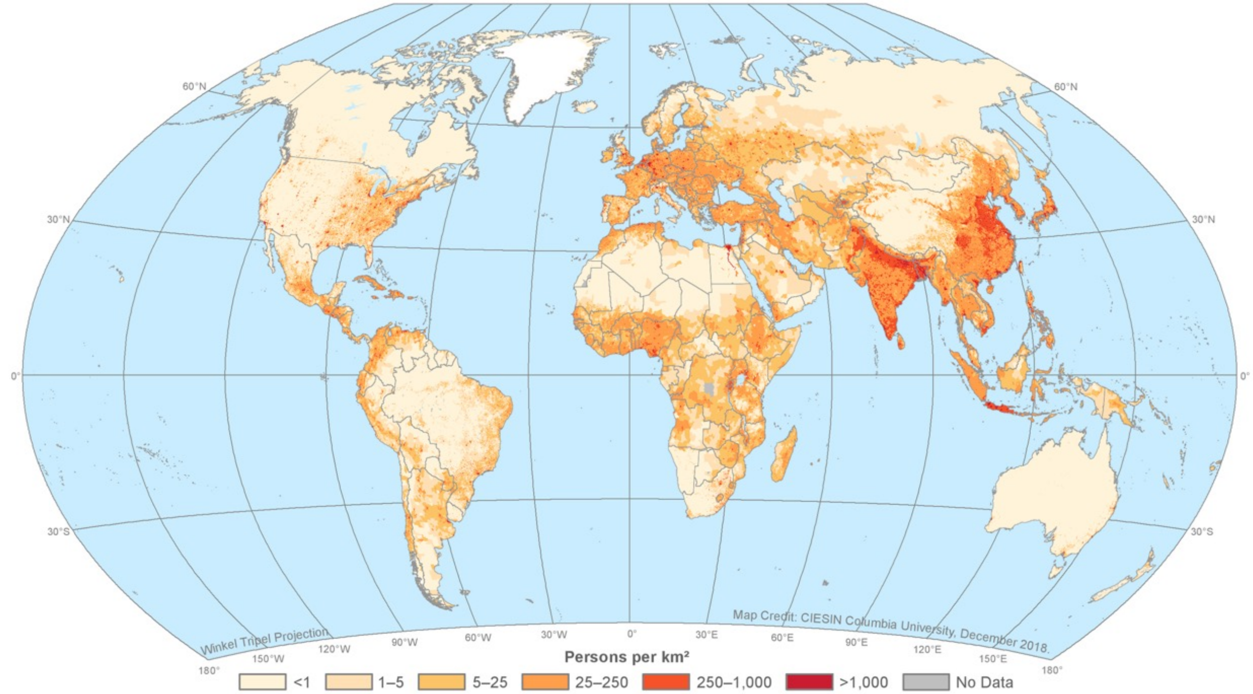
CAP-349 Spatial Databases

Raster Data

Lubia Vinhas

Population Density, v4.11, 2000

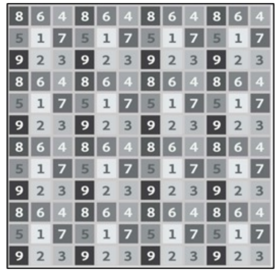
Gridded Population of the World, Version 4 (GPWv4)



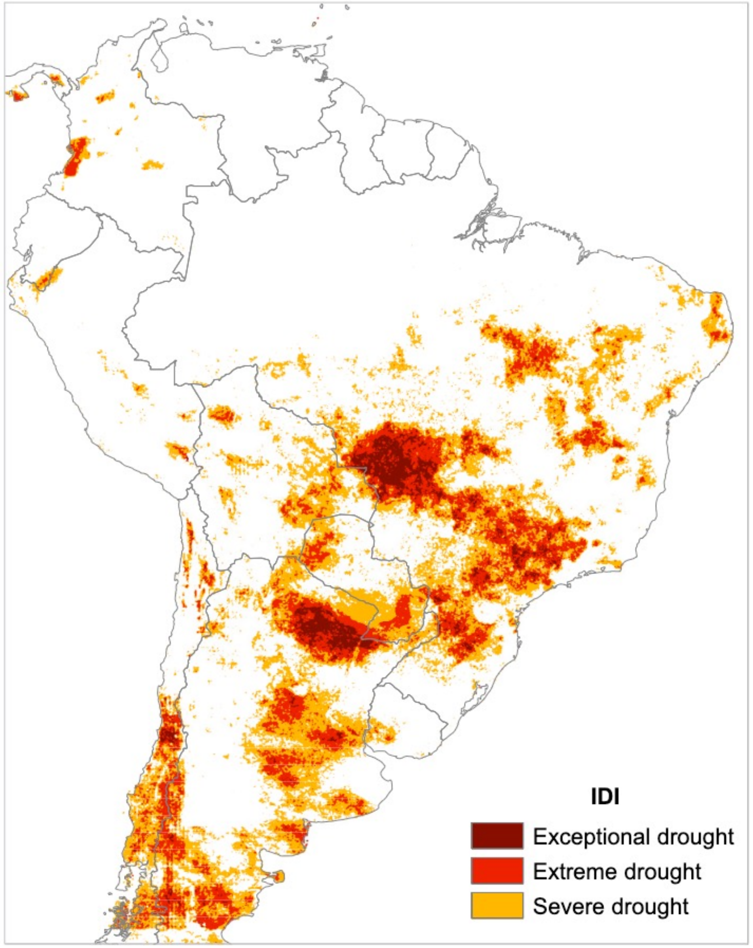
Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11 consists of estimates of human population density based on counts consistent with national censuses and population registers for the years 2000, 2005, 2010, 2015, and 2020. A proportional allocation gridding algorithm, utilizing approximately 13.5 million national and sub-national administrative units, is used to assign population counts to 30 arc-second (approximately 1 km at the equator) pixels. The population count rasters are divided by the land area raster to produce population density rasters with pixel values representing persons per square kilometer.

Center for International Earth Science Information Network
EARTH INSTITUTE | COLUMBIA UNIVERSITY

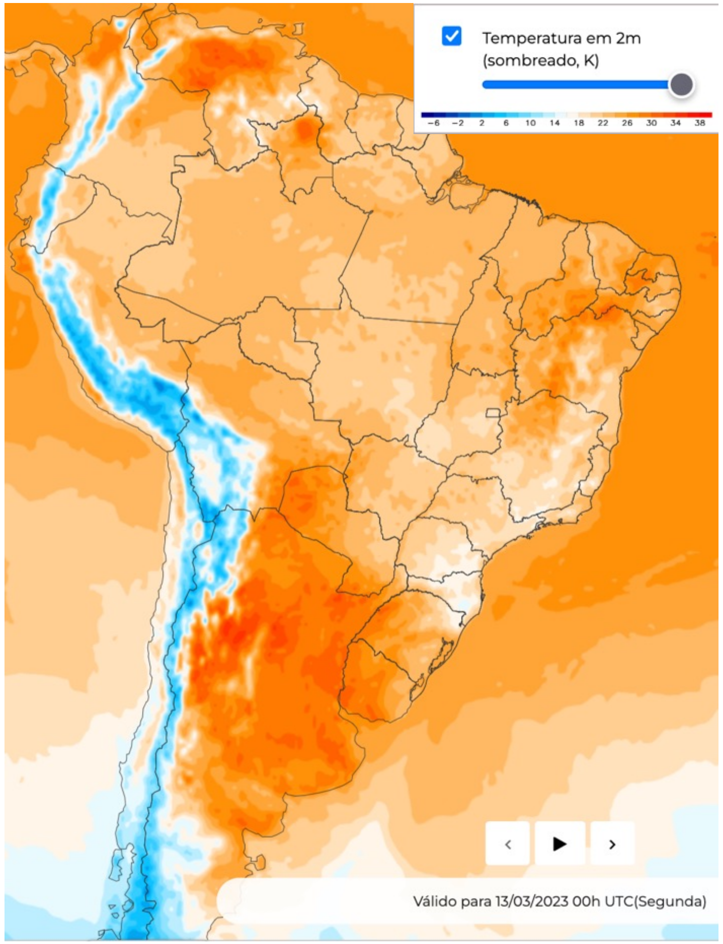
Data Source: Center for International Earth Science Information Network - CIESIN - Columbia University. 2018. Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H49C6VHW.



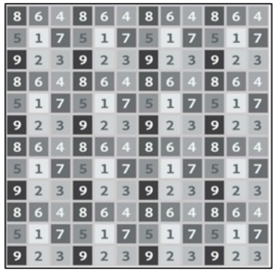
Raster is a possible digital representation for geospatial data from different domains



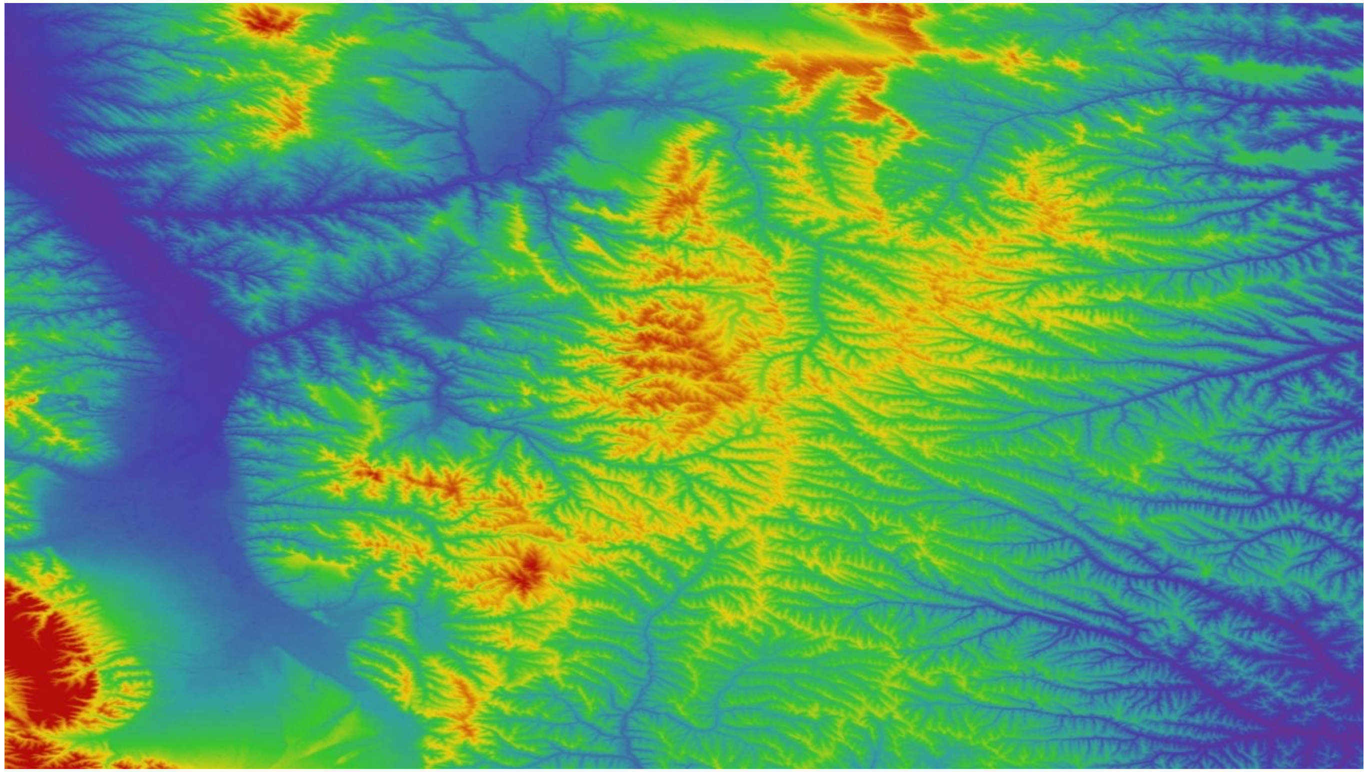
https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate/LAC



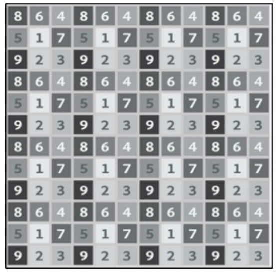
https://previsaonumerica.cptec.inpe.br



Raster is a possible digital representation for geospatial data from different domains

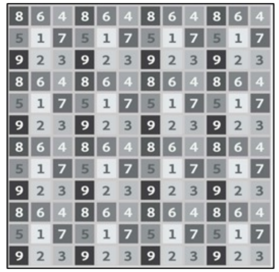


Terra ASTER Global Digital Elevation Model (GDEM) DEM data from the ASTGTM product over northern China between March 1, 2000 and November 30, 2013. Source: https://lpdaac.usgs.gov/products/astgtmv003/



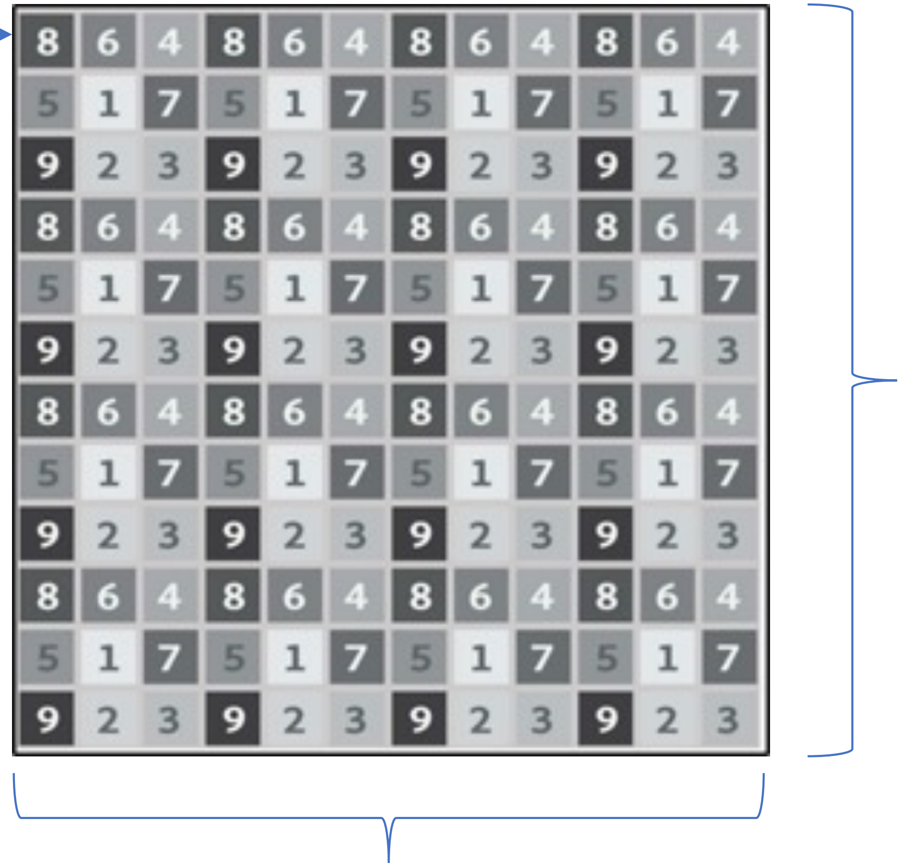
Raster is a possible digital representation for geospatial data from different domains

CBERS-4A WPM Barra do Sahy, São Sbastião, SP- Fev/2023. Source: www.dgi.inpe.br/explore



Raster is a possible digital representation for geospatial data from different domains

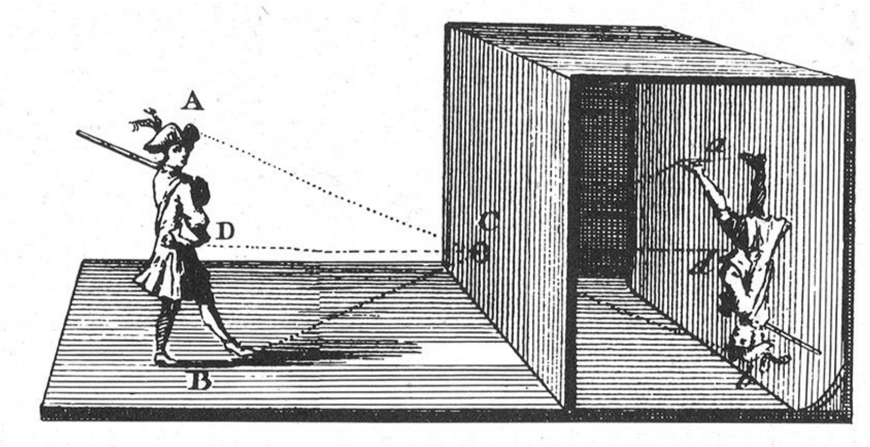
Precision and size of the values. For example, with 1 byte for each cell of the matrix, we could represent 255 different values. With 2 bytes per cell, we can represent floating point single precision numbers.



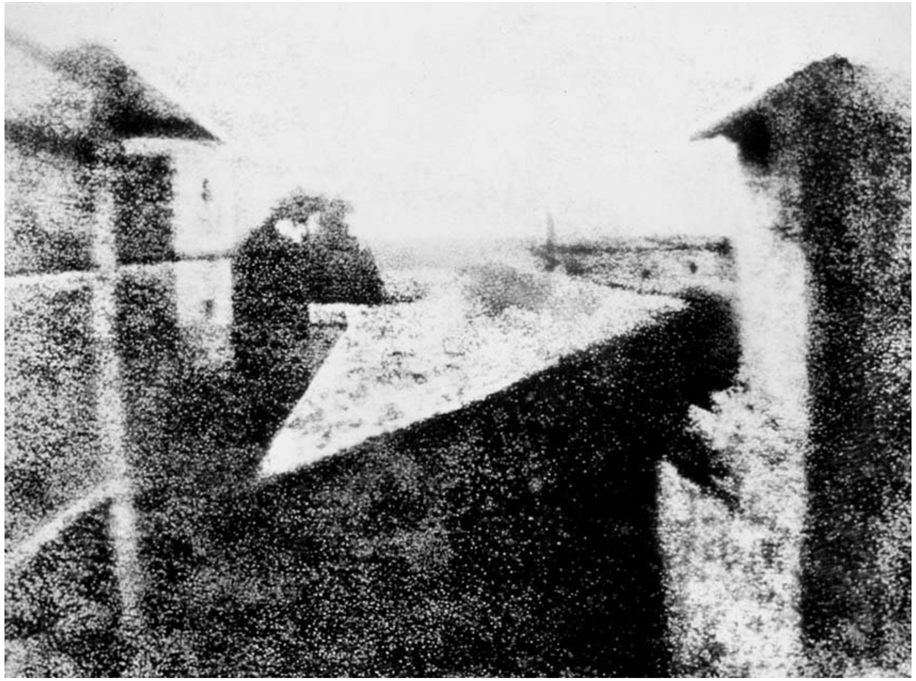
https://gdal.org/drivers/raster/index.html

Earth observation and remote sensing

The capture of light

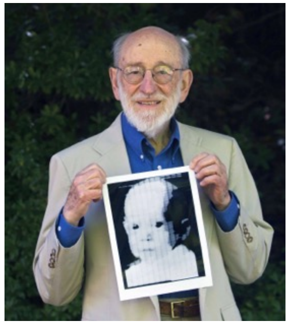


The Camera Obscura was invented around 13-14th centuries. The first photo picture—as we know it—was taken in 1825 by a French inventor Joseph Nicéphore Niépce.



Source: https://photography.tutsplus.com/articles/a-history-of-photography-part-1-the-beginning--photo-1908

Russell A. Kirsch an American engineer at the National Bureau of Standards (now known as the National Institute of Standards and Technology). He was recognized as the developer of the first digital image scanner

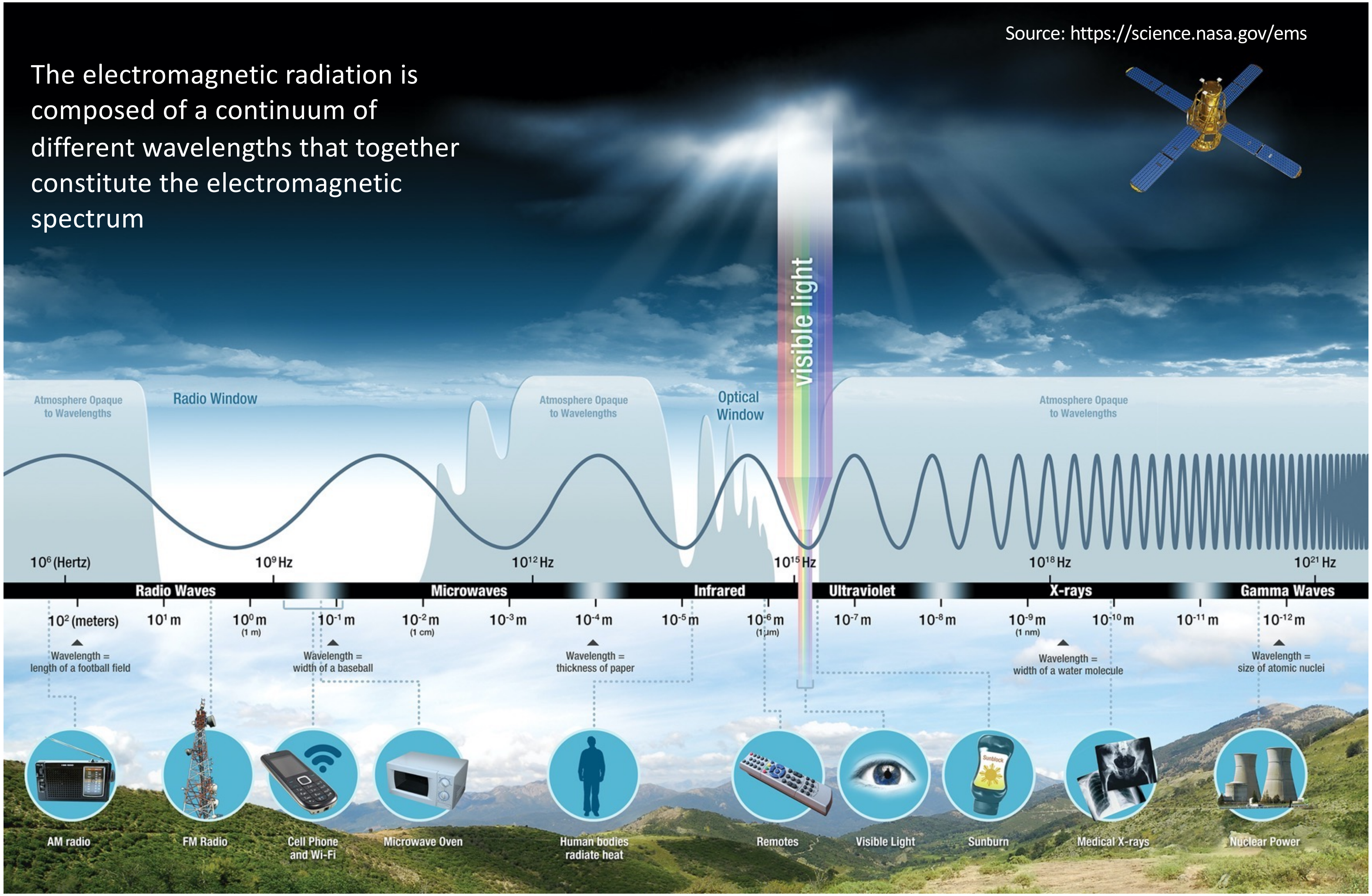


This group used the computer to extract line drawings, count objects, recognize alphanumeric characters, and produce oscilloscope displays.

One of the first image scanned a photo from his son, generating a 176 x 176 pixels digital image. Considered as one of ‘100 Photographs That Changed the World’ by Life Magazine

https://en.wikipedia.org/wiki/Russell_Kirsch

The electromagnetic radiation is composed of a continuum of different wavelengths that together constitute the electromagnetic spectrum



Sensors on board aircraft and satellites can measure and record intervals of the electromagnetic spectrum.

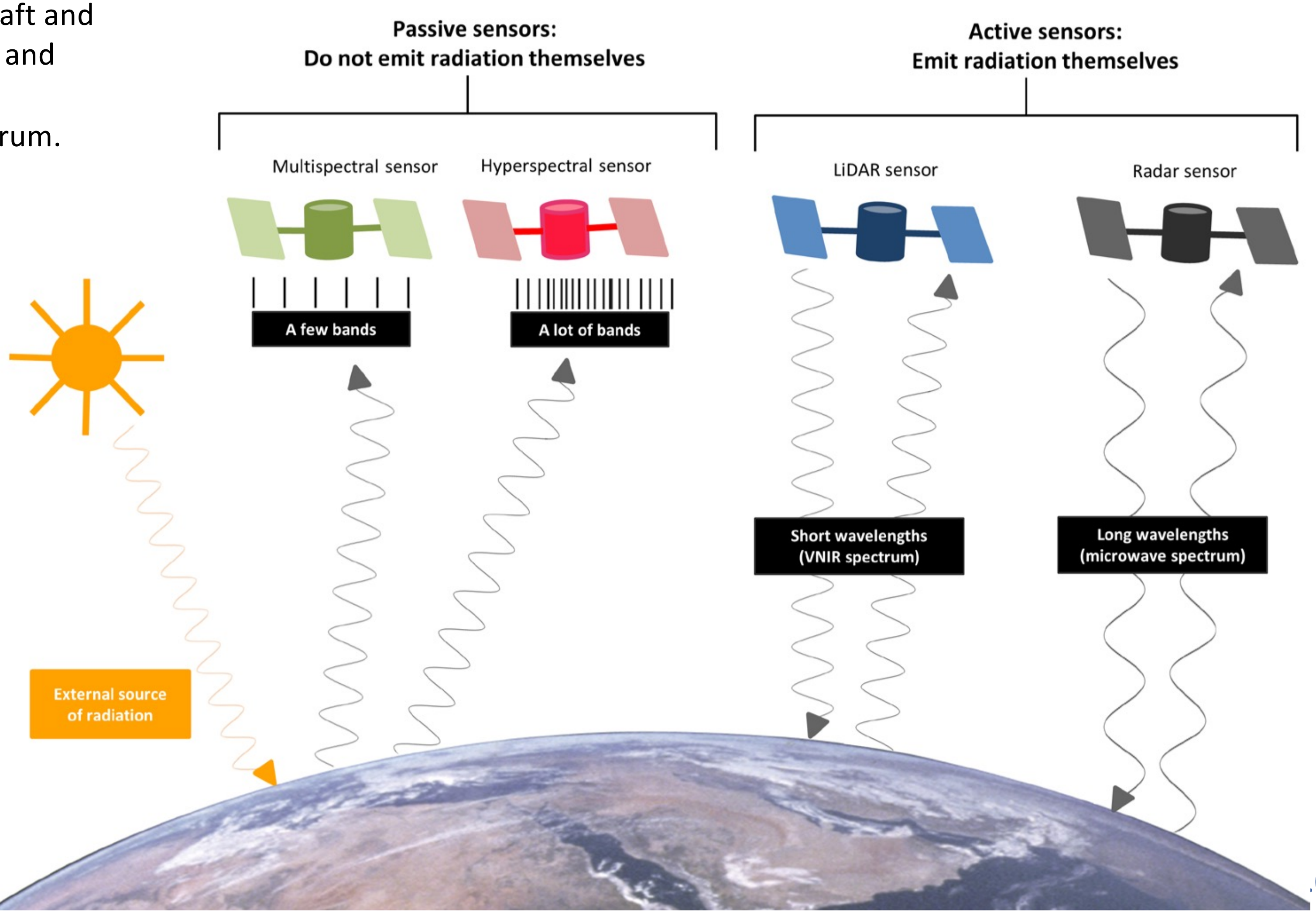
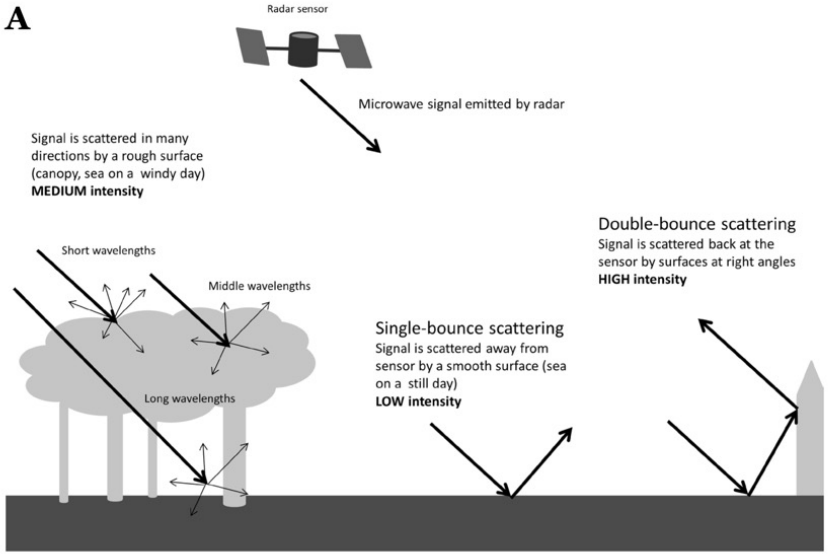
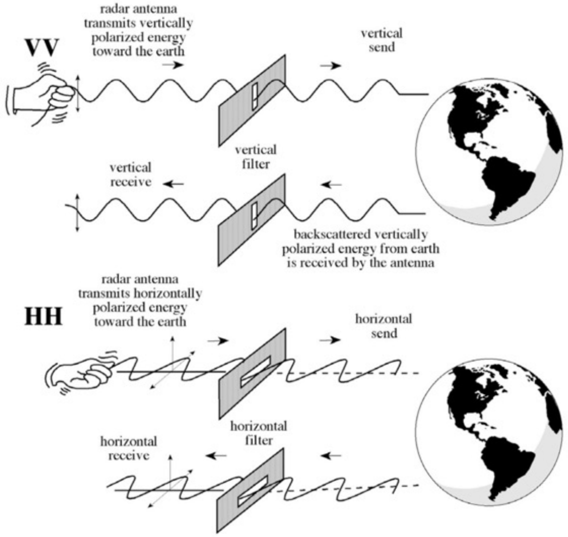


Figure: PETTORELLI, N. et al.

Microwave: penetration and polarization

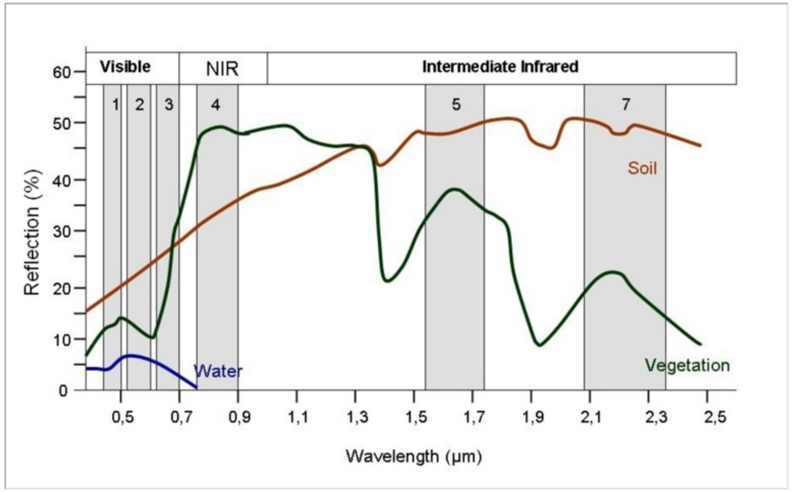


Band	Frequency	Wavelength	Typical Application
Ka	27–40 GHz	1.1–0.8 cm	Rarely used for SAR (airport surveillance)
K	18–27 GHz	1.7–1.1 cm	rarely used (H_2O absorption)
Ku	12–18 GHz	2.4–1.7 cm	rarely used for SAR (satellite altimetry)
X	8–12 GHz	3.8–2.4 cm	High resolution SAR (urban monitoring,; ice and snow, little penetration into vegetation cover; fast coherence decay in vegetated areas)
C	4–8 GHz	7.5–3.8 cm	SAR Workhorse (global mapping; change detection; monitoring of areas with low to moderate penetration; higher coherence); ice, ocean maritime navigation
S	2–4 GHz	15–7.5 cm	Little but increasing use for SAR-based Earth observation; agriculture monitoring (NISAR will carry an S-band channel; expends C-band applications to higher vegetation density)
L	1–2 GHz	30–15 cm	Medium resolution SAR (geophysical monitoring; biomass and vegetation mapping; high penetration, InSAR)
P	0.3–1 GHz	100–30 cm	Biomass. First p-band spaceborne SAR will be launched ~2020; vegetation mapping and assessment. Experimental SAR.



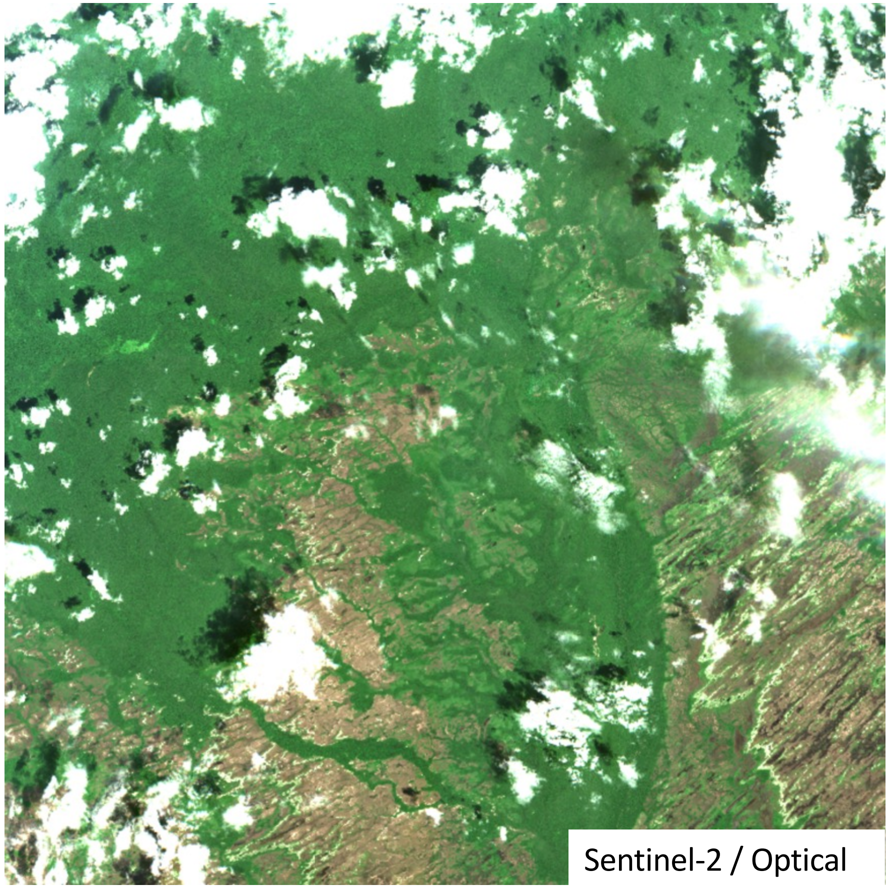
https://appliedsciences.nasa.gov/join-mission/training/english/arset-radar-remote-sensing-land-water-disaster-applications

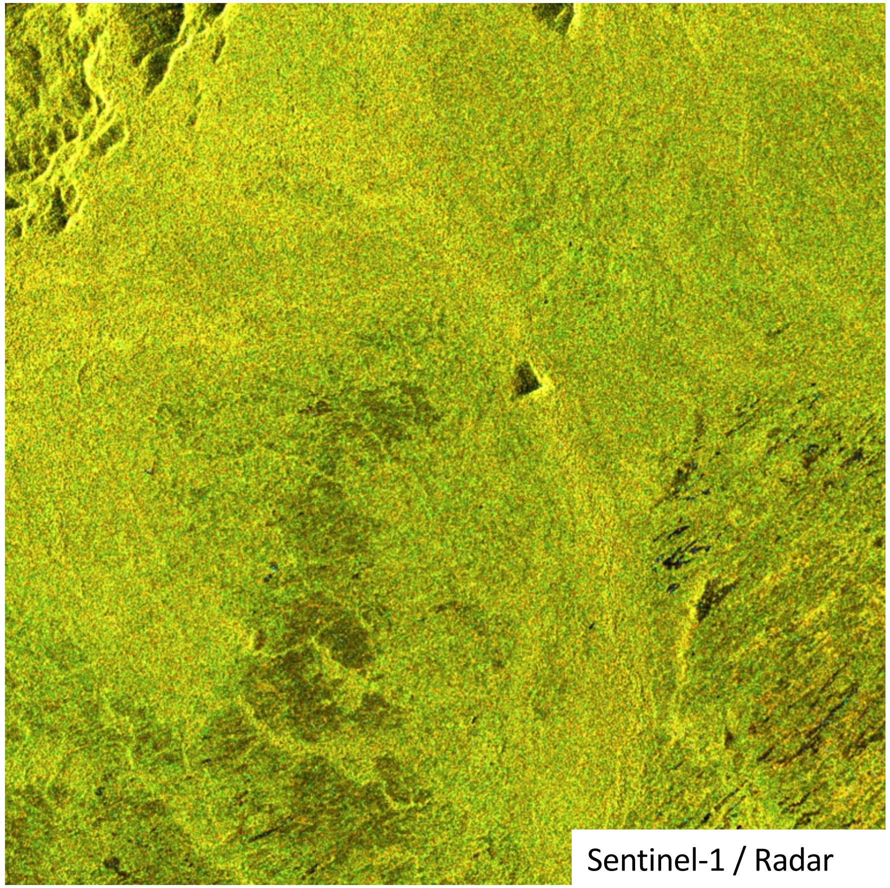
Optical: Spectral signatures



Spectral signatures of soil, vegetation and water, and spectral bands of LANDSAT 7.
Source: Siegmund, Menz 2005 with modifications

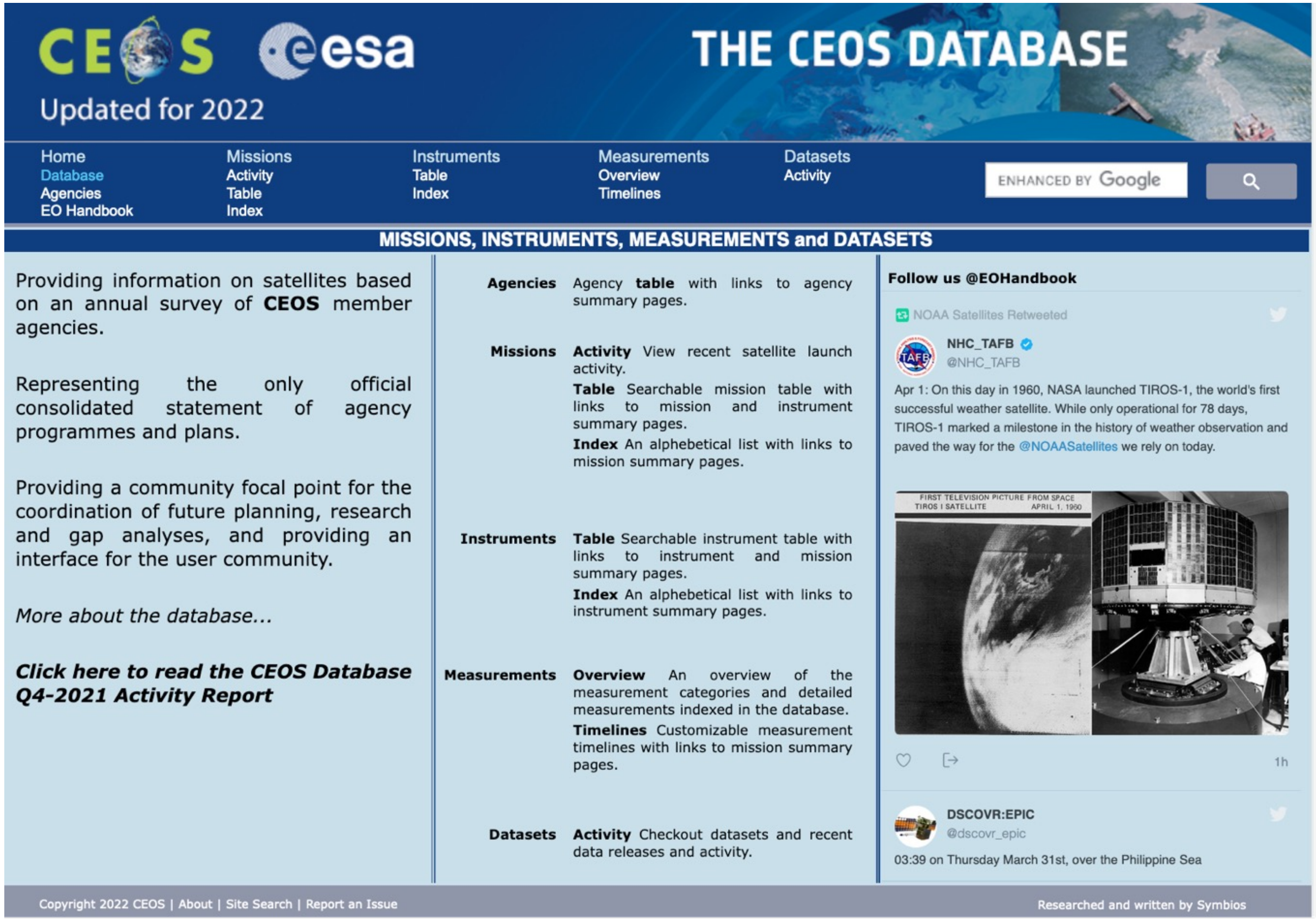
Band Name	Common Interpretations
Panchromatic	Usually samples visible light at a higher resolution
Ultra-blue	Shallow water, suspended sediments, chlorophyll concentrations, algae blooms, and aerosols; also known as the coastal or aerosol band
Blue	Shallow water, land cover, and deciduous/coniferous, sensitive to atmospheric scatter
Green	Emphasizes the true color of vegetation
Red	Discriminates vegetation and chlorophyll absorption for vegetation health
Red edge	Exploits the sharp contrast between red and near infrared
Near Infrared (NIR)	Emphasizes biomass content and shorelines
Short-wave Infrared (SWIR1)	Soil canopy moisture and thin cloud penetration
SWIR2	Soil and canopy moisture and thin cloud penetration
Cirrus	Detection of cirrus clouds
Thermal Infrared (TIR)	Thermal mapping, soil moisture, cloud mapping



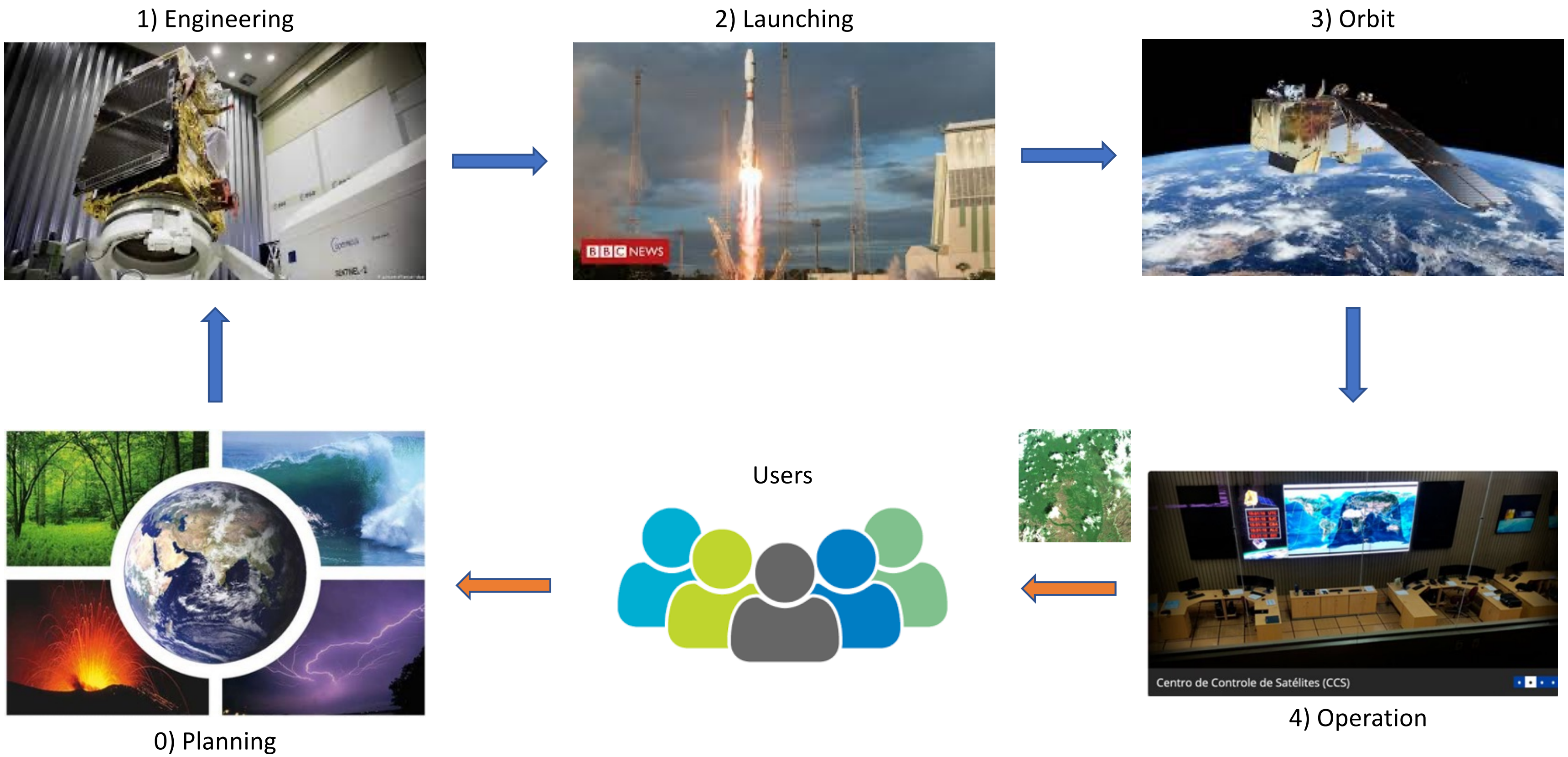


Source: https://www.sentinel-hub.com/explore/eobrowser/

Earth observation satellites provide important data about the Earth and its environment, helping develop our understanding of the basic Earth System and human influences on it. These data cover measurements of a very wide range of geophysical parameters, spanning the whole spectrum of the environment – atmosphere, land, oceans, ice and snow.

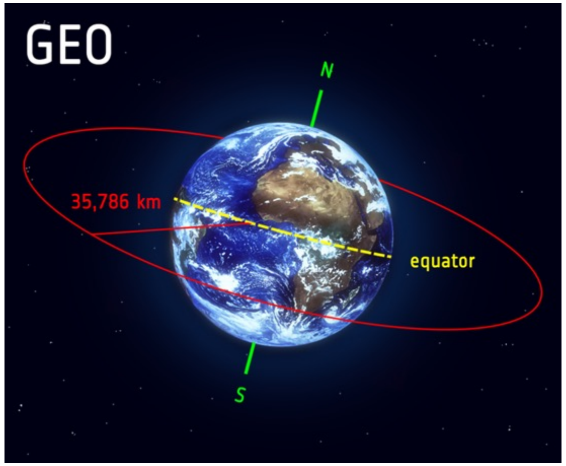


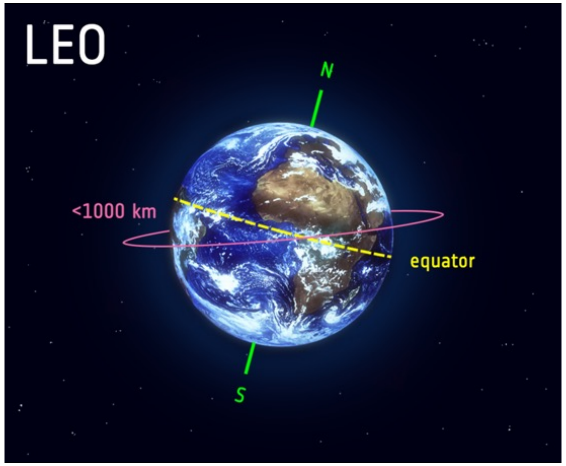
EO Mission

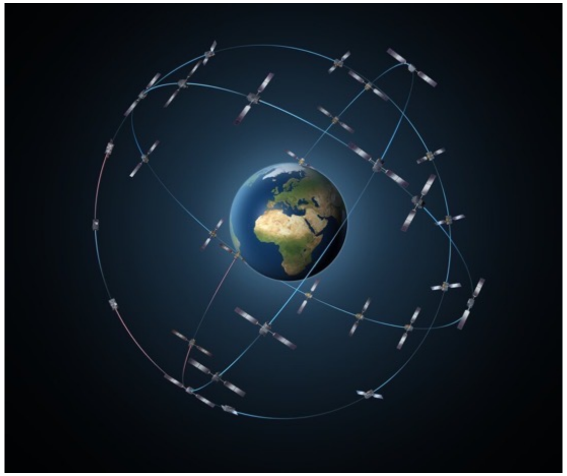


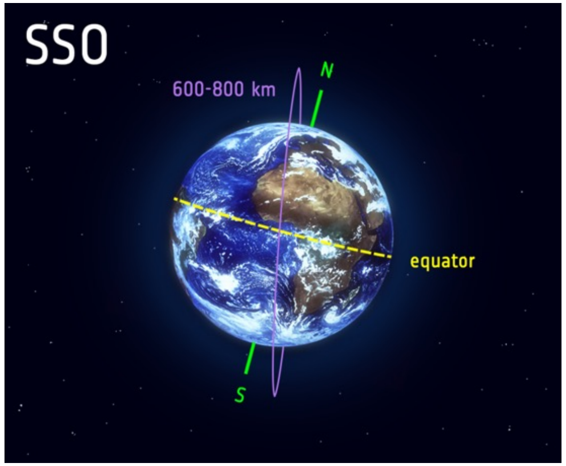
VERSTRAETE, M. M.; DINER, D. J.; BÉZY, J.-L. Planning for a spaceborne Earth Observation mission: From user expectations to measurement requirements. https://doi.org/10.1016/j.envsci.2015.08.005

Types of orbits





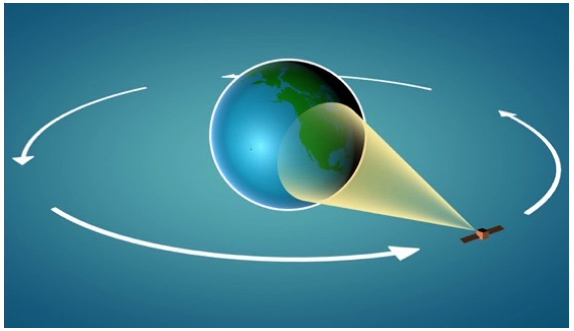


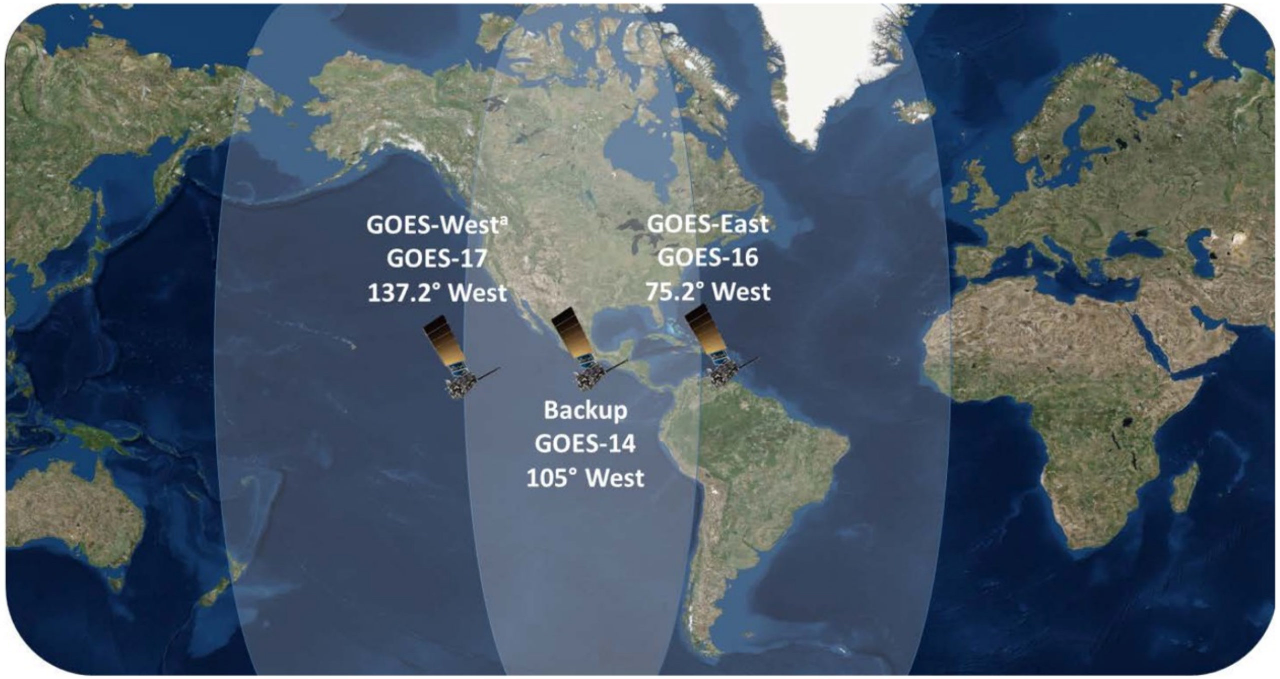


https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits

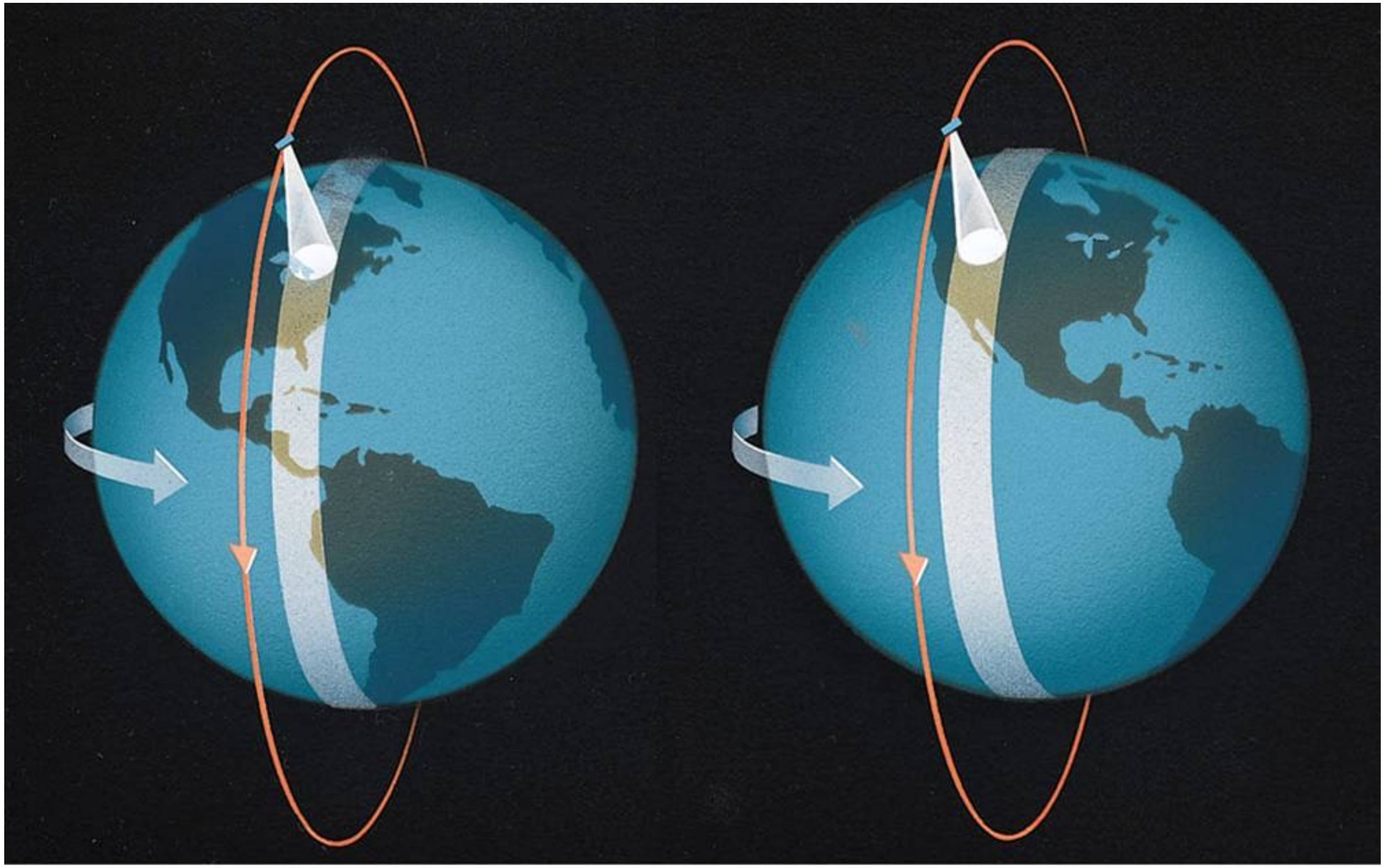
https://svs.gsfc.nasa.gov/vis/a000000/a004000/a004070/earthObsFleet_with_landsat8_1080p60.mp4

A geostationary satellite orbits the Earth while remaining in place (stationary) above a particular spot. In order to remain directly above a particular location, a geostationary satellite must be placed in orbit directly above the equator at an altitude of 35,786 km (22,236 miles).

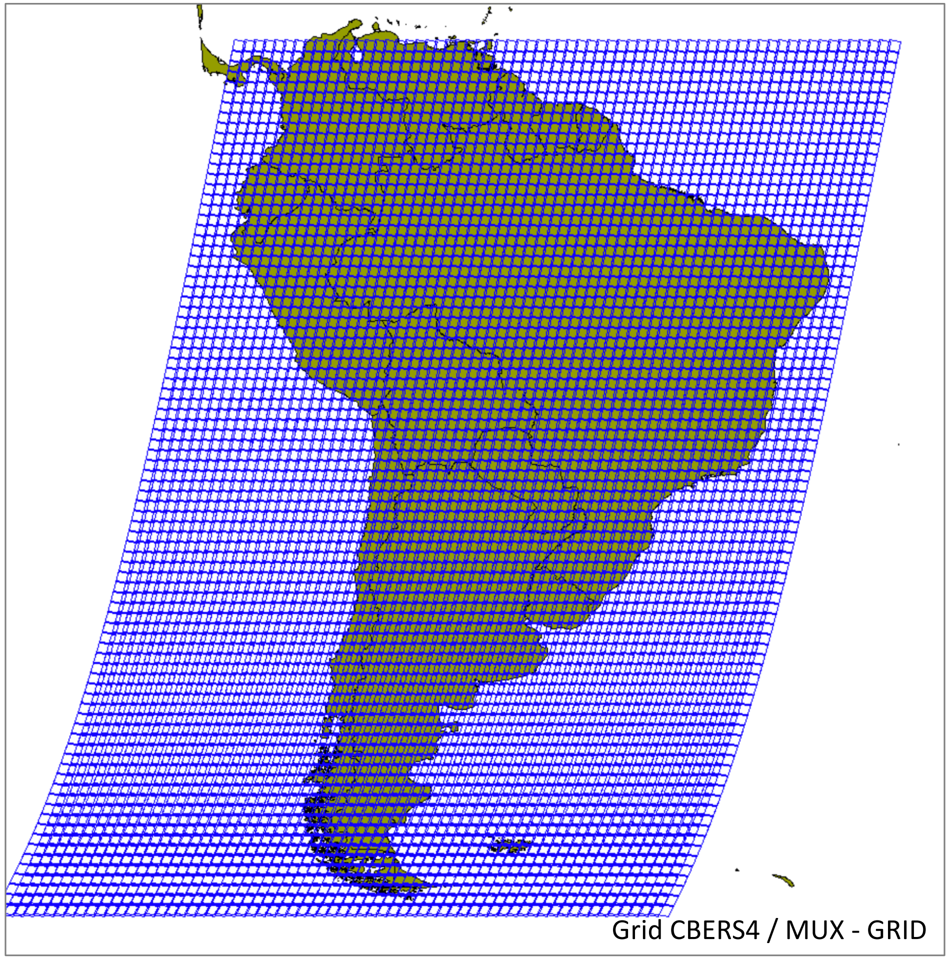




Polar, or near polar, orbits

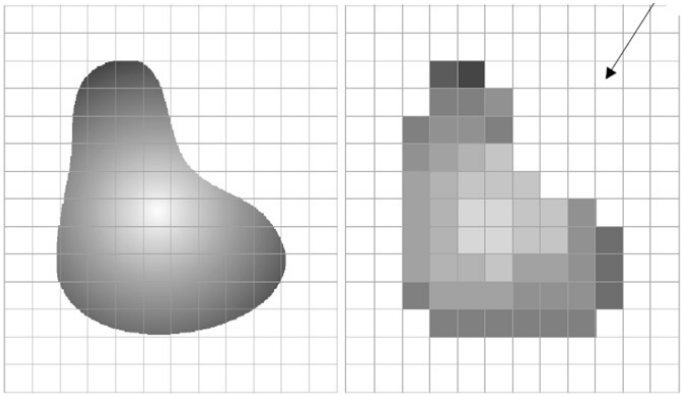



Grid Amazonia-1 / WFI

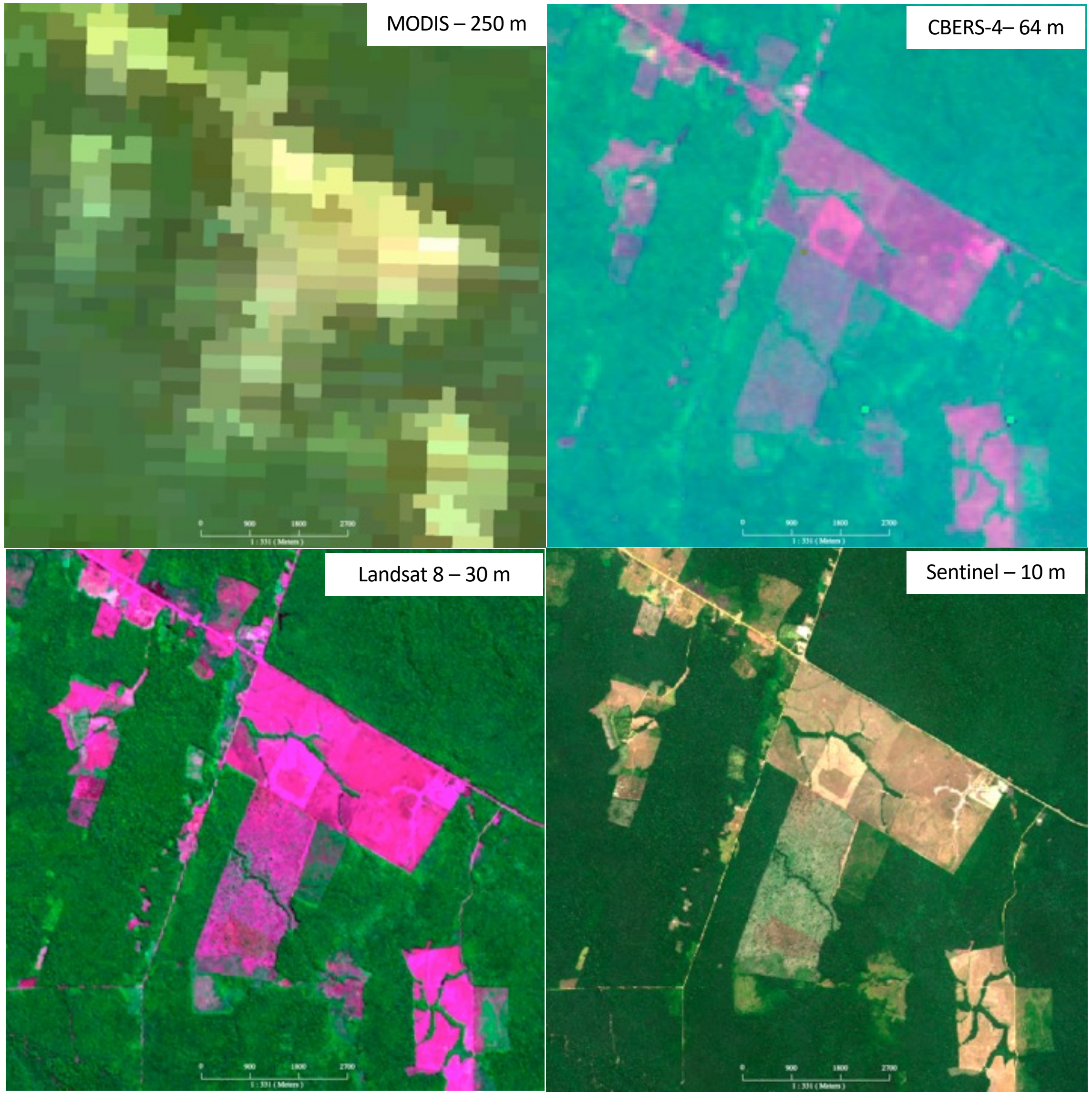

Grid CBERS4 / MUX - GRID

Remote Sensing Images are characterized by 4 parameters:

- Spatial Resolution
- Spectral Resolution
- Radiometric Resolution
- Temporal Resolution



The **spatial resolution** of the sensor refers to the size of the smallest possible feature that can be detected

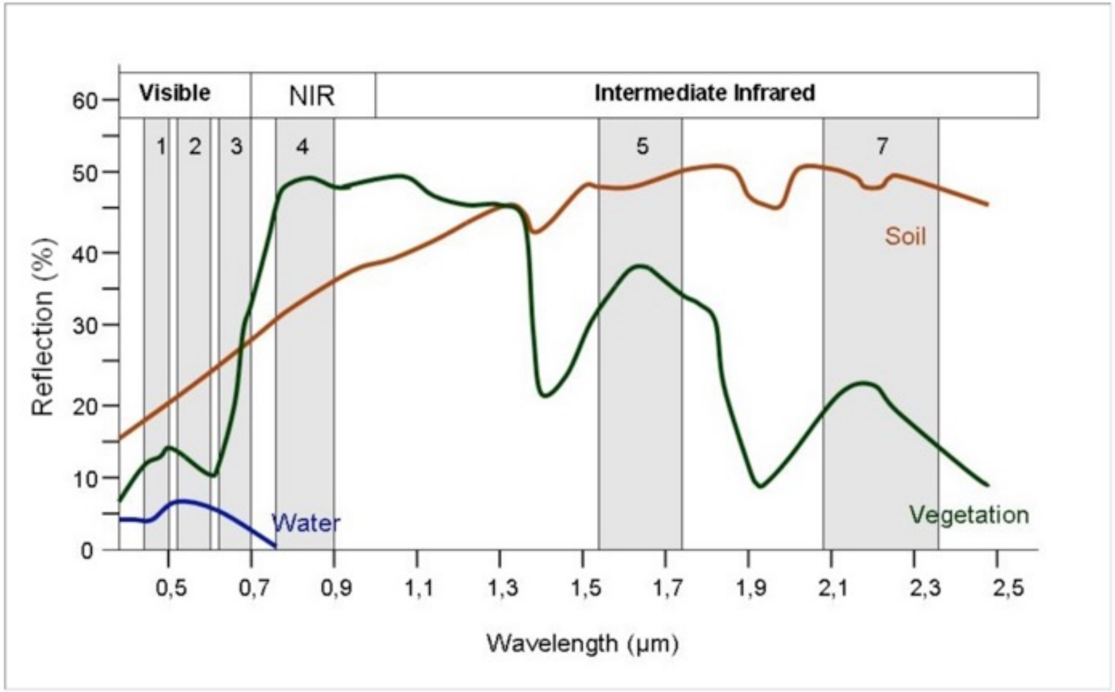


The **radiometric resolution** refers to the ability of the sensor to distinguish different “grey-scale” values

From left to right, 8 bit, 2 bit and 1 bit radiometric resolutions are shown. Adopted from Humboldt State University (2019), course introduction to remote sensing

The **temporal resolution** refers the time interval that the sensor revisits an area (ex. 16 days)

Spectral resolution refers the to the number and dimension of specific wavelength intervals of electromagnetic radiation that a sensor is capable of measuring



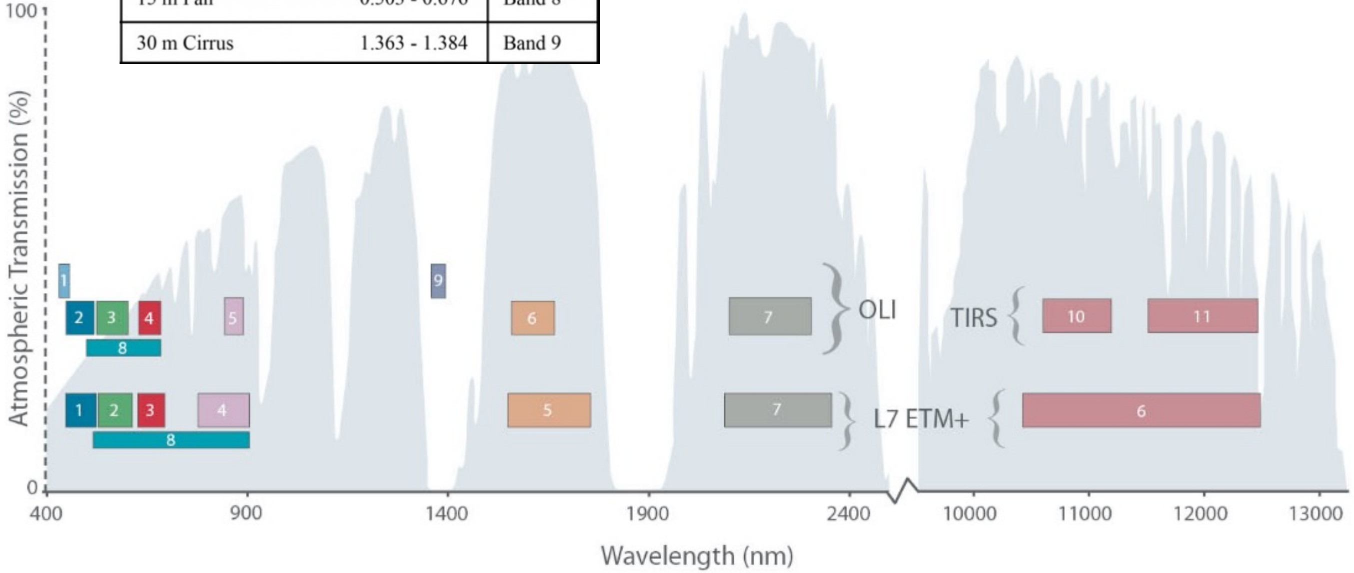
Spectral signatures of soil, vegetation and water, and spectral bands of LANDSAT 7.
Source: Siegmund, Menz 2005 with modifications

close or Esc Key

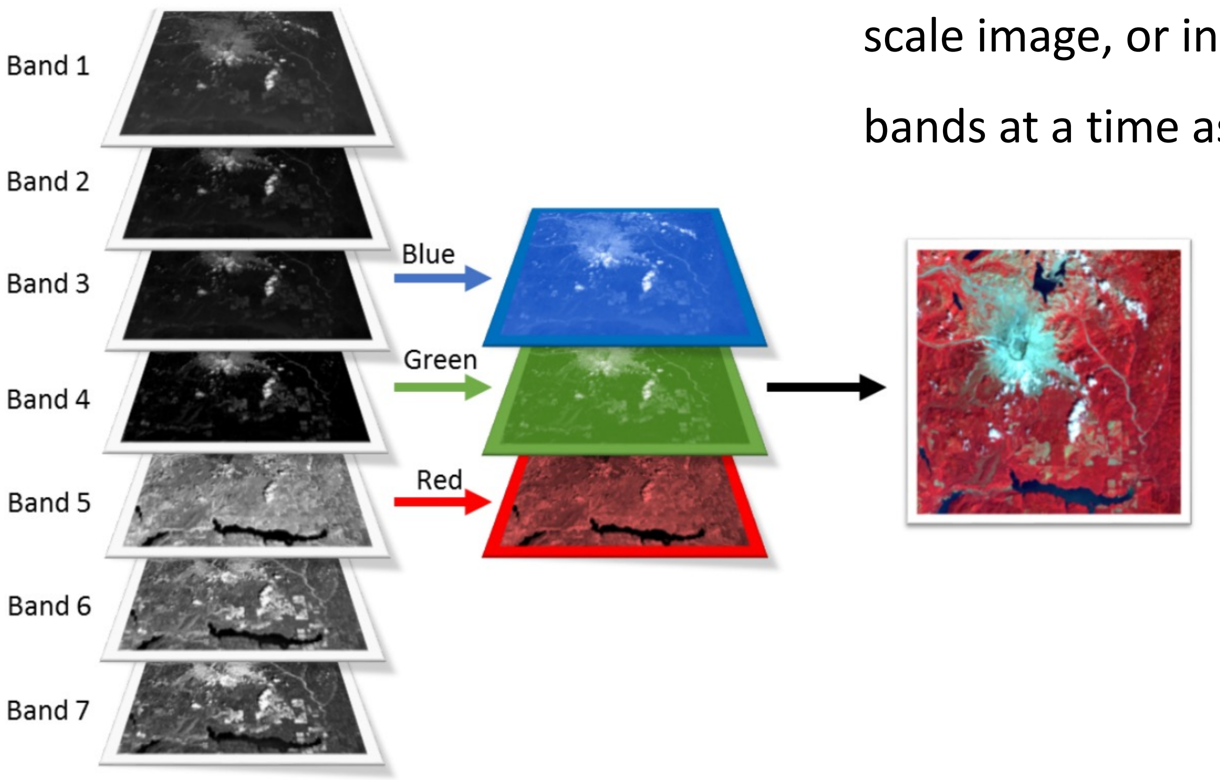
Spectral resolution refers the to the number and dimension of specific wavelength intervals of electromagnetic radiation that a sensor is capable of measuring

Landsat-8 OLI and *TIRS* Bands (μm)		
30 m Coastal/Aerosol	0.435 - 0.451	Band 1
30 m Blue	0.452 - 0.512	Band 2
30 m Green	0.533 - 0.590	Band 3
30 m Red	0.636 - 0.673	Band 4
30 m NIR	0.851 - 0.879	Band 5
30 m SWIR-1	1.566 - 1.651	Band 6
100 m TIR-1	*10.60 – 11.19*	Band 10
100 m TIR-2	*11.50 – 12.51*	Band 11
30 m SWIR-2	2.107 - 2.294	Band 7
15 m Pan	0.503 - 0.676	Band 8
30 m Cirrus	1.363 - 1.384	Band 9

Ex. Landsat 8

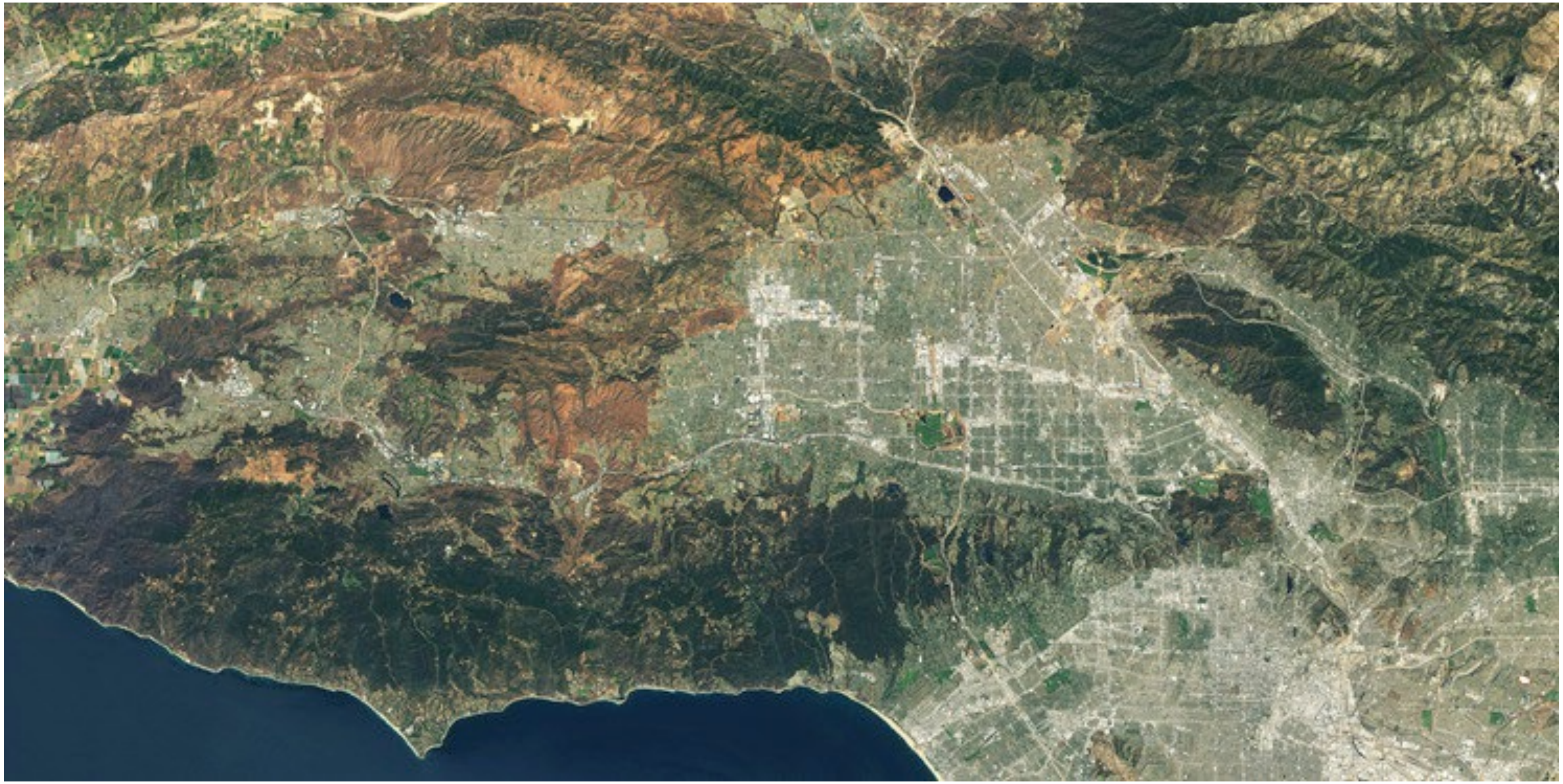


Each band of a multispectral image can be displayed one band at a time as a grey scale image, or in a combination of three bands at a time as a color composite image



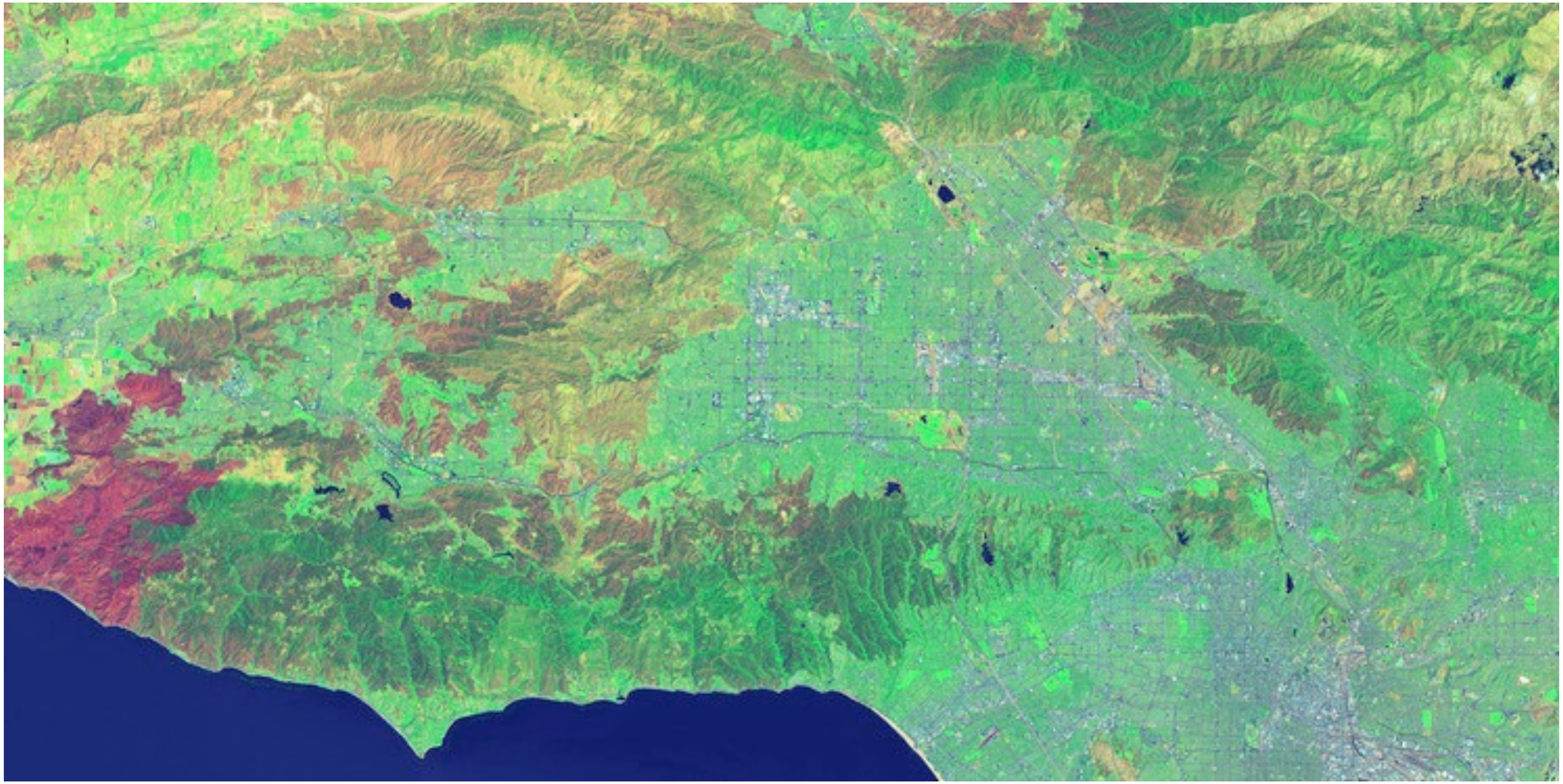
https://blog.mapbox.com/putting-landsat-8s-bands-to-work-631c4029e9d1

Los Angeles, CA, USA – Landsat 8: Blue (R), Green(G) e Red(B)



Los Angeles, CA, USA – Landsat 8: NIR (mono)

Los Angeles, CA, USA – Landsat 8: 7 SWIR (R), NIR(G) and Aerosol(B)



Amazonia-1

Instrumento: AWFI (Advanced Wide Field Imager)

Revisita: cinco dias;

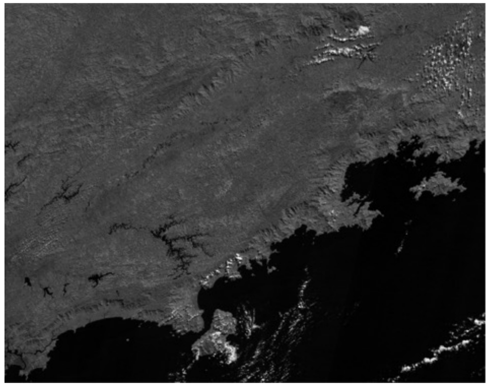
Largura da Faixa Imageada: 850 km;

Tipo de Dado: Número Inteiro Sinalizado 16 Bit;

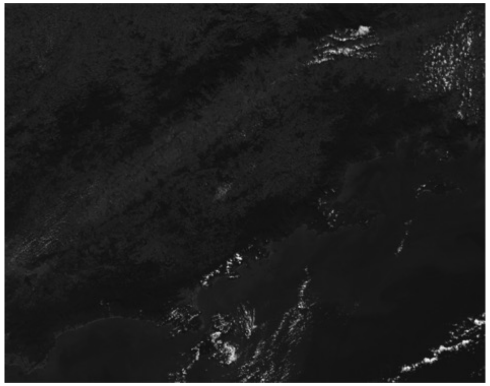
Sistema de Referência: Sistema Projetado, Datum WGS 1984

Imagens: http://www2.dgi.inpe.br/catalogo/explore

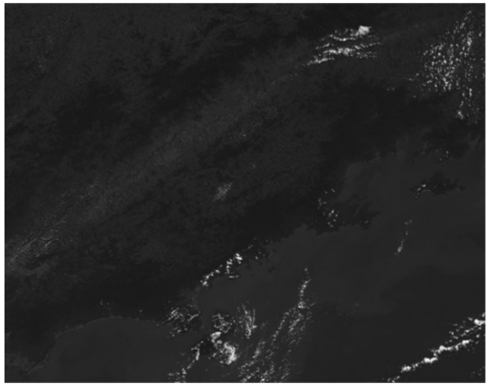
2(R) 1(G) 0(B)



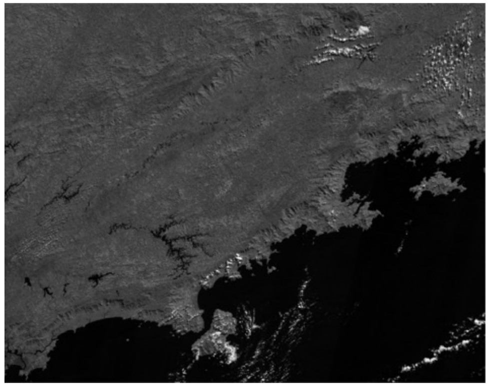
Band 0 - Blue (0.45-0.52 μm)



Band 1 - Green (0.52-0.59 μm)

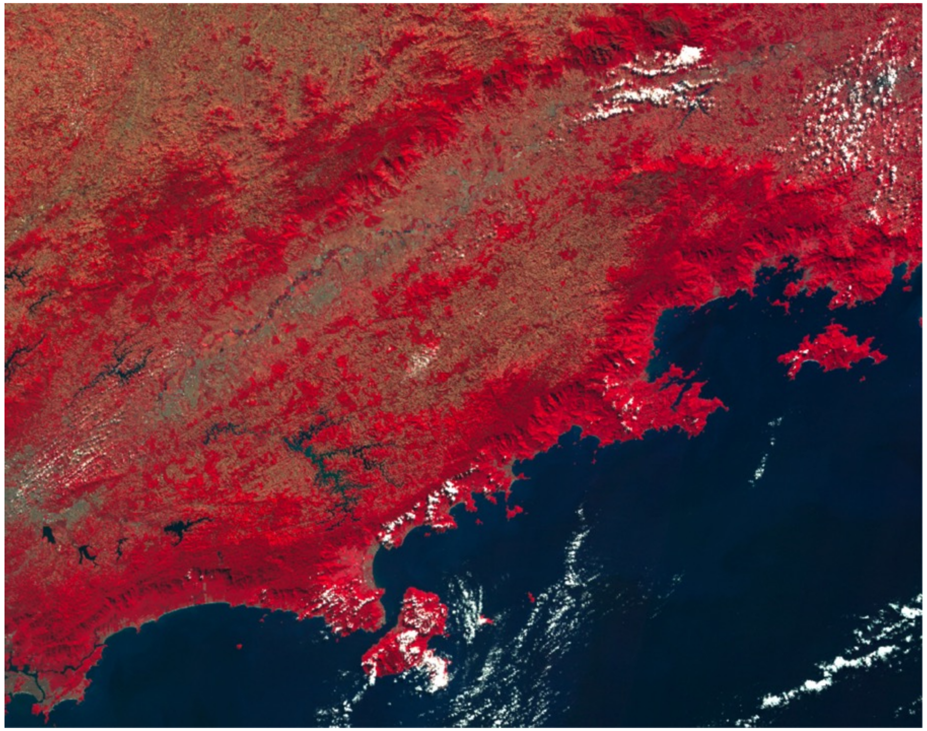


Band 2 - Red (0.63-0.69 μm)

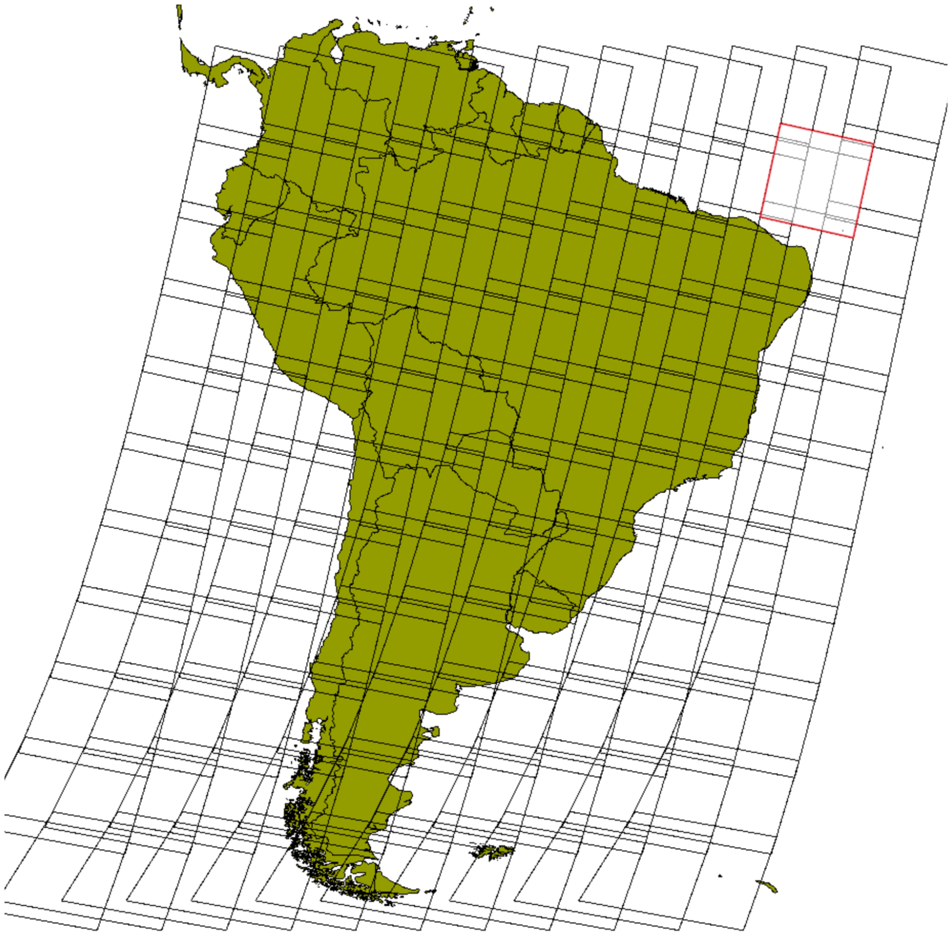


Band 3 - NIR (0.77-0.89 μm)

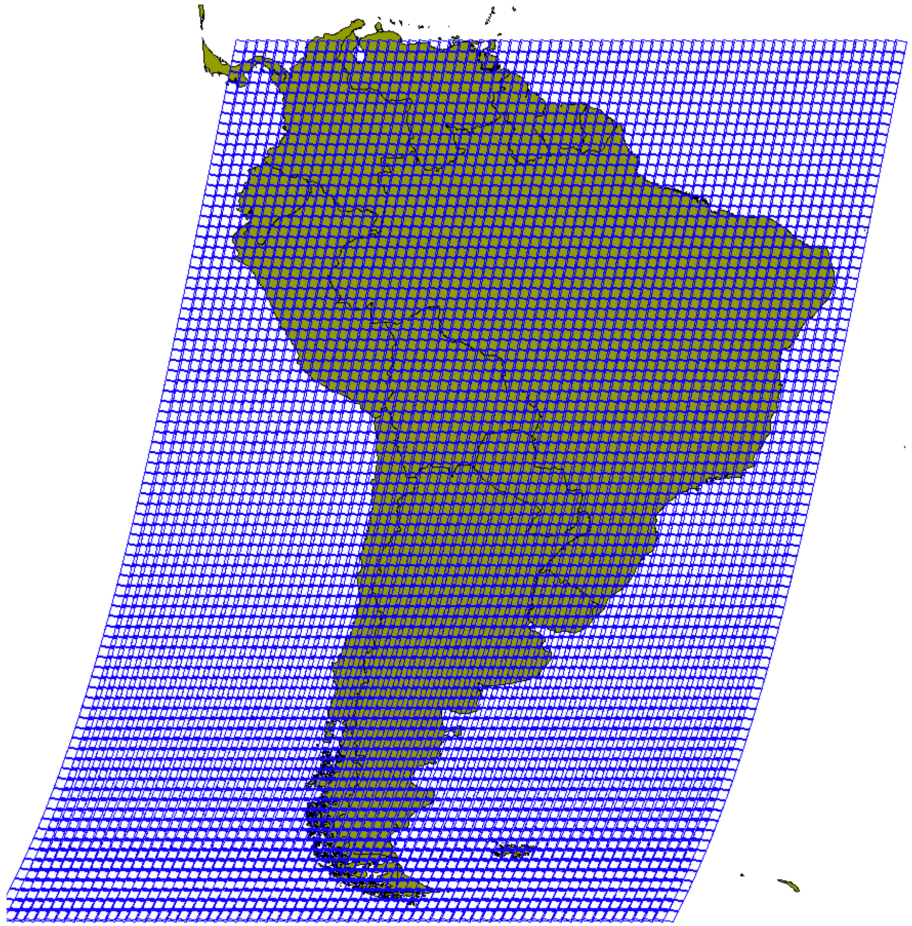
2(R) 1(G) 0(B) - True Color



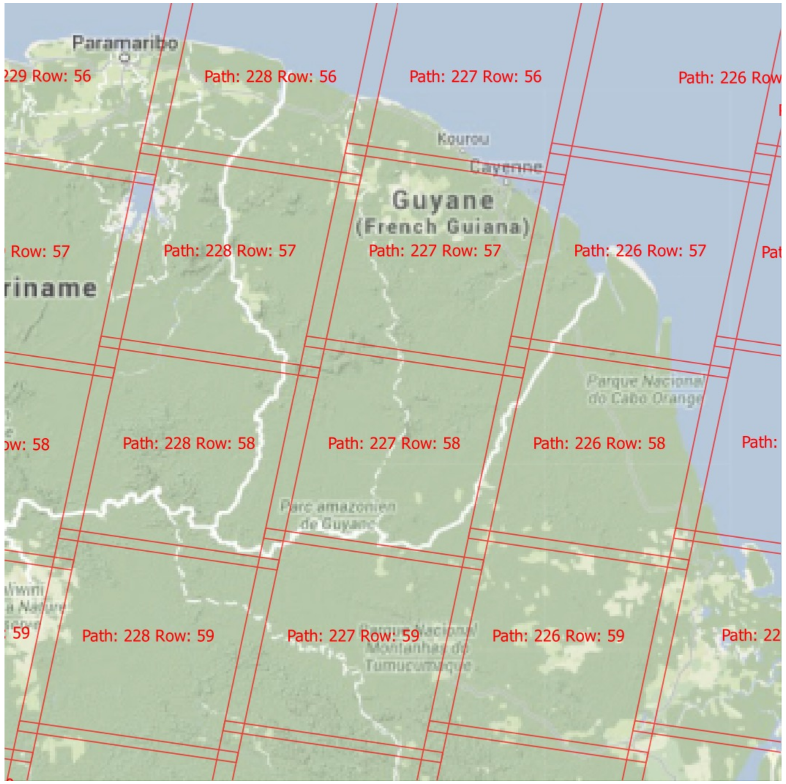
3(R) 2(G) 1(B) - False Color
NIR in the Red channel to enhance vegetation

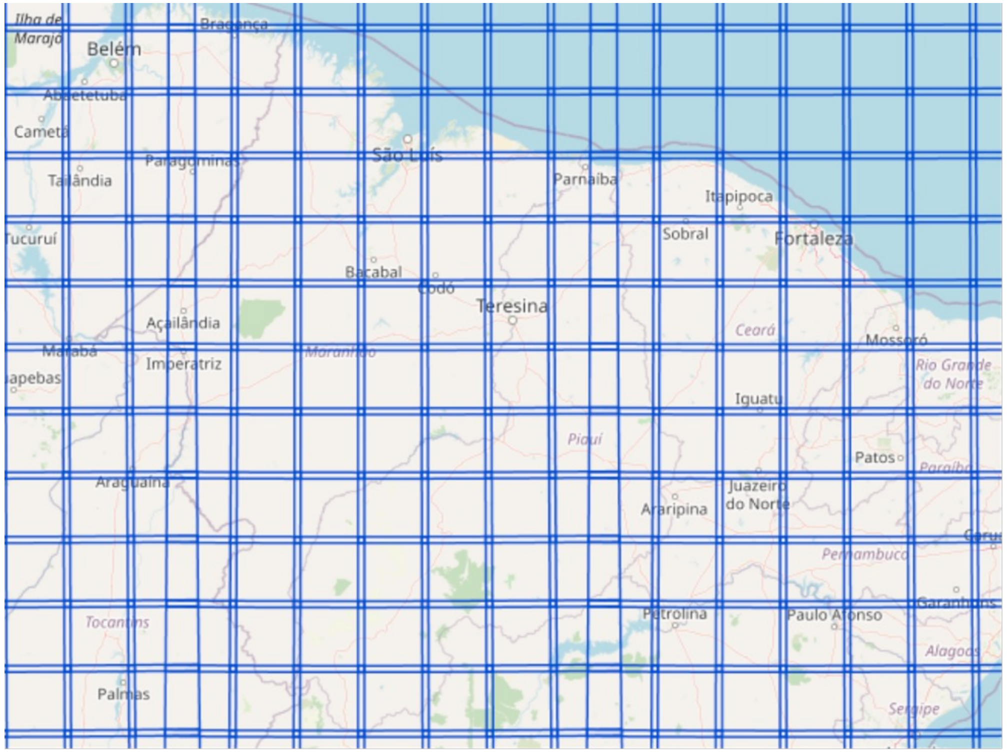


Grid Amazonia-1 / WFI



Grid CBERS4 / MUX - GRID





Landsat Worldwide Reference System
WRS-1 and -2

Sentinel-2 Militar Grid Reference System

Resources

- https://www.dgi.inpe.br/catalogo/explore/
- https://https://data.inpe.br
- http://satelite.cptec.inpe.br/home/index.jsp
- https://ceos-cove.org
- https://gdal.org/