

# → EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

## Urban Development

City Academy: Geospatial Data Applications for Urban Development, Sao Paulo 16.-17.09.2019

## Introduction to Concepts in Remote Sensing

Hervis GHOMSI, SIRS



This presentation will cover the following topics:

- What is Remote Sensing?
- Some keys concepts
- Optical vs Radar remote sensing
- Platforms for images acquisition
- Very high spatial resolution vs high spatial resolution, what difference for what application?
- Some applications of remote sensing

The Topics will be explained by the help of many image examples from current satellites.

# What is Remote Sensing?



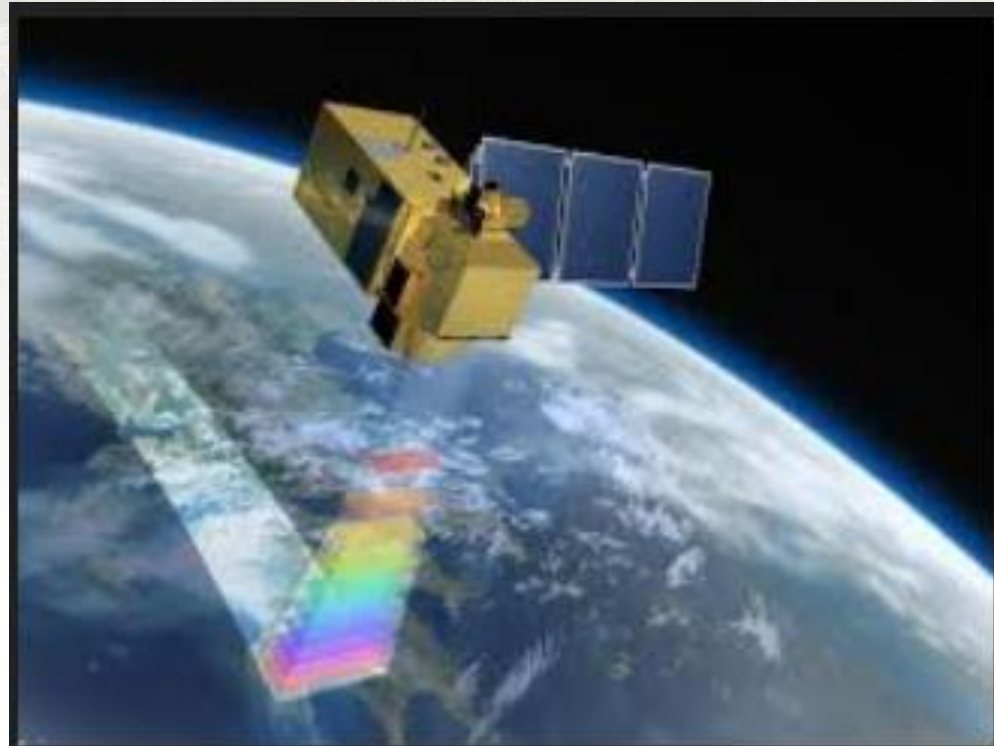
**Remote Sensing:** *A science which obtains information about the Earth by scanning it from a satellite or high flying aircraft.*

*Or*

*The science of acquiring data without being in contact with it.*

## Several motivations:

- Systematic data collection



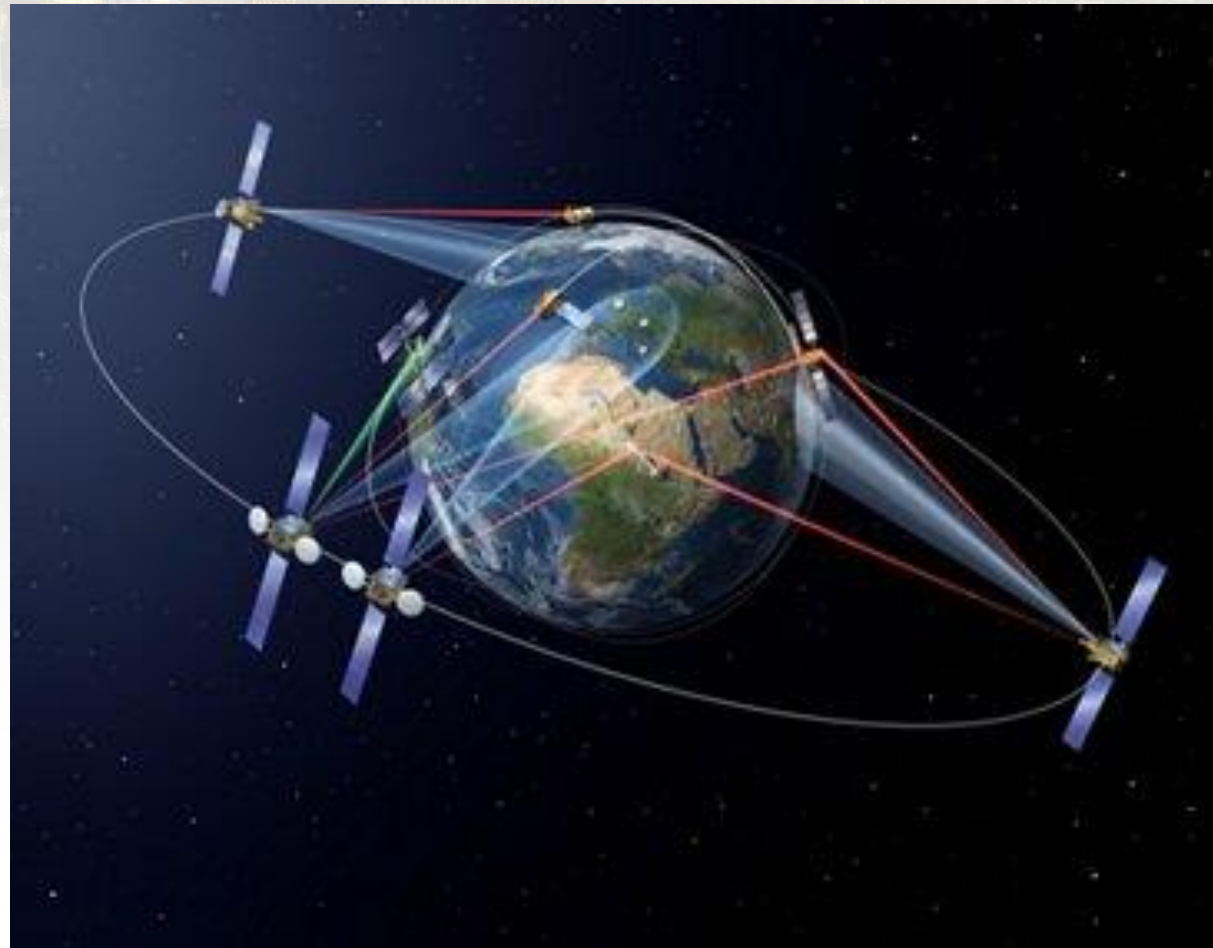
## Several motivations:

- **Repeatability of acquisitions:** Control interval of a sensor. 5 days for Sentinel 2 (A&B) with constellation of 2 satellites

To be taken into account for time series analysis and historical land monitoring.

## Several motivations:

- Global coverage



<https://www.airbus.com/newsroom/press-releases/en/2018/03/SpaceDataHighway-starts-full-Copernicus-service.html>

## Several motivations:

- Inaccessible areas become accessible (rugged terrain)



Example: Machu Picchu, Peru

<https://creativecommons.org/licenses/by-sa/2.0>

**Satellite:** *An artificial body placed in orbit round the Earth or another planet in order to collect information or for communication.*

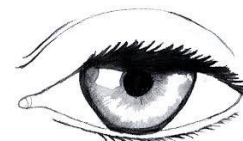
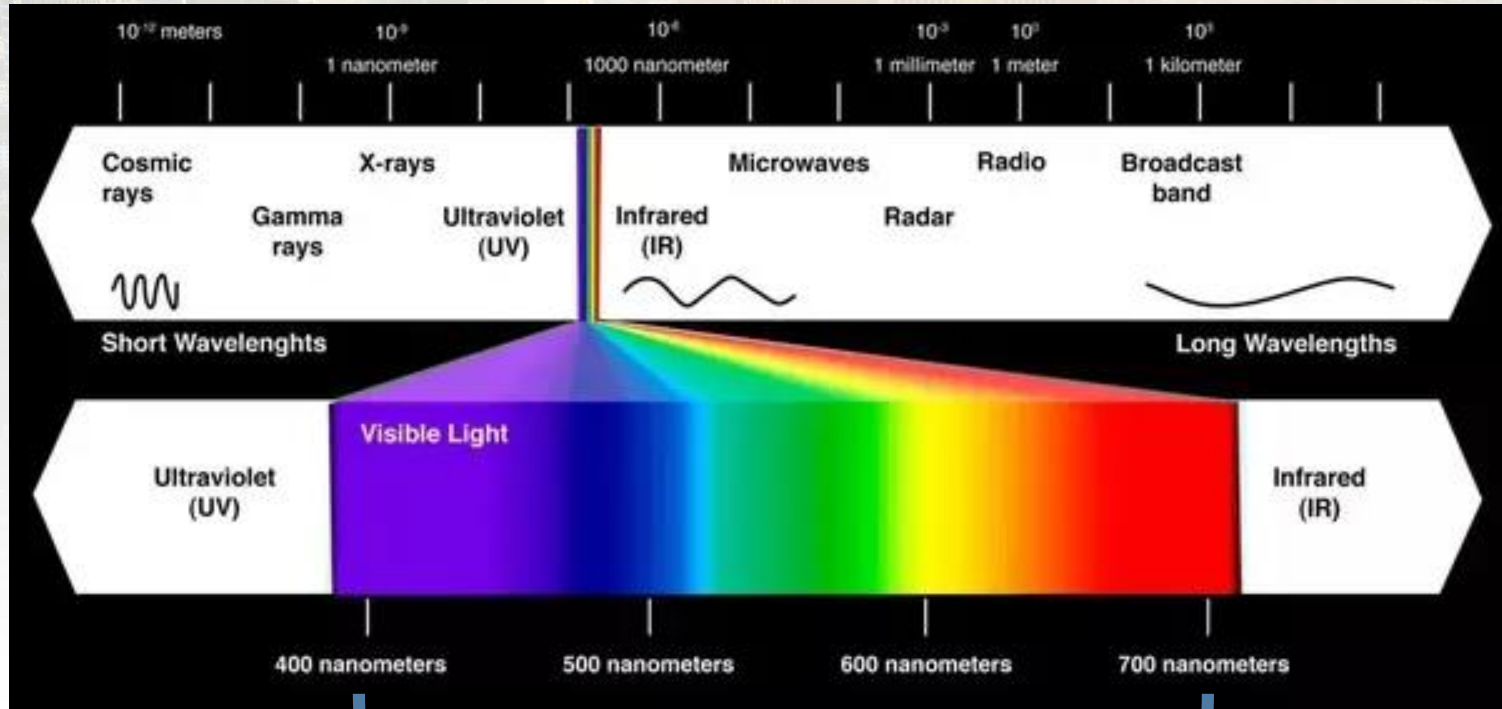
## **Types of satellites:**

- Research
- Weather
- Communication
- Navigation
- *Earth observation*





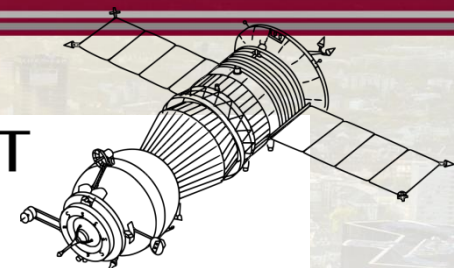
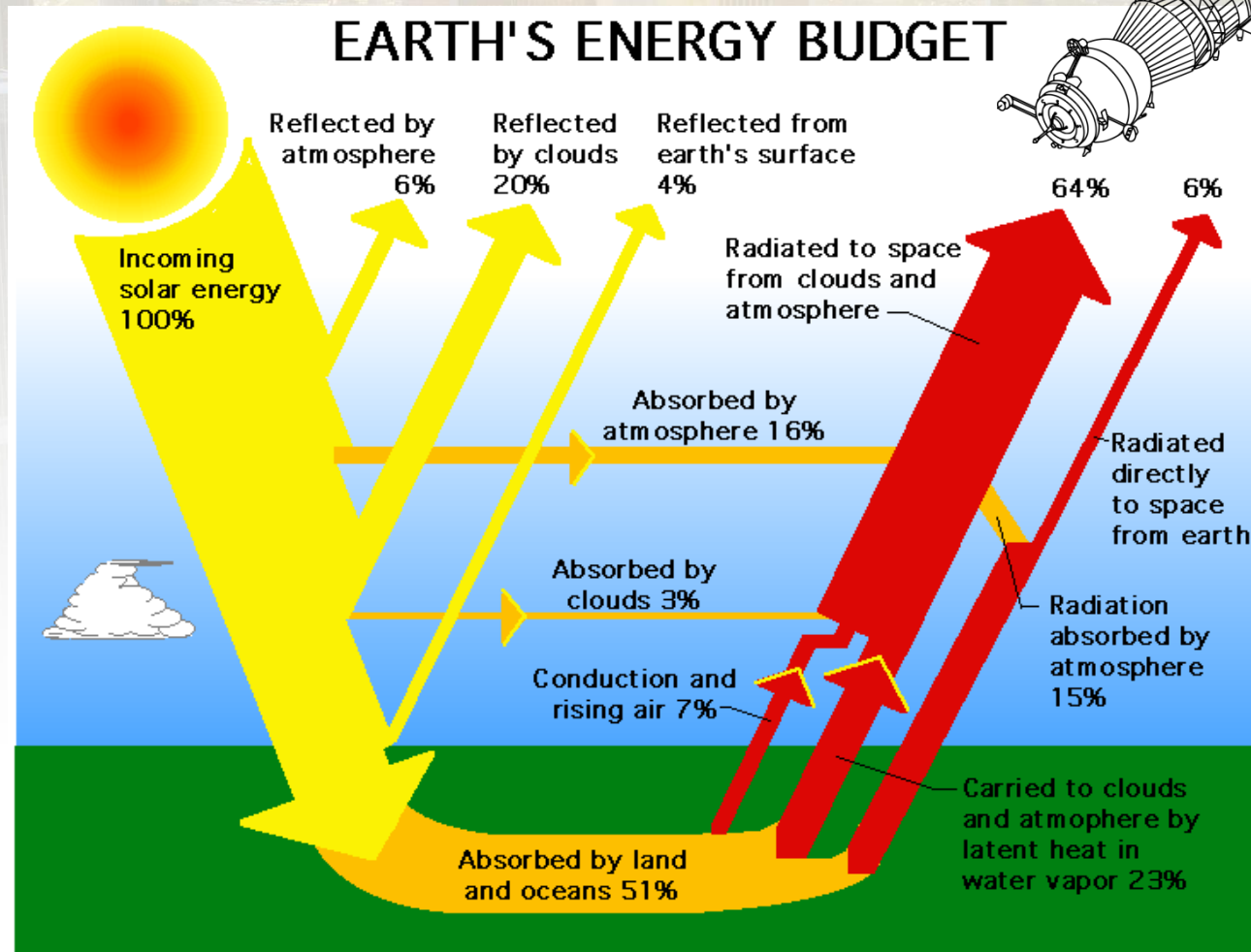
## ElectroMagnetic spectrum (EM-Spectrum)



# Remote sensing: Some keys concepts

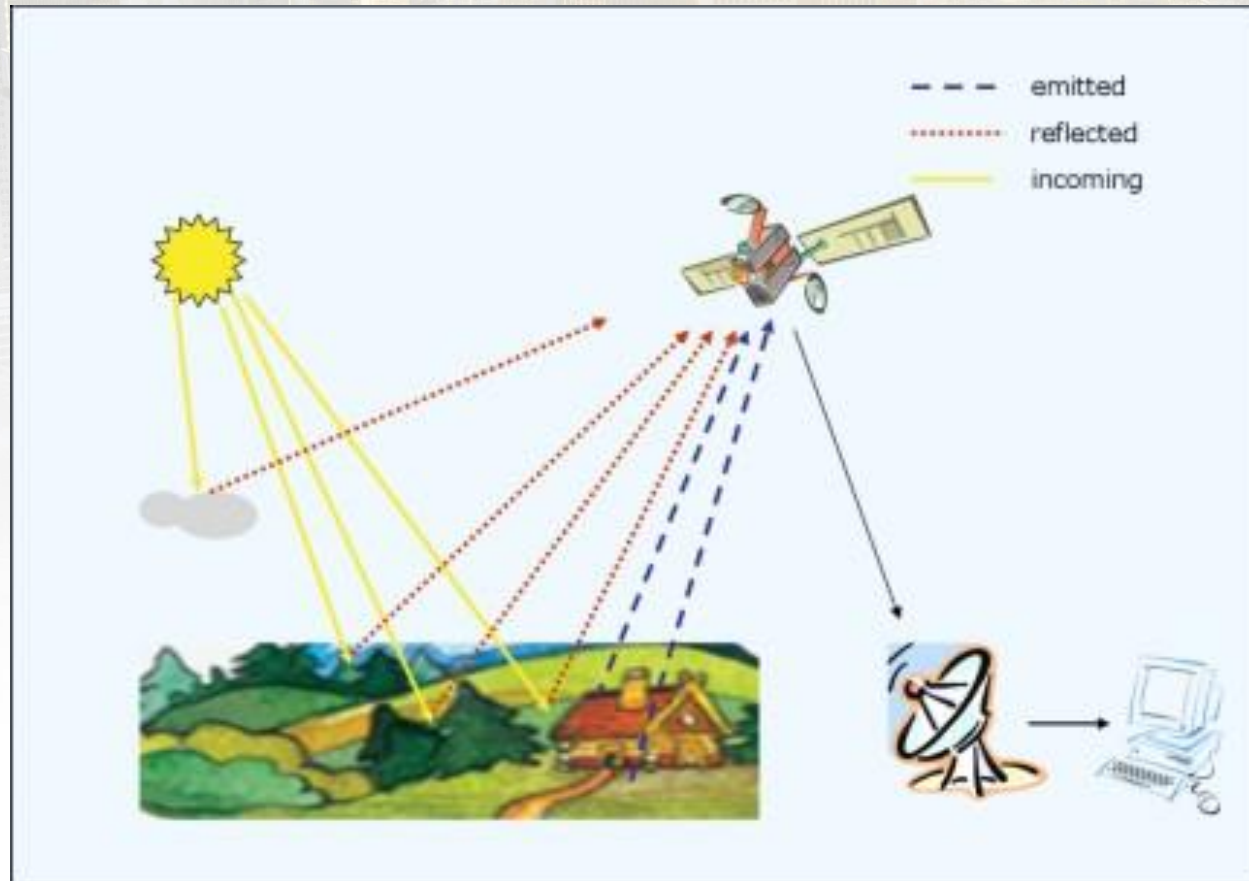


## Energy budget:



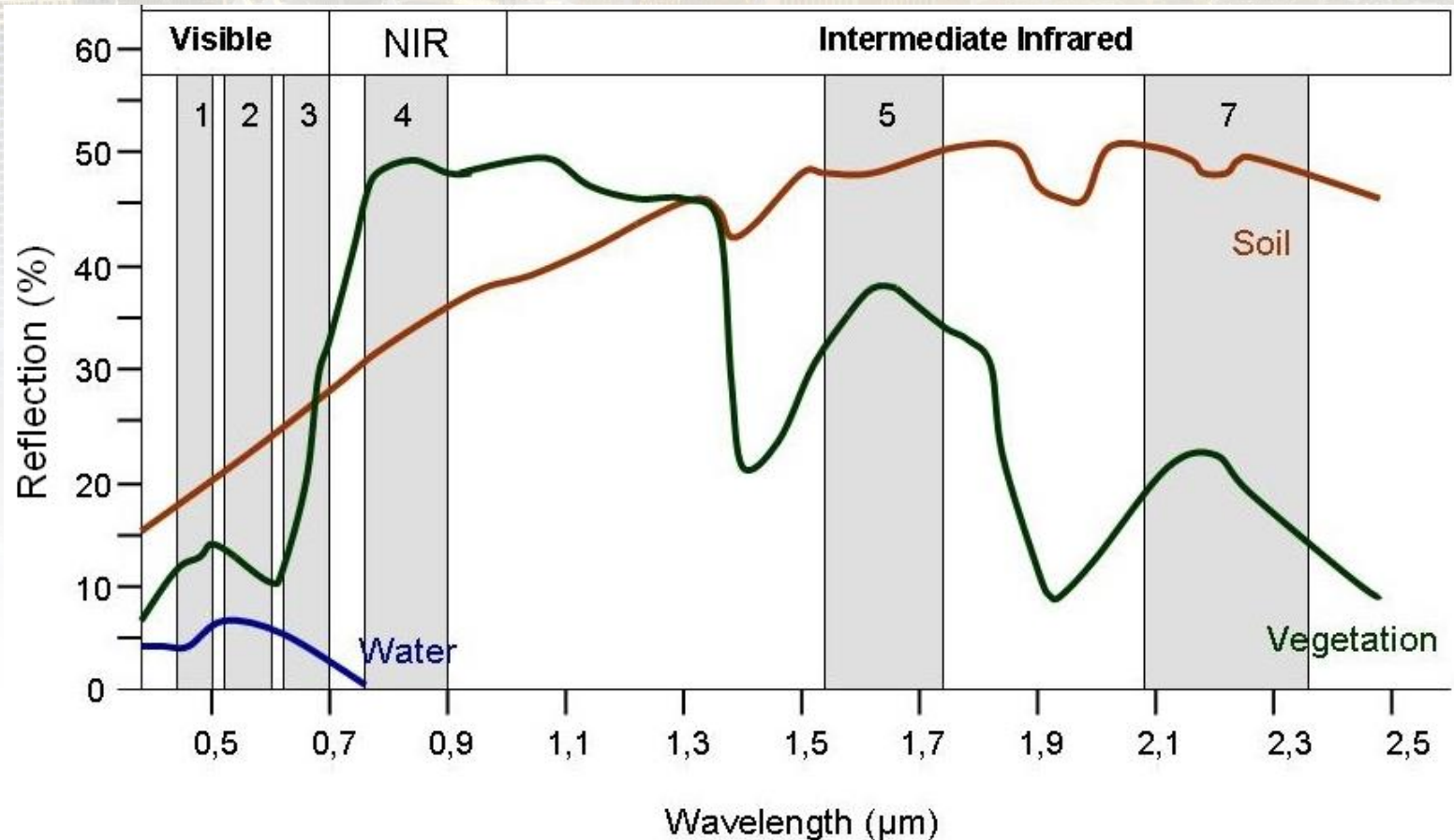
13-9-2018,  
<http://nasawavelength.org/resource/nw-000-000-003-811>

## Reflectance:



13-9-2018, [https://www.tankonyvtar.hu/en/tartalom/tamop425/0027\\_DAI6/ch01s02.html](https://www.tankonyvtar.hu/en/tartalom/tamop425/0027_DAI6/ch01s02.html)

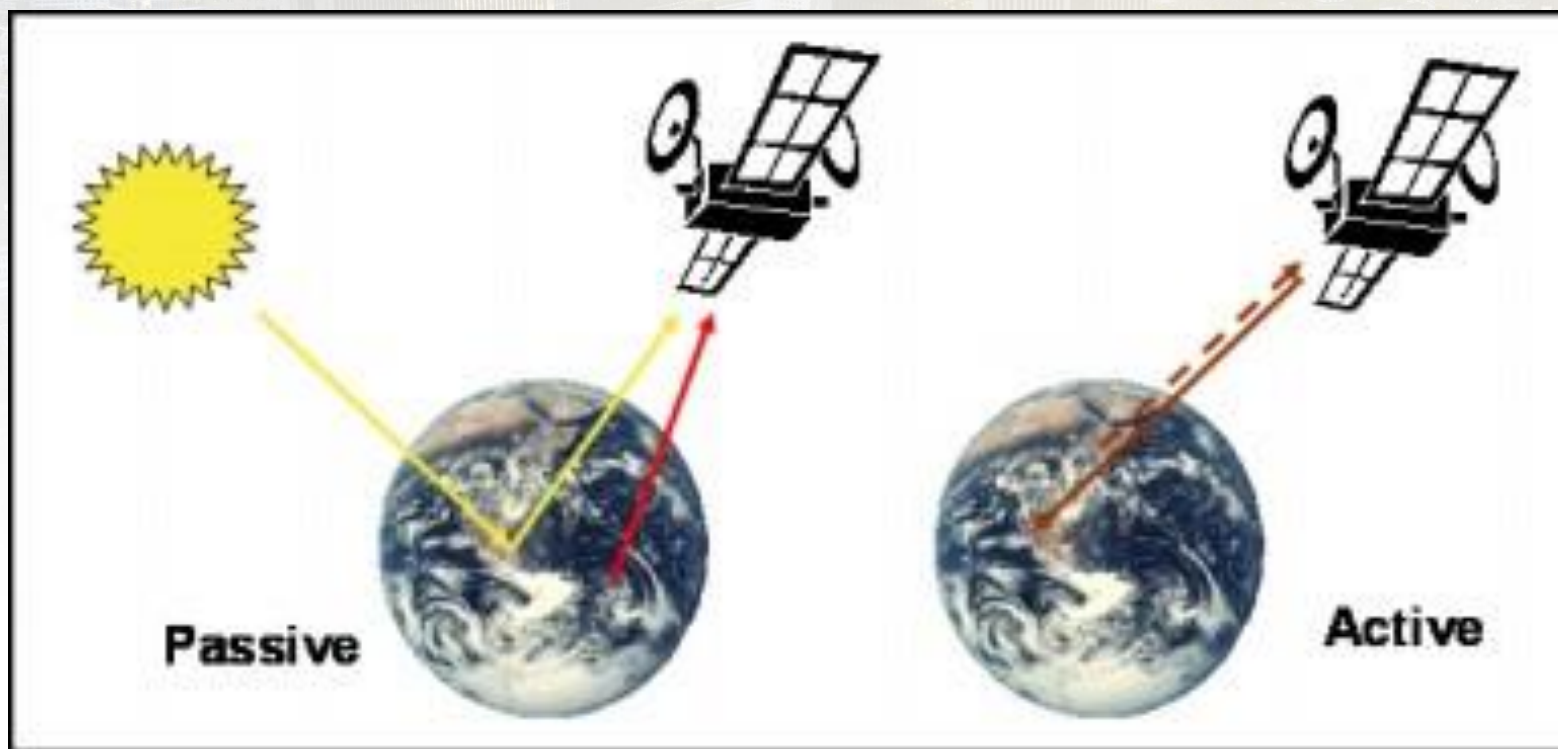
## Reflectance: Object behaviors



13-9-2018, [https://www.thueringen.de/mam/th8/lvg/vw-gemcont/2018\\_tb2017/2017bauer\\_gemusebautag\\_ef\\_phaenopt.pdf](https://www.thueringen.de/mam/th8/lvg/vw-gemcont/2018_tb2017/2017bauer_gemusebautag_ef_phaenopt.pdf)

# Sensors: Passive vs Active

- *Passive sensors*: Records energy reflected or emitted by a target illuminated by **Sun**.
- *Active sensors*: Illuminates the target **itself** and measures its reflectance.

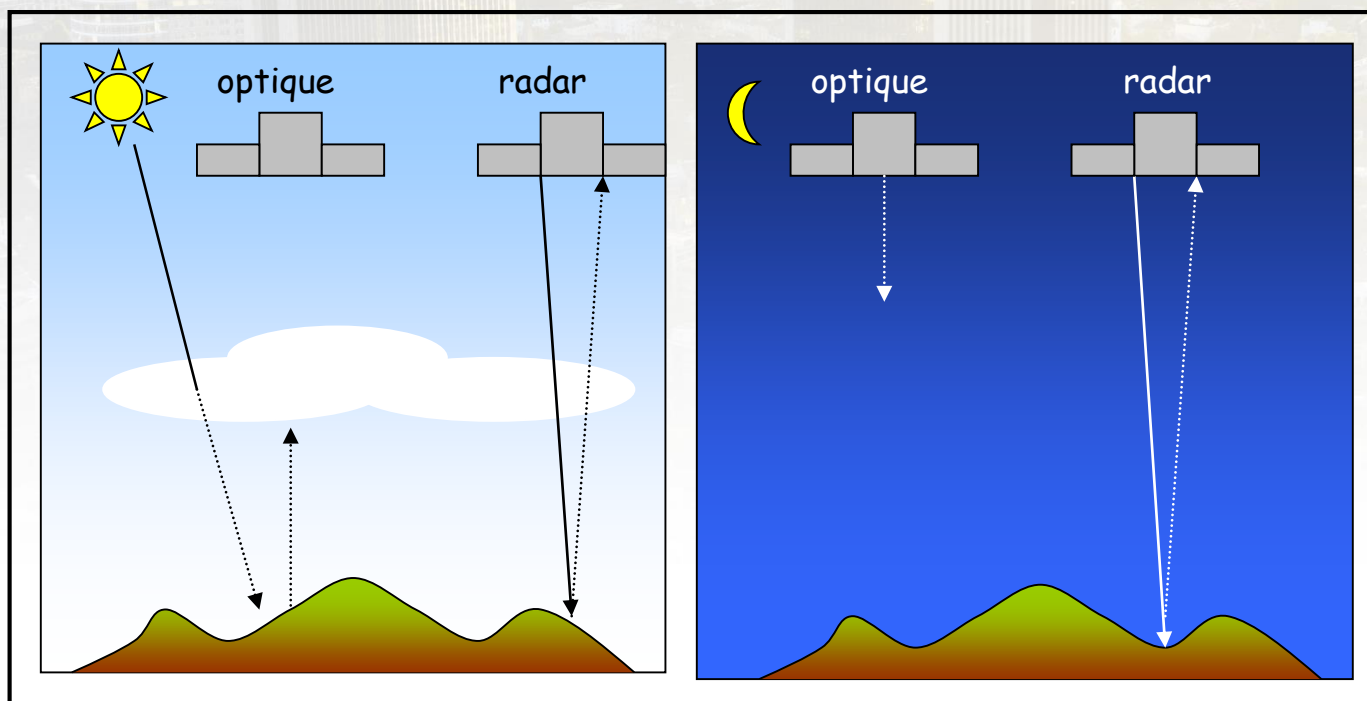


13-9-2018, [https://www.tankonyvtar.hu/en/tartalom/tamop425/0027\\_DAI6/ch01s03.html](https://www.tankonyvtar.hu/en/tartalom/tamop425/0027_DAI6/ch01s03.html)

# Sensors: Passive vs Active

- *Passive sensors*: Records energy reflected or emitted by a target illuminated by **Sun**.

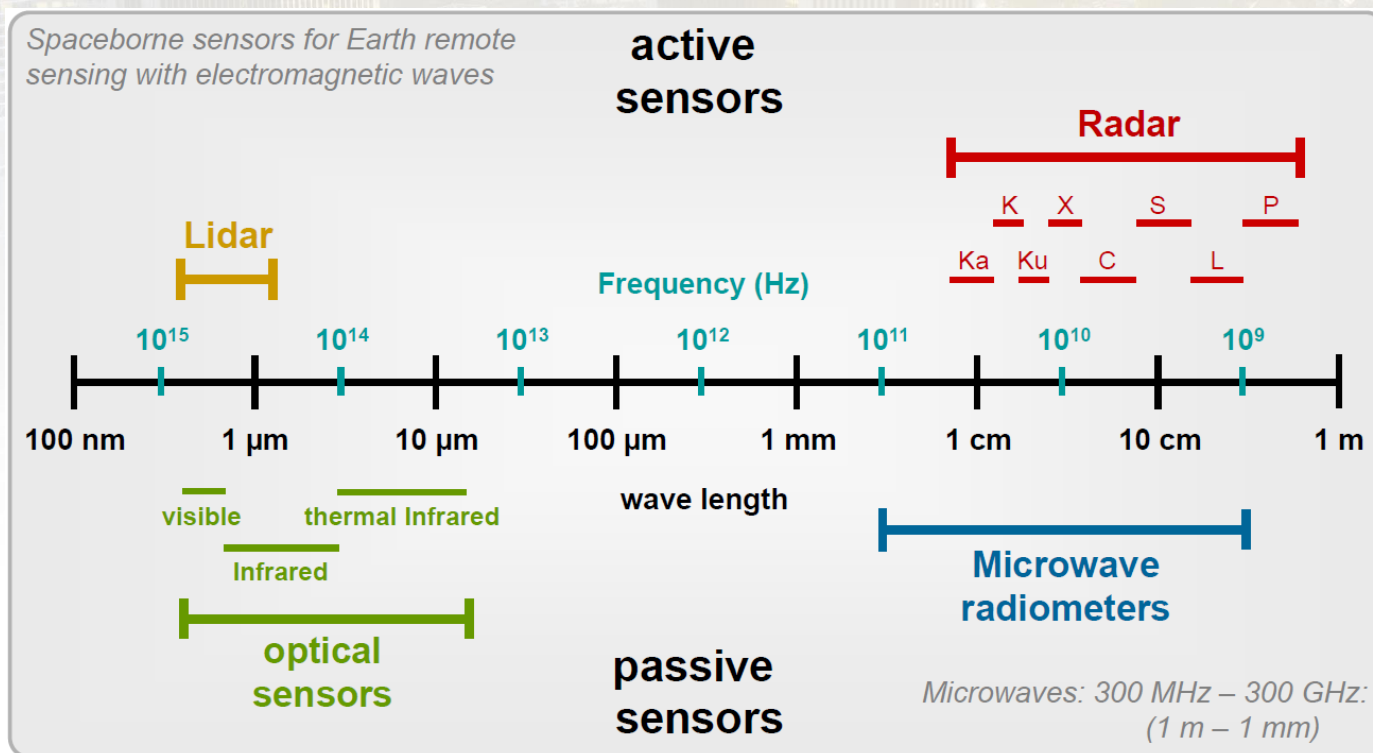
- *Active sensors*: Illuminates the target **itself** and measures its reflectance.



13-9-2018, [https://www.tankonyvtar.hu/en/tartalom/tamop425/0027\\_DAI6/ch01s03.html](https://www.tankonyvtar.hu/en/tartalom/tamop425/0027_DAI6/ch01s03.html)

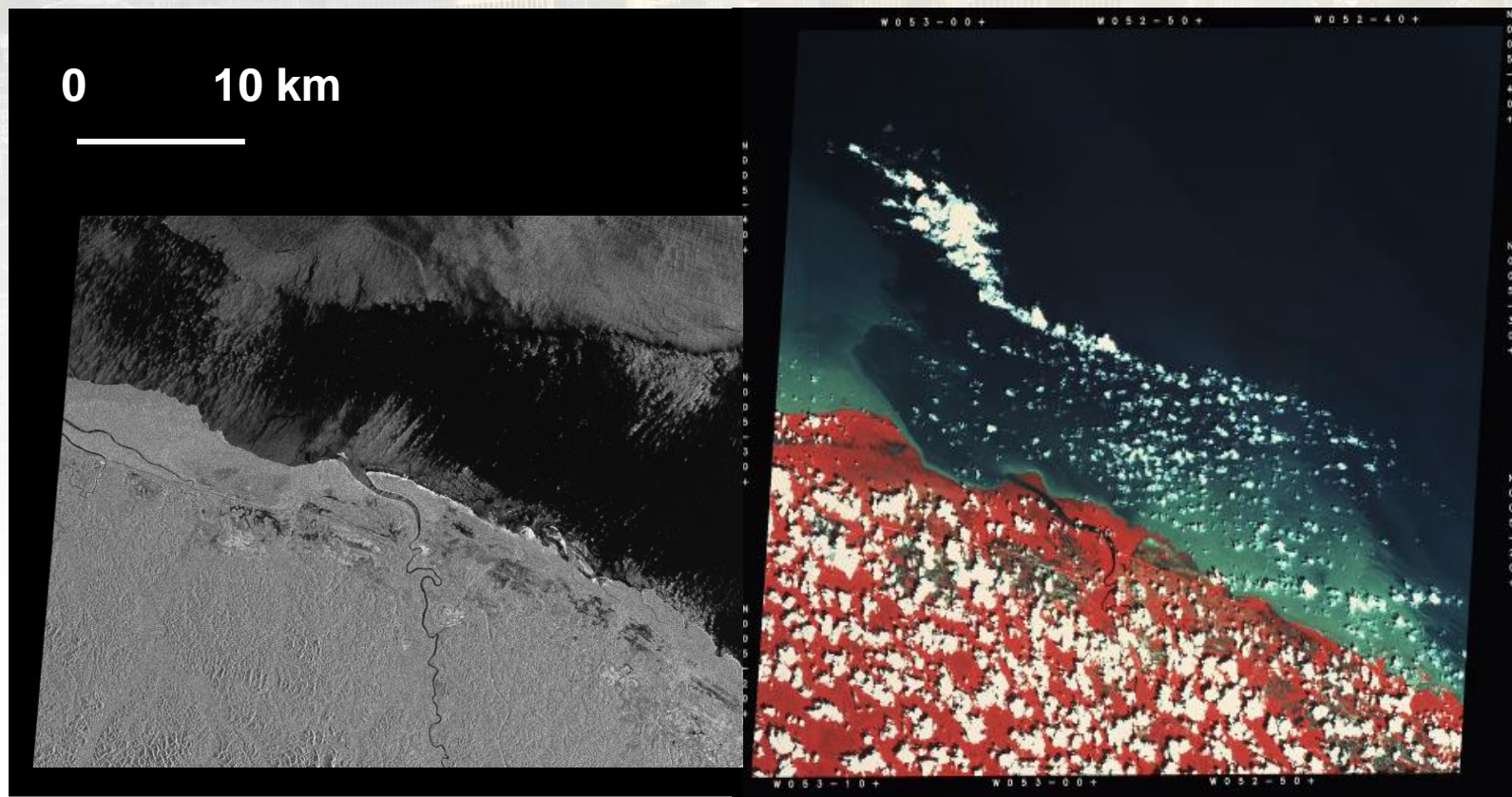
# Sensors: Optical vs Radar

- *Optical sensors* makes use of visible, near infrared and short-wave infrared reflectance.
- *Radar sensor* makes use of *radio wavelengths*



# Sensors: Optical vs Radar

- *Radar sensors* are not sensitive to atmospheric effects
- *Optical sensors* are sensitive to atmospheric effects





# Sensors: Optical vs Radar



- Some differences

<b>Characteristics</b>	<b>Optical</b>	<b>Radar</b>
Plate-forme	Plane/Satellite	Plane/Satellite
Radiation	passive	Active
Frequency	Several frequencies	Several frequencies
Polarimetry	N/A	Several polarization
Acquisition	Day	Day & night
Weather/cloud sensitivity	Sensitive	Not sensitive
Electromagnetic Spectrum	0,3 $\mu\text{m}$ - 14 $\mu\text{m}$ .	0,8 mm - 1,3 m

# Platforms for image acquisition:

- *Satellite*
- *Plane*
- *Helicopter*
- *Drone /UAV*
- *Etc.*



<https://www.satimagingcorp.com/satellite-sensors/spot-6/>

# Platforms for image acquisition:

- *Satellite*
- *Plane*
- *Helicopter*
- *Drone/UAV*
- *Etc.*



<https://www.aerobuzz.fr/breves-aviation-generale/green-observer-lavion-au-service-de-la-photo-aerienne/>

# Platforms for image acquisition:

- *Satellite*
- *Plane*
- *Helicopter*
- *Drone /UAV*
- *Etc.*



<http://www.ccg-gcc.gc.ca/Flotte/Helicopteres>

# Platforms for image acquisition:

- *Satellite*
- *Plane*
- *Helicopter*
- *Drone /UAV*
- *Etc.*



<https://crss-sct.ca/fr/conferences/sct2017/atelier-de-demonstration-de-vols-de-drones-et-dacquisitions-dimages/>

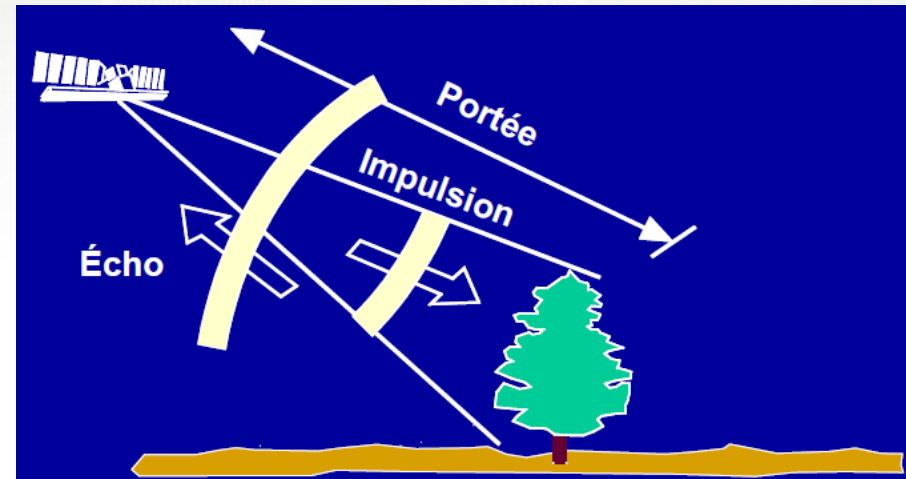
# Two types of Remote sensing:

## • *Radar remote sensing:*

Radar system has 03 main functions:

- Transmit a microwave (radio) signal to a scene
- Receive the backscattered signal from the scene
- Record the intensity (detection) of the return signal and the delay between it and the transmitted signal.

Acquisition possible at night as well as during the day and under cloud cover.



Source: rnca

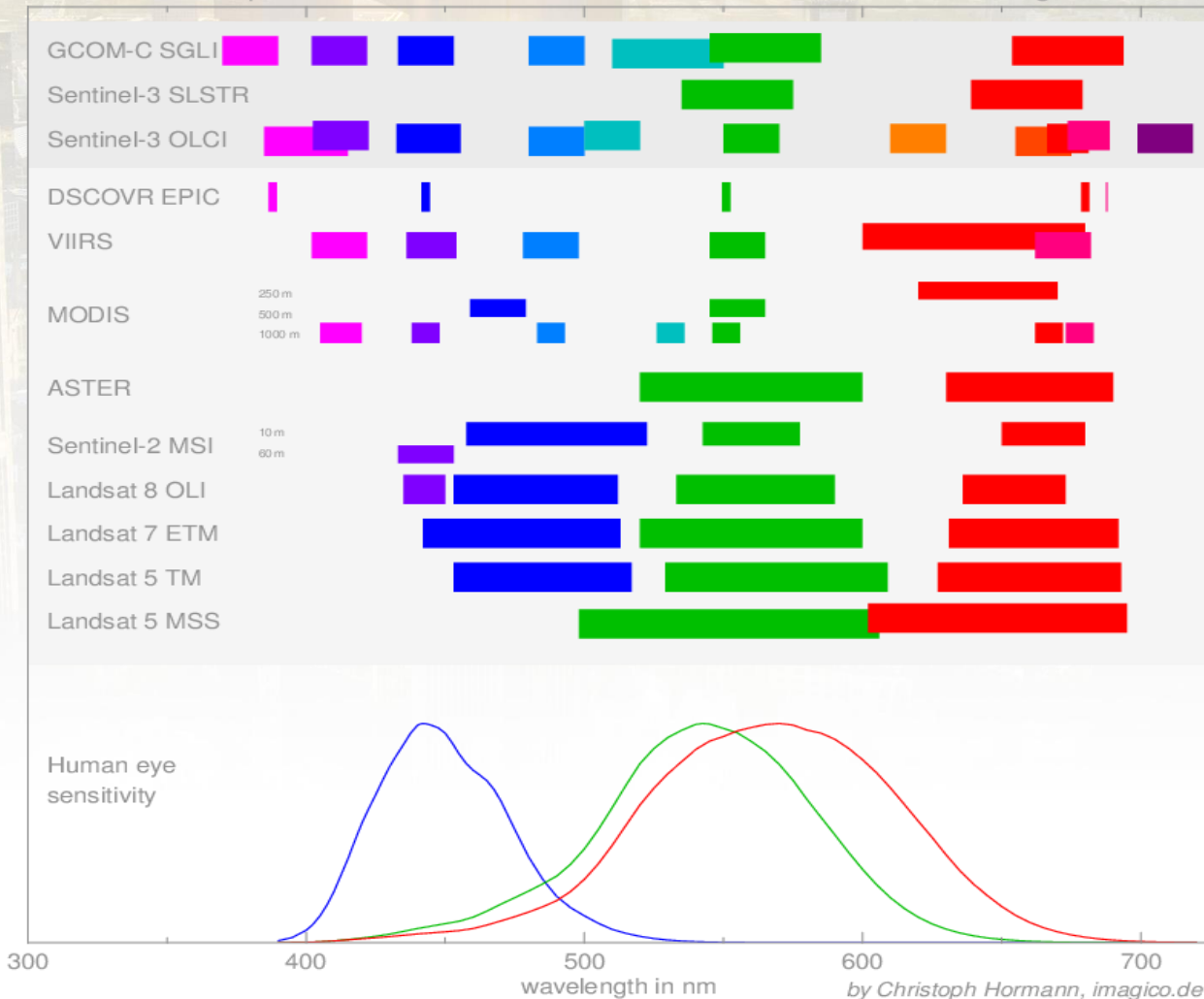
# Some Sensors resolutions

▪ **Spatial**

▪ **Spectral**

▪ **Temporal**

Multispectral earth observation satellite sensors in the visual range




# Some Sensors resolutions: VHR vs HR



Case study: **Pléiades**



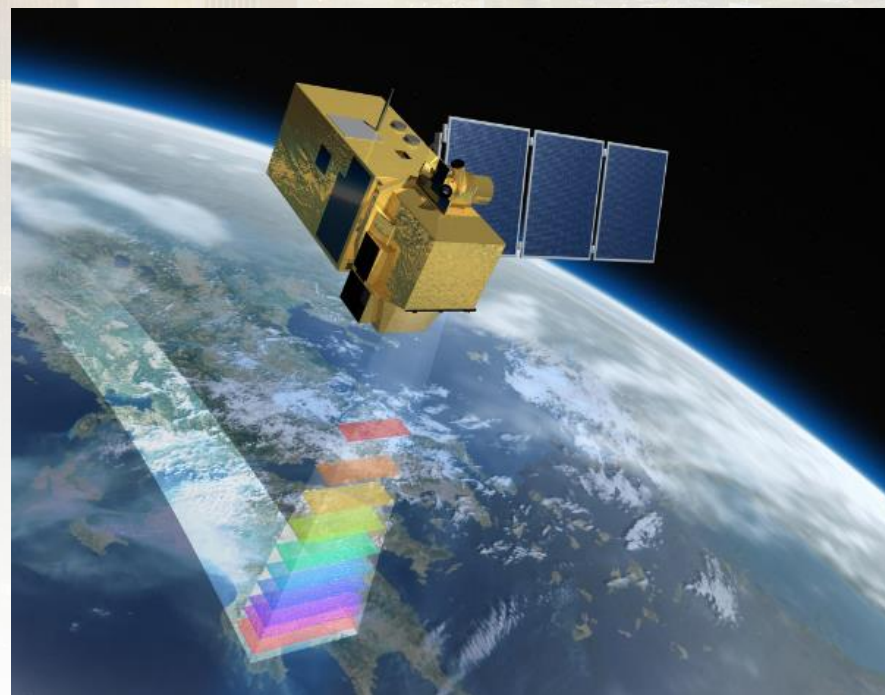
 © cnes / illustration Pierre CARRIL - 2005

17/12/2011: Pléiades-1A  
02/12/2012: Pléiades-1B

©CNES

vs

**Sentinel-2**



23/06/2015: Sentinel-2A  
07/03/2017: Sentinel-2B

©ESA



# Some Sensors resolutions: VHR vs HR



Case study:

Pléiades

vs

Sentinel-2

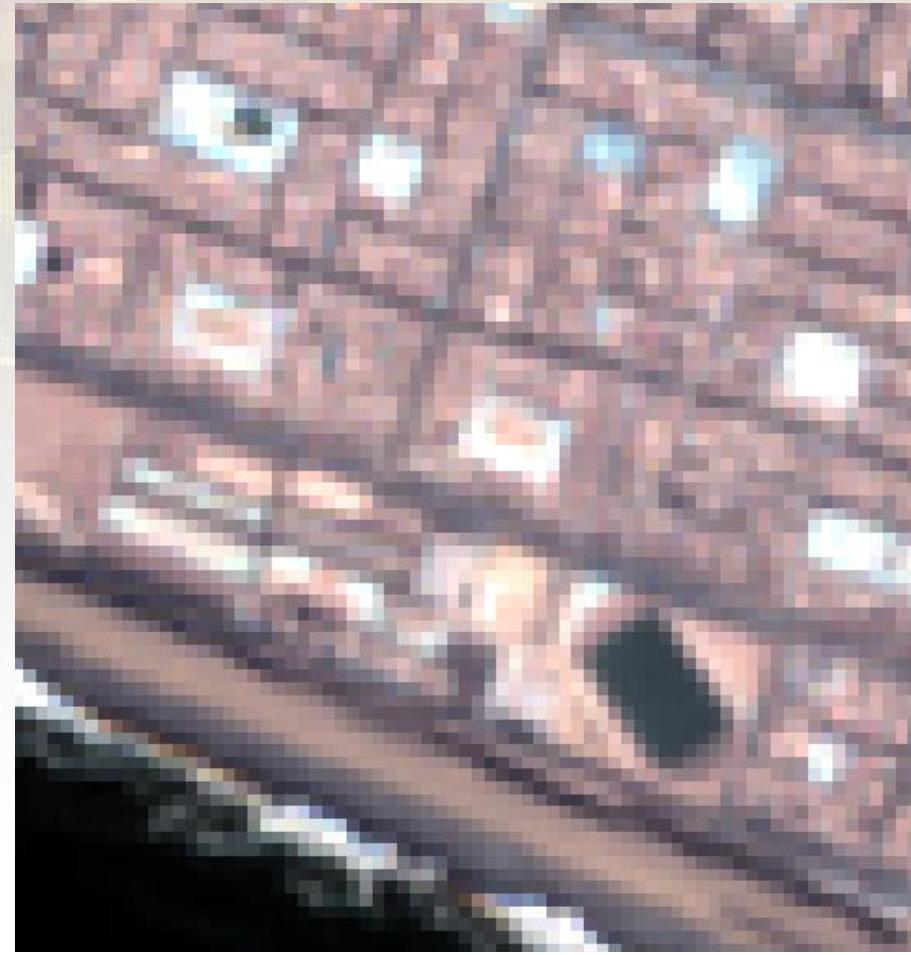
Characteristics	Very High Resolution (VHR)	High Resolution (HR)
Spatial Resolution	0,5 - 2m)	10m - 60m
Level of detail	High	Low
Mapping Accuracy	High	Low
Territorial scale	Small	Large
Swath	20km	290km
Data cost	<b>Expensive (eg: ±21,25\$ /km<sup>2</sup> for Pleiades images)</b>	Free access (eg: Sentinel2)

# Some Sensors resolutions: VHR vs HR



Lima: 20/03/2016  
**Pléiades (0,5m)**

Scale: 1/7000



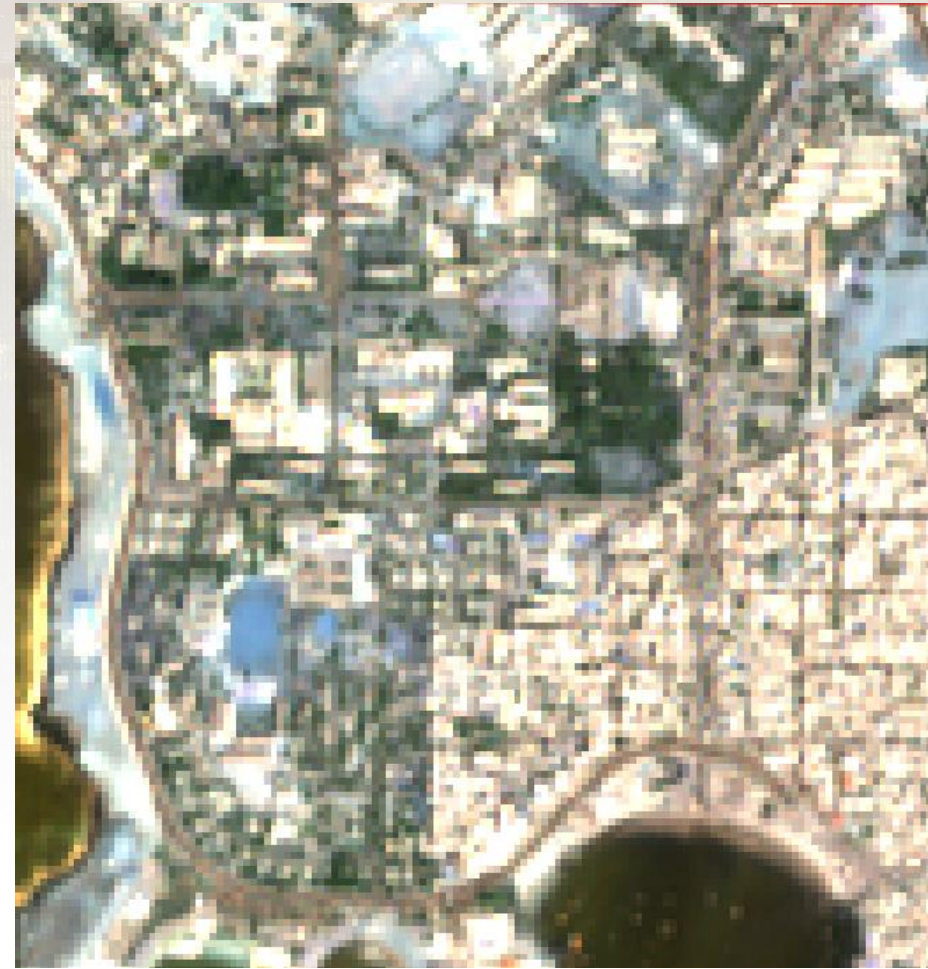
Lima: 21/04/2018  
**Sentinel2 (2m)**

# Some Sensors resolutions VHR vs HR



Lima: 27/02/2018  
**Pléiades (2m)**

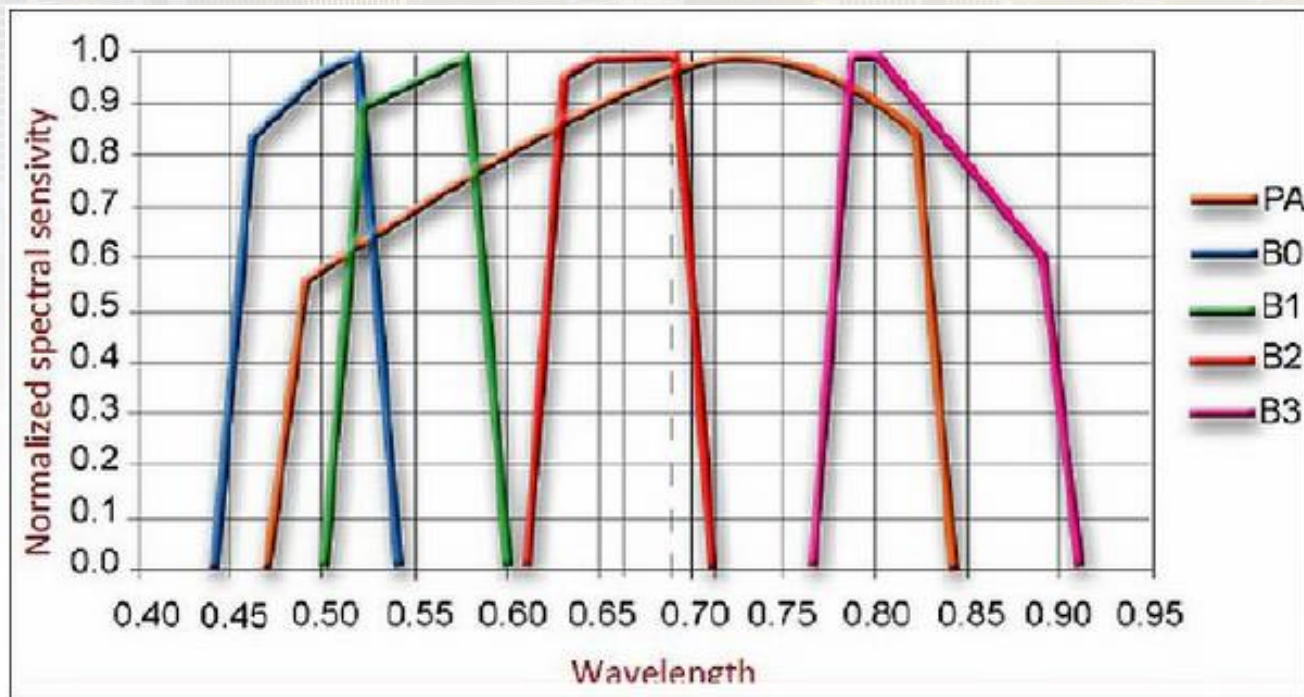
Scale: 1/7000



Lima: 01/03/2018  
**Sentinel2 (10m)**

# Sensor Panchromatic vs Multi-spectral

Data	Spatial Resolution	Spectral Resolution
Panchromatic	High (eg: Pleiades 0,5m)	single spectral channel
Multi-spectral	Low (eg: Pleiades 2m)	Several spectral channels



**Pleiades spectral bands** (*image credit: CNES*)

# Sensor Panchromatic vs Multi-spectral



*Dakar: Pléiades 01/03/2018*

***Panchromatic (0,5m)***



*Scale: 1/1800*

***Multi-spectral (2m)***

# Sensor Panchromatic vs Multi-spectral



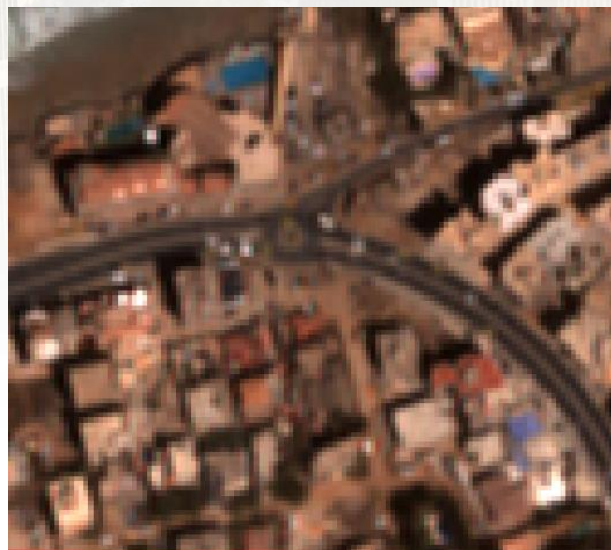
- **Pansharpening operation:** This operation consists of merging the panchromatic image and the multispectral image to create a new image containing the spatial resolution of PAN image and spectral resolution of MS image.

- *Dakar: Pléiades 01/03/2018*



**PAN (0,5m)**

+



**MS (2m)**

=



**PANSHARPEN (0,5m)**

# Sensor-example: Sentinel-2

## ▪ Sentinel-2A & Sentinel-2B:

- Earth observation mission developed by ESA
- MultiSpectralImager (MSI sensor)
- Spatial resolution: 10 m, 20 m, 60m
- 5 days revisit time with 2 satellites

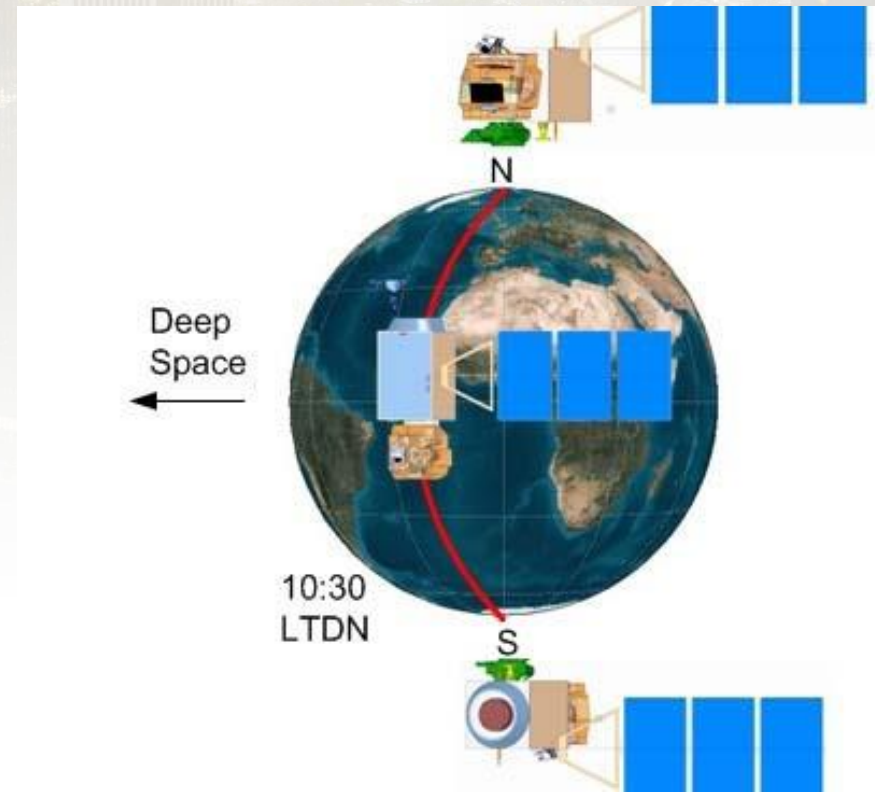
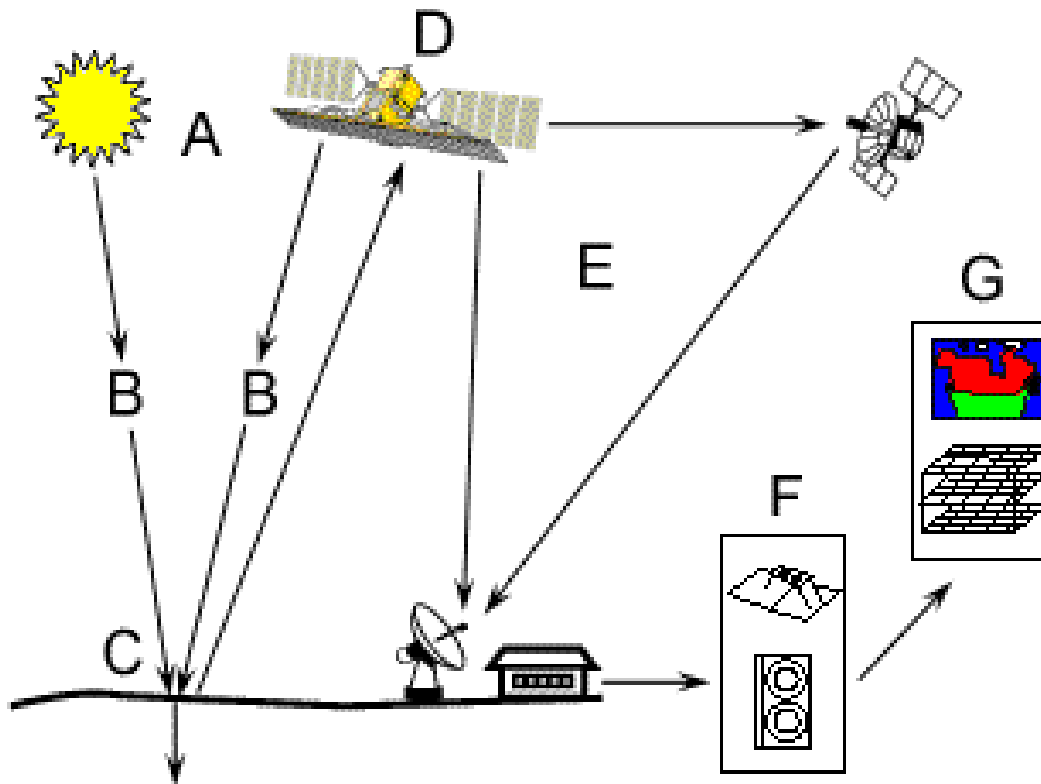


Fig: Twin observation configuration of the Sentinel-2 spacecraft constellation

(image credit: <http://spaceflight101.com/copernicus/sentinel-2/>)

## Remote sensing operating chain



- (A) The energy source or radiation
- (B) The radiation of the atmosphere
- (C) Interaction with the target
- (D) The recording of energy by the sensor
- (E) Transmission, reception and processing
- (F) Interpretation and analysis
- (G) The application



## ▪ Historical monitoring of urban expansion

### Land Use / Land Cover

#### Artificial Areas

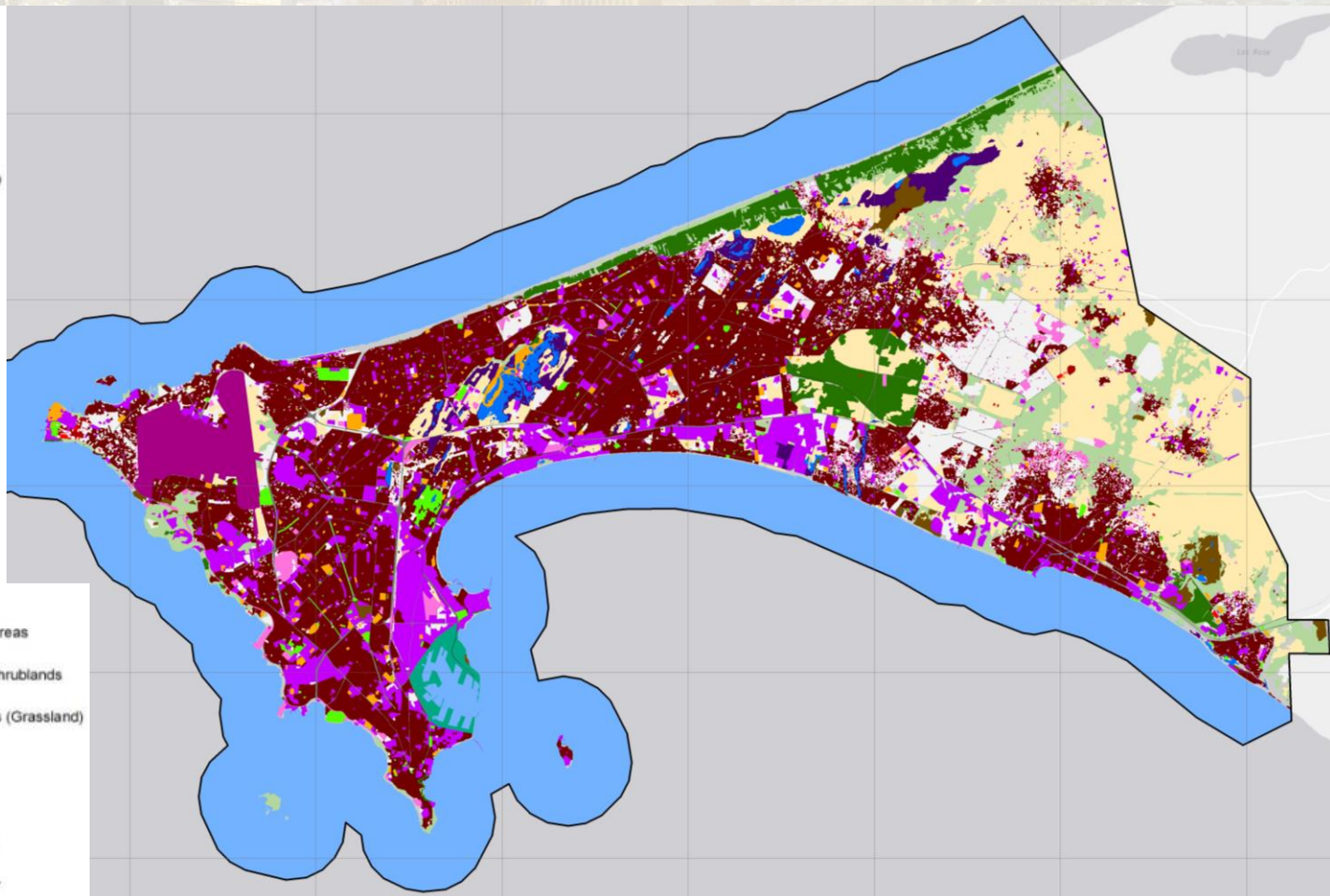
- Continuous Urban Fabric (80 - 100 % Sealed)
- Discontinuous dense urban fabric (50 - 80 % Sealed)
- Discontinuous medium density urban fabric (30 - 50 % Sealed)
- Discontinuous low density urban fabric (10 - 30 % Sealed)
- Discontinuous very low density urban fabric (0 - 10 % Sealed)
- Industrial, Commercial, Public, Military and Private Units
- Arterial Roads
- Collector Roads
- Railway
- Port Area
- Airport
- Mineral Extraction and Dump Sites
- Construction Sites
- Land Without Current Use
- Green Urban Areas
- Sports and Leisure Facilities

#### Other Types

- Agricultural Areas
- Forest and Shrublands
- Natural Areas (Grassland)
- Bare Soil
- Wetlands
- Inland Water
- Marine Water

#### Overview Map

- Area of Interest for EO Data Acquisition and Mapping



## Historical monitoring of urban expansion

### Land Use / Land Cover

#### Artificial Areas

- Continuous Urban Fabric (80 - 100 % Sealed)
- Discontinuous dense urban fabric (50 - 80 % Sealed)
- Discontinuous medium density urban fabric (30 - 50 % Sealed)
- Discontinuous low density urban fabric (10 - 30 % Sealed)
- Discontinuous very low density urban fabric (0 - 10 % Sealed)
- Industrial, Commercial, Public, Military and Private Units

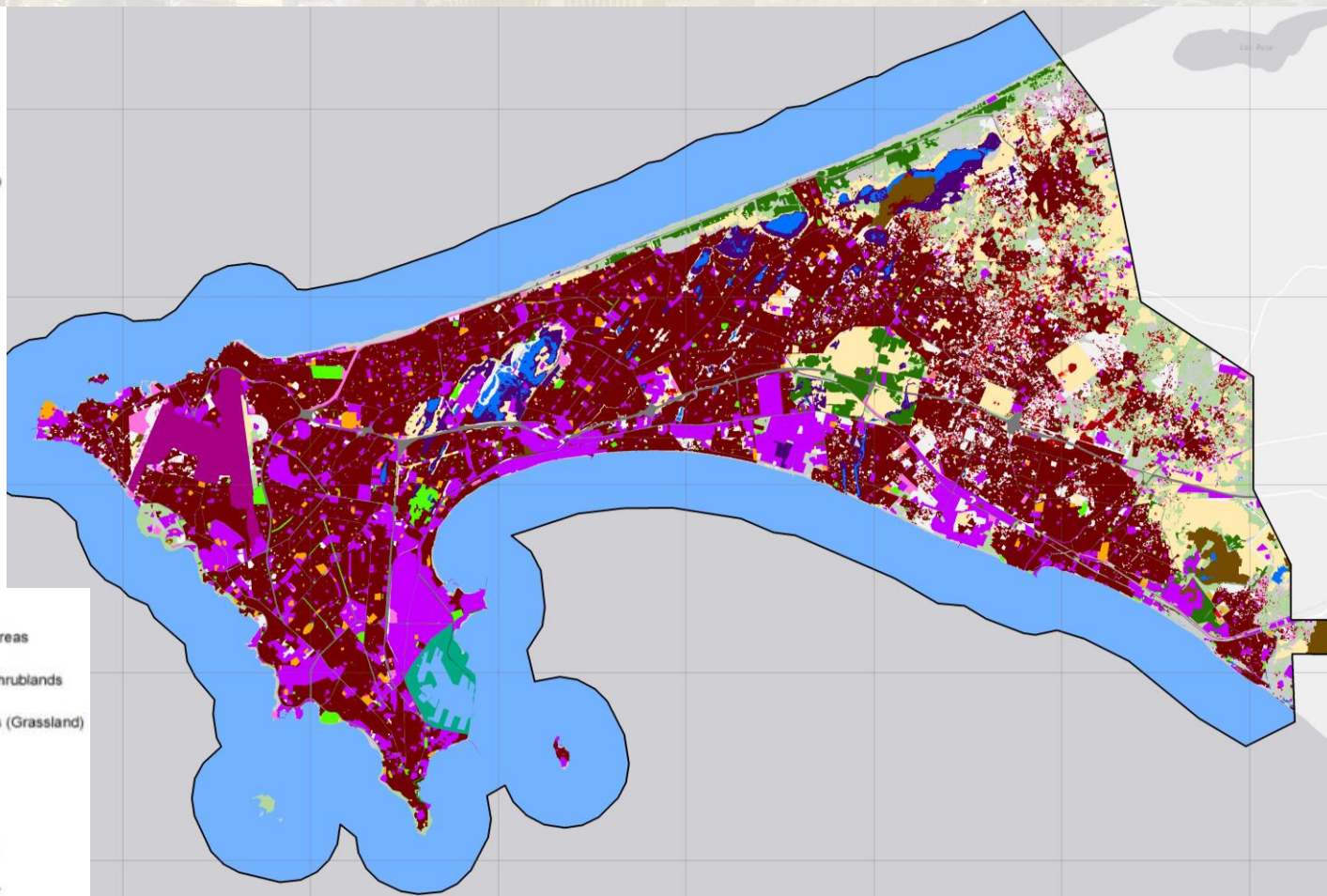
- Arterial Roads
- Collector Roads
- Railway
- Port Area
- Airport
- Mineral Extraction and Dump Sites
- Construction Sites
- Land Without Current Use

#### Other Types

- Agricultural Areas
- Forest and Shrublands
- Natural Areas (Grassland)
- Bare Soil
- Wetlands
- Inland Water
- Marine Water
- Green Urban Areas
- Sports and Leisure Facilities

#### Overview Map

- Area of Interest for EO Data Acquisition and Mapping



## ▪ Historical monitoring of urban expansion

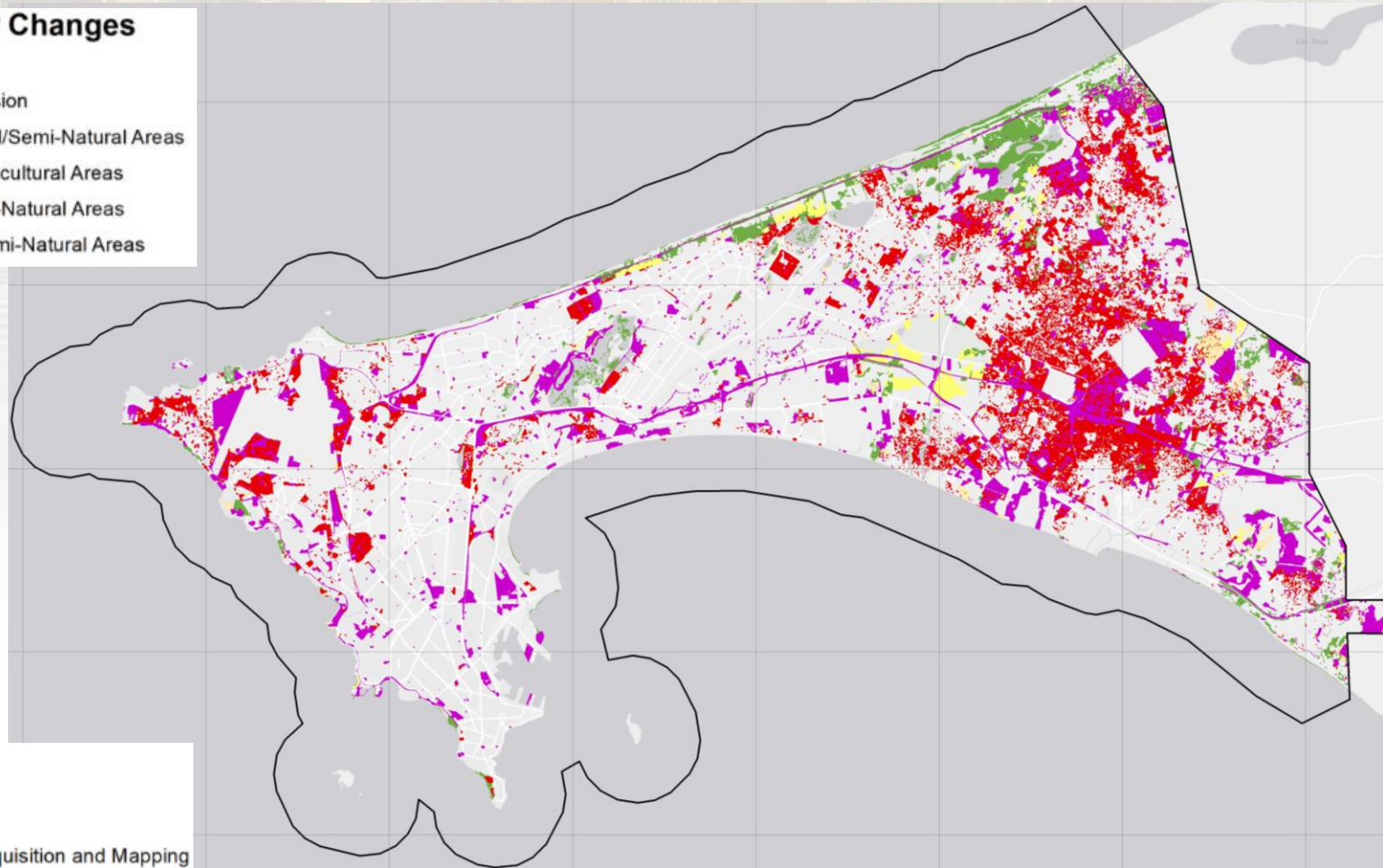
### Land Use / Land Cover Changes

- Urban Residential Expansion
- Other Urban Land Use Expansion
- Urban to Agricultural or Natural/Semi-Natural Areas
- Natural or Semi-Natural to Agricultural Areas
- Agricultural to Natural or Semi-Natural Areas
- Change within Natural and Semi-Natural Areas

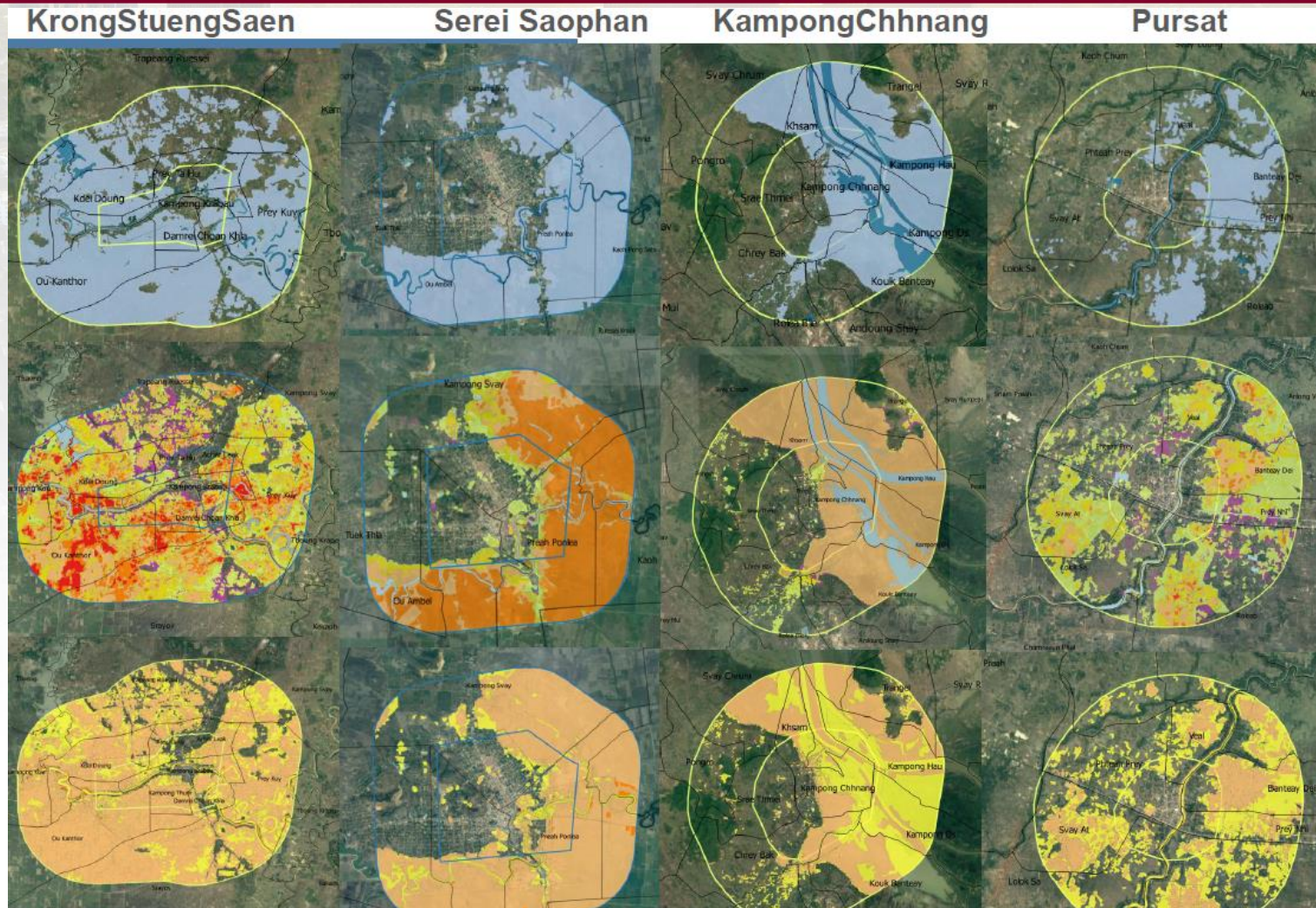
Core City Area

Overview Map

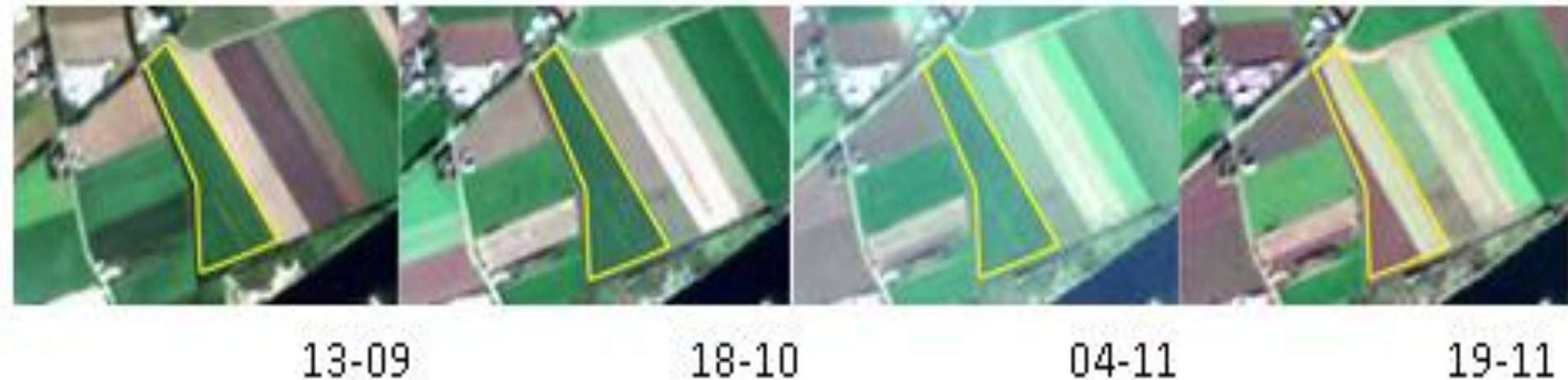
Area of Interest for EO Data Acquisition and Mapping



# Some applications: Monitoring Floods events



## ▪ Historical monitoring of Farmland



# Thank you for your attention!

SIRS

Dr Christophe Sannier

Hervis Ghomsi

Sebastien Delbour

27 Rue du Carrousel, 59650

Villeneuve-d'Ascq

France

[christophe.sannier@sirs-fr.com](mailto:christophe.sannier@sirs-fr.com)

[hervis.ghomsi@sirs-fr.com](mailto:hervis.ghomsi@sirs-fr.com)

[sebastien.delbour@sirs-fr.com](mailto:sebastien.delbour@sirs-fr.com)

[contact@sirs-fr.com](mailto:contact@sirs-fr.com)

[info.gaf.de](mailto:info.gaf.de)