Introduction to selected areas of geomatics

Lecture 1

CTU in Prague, Faculty of Civil Engineering, Department of Geomatics
EU, Czech Republic

Karel Pavelka

pavelka@fsv.cvut.cz

Introduction to the following areas:

Remote sensing

Photogrammetry

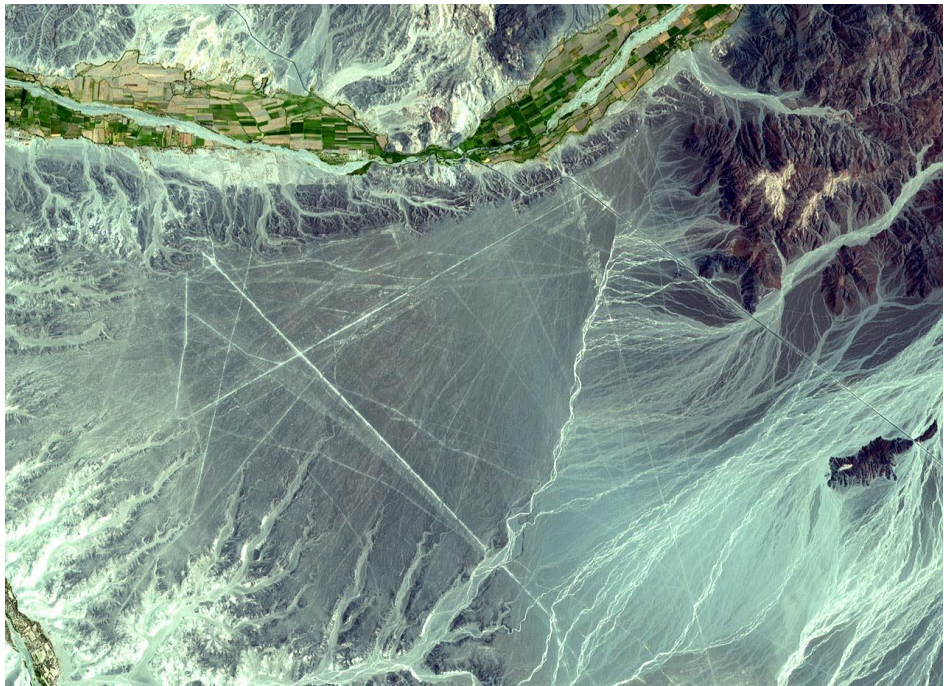
Laserscanning

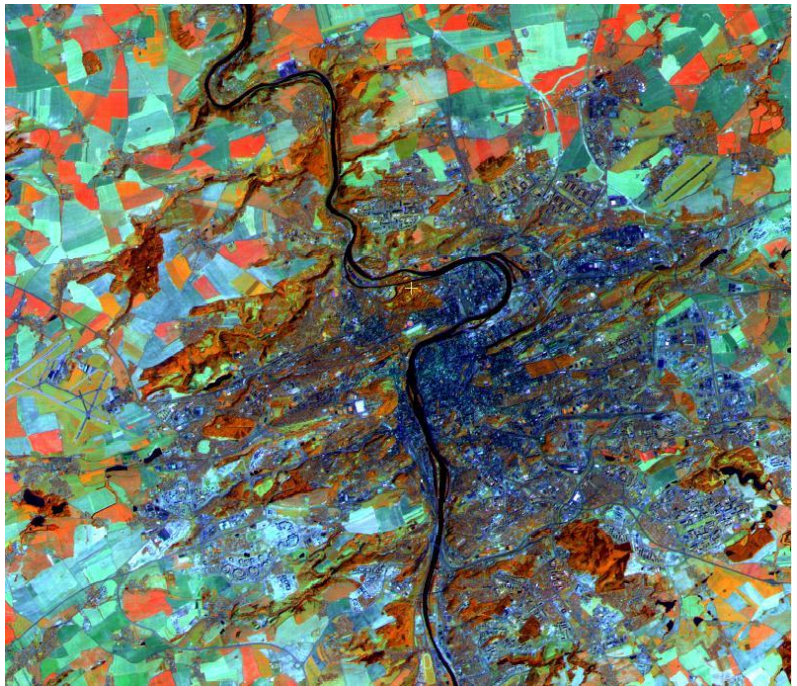
GNSS

VR/AR

Remote sensing (RS)

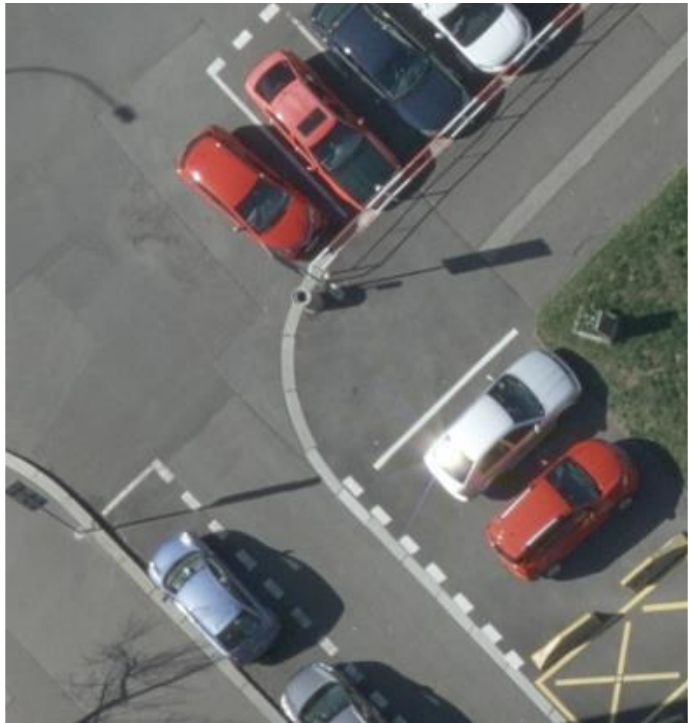
- Obtaining information about the Earth without physical contact.
- Satellite, aerial and radar sensors.
- Monitoring of the landscape, changes and crisis phenomena.

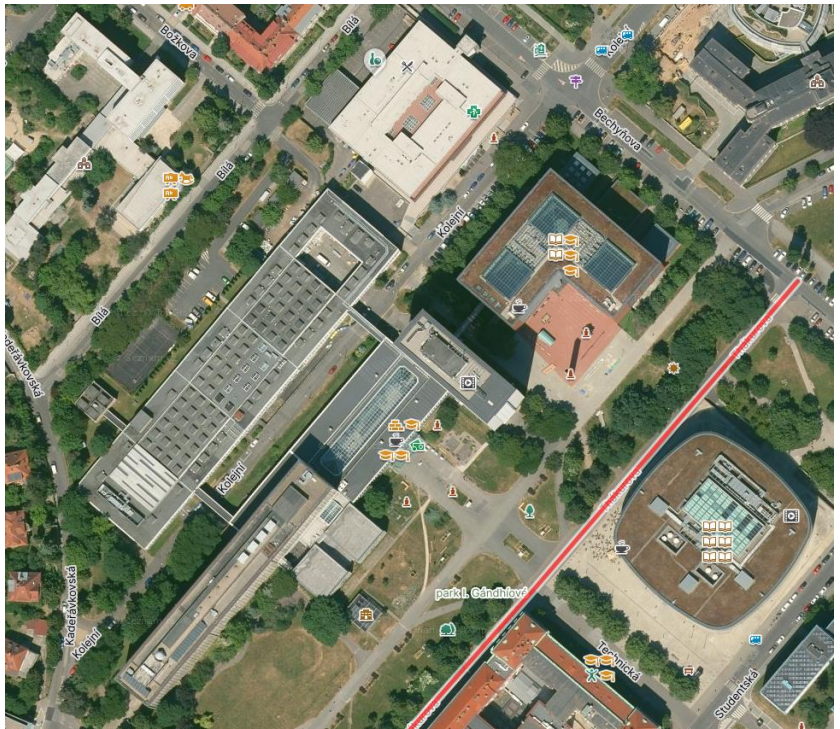




Photogrammetry

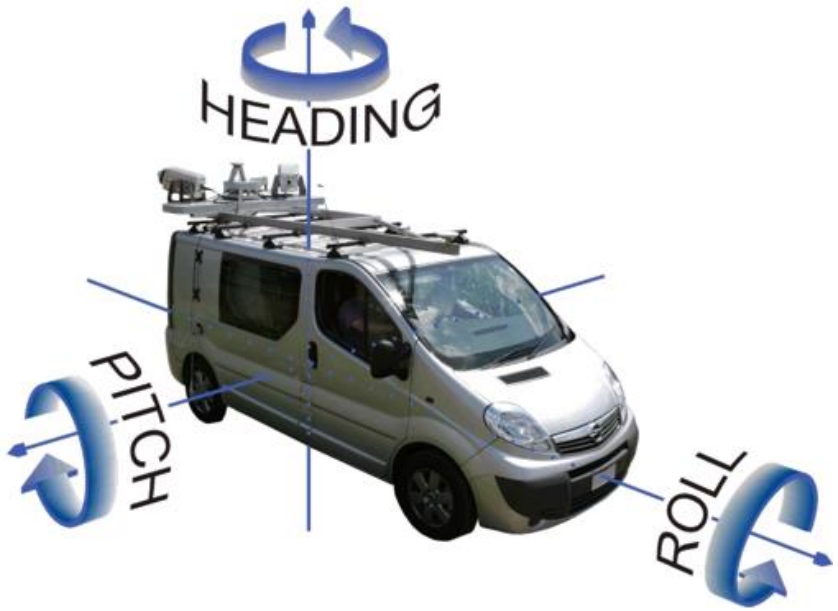
- Reconstruction of 3D information from overlapping photographs.
- Drones, aircraft, ground systems.
- Outputs: orthophotos, DTM/DSM, 3D models.

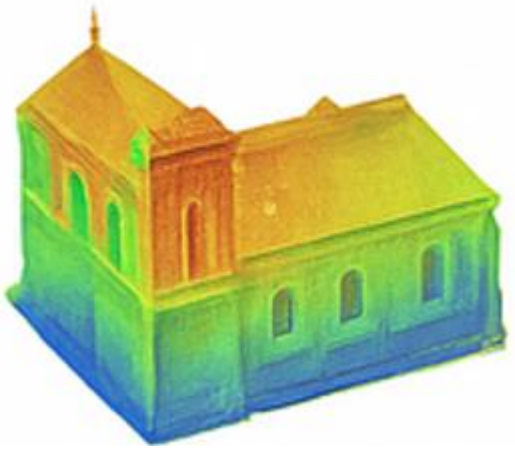




Laser scanning (LiDAR)

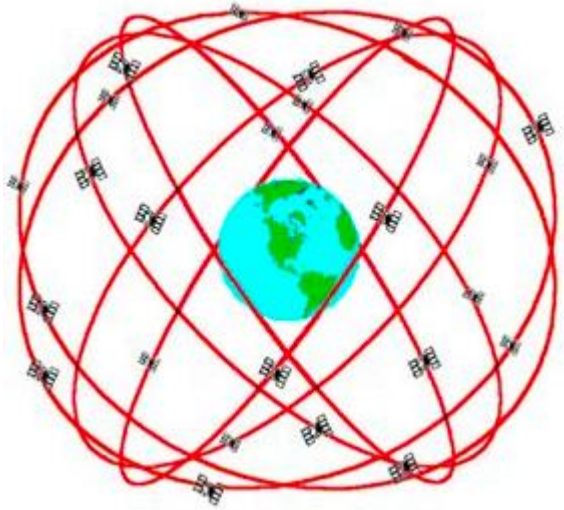
- Distance measurement using laser pulses.
- Dense and accurate point clouds.
- Aerial, ground-based and mobile systems (MLS, PLS, ALS).





GNSS technology

- Global satellite navigation systems.
- GPS, Galileo, GLONASS, BeiDou.
- RTK and PPP provide centimetre-level accuracy.



VR/AR

Virtual reality (VR) creates a fully digital environment, necessary to have special glasses or a headset

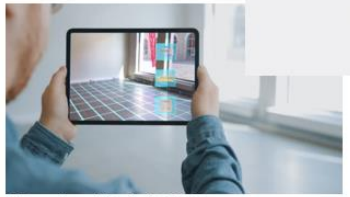
Augmented Reality (AR), on the other hand, supplements the real world with digital elements- such as text, 3D objects, or navigation symbols

Modern VR and AR visualisation Virtual reality and augmented reality

Hardware for VR and AR

HTC Vive Pro with controllers and beacons

Oculus - Rift S



iPad with LiDAR

Microsoft HoloLens 2

+ expensive graphics card (starting with GeForce GTX 1080) and a good computer

Comparison of methods

- DPZ: large areas, spectral information.
- Photogrammetry: detailed 3D reconstruction.Mapping.
- LiDAR: precise geometry, even under vegetation.
- GNSS: fast and accurate positioning in the field.
- VR/AR for data analysis and vizualization

Typical applications in geomatics

Geodesy

- Cadastre, construction, monuments.
- Landscape monitoring and land use.
- Industry and metrology

Geology, Navigation, Marine and coastal applications, Ecology, Transport infrastructure, BIM/HBIM

Introduction to Remote sensing

Defining RS

•RS is a method that allows the acquisition and processing of data measured in a non-contact manner. The carrier of the information is electromagnetic radiation.

Information about an object, area, or phenomenon is obtained through the analysis of data acquired by a device that is not in a direct contact with the object, area, or phenomenon under investigation (Lillesand, 2004)

•Principle: each object or state characteristically affects the surrounding force-fields(in this case, the electromagnetic radiation)

Content

- Principle
- History

1. Optical RS
2. Radar RS
3. Aerial RS
4. RPAS

- Land application in all above mentioned parts
- Conclusion

What is remote sensing?

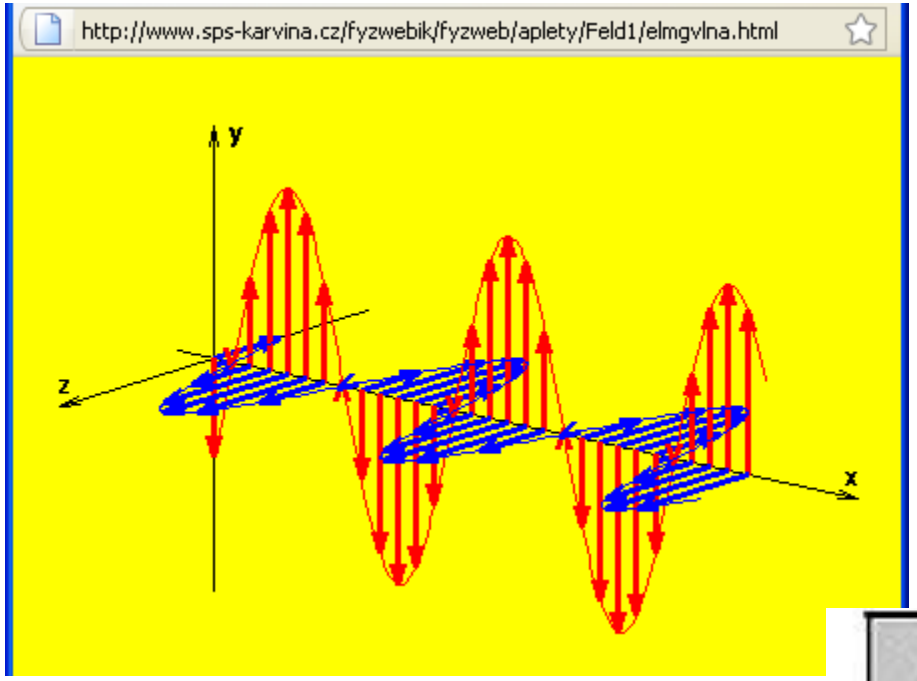
- **Remote sensing** (RS) is the acquisition of information about an object or phenomenon without making physical contact with the object
- **Development** from aerial photography in WW II. and during Cold War
- **After** Cold war and using of digital technology rapid development in civilian praxis

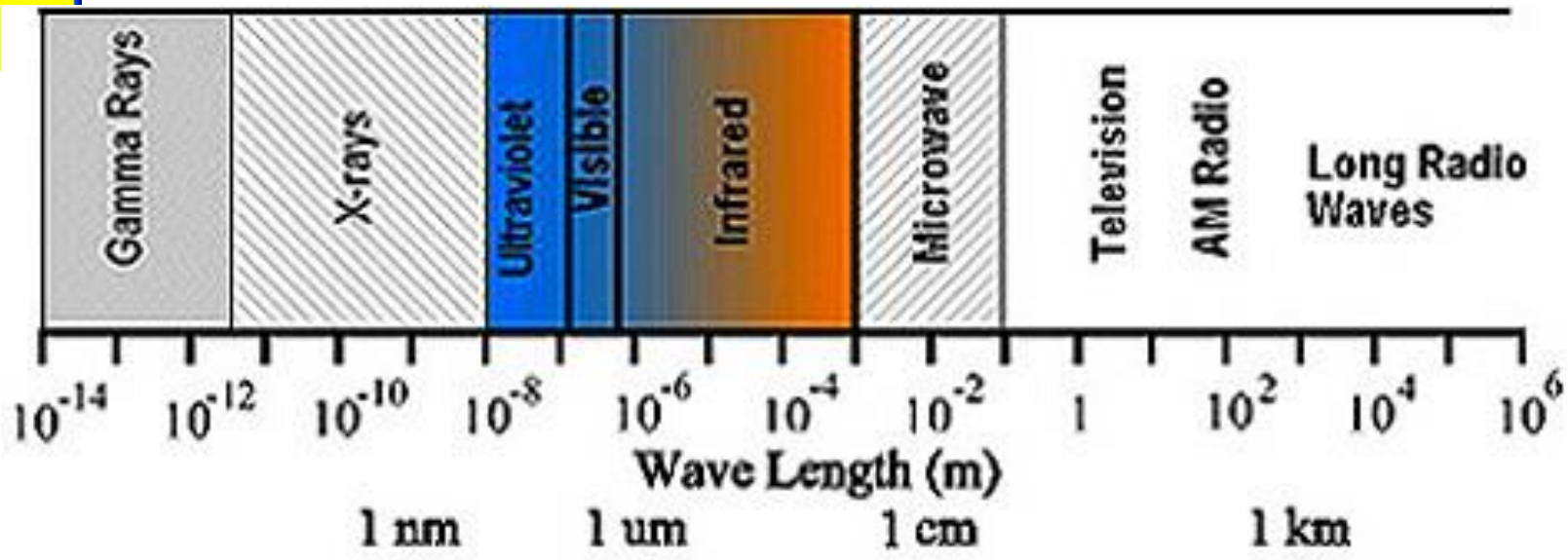
Electromagnetic radiation

- 1666 - Isaac Newton uses an optical prism to split white light into its individual spectral colours

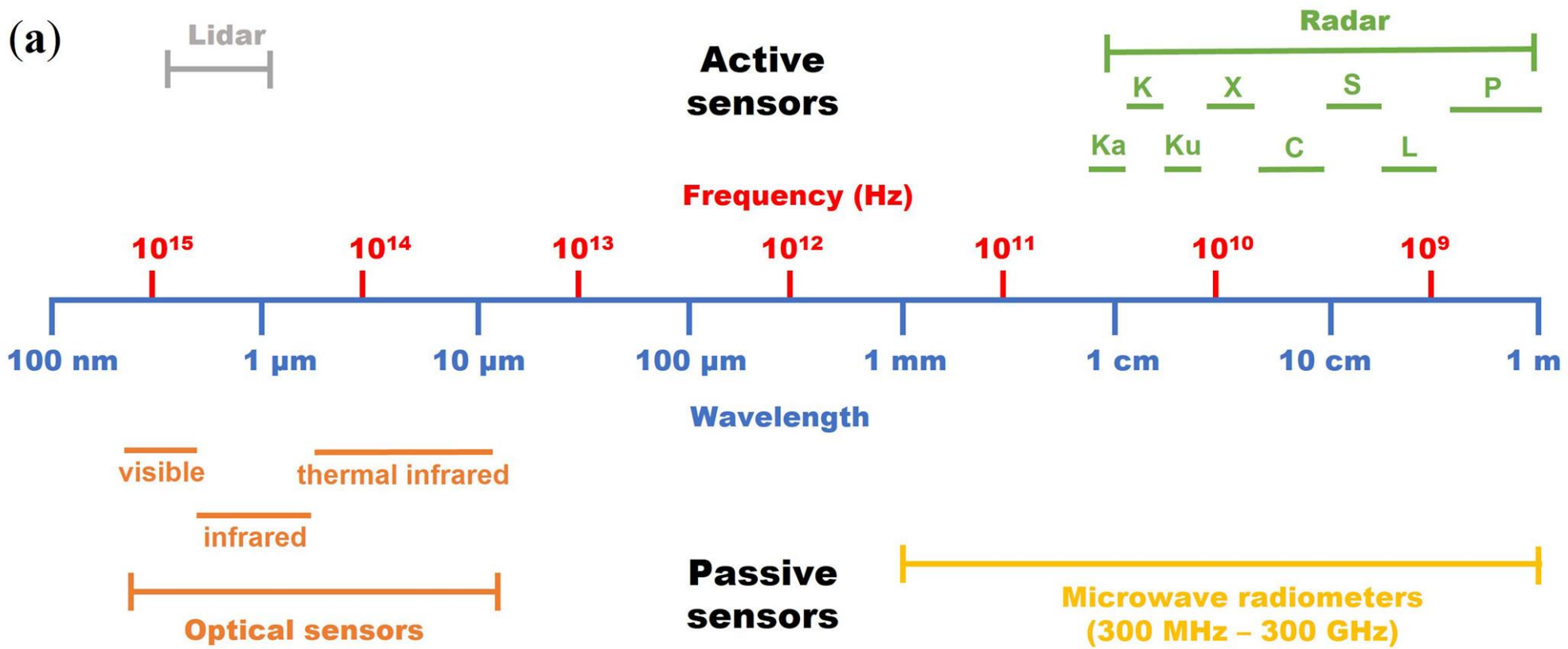
- 1800 -discovery of infrared radiation (Sir W. Herschel)
- 1847 - A.H.L. Fizeau and B.L. Foucault prove that infrared radiation has similar properties to visible radiation
- 1873 - Physical theory of electromagnetic radiation, equations (J.C. Maxwell)

Electromagnetic radiation and spectrum





(a)



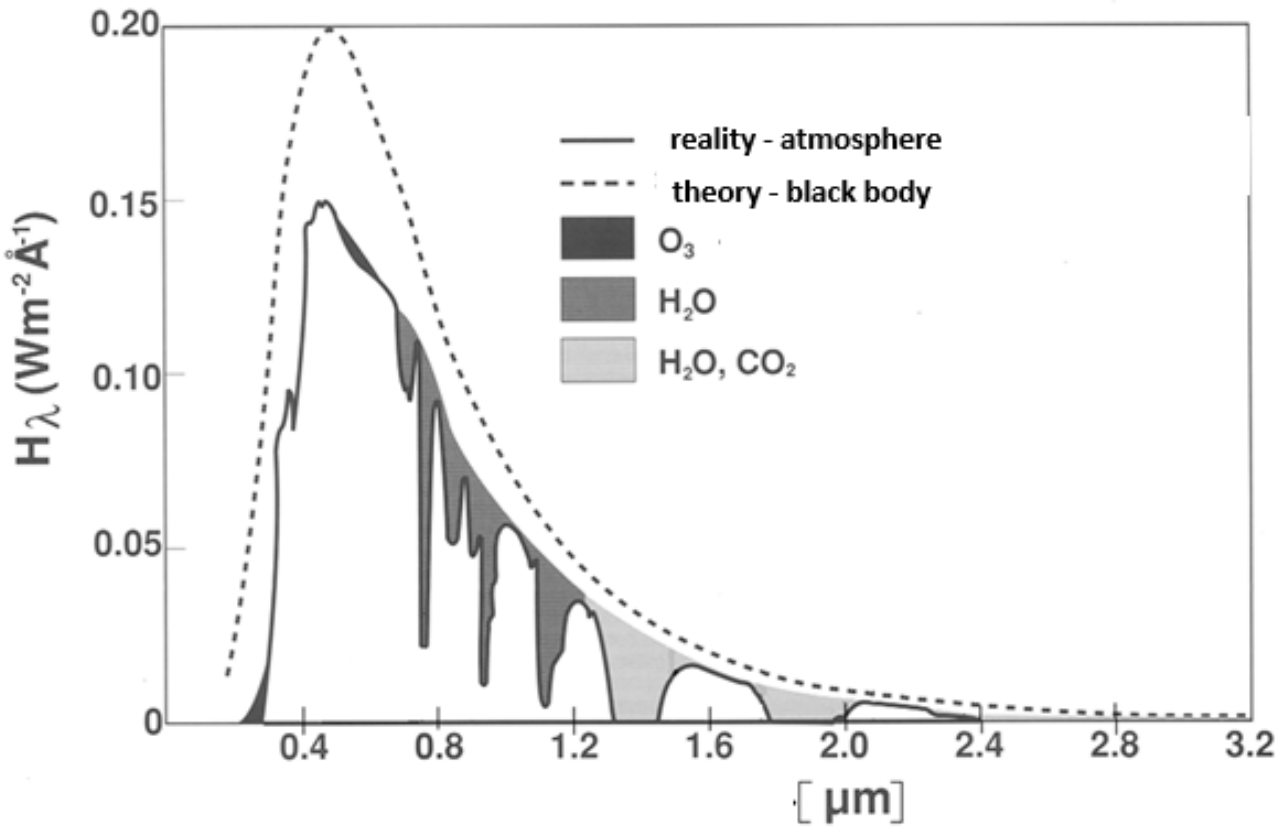
(b)

Band	Ka	K	Ku	X	C	S	L	P
Frequency (GHz)	40-27	27-18	18-12	12-7.5	7.5-3.75	3.75-2	2-1	1-0.3
Wavelength (cm)	0.8-1.1	1.1-1.7	1.7-2.5	2.5-4	4-8	8-15	15-30	30-100

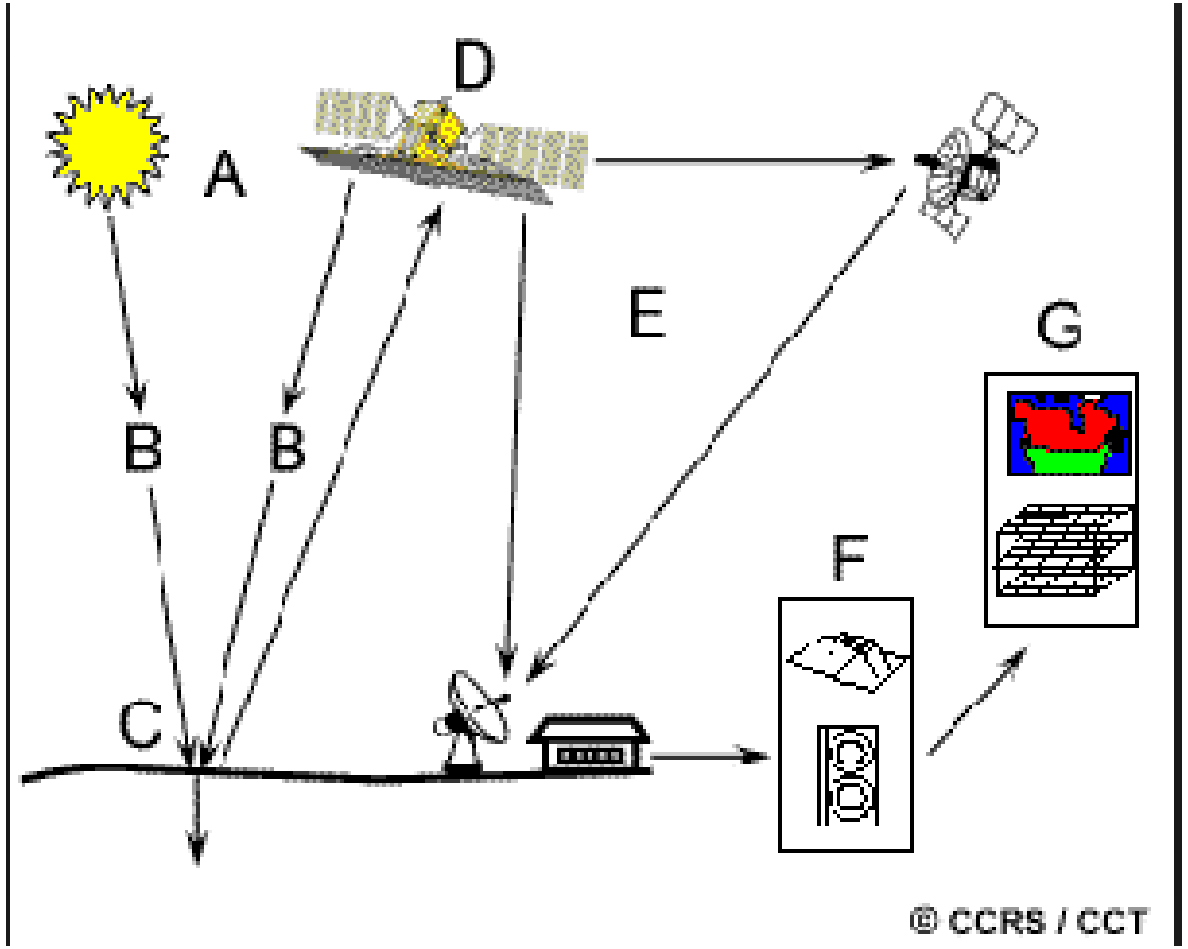
(a) Spectrum of electromagnetic waves for spaceborne and airborne sensors for Earth remote sensing.
(b) (b) Frequency and wavelength of microwave bands commonly used for radar.
(https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2023RG000821)

- Planck's equation - and the actual course - of solar absorption through the Earth's atmosphere

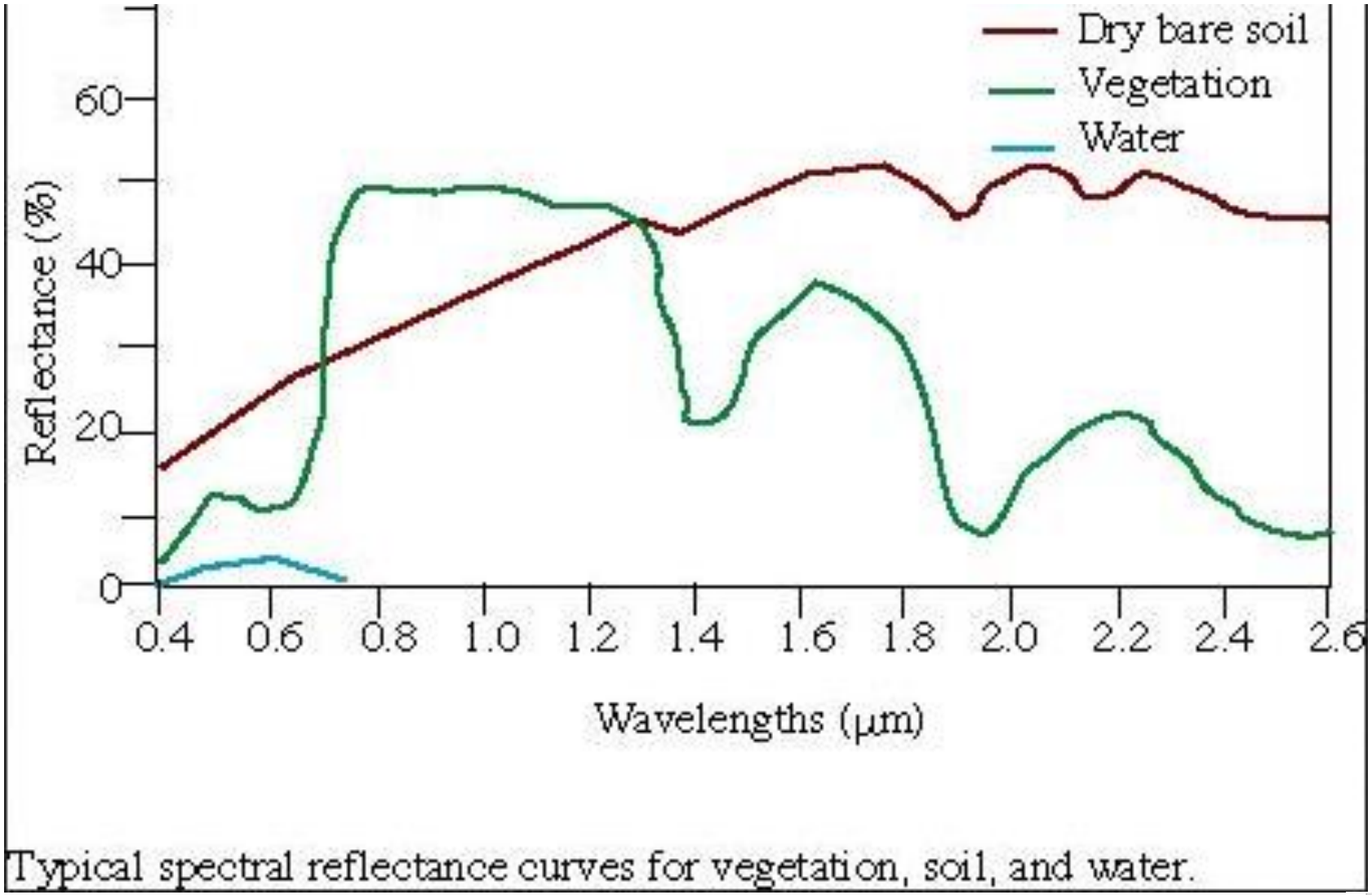
$$B_\nu = \frac{2h\nu^3}{c^2} \cdot \frac{1}{\exp\left(h\nu/kT\right) - 1}$$



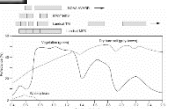
How it works?
Information are mediated by electromagnetical radiation



Principle

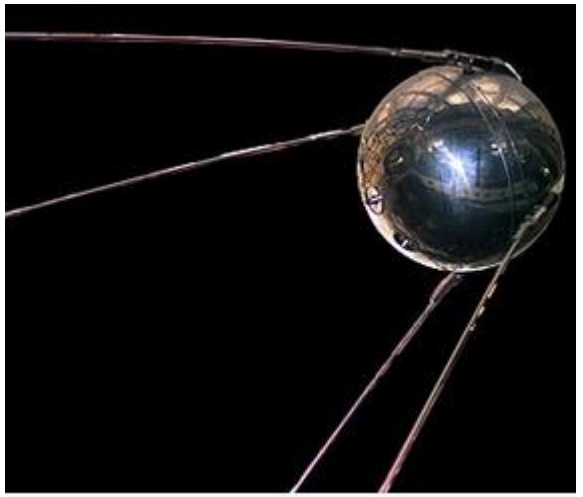


Typical spectral reflectance curves for vegetation, soil, and water.



History

- Aerial RS
- First satellites (Sputnik, Oct4th, 1957, UdSSR)
- Human spaceflight (Skylab, MIR, ISS)
- Meteorological satellites
- First specialised satellites (Landsat, Spot,…)



Remote sensing (RS) - history

- reconnaissance satellite (1960-1990), military

Civilian use since 1972

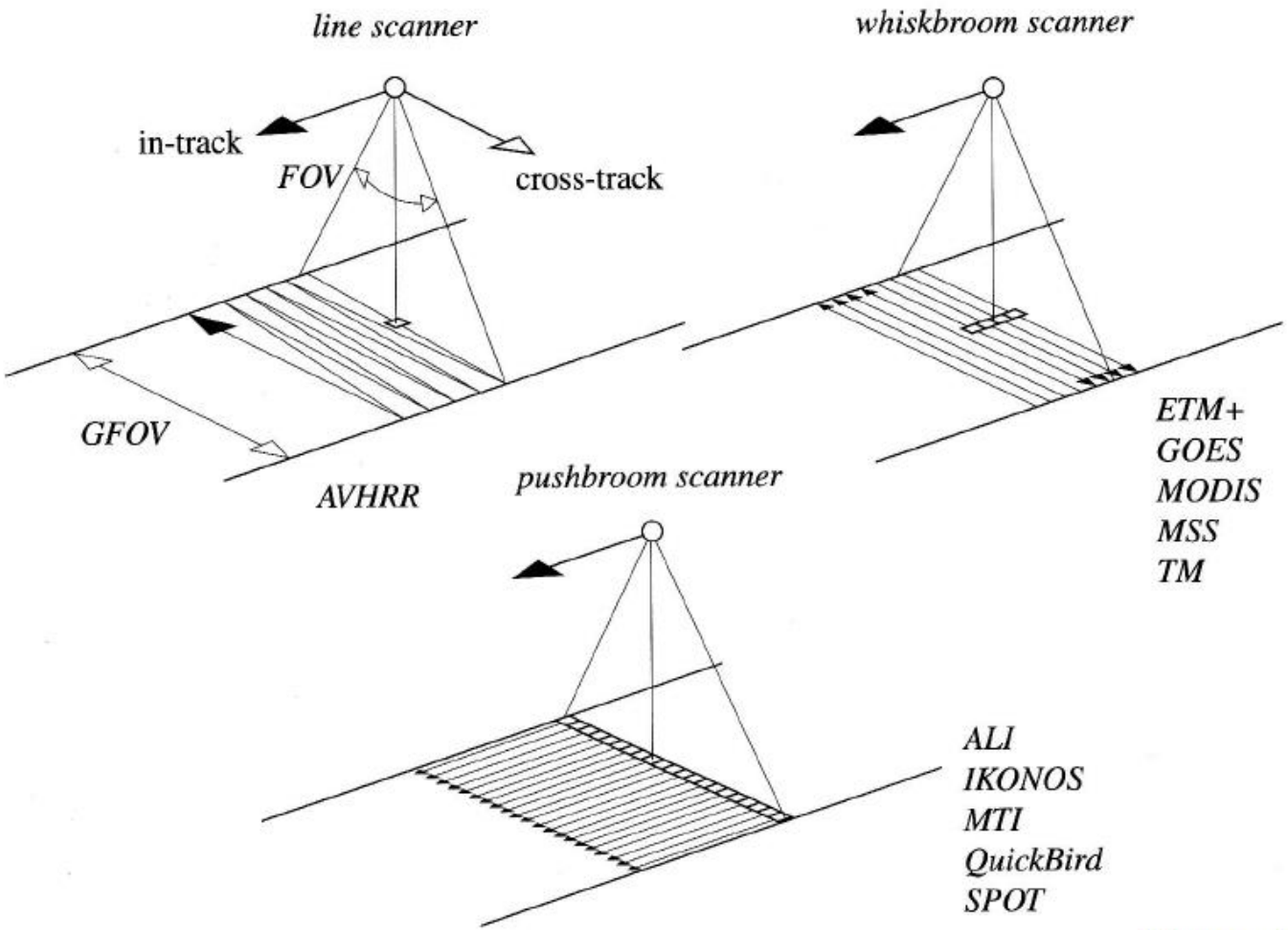
- RS „multispectral“ satellites 1972
- Radar satellites 1978
- Satellite stereo-images 1986
- Hyperspectral technology 2000
- Private sector – better than „1m data“ since 1999

Optical satellite remote sensing

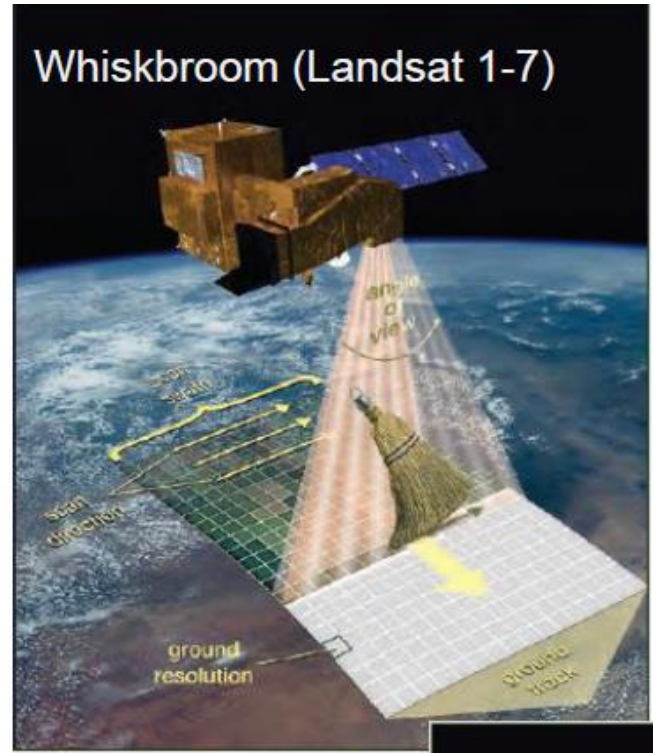
Passive sensors based on reflected radiation fro the Sun or Earth radiation (thermal)

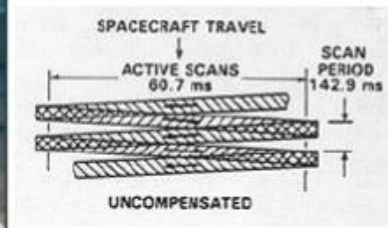
- Meteorological satellites
- Military reconnaissance satellites
- RS satellites

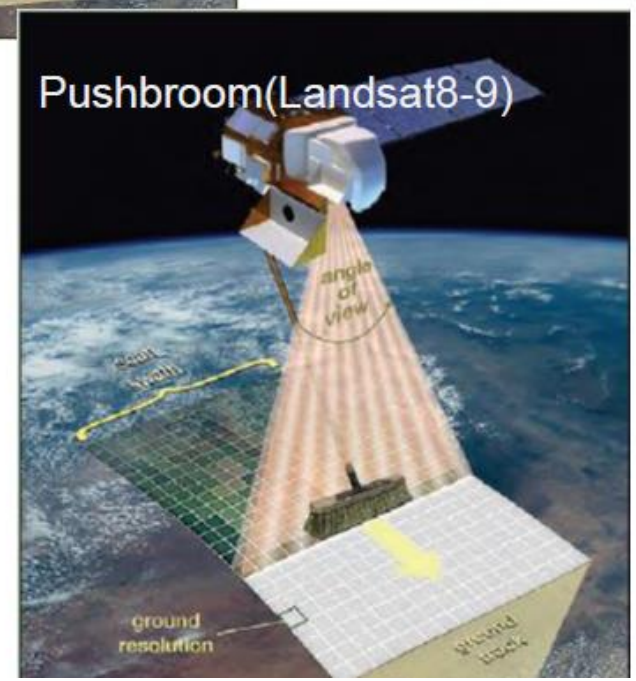
Sensors for optical RS



Schowengerdt. (2007)

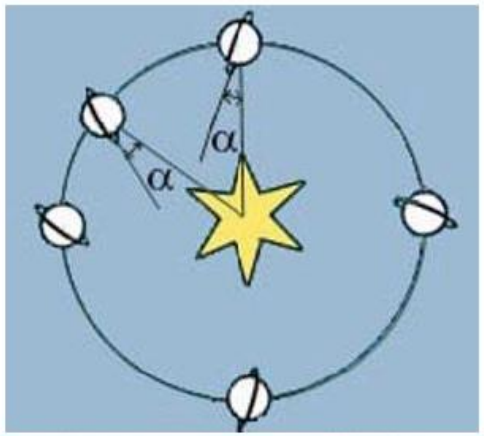


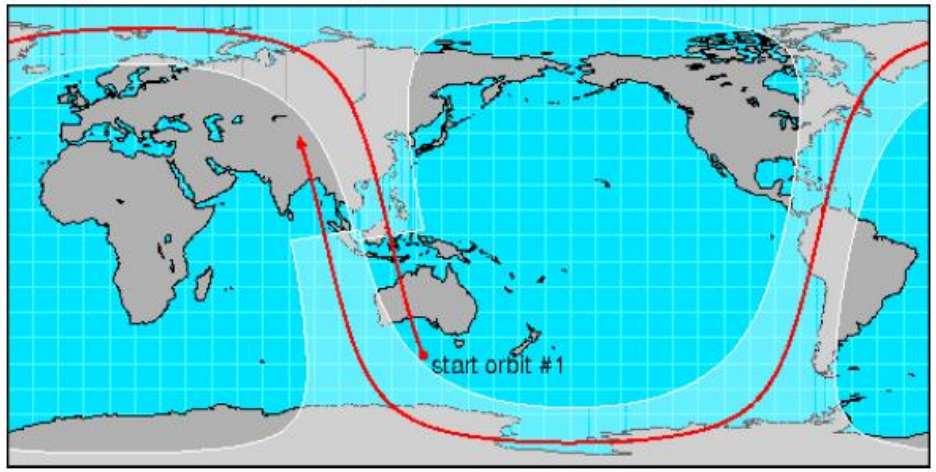




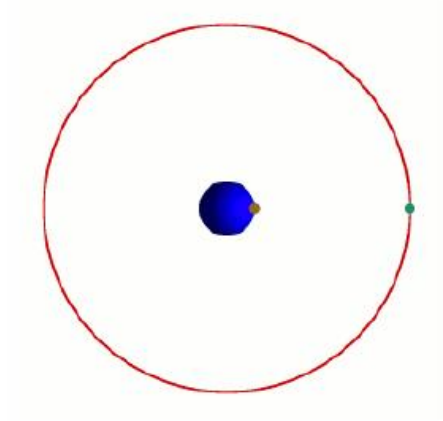
Satellite orbits

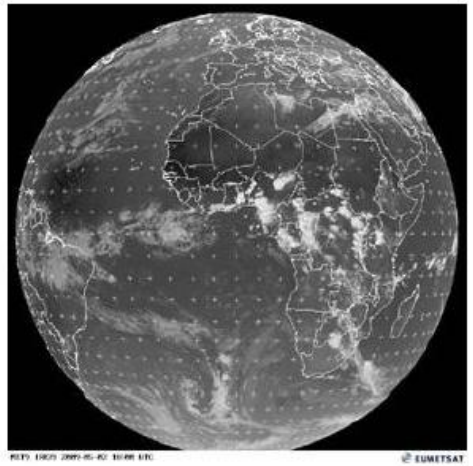
- Polar, sun synchronous





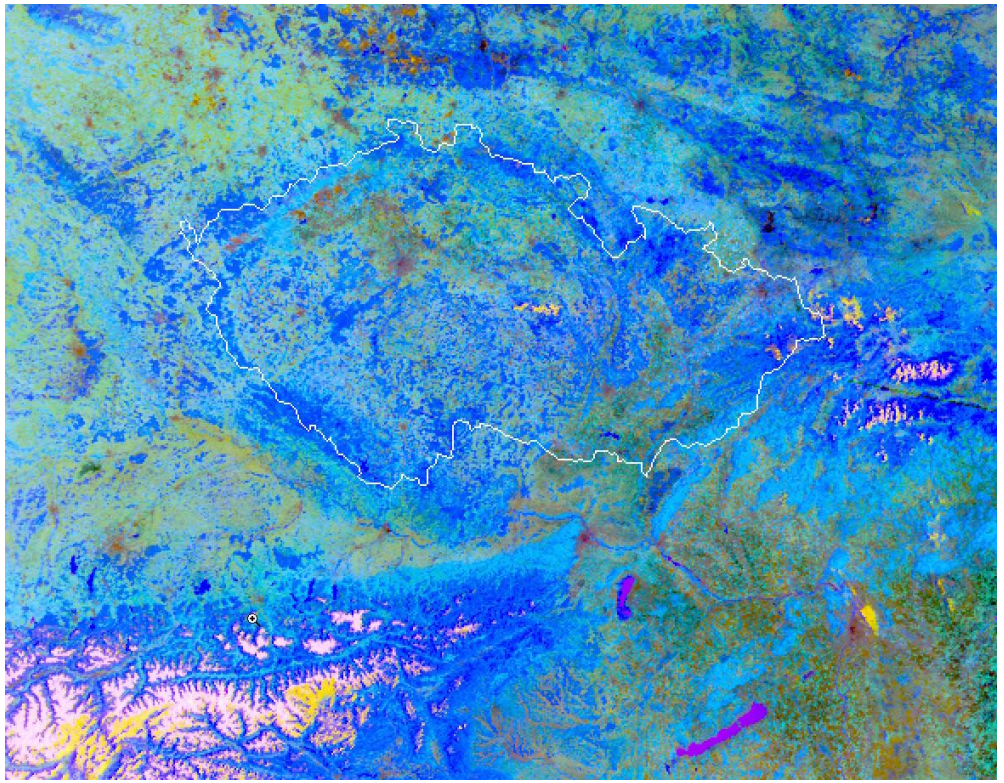
- Geostationary



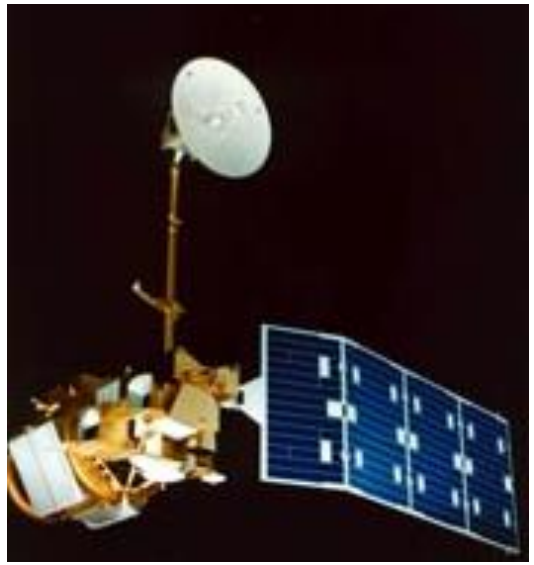


Meteorological satellites

- Geostationar satellites
- Polar satellites (NOAA, Meteor, FengYun,...

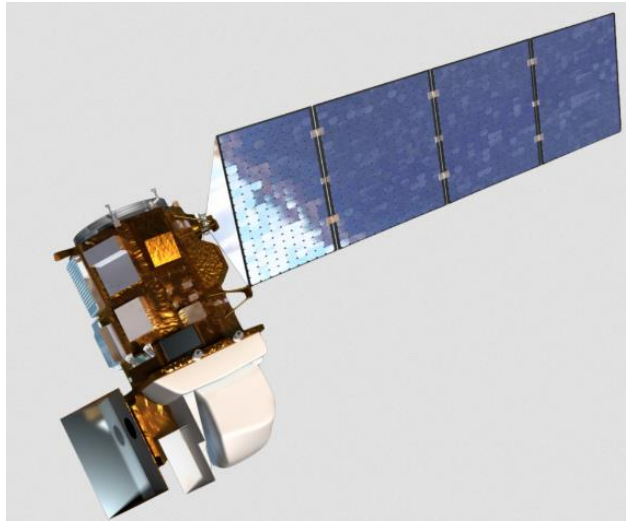


RS satellites on polar orbits



Landsat

(ERTS) Landsat 1,2,3 (since 1972)
Landsat 4,5 (since 1982)
Landsat 7 (1999)
Landsat 8 (2013)
Landsat9 (2021)



Landsat

MSS Bands

Band # (L4-L5)	µm	Resolution*
1	0.5-0.6	68 m X 83 m
2	0.6-0.7	68 m X 83 m
3	0.7-0.8	68 m X 83 m
4	0.8-1.1	68 m X 83 m
N/A	10.4-12.6	68 m X 83 m

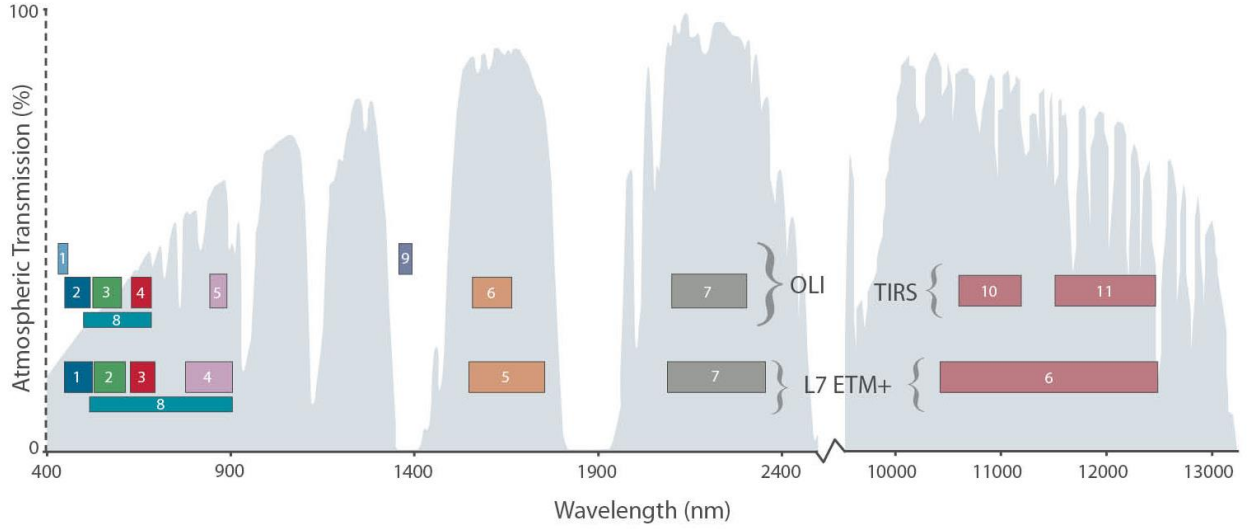
TM Bands

Band Number	µm	Resolution
1	0.45-0.52	30 m
2	0.52-0.60	30 m
3	0.63-0.69	30 m
4	0.76-0.90	30 m
5	1.55-1.75	30 m
6	10.41-12.5	120 m
7	2.08-2.35	30 m

ETM+ Bands

Band Number	µm	Resolution
1	0.45-0.515	30 m
2	0.525-0.605	30 m
3	0.63-0.69	30 m
4	0.775-0.90	30 m
5	1.55-1.75	30 m
6	10.4-12.5	60 m
7	2.08-2.35	30 m
8	0.52-0.9	15 m

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



SPOT

Spot 1, 2,3,4 (1986 - 1998), 10m (PAN), 20m multispectral resolution
-not in use since 2013
Spot 5 (2005-2015) 2.5 m, 5 m (PAN) and 10 m MSS + vegetation
Spot 6,7 (2012, 2014)) 1.5 m (PAN) and 6 m MSS

- Panchromatic (450 – 745 nm)
- Blue (450 – 525 nm)
- Green (530 – 590 nm)
- Red (625 – 695 nm)
- Near-infrared (760 – 890 nm)

Pleiades

- Pleiades 1A, 1B (2011, 2012)
- 0,5m (PAN) and 2m (MS)
- Similar to SPOT 6,7

Copernicus system

- ESA spent some 3.2 billion euros on space-based Earth observation network (Sentinel optical and radar satellites).
- Sentinel 1A (2014), Sentinel 1B (25.4.2016)

  Radar satellite, monitoring sea ice, oil spills, marine winds, waves & currents, land-use change, land deformation among others, and to respond to emergencies such as floods and earthquakes
- Sentinel 2 (2015) **Main applications**: Monitoring agriculture, forests, land-use change, land-cover change; mapping biophysical variables such as leaf chlorophyll content, leaf water content, leaf area index; monitoring coastal and inland waters; risk mapping and disaster mapping

Online resources

- Copernicus Browser: https://browser.dataspace.copernicus.eu/
- USGS Earth Explorer: https://earthexplorer.usgs.gov/
- Esa SENTINEL tutorials: https://step.esa.int/main/doc/tutorials/
- EO College online courses: https://eo-college.org/courses/
- Other tutorials
- ESA: https://earth.esa.int/web/guest/eo-education-and-training
- CanadaCentre forRS https://natural-resources.canada.ca/science-data/science-research/geomatics/remote-sensing/remote-sensing-software-tools

Other satellite systems

- IRS
- JERS
- NOAA
- Terra / Aster…

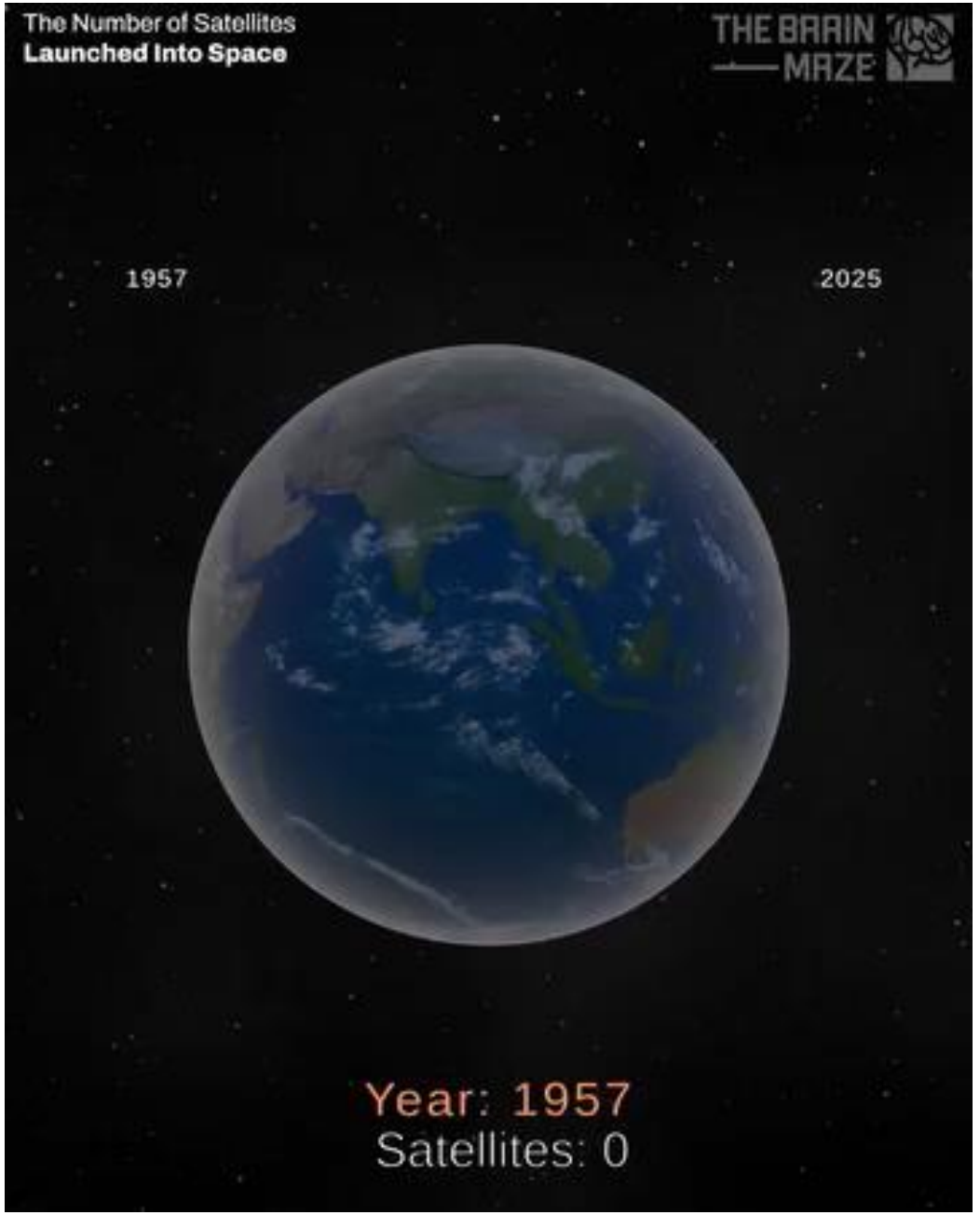
- Small satellites

VHR satellites

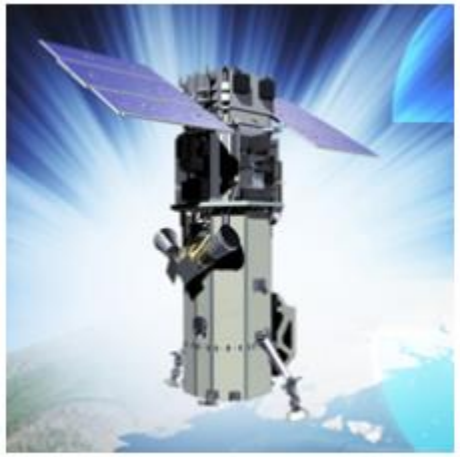
- 1m or sub-m geometric resolution

- Ikonos (1999)
- QuickBird (2001)
- OrbView, GeoEye…
- Today dozens of systems on the orbit

- Very important: GoogleEarth

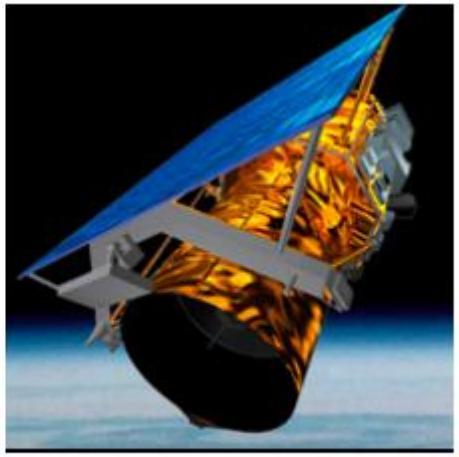


VHR satellites

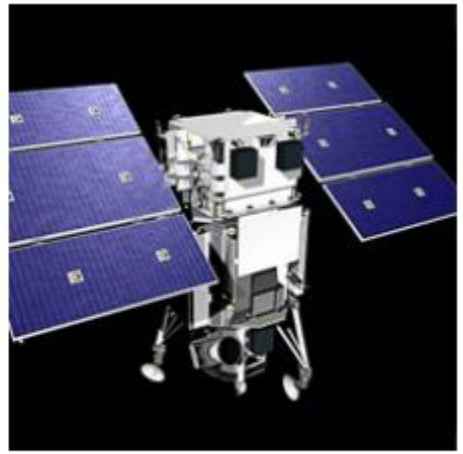


WORLDVIEW-3

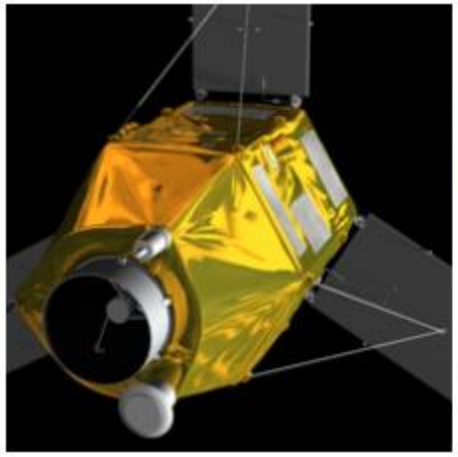
WORLDVIEW-2



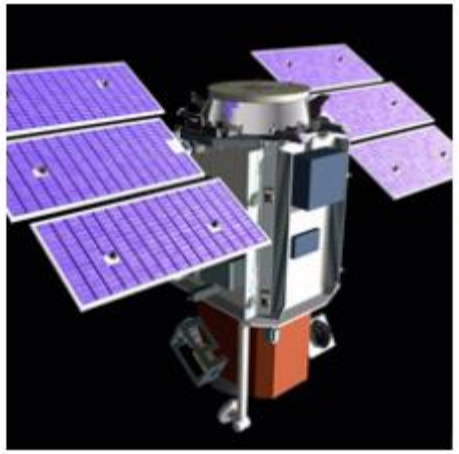
GEOEYE-1



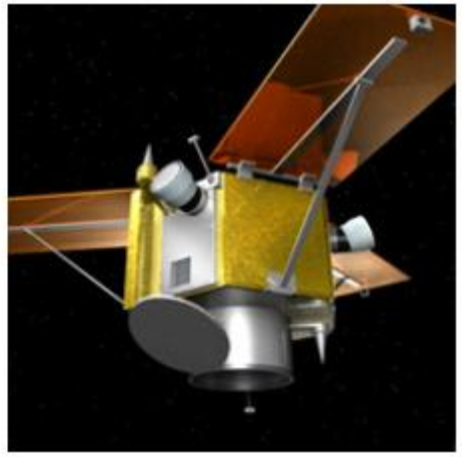
WORLDVIEW-1



PLEIADES



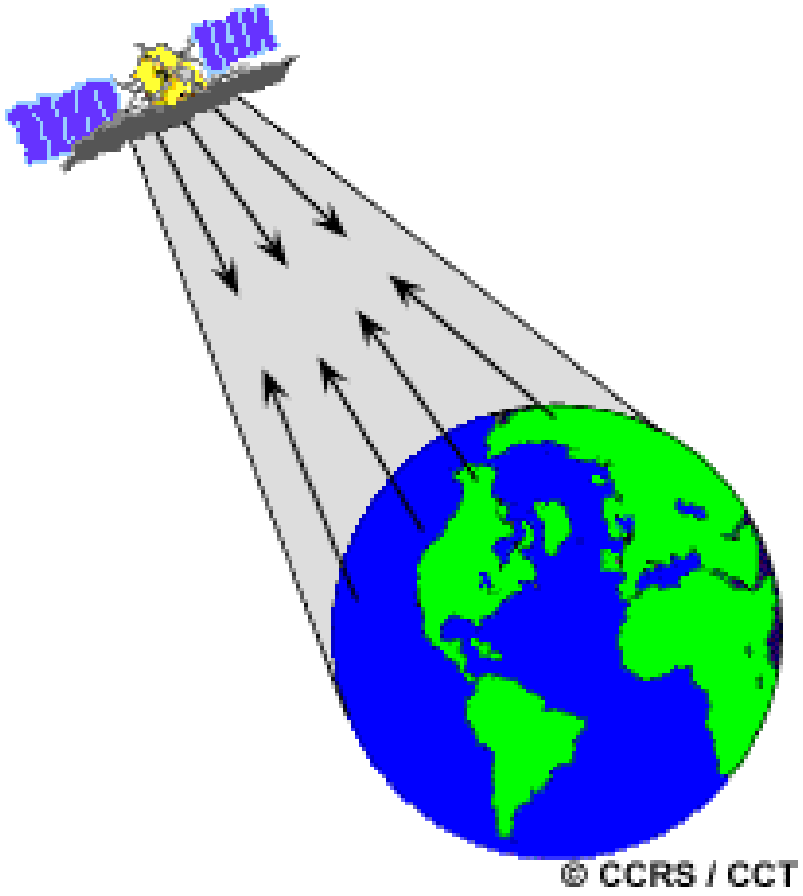
QUICKBIRD



IKONOS

Radar satelite remote sensing

Active sensors based on emitting of its own radiation



Satellite systems

- SeaSat (1978)
- Shuttle Imaging Radar, SIR-A, SIR-B, SIR-C (2000) - SRTM
- ERS – 1 (1991), ERS –2 (1995)
- ENVISAT (2002)
- JERS –1 (1992)
- Radarsat-1 (1995)
- TerraSar X (2008)

Seasat, 1978

Sentinel 1A