspectral imaging**
  - Continuity of Landsat, SPOT - type of data for land mapping
- **Sentinel 3 – Ocean monitoring**
  - Wide-swath ocean color, surface temperature and land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

Sentinel -1

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

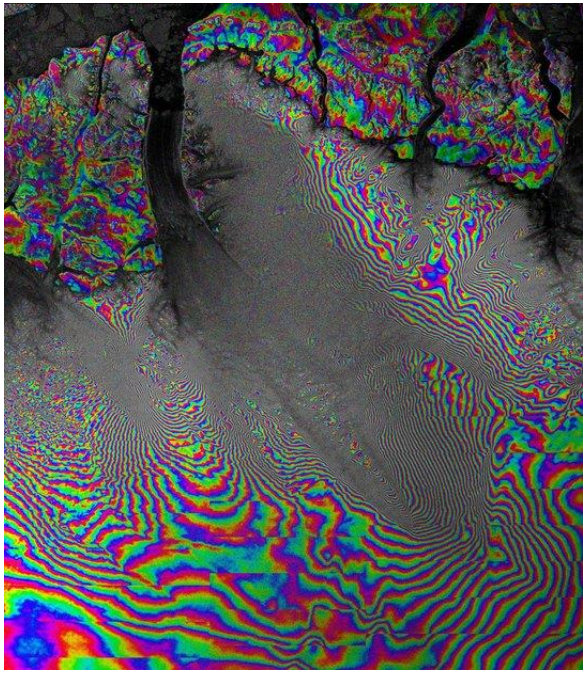
At the equator, however, the repeat frequency is just three days and less than one day over the Arctic. Europe, Canada and main shipping routes are covered in less than three days.



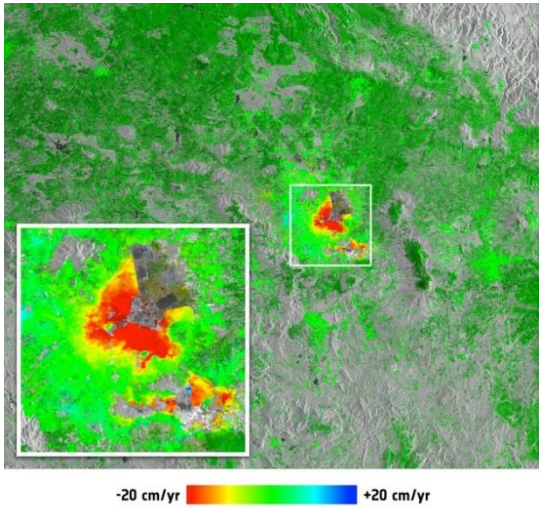
Sentinel -1

Aplicações

Oceano e Gelo



Changing lands



Emergency response

Sentinel -1

Visão Radar

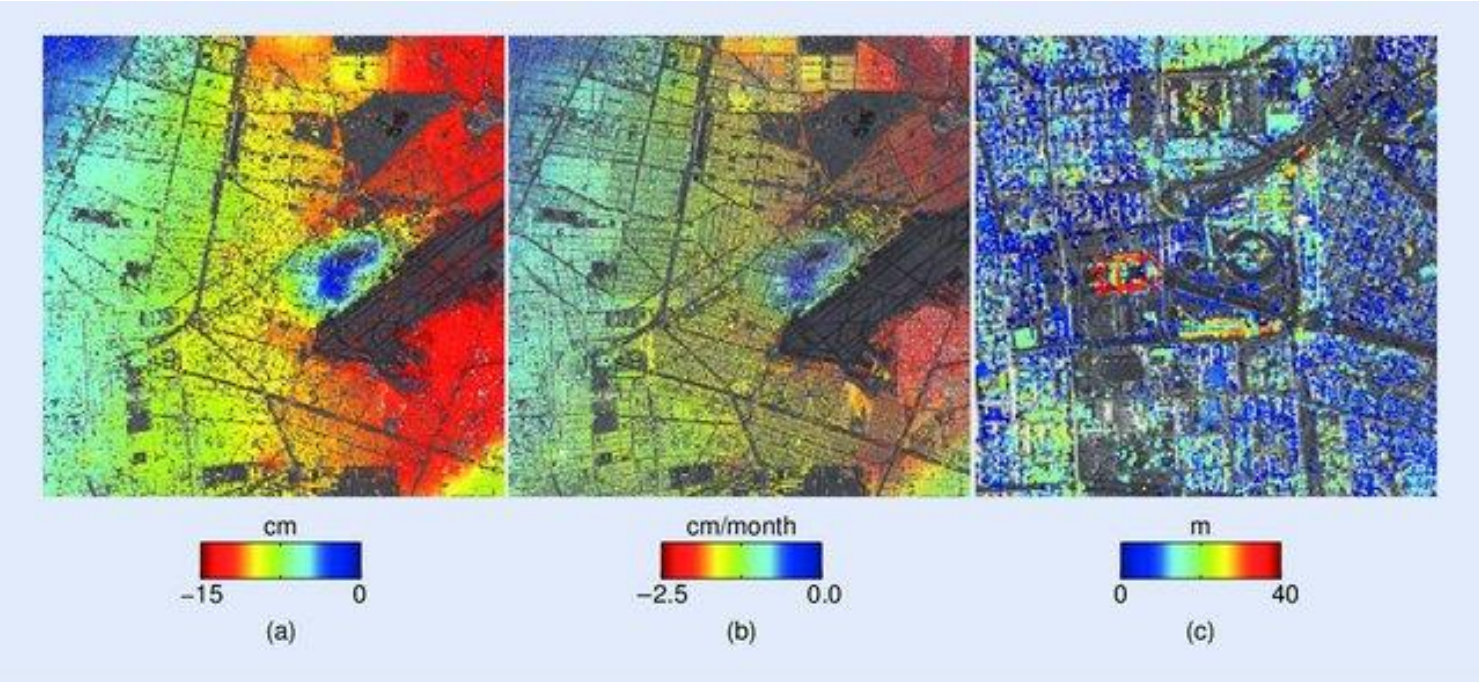
The radar operates in two main modes: Interferometric Wide swath and Wave.

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

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

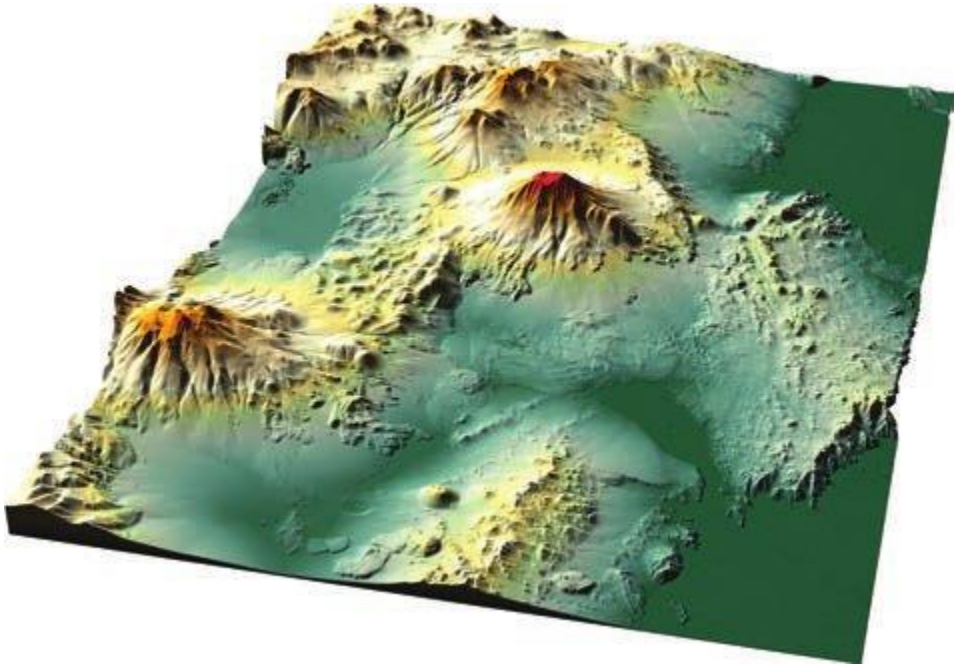
There's also the potential for operating it in two additional modes: Stripmap (5m x 5m) and Extra Wide Swath 20mx 40m).

Sentinel -1

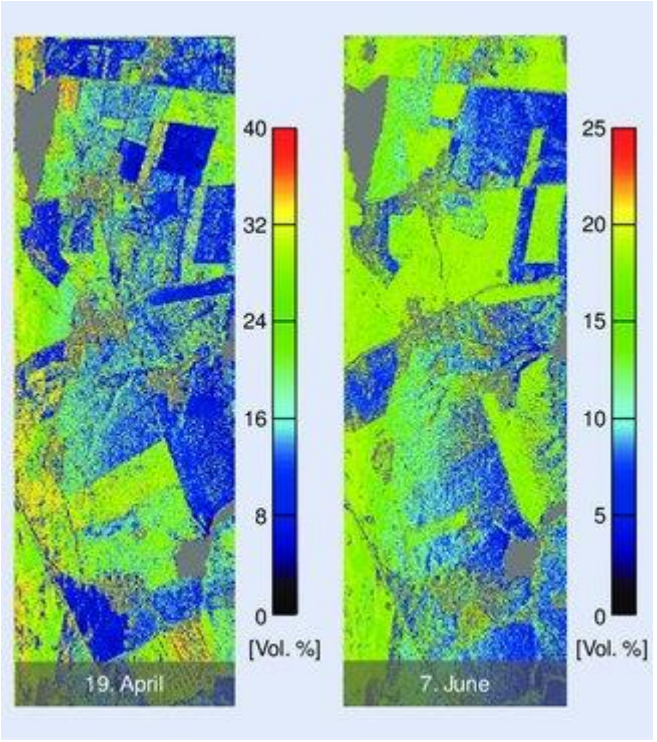


(a) **Estimated subsidence** over Mexico City obtained with two TerraSAR-X images acquired with a 6-month difference (overlay of reflectivity and phase). Low coherence areas have been masked out. (b) **Mean deformation velocity** estimated over Mexico City using the PS technique. (c) Zoom over the city of the **refined DEM** retrieved as an additional product to the deformation velocity, where the individual buildings can be observed.

Sentinel -1



Geocoded digital elevation model (DEM) derived from the unwrapped interferometric phase



Soil moisture maps obtained after applying a model-based polarimetric decomposition to remove the vegetation layer and inverting the remaining ground component.

Sentinel -2

Copernicus 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.

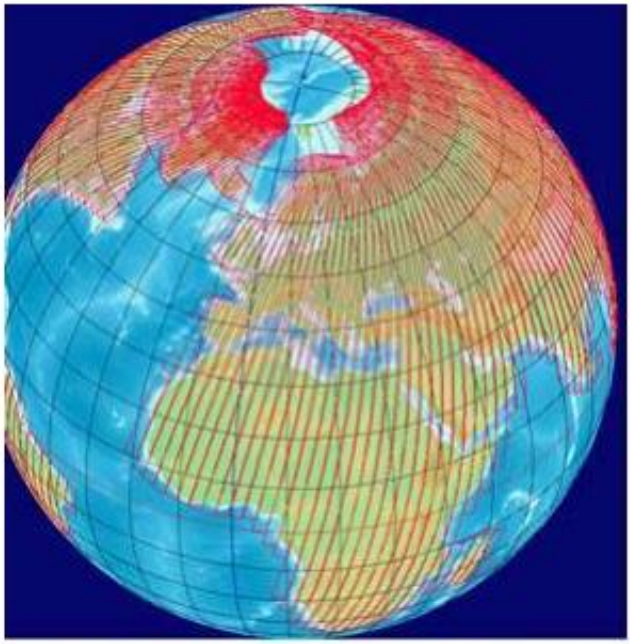
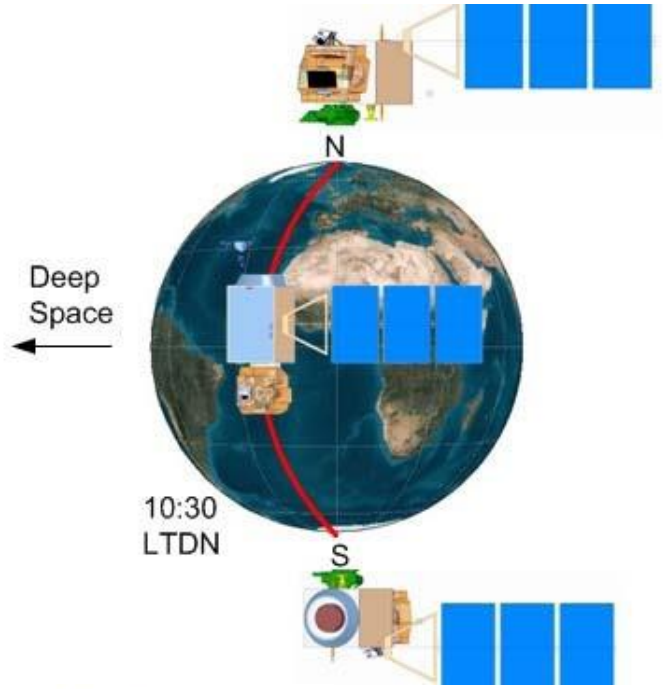


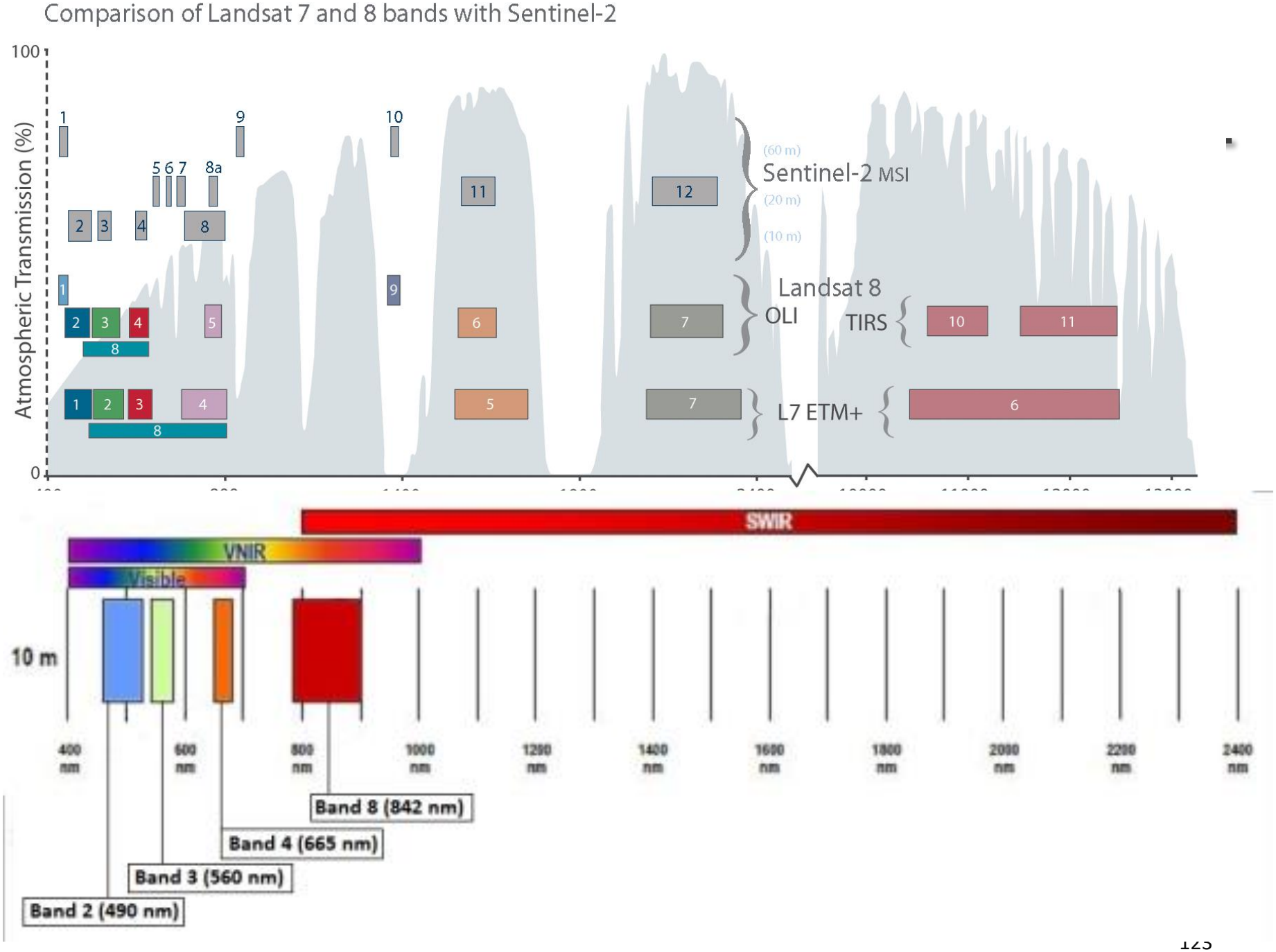
Figure 22: Modelled Sentinel-2 Coverage

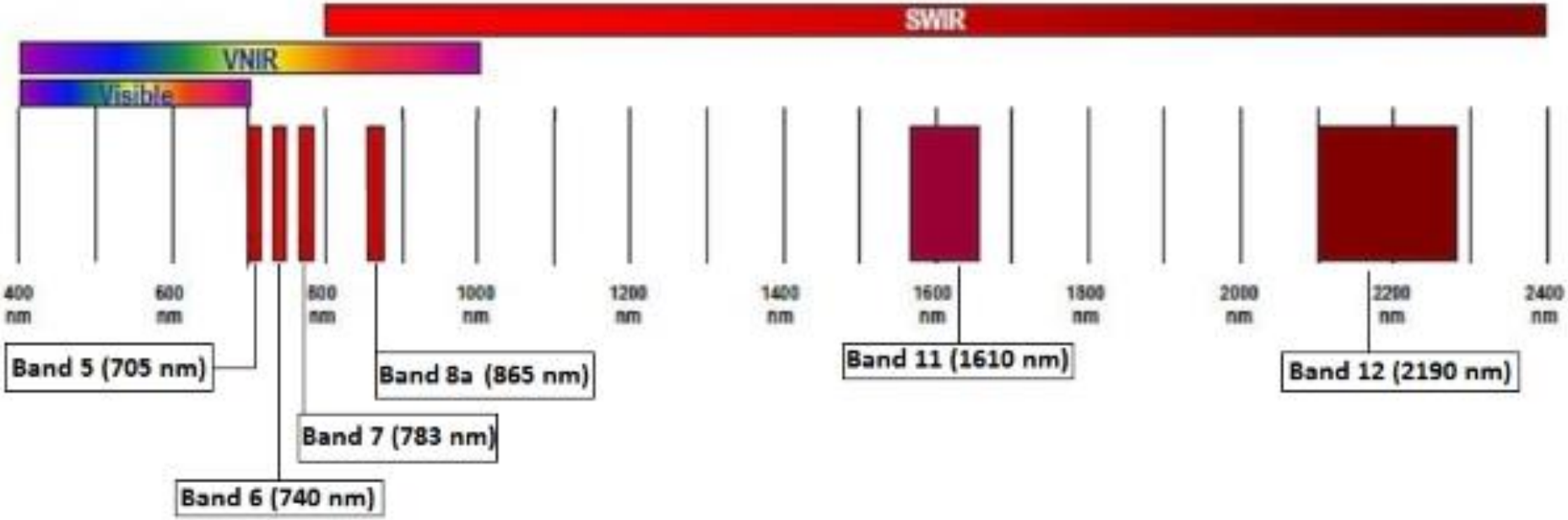
Sentinel -2

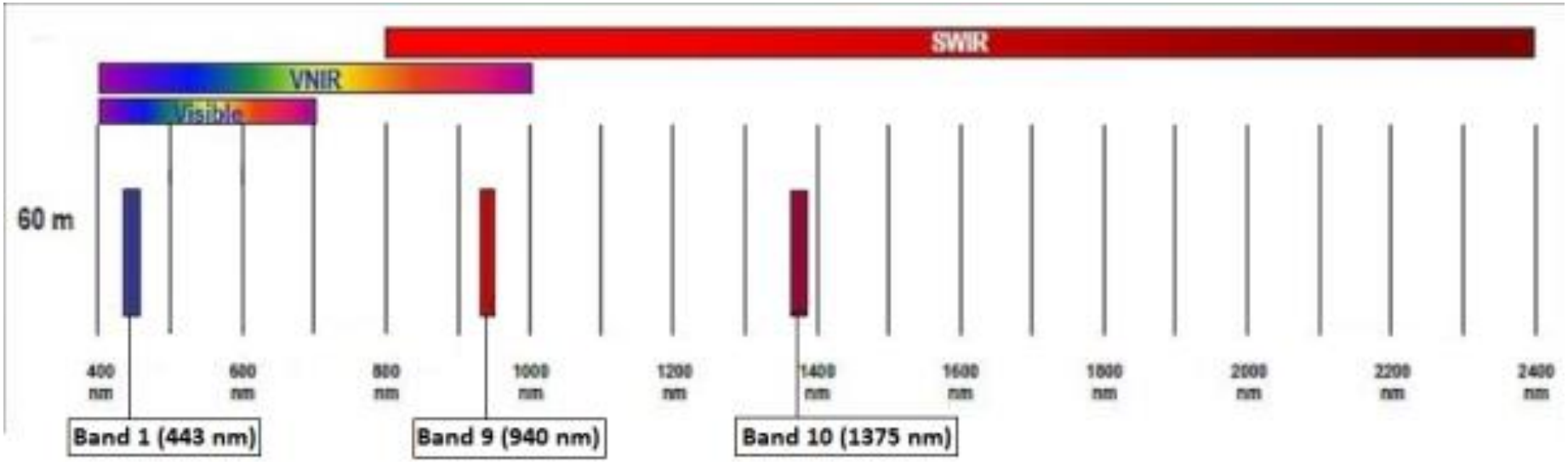
The **Sentinel-2** satellites are placed in the same sun-synchronous orbit, phased at 180° to each other, at an altitude of 786 km and an inclination of 98.5 degrees for 14.3 revolutions per day and a 10:30 Local Time of Descending Node that has been chosen to minimize cloud cover and ensure a good solar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

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

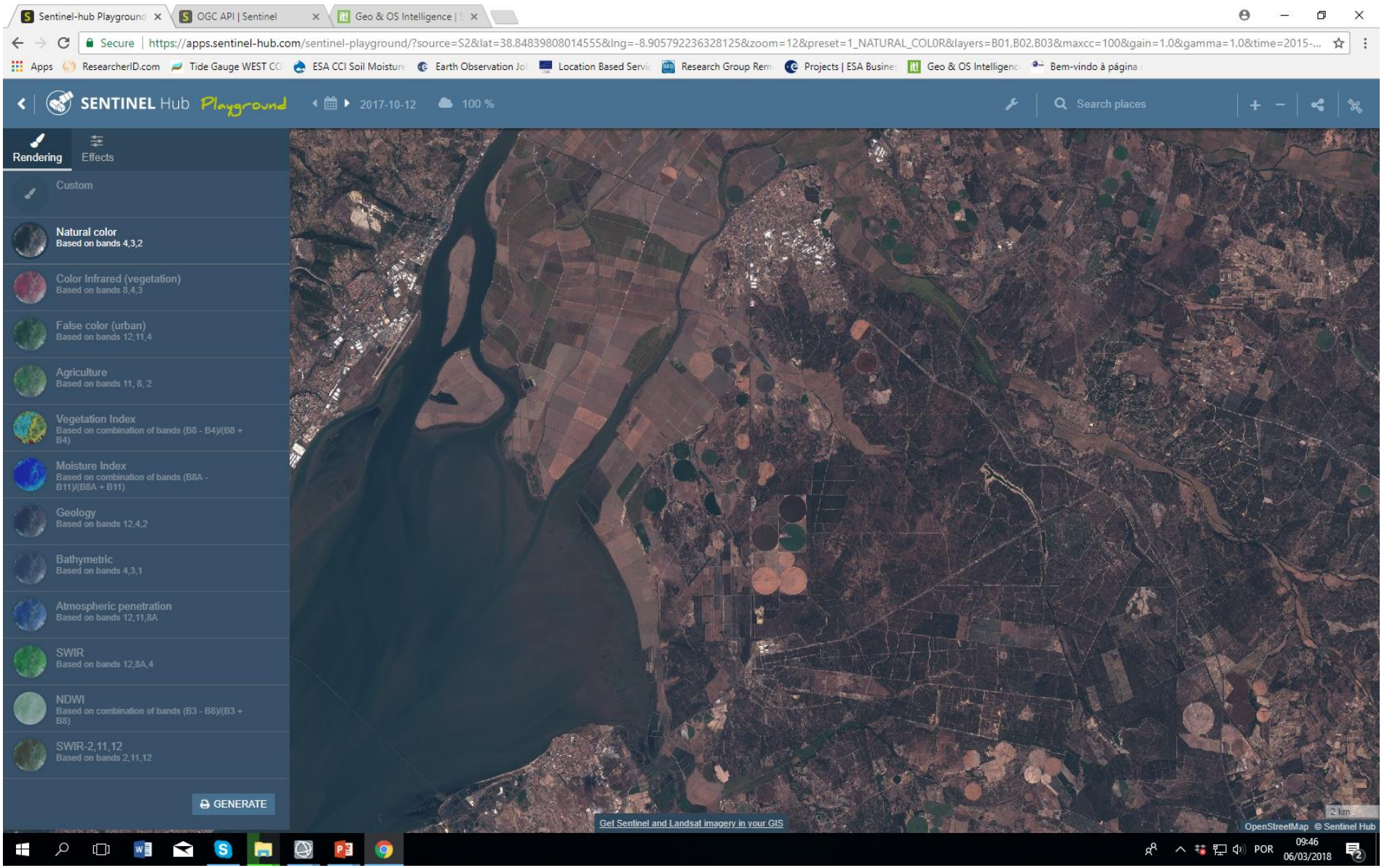



Comparison of Landsat 7 and 8 bands with Sentinel-2
Atmospheric Transmission (%)
100
0
Sentinel-2 MSI
(60 m)
(20 m)
(10 m)
Landsat 8
OLI
TIRS
L7 ETM+
SWIR
VNIR
Visible
10 m
400 nm
600 nm
800 nm
1000 nm
1200 nm
1400 nm
1600 nm
1800 nm
2000 nm
2200 nm
2400 nm
Band 8 (842 nm)
Band 4 (665 nm)
Band 3 (560 nm)
Band 2 (490 nm)


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


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

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



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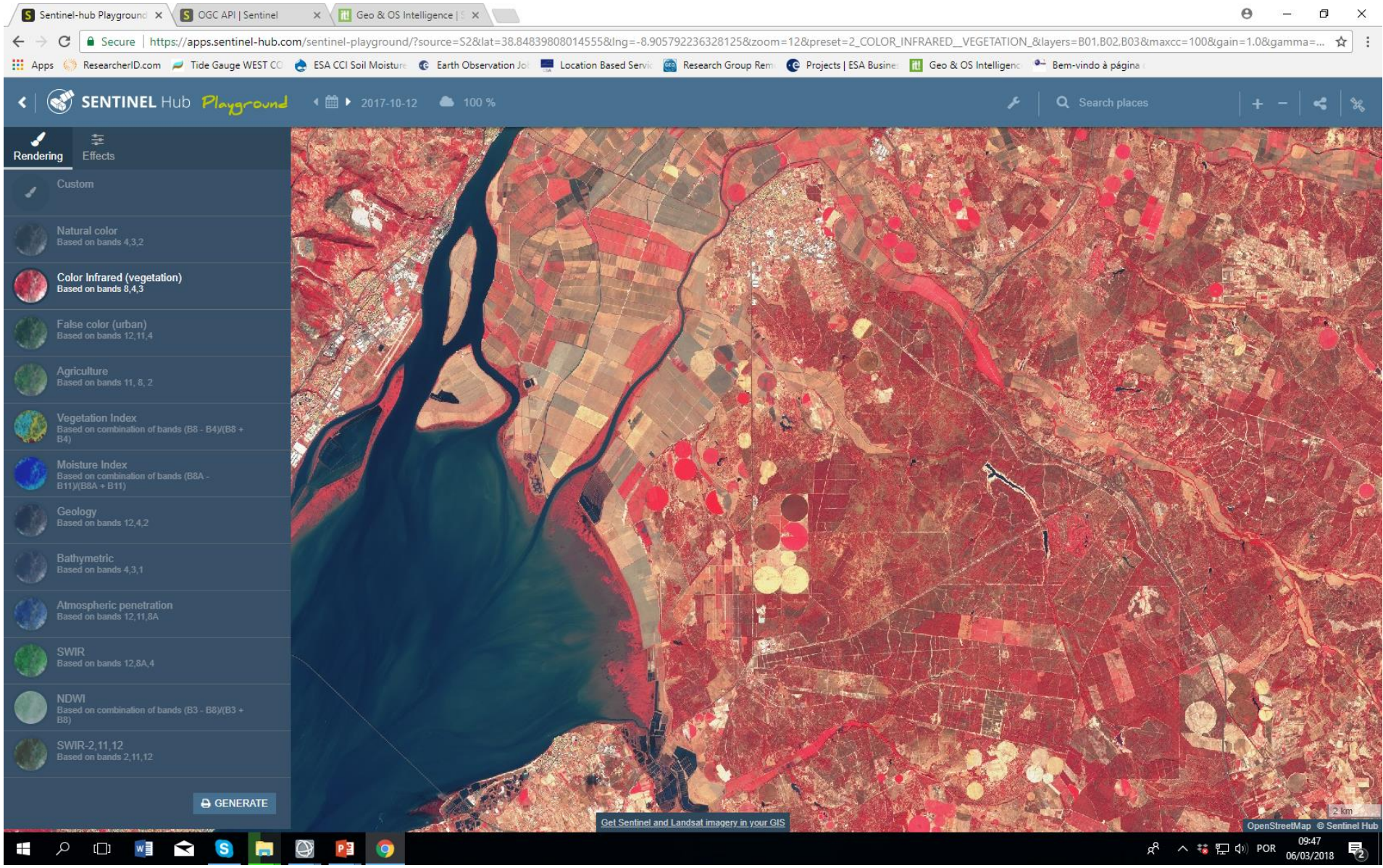

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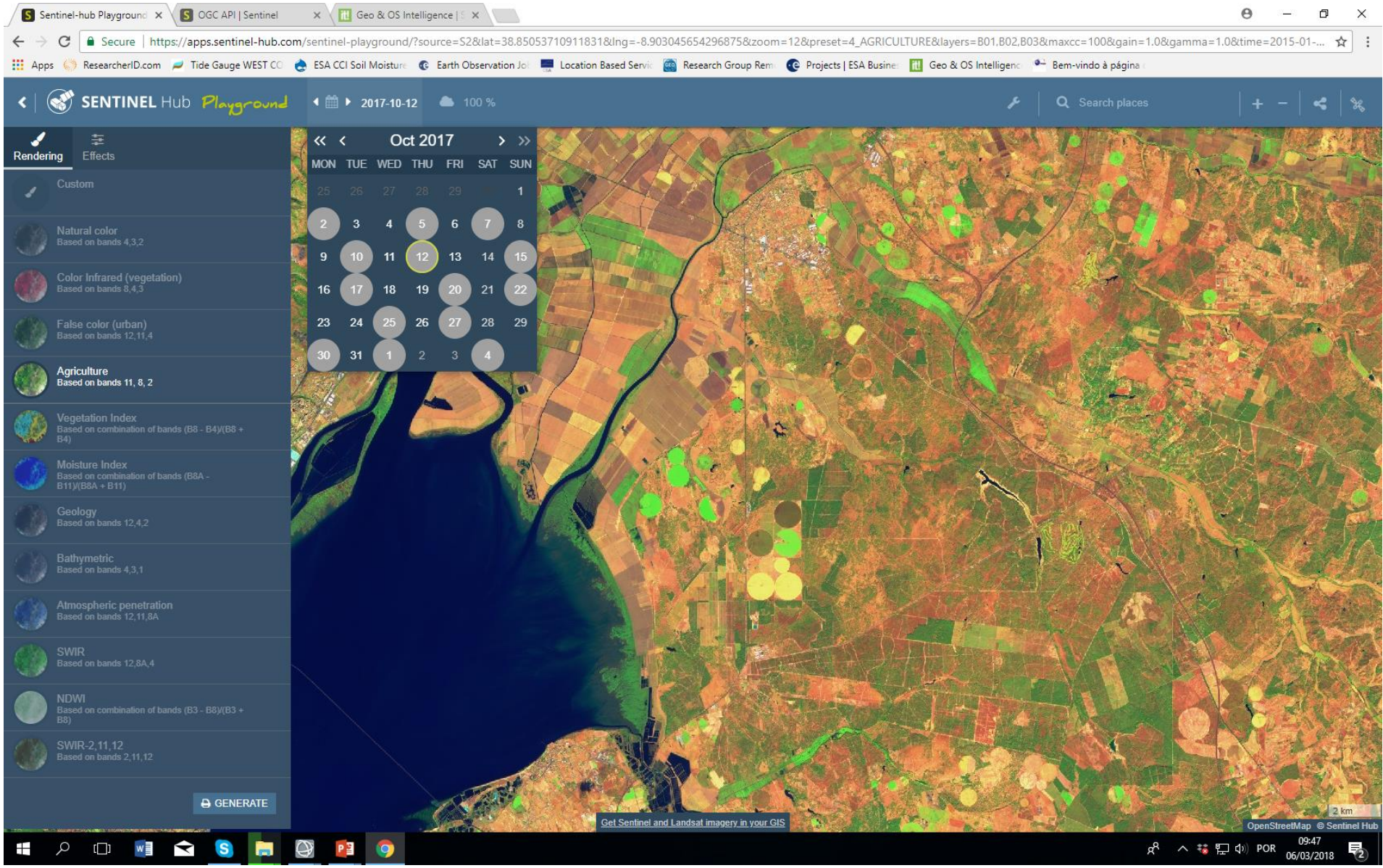


Sentinel -3

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 -5P

The Copernicus Sentinel-5 Precursor mission is the first Copernicus mission dedicated to monitoring our atmosphere.
The mission consists of one satellite carrying the TROPOspheric Monitoring Instrument (TROPOMI) instrument.

The **main objective** of the Copernicus Sentinel-5P mission is to perform atmospheric measurements with high spatio-temporal resolution, to be used for air quality, ozone & UV radiation, and climate monitoring & forecasting.

The Copernicus Sentinel-5 Precursor mission reduces gaps in the availability of global atmospheric data products between SCIAMACHY/Envisat (which ended in April 2012), the OMI/AURA mission and the future Copernicus Sentinel-4 and Sentinel-5 missions.

The satellite was successfully launched on 13 October 2017 from the Plesetsk cosmodrome in Russia.

Sentinel – 4 & Sentinel – 5

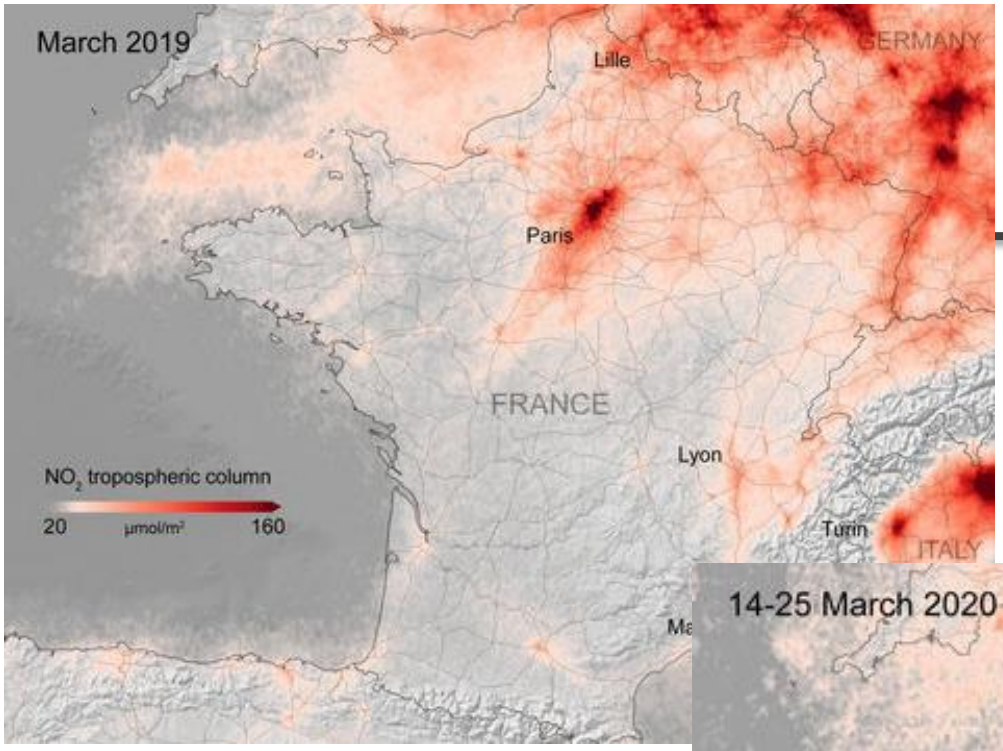
The instrument will be carried on the MetOp-SG A satellite.

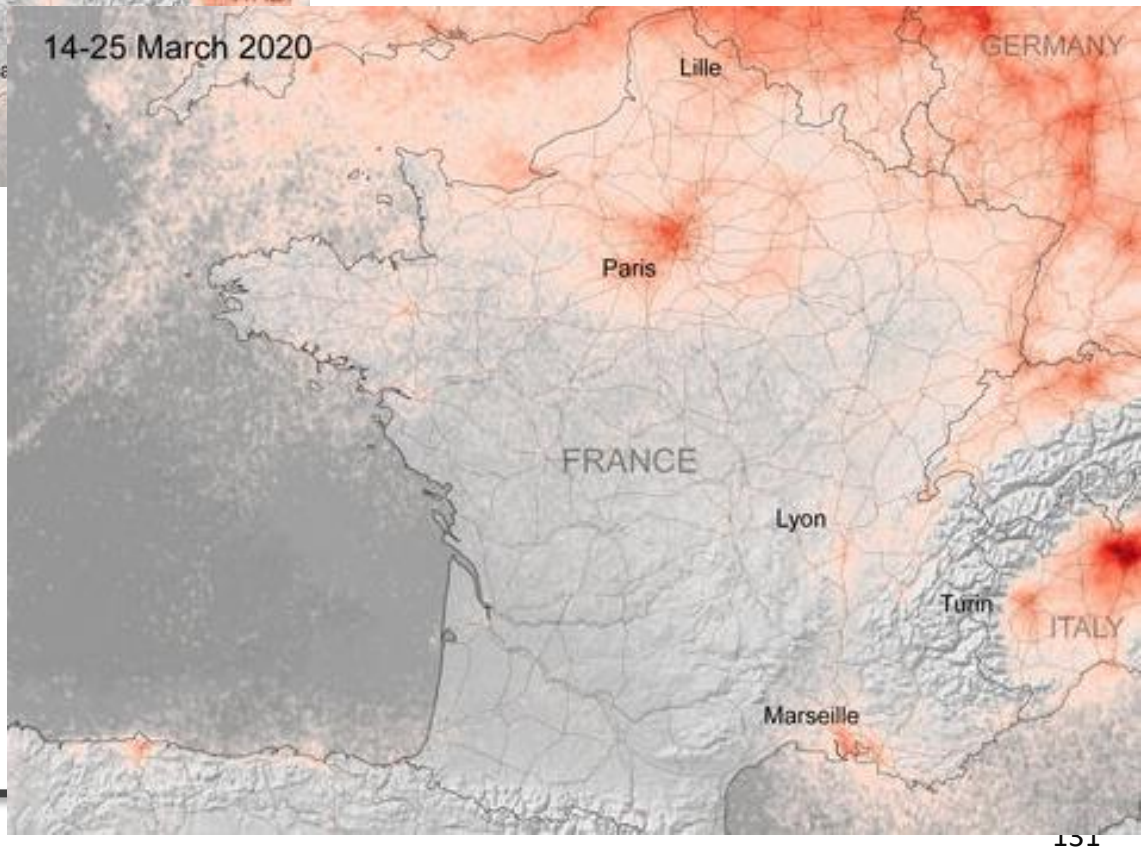
The missions SENTINEL-4, -5 and -5 precursor (S4, S5, S5P, respectively) are conceived as complementary elements of a constellation serving the specific needs of the Copernicus Atmospheric Monitoring Services (CAMS).

SENTINEL-5 is focused on air quality and composition-climate interaction with the main data products being O_3, NO_2, SO_2, HCHO, CHOCHO and aerosols.

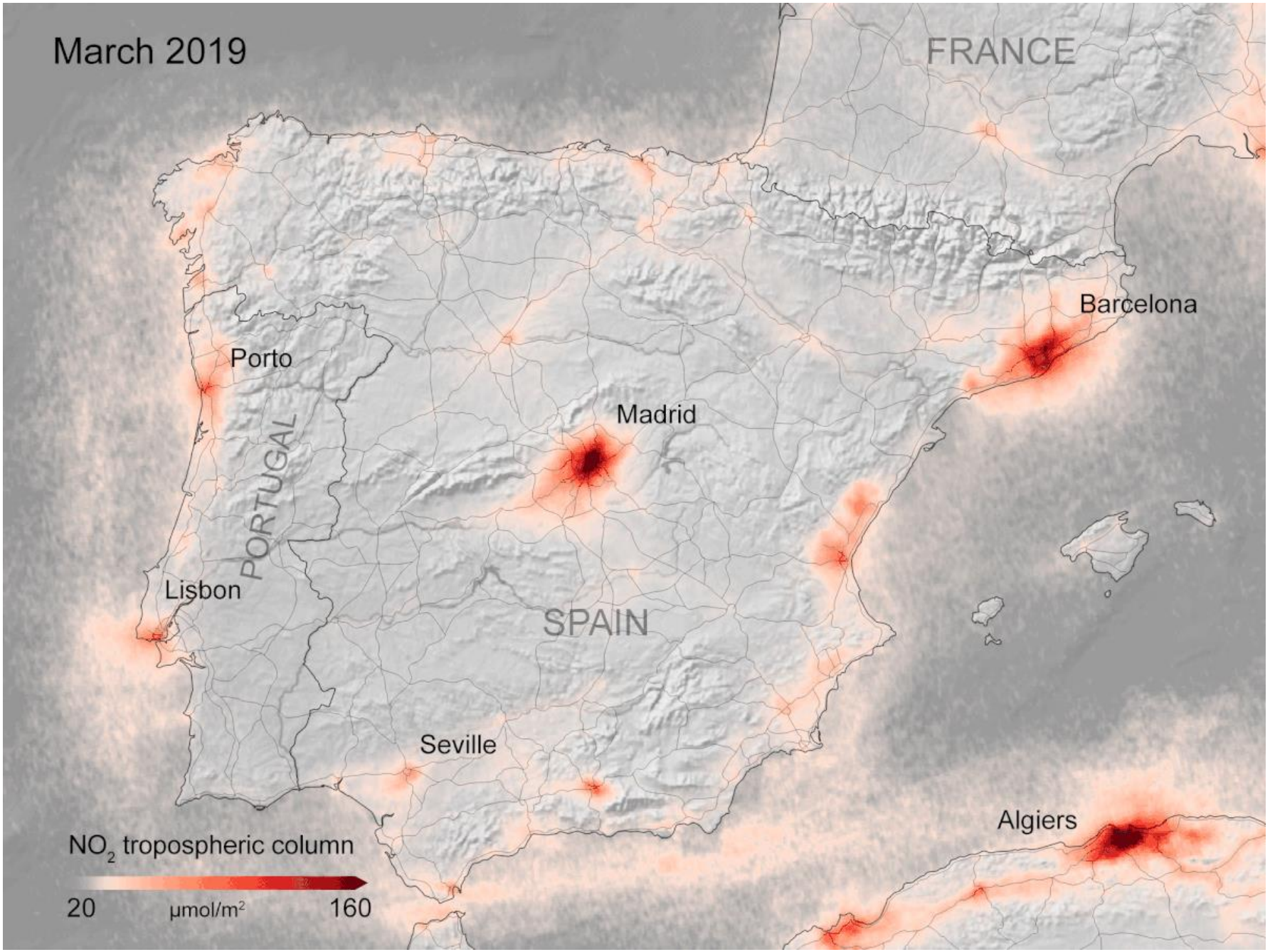
Additionally SENTINEL-5 will also deliver quality parameters for CO, CH_4, and stratospheric O_3 with daily global coverage for climate, air quality, and ozone/surface UV applications.

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
Lille
GERMANY
Paris
FRANCE
Lyon
Turin
ITALY
NO_2 tropospheric column
20
µmol/m²
160


14-25 March 2020
Lille
GERMANY
Paris
FRANCE
Lyon
Turin
ITALY
Marseille

March 2020


March 2019
FRANCE
Barcelona
Porto
Madrid
PORTUGAL
Lisbon
SPAIN
Seville
Algiers
NO2 tropospheric column
20
µmol/m2
160

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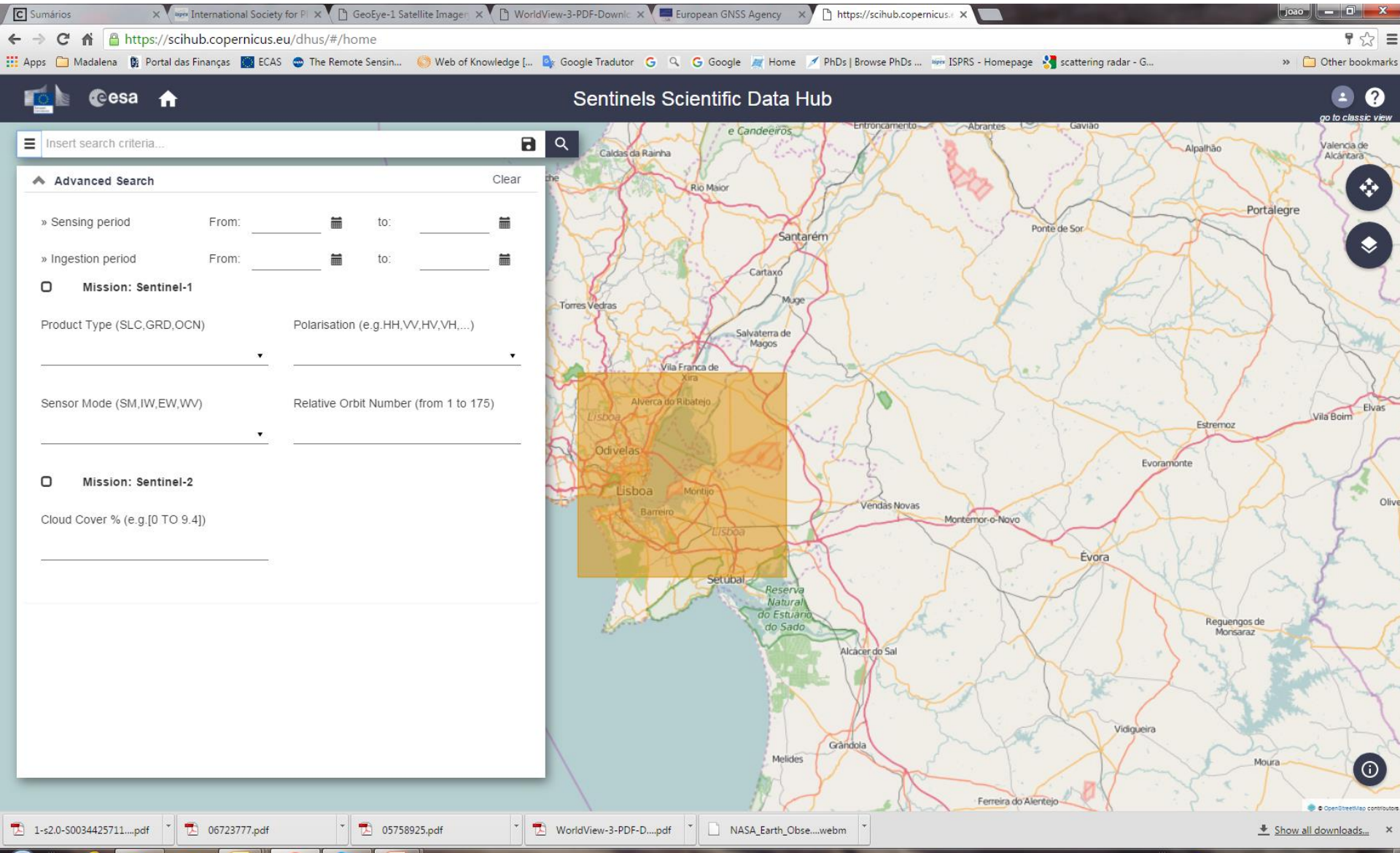
Sentinel Hub, https://scihub.copernicus.eu/dhus/#/home



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step
science toolbox exploitation platform

esa

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

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

Search...

seom
scientific exploitation of operational missions

Home > Toolboxes > SNAP

SNAP

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

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

Feature Highlights

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

SNAP Frequently Asked Questions

SNAP is using the following technologies

2017

EO Open Science 2017

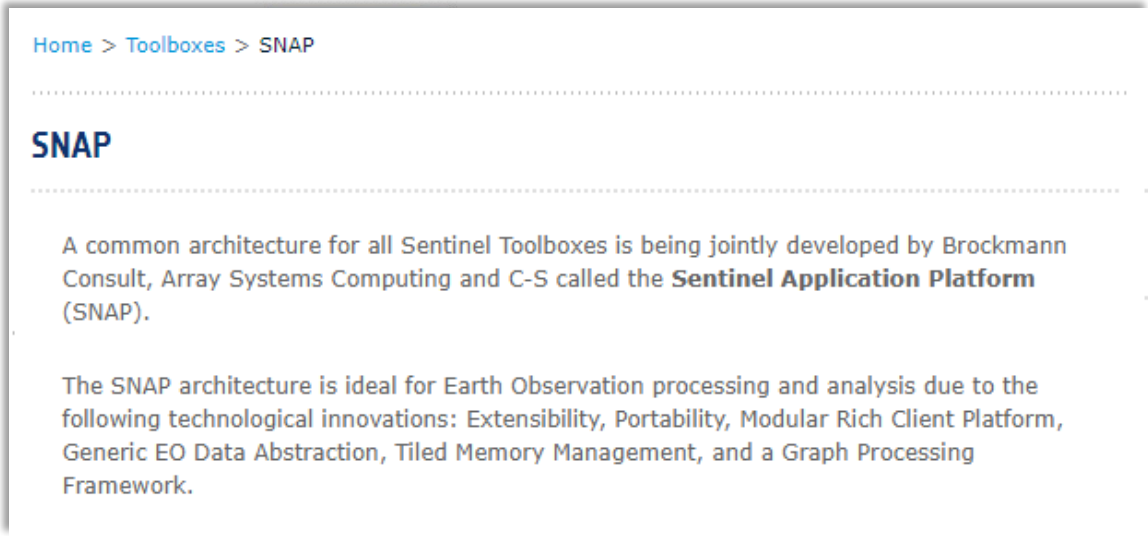
7th Advanced Land Training Course

ESA POLinSAR 2017 Workshop

2016

Colour and Light in the Ocean from Earth Observation

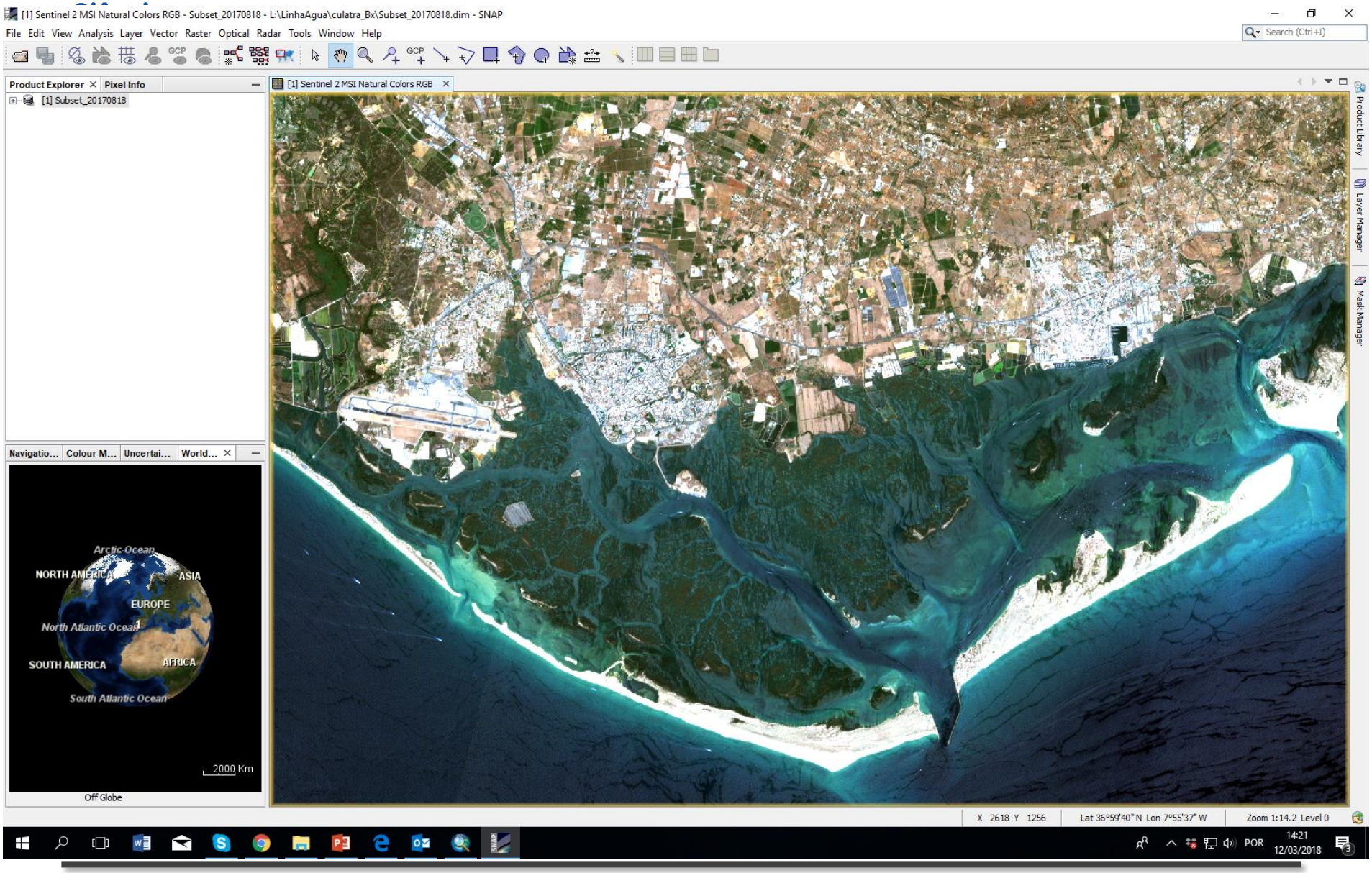
Sentinel Toolboxes

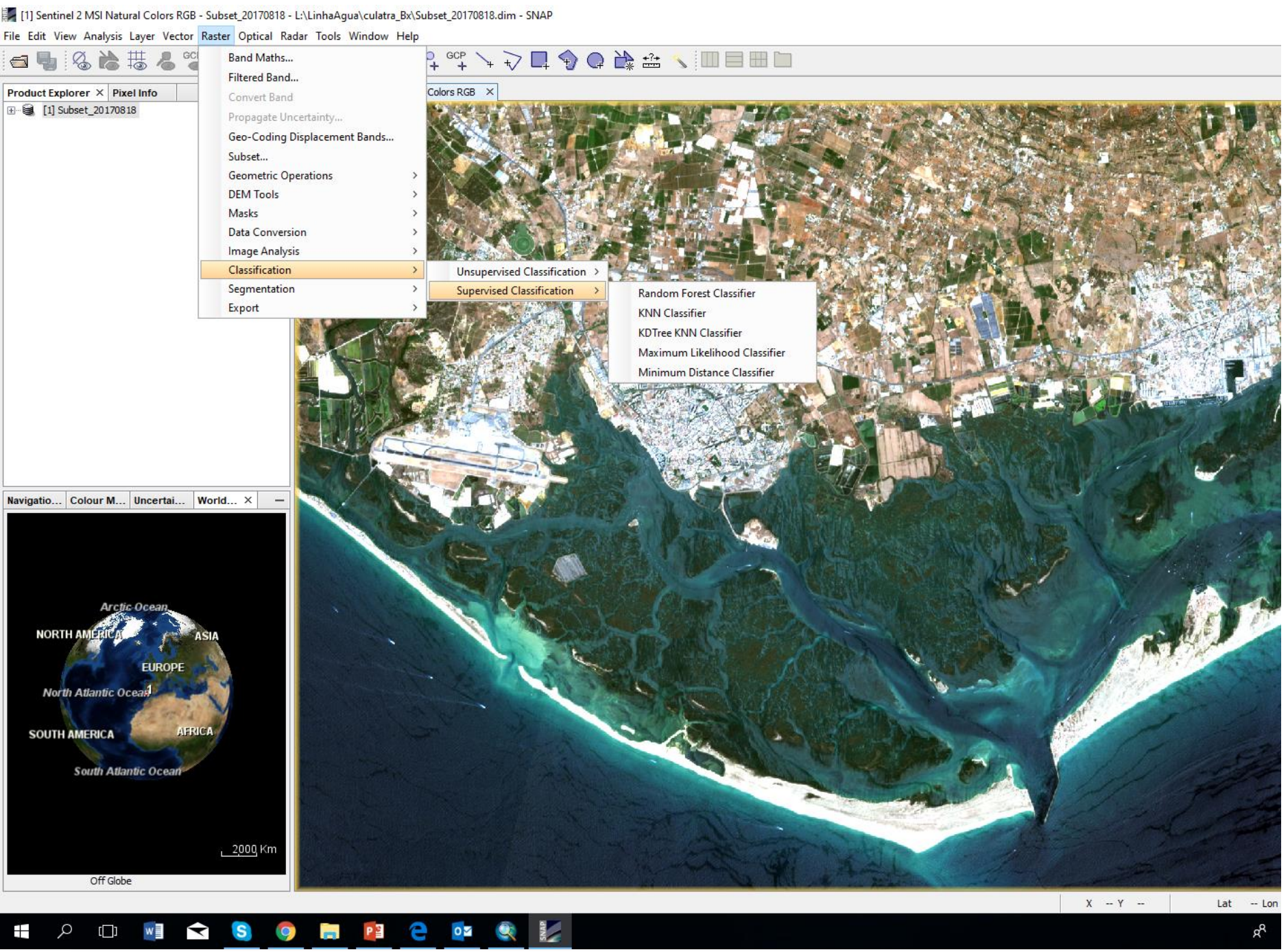


http://step.esa.int/main/toolboxes/

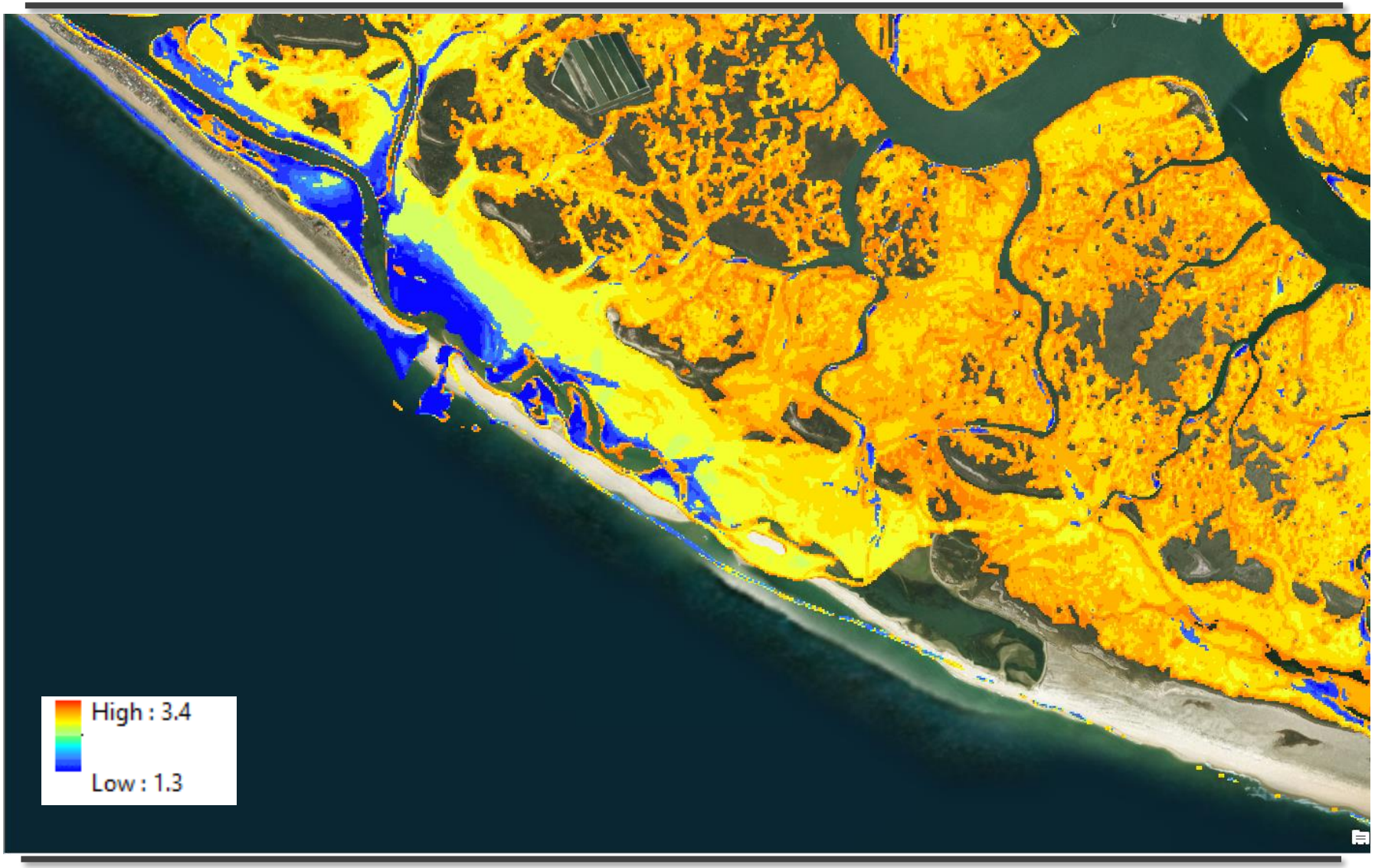
http://step.esa.int/main/toolboxes/snap/

SNAP software




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

Intertidal bathymetry


High : 3.4
Low : 1.3