



MASTER IN CITY & TECHNOLOGY
DIGITAL TOOLS AND BIG DATA
2019/2020

FACULTY DIEGO PAJARITO

Satellite Imagery

Earth observation from the space

"Aerial photography was first practiced by the French photographer and balloonist **Gaspard-Félix Tournachon**, known as "Nadar", in **1858** over Paris, France. However, the photographs he produced no longer exist and therefore the earliest surviving aerial photograph is titled '***Boston, as the Eagle and the Wild Goose See It.***' Taken by James Wallace Black and Samuel Archer King on October 13, **1860**, it depicts Boston from a height of **630m.**"



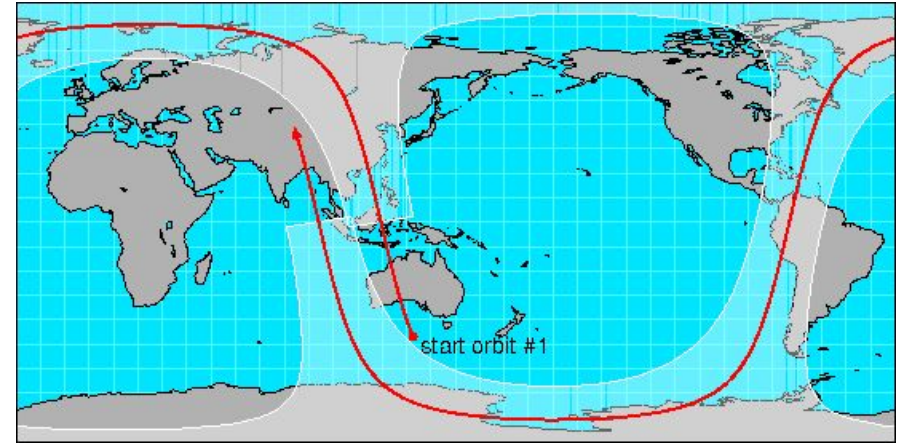
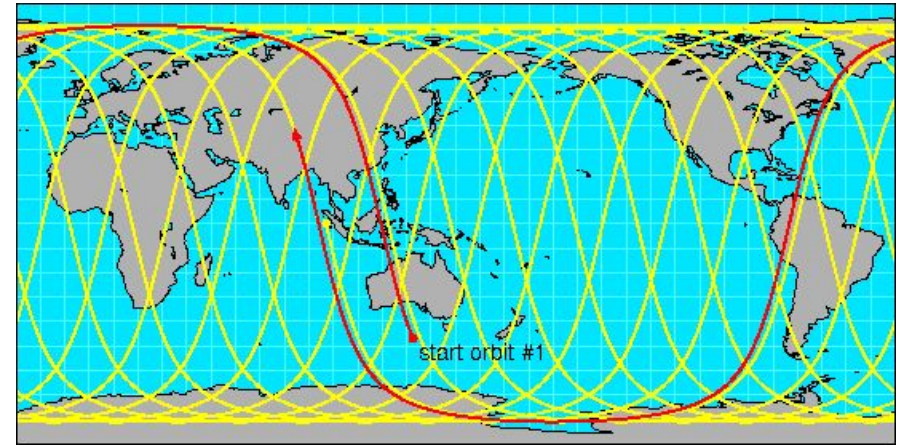
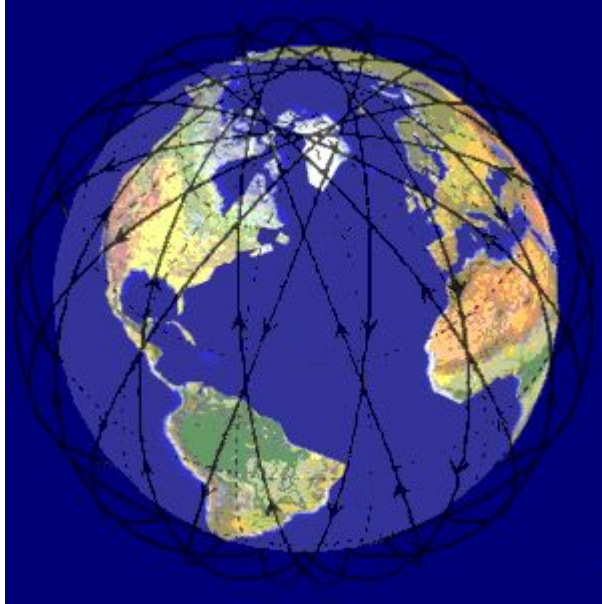
“Since the first **Landsat satellite** launched in 1972, the mission has **collected data** on the forests, farms, urban areas and freshwater of our home planet, generating the longest continuous record of its kind. Decision makers from across the globe use **freely available** Landsat data to better **understand** environmental change, manage agricultural practices, allocate scarce water resources, respond to natural disasters and more.”



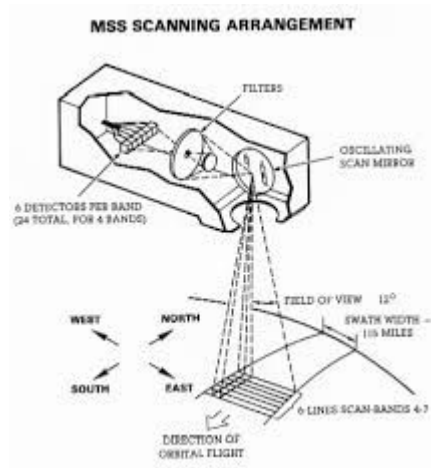
“Sentinel-2 is providing **high-resolution** optical imagery of agriculture, forests, land-use change and land-cover **change**. It is mapping biophysical variables such as leaf chlorophyll content, leaf water content and leaf area index. It is also monitoring coastal and inland waters and **helping with risk and disaster mapping**. The Sentinel-2 mission is providing **global coverage** of Earth's land surface every 10 days with the first spacecraft, reducing to **every 5 days** once both are in orbit.”



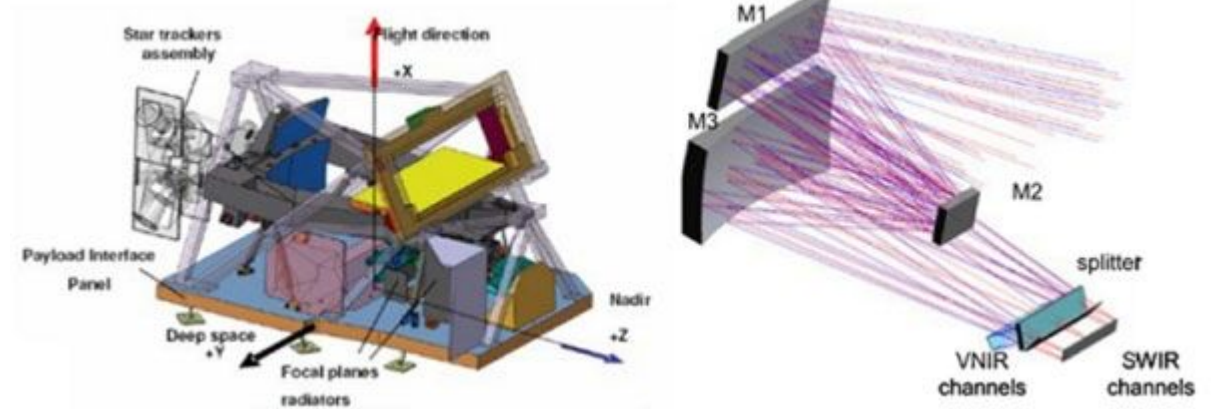
Source: https://www.esa.int/Enabling_Support/Operations/Sentinel-2_operations



Source: http://tornado.sfsu.edu/geosciences/classes/m415_715/MonteVerdi/Satellite/PolarOrbiter/Polar_Orbits.html



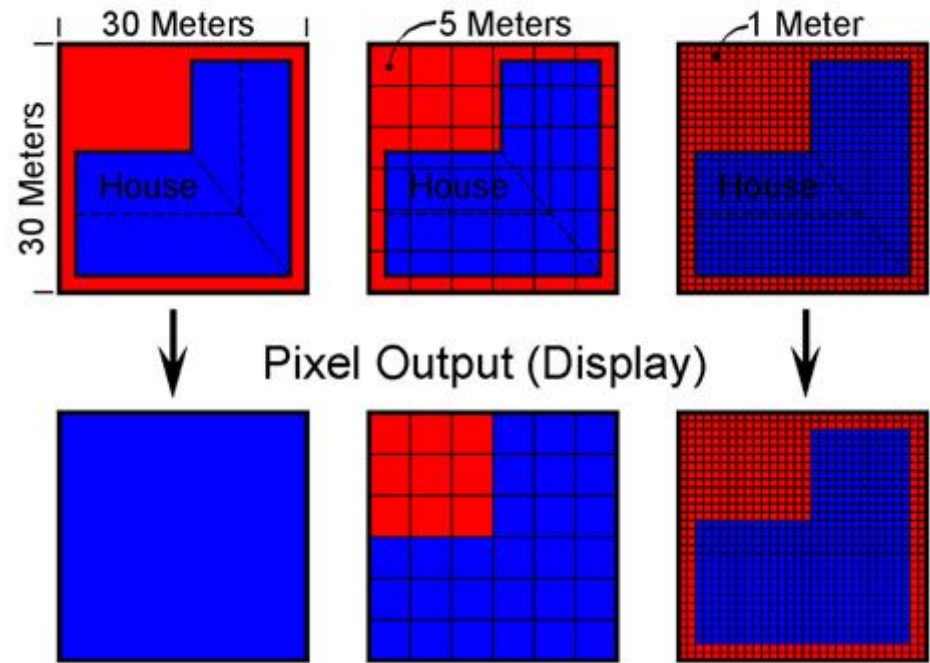
Source: <http://uregina.ca/piwowarj/Satellites/Landsat.html>



Source: <https://earth.esa.int/web/sentinel/technical-guides/sentinel-2-msi/msi-instrument>

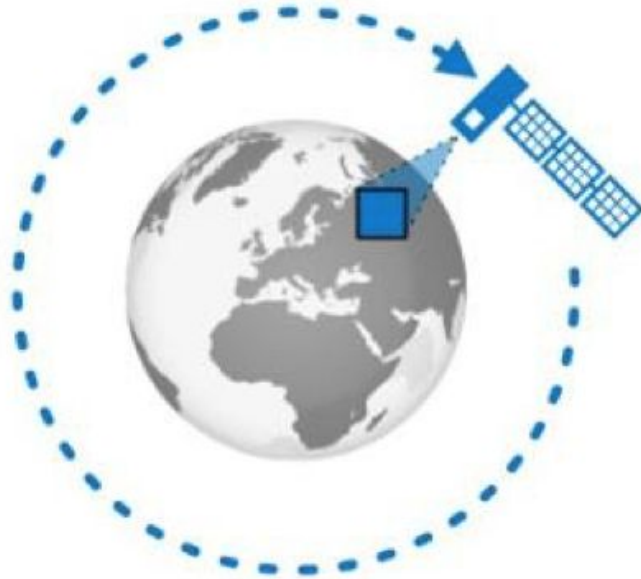
Spatial resolution refers to the size of one pixel on the ground. Naturally linked to the raster format. For regular-pixel raster models, it measures the length of a pixel side.

No object / surface smaller than the pixel size can be recognised. Theoretically, all values falling into the pixel area are used to calculate an average digital value

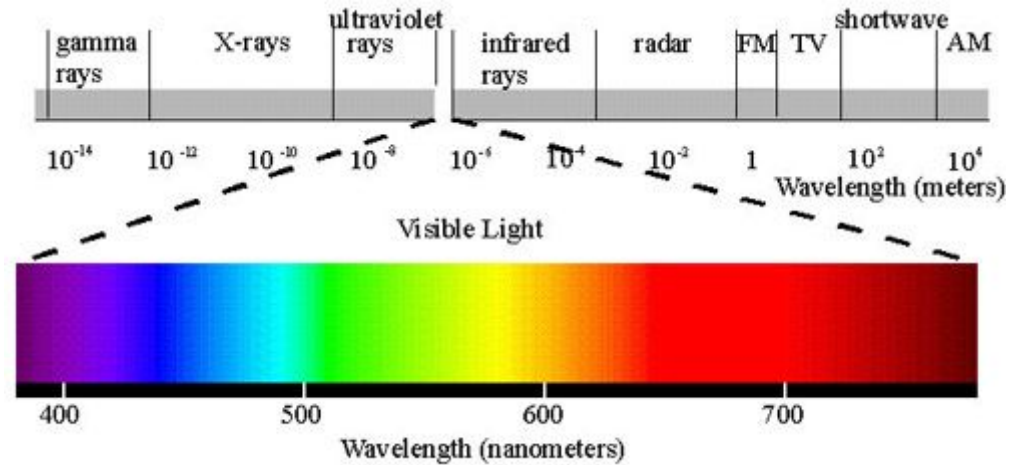
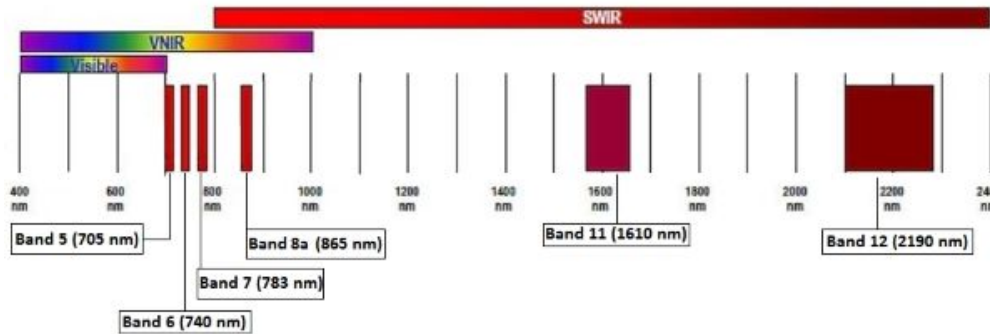
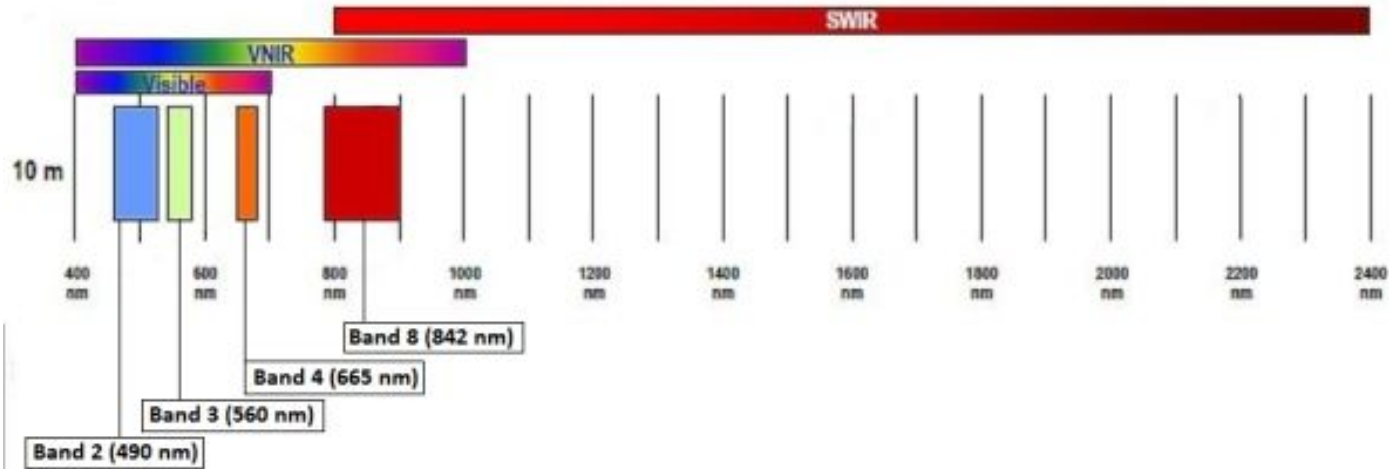


Temporal Resolution

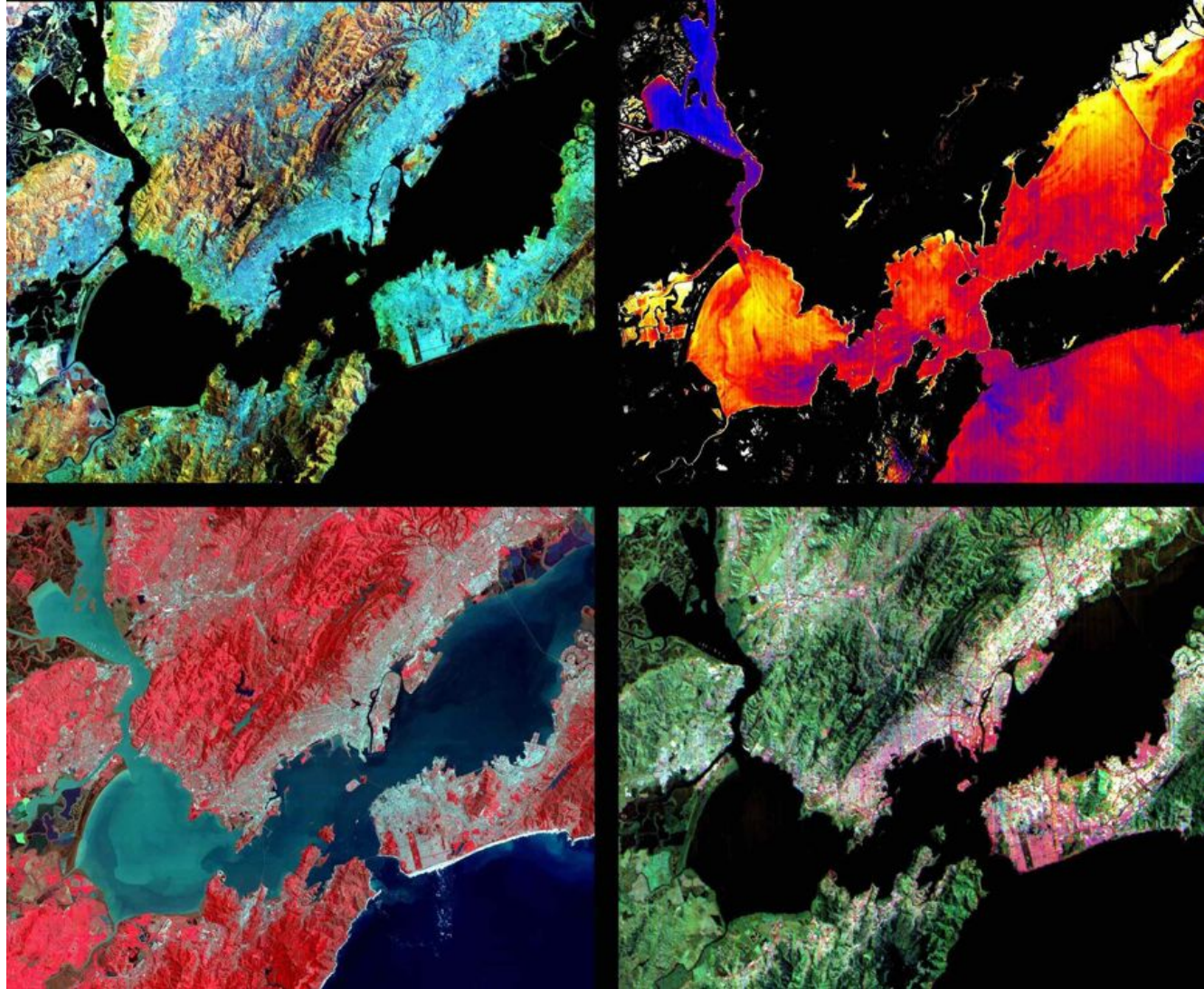
Temporal resolution varies by satellite and describes the time it takes for an individual satellite to orbit and revisit a specific area. Some satellites operate as a constellation with multiple satellites working together to increase their global coverage daily.



	(#)	Days between images
Aqua (MODIS)	(1)	■
PlanetScope (Dove)	(172)	■
Worldview-4	(1)	■ (When requested)
Pleiades	(2)	■ (When requested)
Sentinel-2	(2)	■ ■ ■ ■ ■ 5 Days
Landsat-8	(1)	■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ 16 Days



Spectral features



Bands (Image)

Channels (Screen)

(Landsat)

B1: Blue

B2: Green

B3: Red

B4: Close IR

(Sentinel 2)

B2: Blue

B3: Green

B4: Red

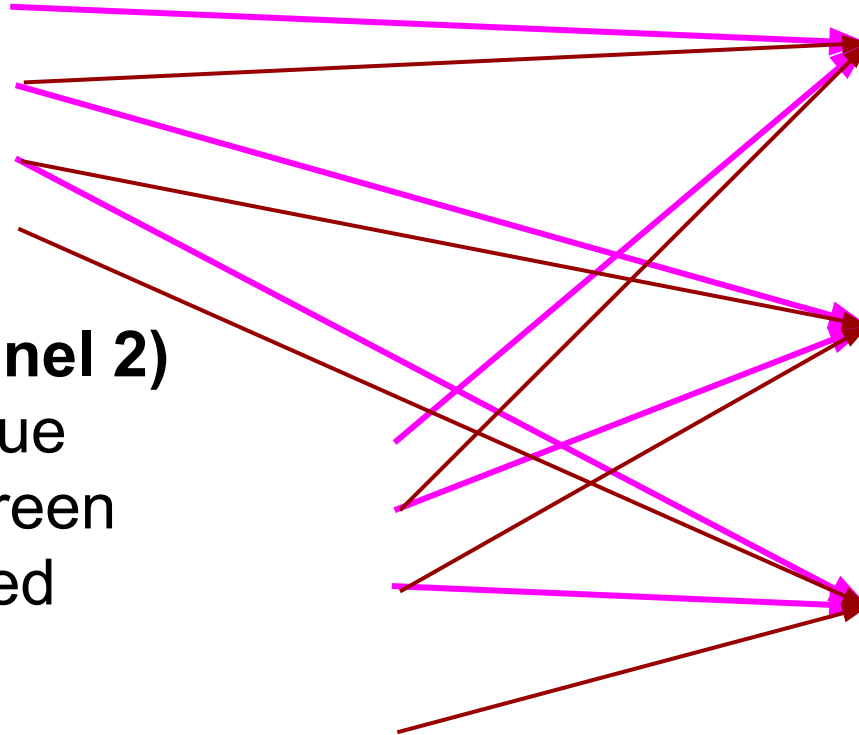
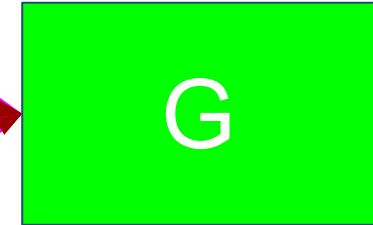
...

B8: IR

True Color

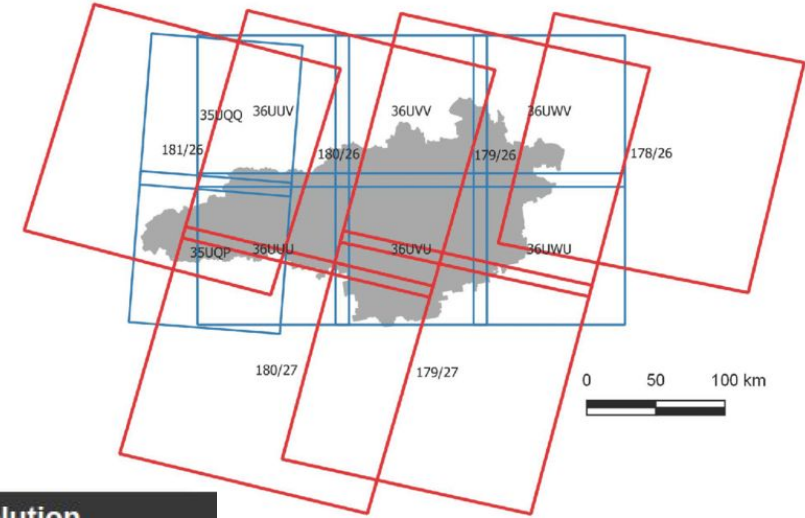


False Color



Spatial coverage

Pixel size versus image footprint



30m Resolution



15m Resolution



1m Resolution



Coverage of Landsat-8 scenes and Sentinel-2A tiles. Example from a particular study.

Sources:

https://www.researchgate.net/figure/Coverage-of-Landsat-8-scenes-and-Sentinel-2A-tiles-over-the-study-area_fig3_317095580

http://gsp.humboldt.edu/OLM/Courses/GSP_216_Online/lesson3-1/resolution.html

- 1 USGS Earth Explorer
- 2 Sentinel Open Access Hub
- 3 NASA Earthdata Search
- 4 NOAA Data Access Viewer
- 5 DigitalGlobe Open Data Program
- 6 Geo-Airbus Defense
- 7 NASA Worldview
- 8 NOAA CLASS

- 9 National Institute for Space Research (INPE)
- 10 Bhuvan Indian Geo-Platform of ISRO
- 11 JAXA's Global ALOS 3D World
- 12 VITO Vision
- 13 NOAA Digital Coast
- 14 Satellite Land Cover
- 15 UNAVCO

Source: <https://gisgeography.com/free-satellite-imagery-data-list/>

Hands-on

How we can see through satellite imagery

Let's discuss how we would use satellite imagery



<https://www.directpoll.com/>

<http://etc.ch/vPqG>

** This survey is designed only for the live session*

Image from 2015

Bands 1 to 12 + band 8a

True colour image (TCI)

* Image names do not contain info about spatial resolution

Image from 2019

Bands grouped by spatial resolution
10m - 20m - 60m

Bands

True colour image (TCI)
Aerosol Optical Thickness (AOT)
Water Vapour (WPV)

* Image names contain info about spatial resolution

Source: <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/processing-levels/level-2>

Video number 1 explains the process to get satellite images from the sentinel 2 constellation and how to visualise these images using QGIS

(Check Google Drive folder for this video)

What kind of data coming from satellite imagery is potentially useful for urban design?

How difficult would be to integrate satellite image processing into the urban design workflow?

To which extent is it already present?

Maths & Algorithms

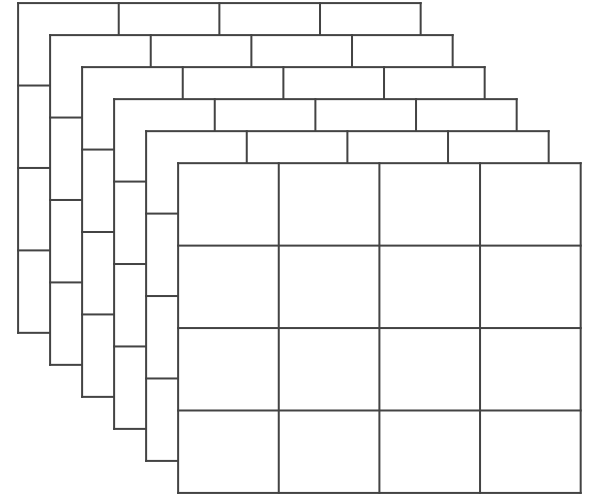
How we can extract data from satellite imagery

Digital levels are stored using a grid-based structure equivalent to a matrix.

Multiple bands (i.e., *values from different spectral regions*) are stored as individual matrices

Since all are numeric values, algebraic operations using bands are supported

A simple sandbox [here!!](#)



A common algebraic operation for satellite image processing is the Normalised Digital Vegetation Index.

$$\frac{(\text{IRB} - \text{RB})}{(\text{IRB} + \text{RB})}$$

Having:

- IRB: Infrared band
- RB: Red band

Find additional descriptions of common indexes in this post:

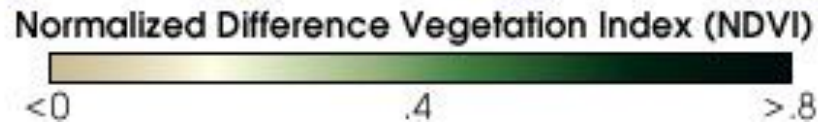
<https://medium.com/regen-network/remote-sensing-indices-389153e3d947>

(-1 to 0) Negative values of NDVI represent Water bodies.

(0.1 and below) Very low values correspond to barren areas of rock, sand, or snow.

(0.2 to 0.3) Moderate values of NDVI represent shrub and grassland

(0.6 to 0.8) High values indicate temperate and tropical rainforests .



Source: <https://earthobservatory.nasa.gov/features/MeasuringVegetation>

A new index for the analysis of urban areas have emerged. It highly depends on infrared bands.

$$\frac{(B11 - B8)}{(B11 + B8)}$$

Having:

- B11: Sentinel 2 - SWIR
- B8: Sentinel 2 - NIR

The operation depends strongly on the definition of individual bands of every satellite system.

Source:

<https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-1-W2/43/2019/isprs-archives-XLII-1-W2-43-2019.pdf>

The Normalized Difference Build-up Index value lies between -1 to +1

(-1 to 0) Negative values of NDBI represent water bodies

(Close to 1) Higher values represent build-up areas

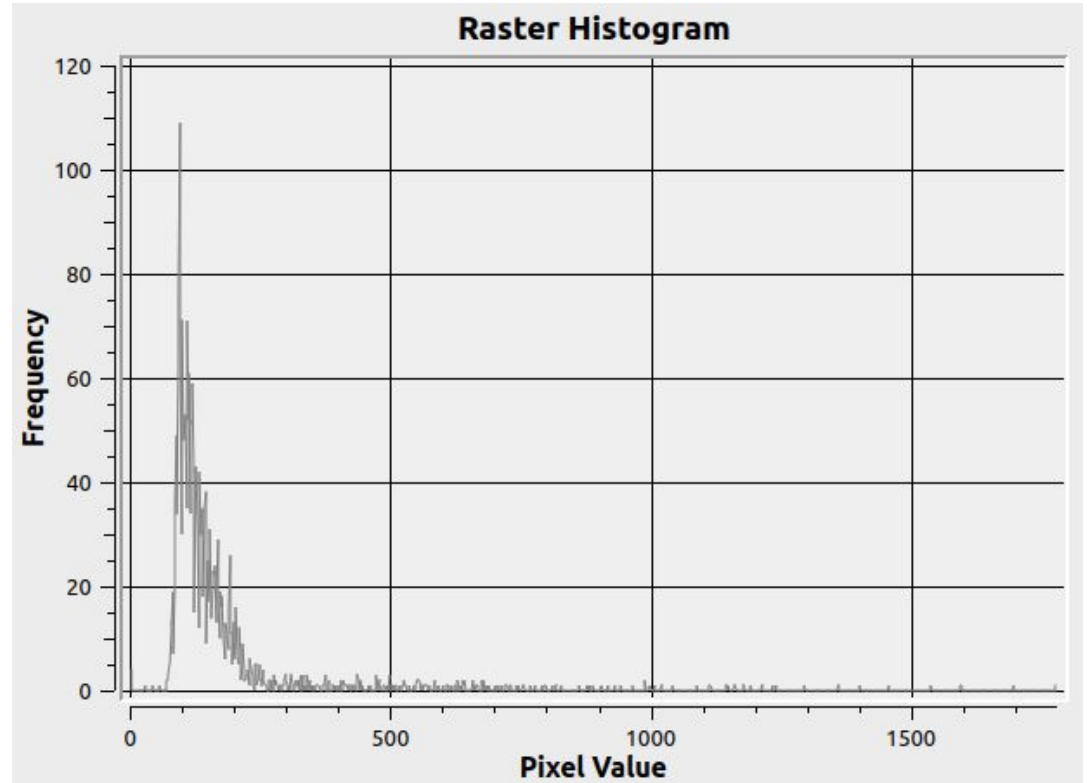
**NDBI value for vegetation is low*

Chunyang He , Peijun Shi , Dingyong Xie & Yuanyuan Zhao
<https://doi.org/10.1080/01431161.2010.481681>

An overview of index (as well as digital levels) distribution.

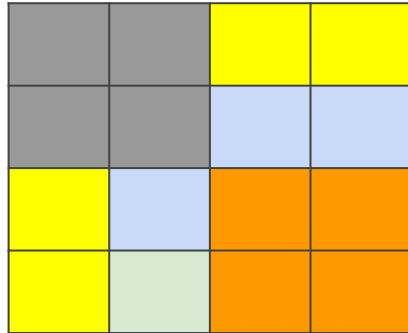
Quick interpretation of the amount of greenery / built-up areas.

Computed by default when visualising images



An operation to summarize
the areas covered by groups
of digital levels.

Polygons also serve to
perform calculations



Zone	Pixels	Area (%)
1	450.000	30%
2	225.000	15%
3	150.000	10
...		

Hands-on

How we can see through satellite imagery

Let's see what we are thinking



<http://etc.ch/EPz4>

<https://www.directpoll.com/>

** This survey is designed only for the live session*

Let's map some areas of interest together

Add your polygons here!!

Add your polygons here!!

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