การสำรวจระยะไกล (remote sensing: RS) เบื้องต้นและการประยุกต์ใช้

วัตถุประสงค์

1. ให้ผู้เรียนมีความรู้เรื่องการใช้ข้อมูล RS เบื้องต้น

2. ผู้เรียนมีแนวคิดในการประยุกต์ใช้ข้อมูล RS ในงานด้านต่างๆ

หลักสูตรหัวข้อ

1. หลักการเบื้องต้นของข้อมูลการสำรวจระยะไกล (remote sensing: RS)
2. การประยุกต์ใช้ข้อมูลการสำรวจระยะไกลในงานด้านต่างๆ

Principles of Remote Sensing

What is remote sensing ?

- ✓ Humans with the aid of their eyes, noses, and ears are constantly seeing, smelling, and hearing things from a distance as they move through an environment.
- ✓ The activities of recording/observing/perceiving (**sensing**) objects or events at far away (**remote**) places.
- ✓ Remote sensing is the art and science of recording, measuring, and analysing information about a phenomenon from a distance.
- ✓ The acquisition of information about an object or phenomenon without making physical contact with the object

The acquisition of information

- ✓ In order to study large areas of the Earth's surface geographers use devices known as remote sensors.

- ✓ These sensors are mounted on platforms such as helicopters, planes, satellites, and UAV (drone)

- ✓ Make it possible for the sensors to observe the Earth from above.

The acquisition of information (con.)

- Most sensors record information about the Earth's surface by measuring the transmission of energy from the surface in different portions of the electromagnetic (EM) spectrum
- Because the Earth's surface varies in nature, the transmitted energy also varies.
- This variation in energy allows images of the surface to be created. Human eyes see this variation in energy in the visible portion of the EM spectrum.
- Sensors detect variations in energy in both the visible and non-visible areas of the spectrum.

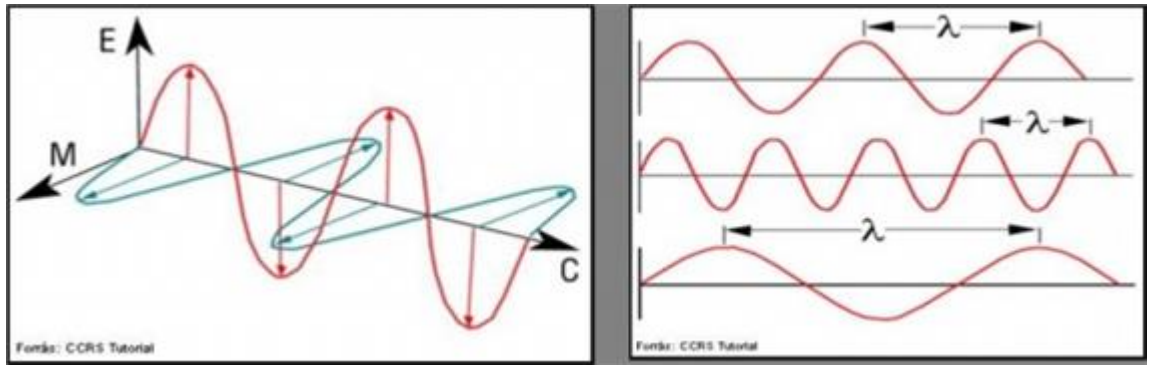
Electromagnetic radiation

- The energy to use in remote sensing is in the form of electromagnetic radiation. For understanding remote sensing we need to understand two important characteristics of electromagnetic radiation, which are basic to wave theory. These are the wavelength and frequency.

- The wavelength is the distance between successive wave crests. Wavelength is usually represented by lambda (λ) and measured in meters or some factor of meters such as nanometers (nm, 10^{-9}m) or micrometers (μm, 10^{-6}m).

Electromagnetic radiation (con.)

- Frequency refers to the number of cycles of a wave passing a fixed point per unit of time. Frequency is normally measured in hertz (Hz) which is cycle per second. Frequency and wavelength are inversely proportional: the higher the frequency, the shorter the wavelength.

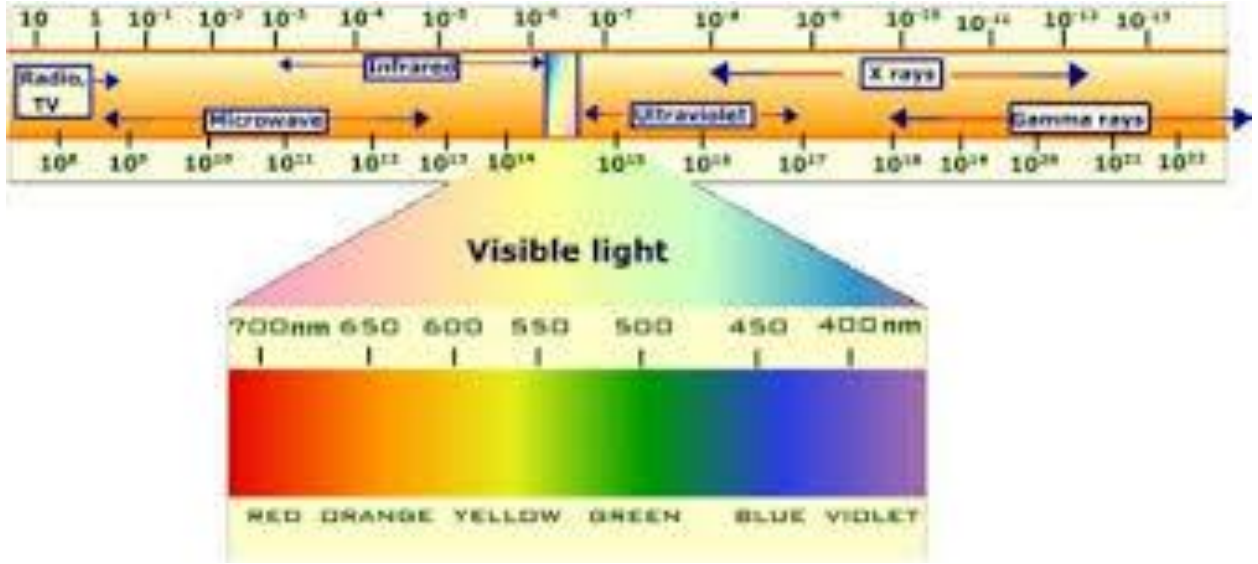


Source:
http://www.landmap.ac.uk/ipc/ccrs/chapter1/chapter1_2_e.html

The electromagnetic spectrum (con.)

- The electromagnetic spectrum ranges from
- the visible light spectrum
- the shorter wavelengths (including gamma and x-rays)
- the longer wavelengths (including microwaves and broadcast radio waves)

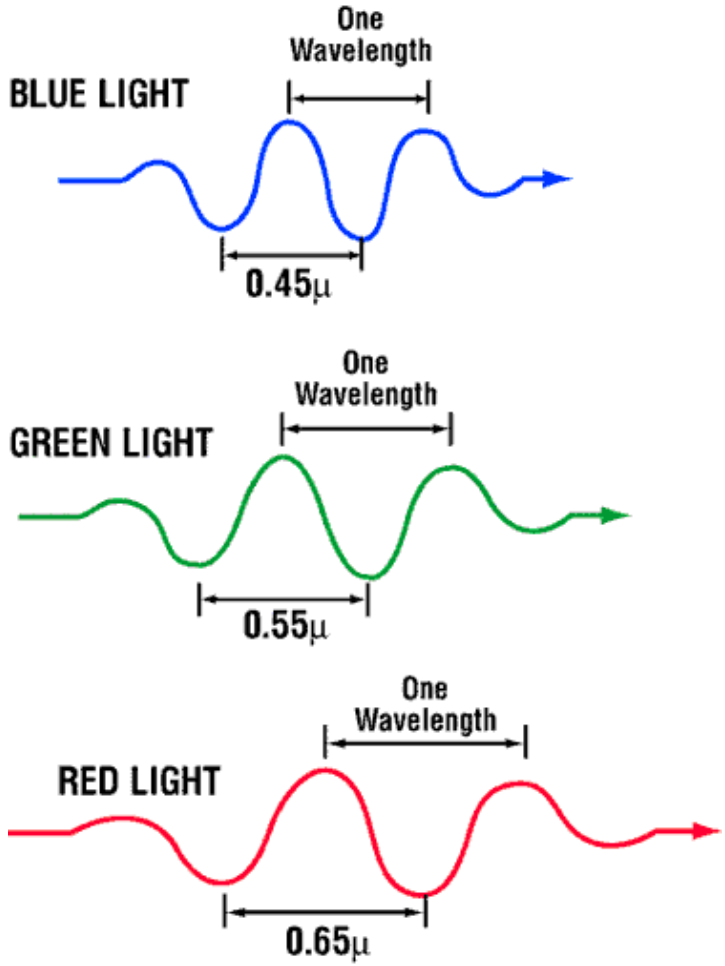
- There are several regions of the electromagnetic spectrum which are useful for remote sensing



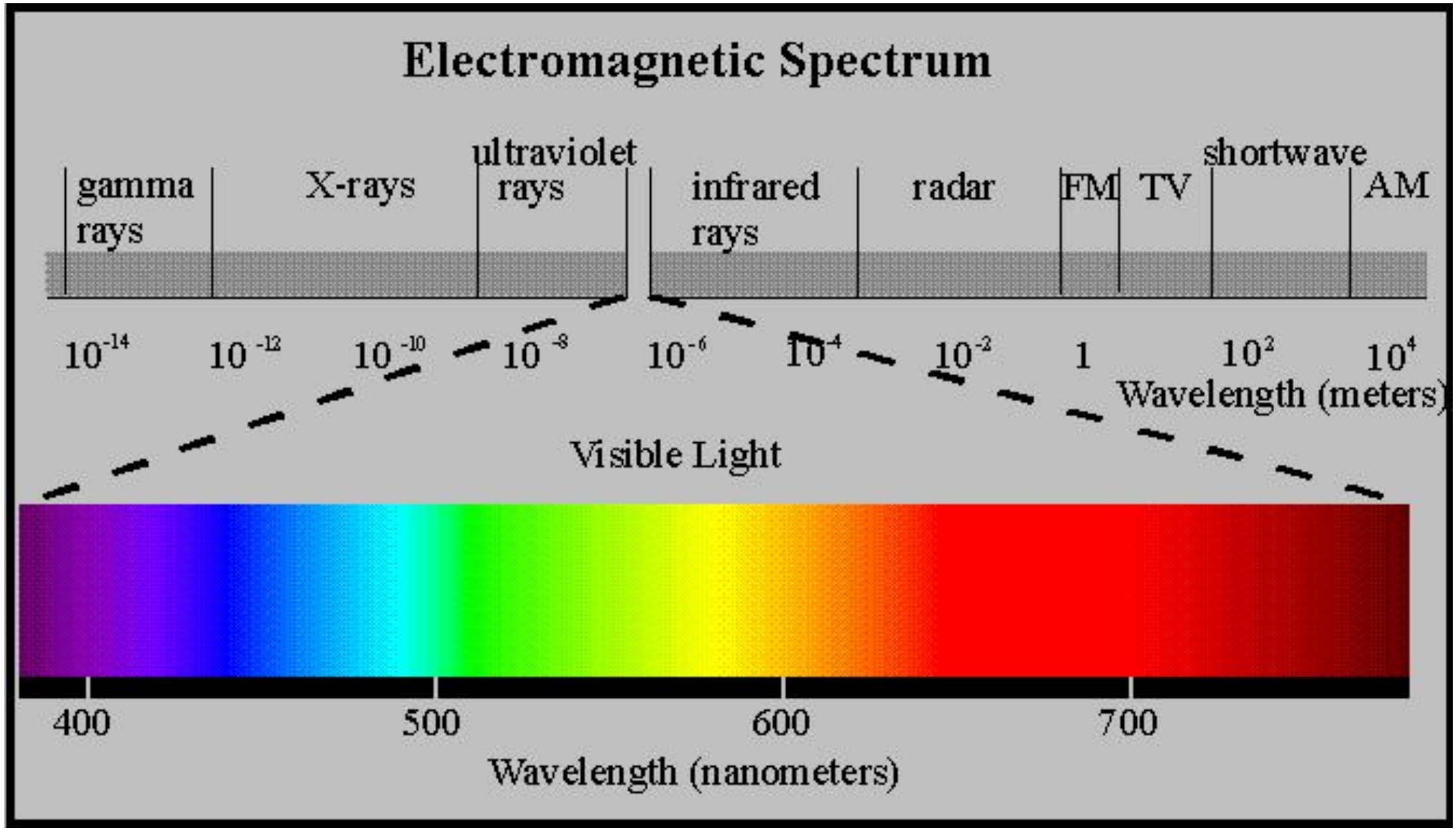
Wavelength for Remote Sensing

- Optical Wavelength (0.4 -14 µm)
  - ✓ Visible light (0.4 – 0.7 µm)
  - ✓ Near Infrared (0.7 - 3 µm)
  - ✓ Thermal Infrared (3-15 µm)

- Microwave Wavelength (1 mm - 1 m)
  - ✓ - X - band ความถี่ 8 - 12.5 GHz หรือ ความยาวคลื่น 2.4 - 3.75 ซม.
  - ✓ - C - band ความถี่ 4 - 8 GHz หรือ ความยาวคลื่น 3.75 - 7.5 ซม.
  - ✓ - S - band ความถี่ 2 - 4 GHz หรือความยาวคลื่น 7.5 - 15 ซม.
  - ✓ - L - band ความถี่ 1 - 2 GHz หรือความยาวคลื่น 15 - 30 ซม.
  - ✓ - P - band ความถี่ 0.3 - 1 GHz หรือความยาวคลื่น 30 - 100 ซม.



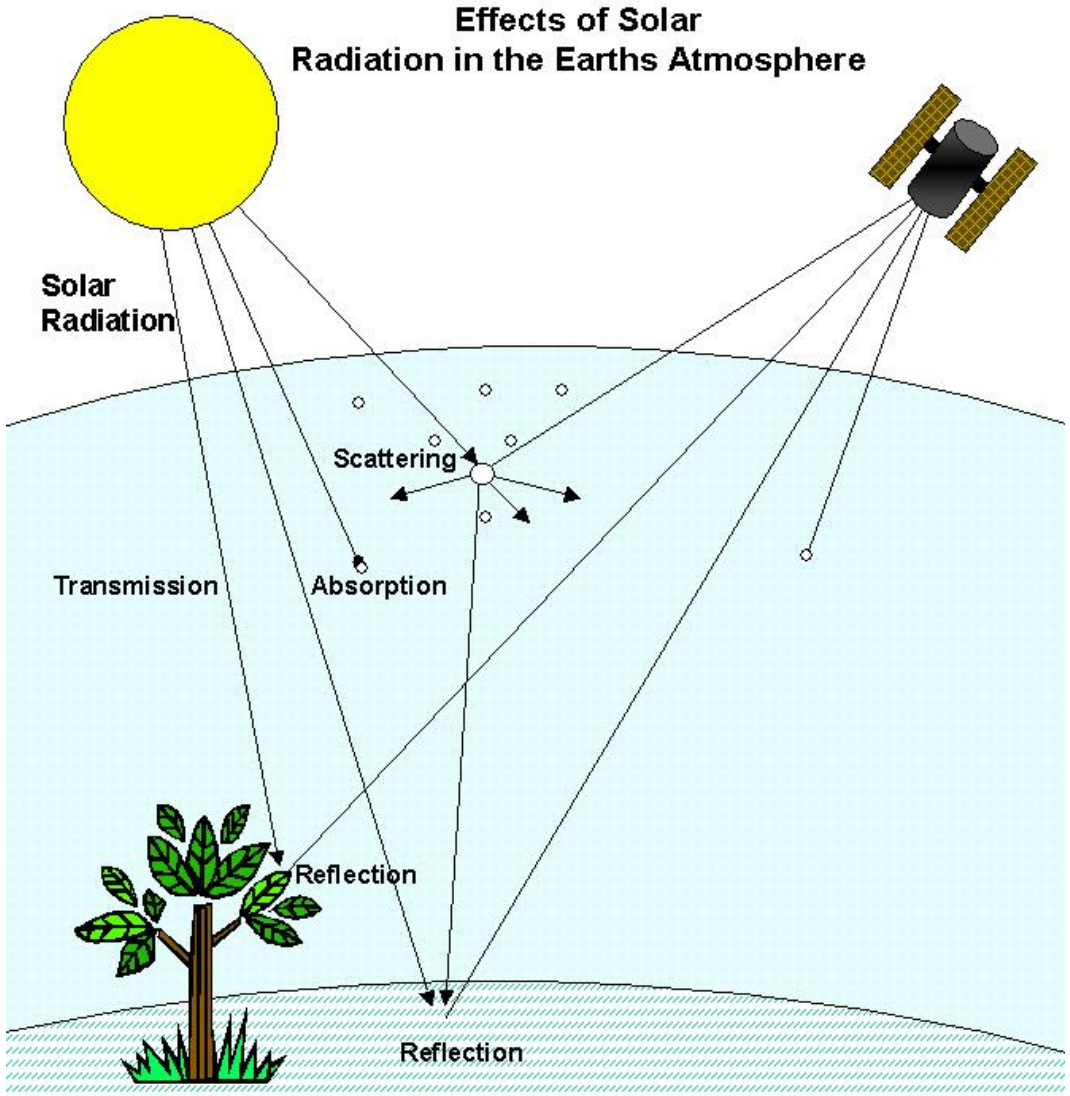
Visible light

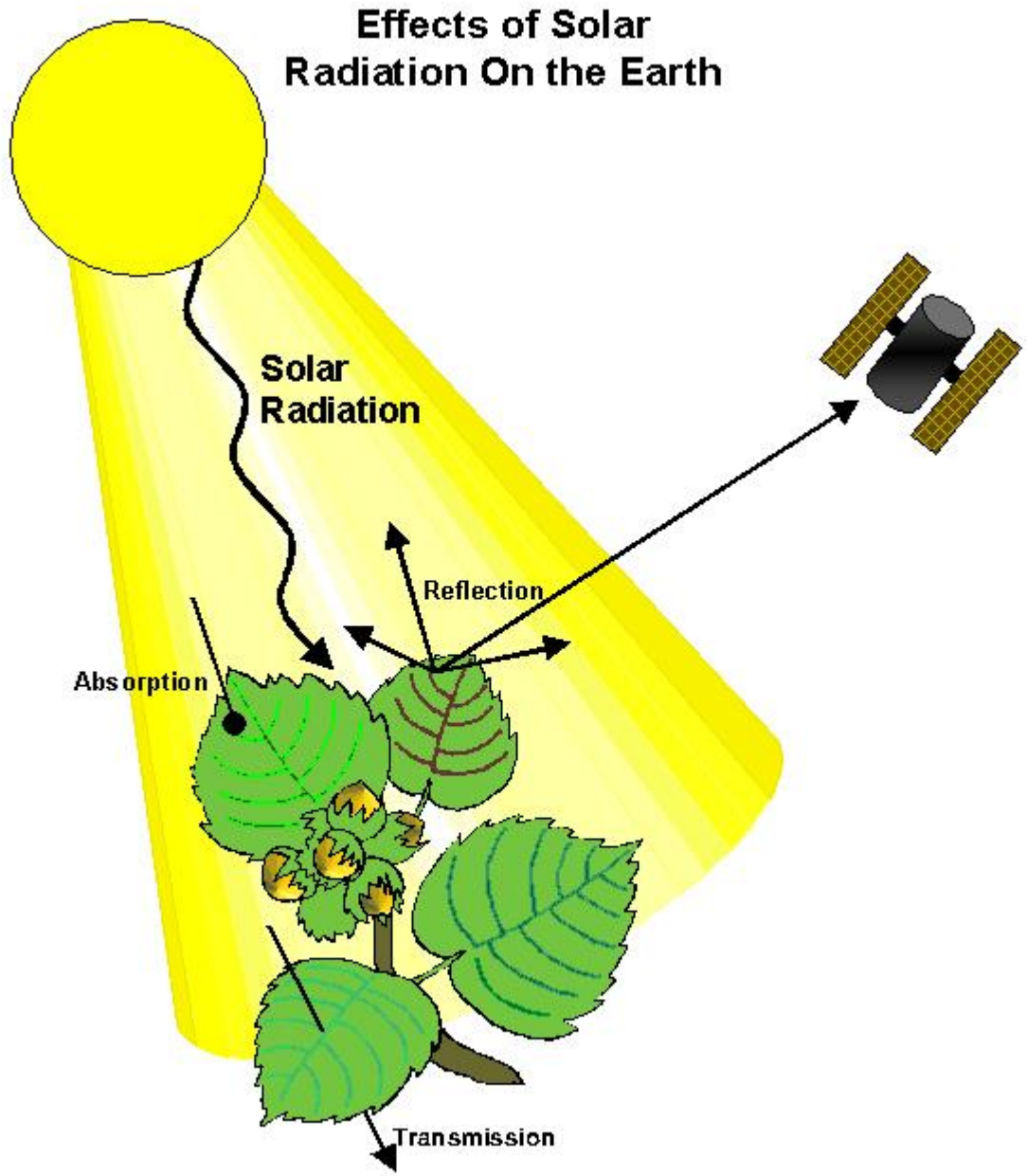

Electromagnetic Spectrum
gamma rays
X-rays
ultraviolet rays
infrared rays
radar
FM
TV
shortwave
AM
10^-14
10^-12
10^-10
10^-8
10^-6
10^-4
10^-2
1
10^2
10^4
Wavelength (meters)
Visible Light
400
500
600
700
Wavelength (nanometers)

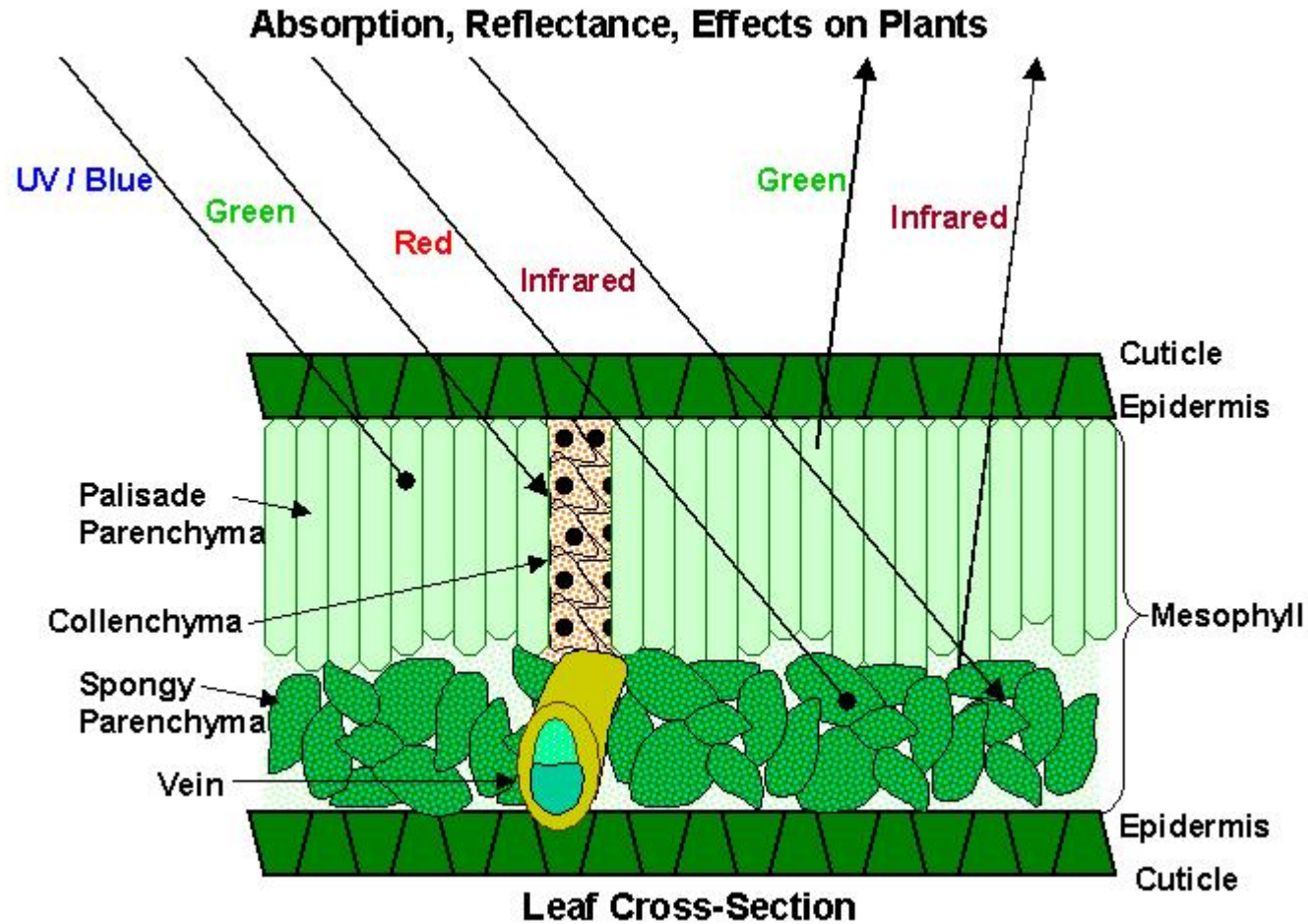
Atmospheric radiation

Atmospheric radiation is responsible for many events that happen in our atmosphere every day.

- Reflection
- Absorption
- Transmission
- Scattering



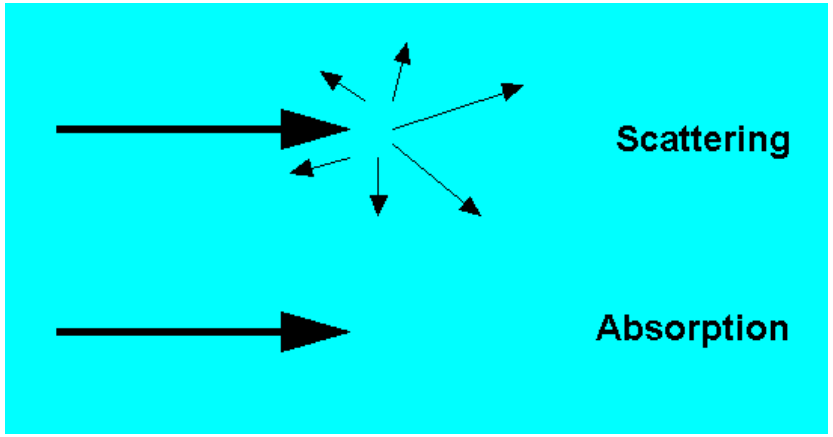

Effects of Solar
Radiation On the Earth
Solar
Radiation
Reflection
Absorption
Transmission



https://landsat.usgs.gov/atmospheric-transmittance-information

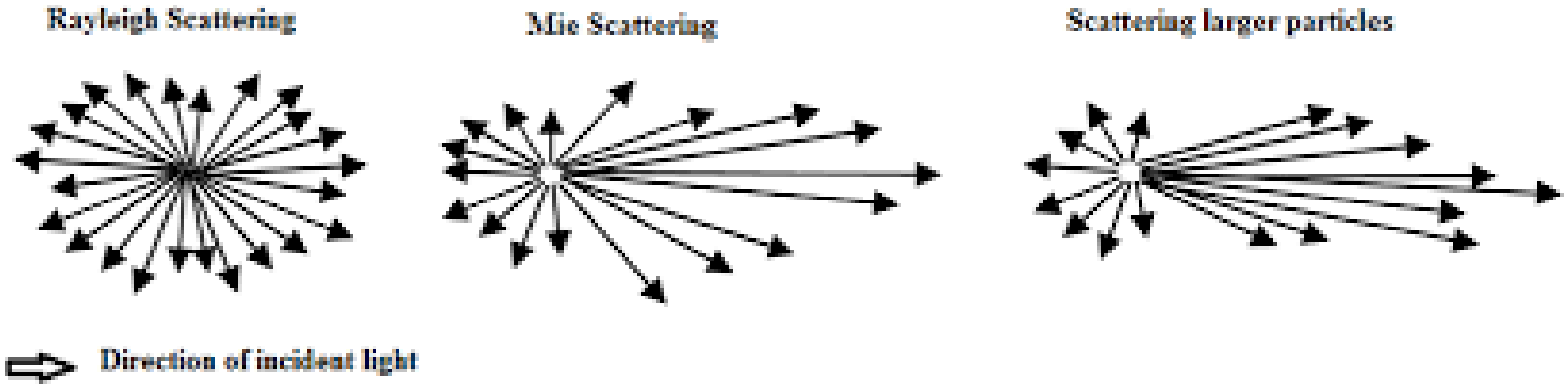
Interaction with the Atmosphere

- Particles and gases in the atmosphere have effect on remote sensing data and on spectral band selection. These effects are caused by the mechanisms of scattering and absorption.
- Scattering occurs when radiation is reflected or refracted by particles or large gas molecules present in the atmosphere. Redirection of the electromagnetic radiation depends on several factors including the wavelength of the radiation, the size of particles or gases, and the distance the radiation travels through the atmosphere.



Types of scattering

- Rayleigh scattering (*atmospheric gas; N2, O2)*
- Mie scattering (*Dust, aerosol, moisture)*
- Non-selective scattering (water droplets, which make up clouds and fog banks)

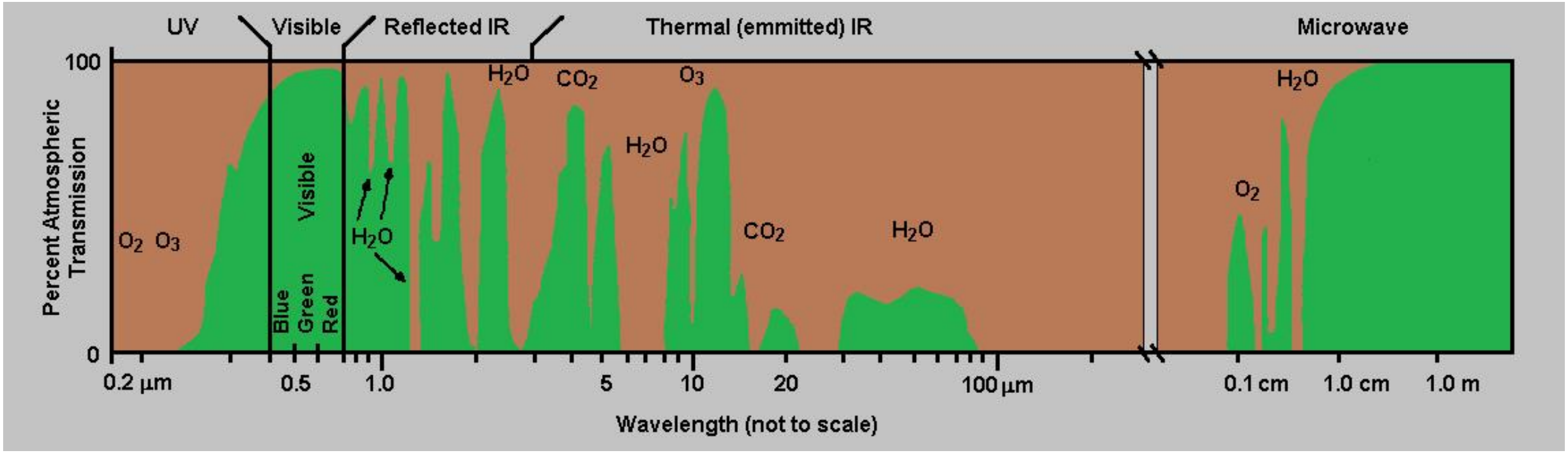


Absorption Bands and Atmospheric Windows

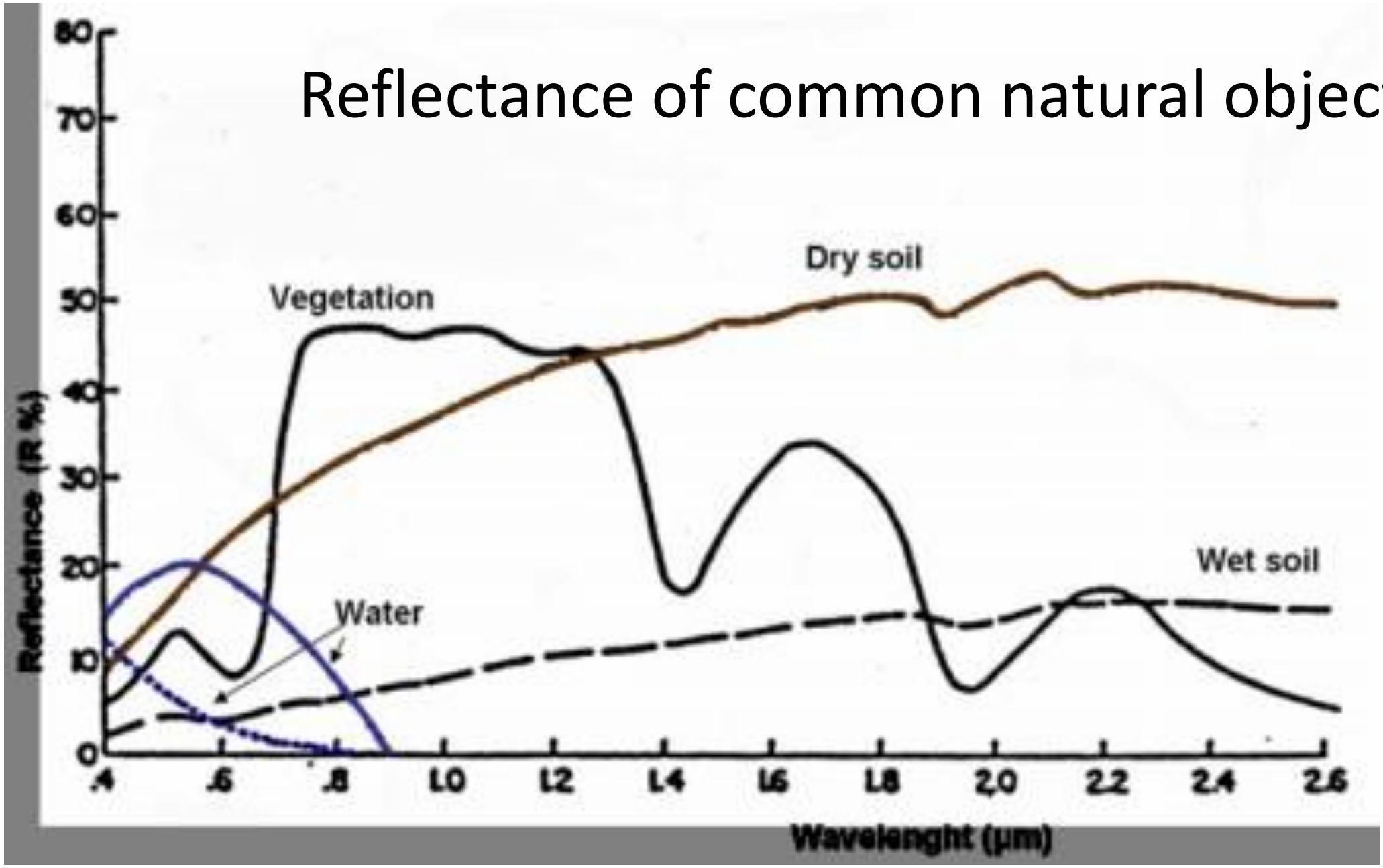
- Some types of electromagnetic radiation easily pass through the atmosphere
- Other types do not.
- The ability of the atmosphere to allow radiation to pass through it is referred to as its transmissivity
- Varies with the wavelength/type of the radiation.
- The gases that comprise our atmosphere absorb radiation in certain wavelengths while allowing radiation with differing wavelengths to pass through.

Atmospheric Windows

- The areas of the EM spectrum that are absorbed by atmospheric gases such as water vapor, carbon dioxide, and ozone are known as absorption bands.
- Absorption bands are represented by a low transmission value that is associated with a specific range of wavelengths.



Reflectance of common natural objects



Digital Image

- Electromagnetic energy be detected by sensor
  - A digital image comprises of

✓ A two dimensional array of individual picture elements (**pixels)**

✓ Arranged in columns and rows

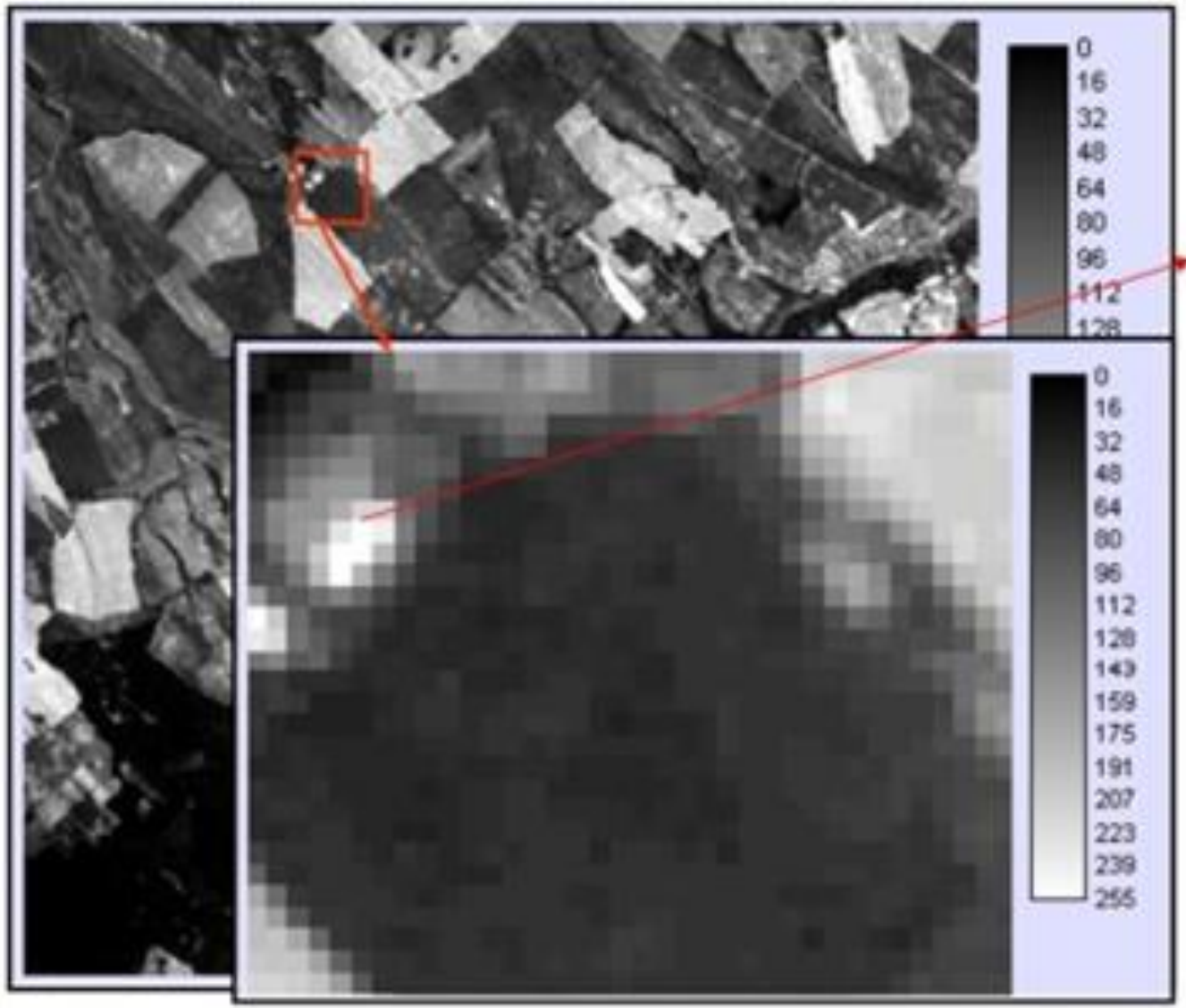
✓ Each pixel represents an area on the Earth's surface.

✓ A pixel has an **intensity value** and a **location address** in the two dimensional image

Digital Image (cont.)

- ✓ The **intensity value** represents the measured physical quantity such as the solar radiance in a given wavelength band reflected from the ground, emitted infrared radiation or backscattered radar intensity.

- ✓ This value is normally the average value for the whole ground area covered by the pixel.



174	212	212	114	81	
228	225	239	125	43	
255	255	185	108		
255	179				

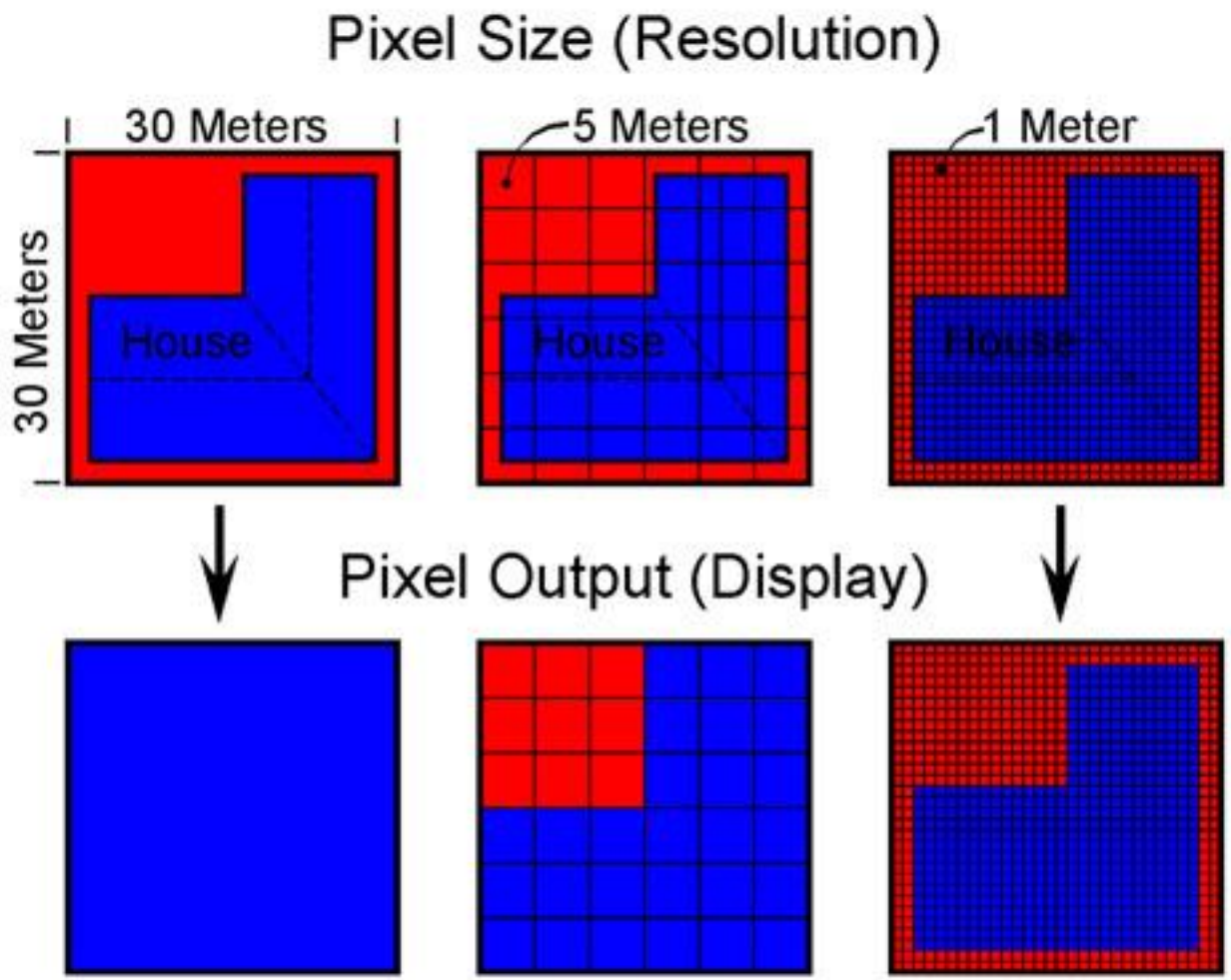
Resolutions of Remote Sensing

1. Spatial (what area and how detailed)
2. Spectral (what colors – bands)
3. Temporal (time of day/season/year)
4. Radiometric (color depth)

1. Spatial (what area and how detailed)

- Spatial Resolution describes how much detail in a photographic image is visible to the human eye.
- The ability to "resolve," or separate, small details

Spatial Resolution



Spatial resolution of images acquired by satellite sensor

- systems is usually expressed in meters.
- Landsat as having “30-meter" resolution, which means that two objects, thirty meters long or wide, sitting side by side, can be separated (resolved) on a Landsat image.

  - High spatial resolution: 0.41 - 4 m
  - Low spatial resolution: 30 - > 1000 m

Spectral resolution

- The ability to resolve **spectral** features and bands into their separate components.
- The **spectral resolution** required by the analyst or researcher depends upon the application involved. For example, routine analysis for basic sample identification typically requires low/medium **resolution**.
- The spectral reflectance curves, or spectral signatures, of different types of ground targets provide the knowledge base for information extraction.

Multispectral and *Hyperspectral* imagery

Spectral resolution (Cont.)

- ✓High spectral resolution: - 220 bands
- ✓Medium spectral resolution: 3 - 15 bands
- ✓Low spectral resolution: - 3 bands

Multispectral and *Hyperspectral* imagery

Temporal Resolution

- The specifies the revisiting frequency of a satellite sensor for a specific location.

- High temporal resolution: < 24 hours - 3 days
  Medium temporal resolution: 4 - 16 days
  Low temporal resolution: > 16 days

Radiometric resolution

- The radiometric resolution specifies how well the differences in brightness in an image can be perceived
- This is measured through the number of the grey value levels
- The maximum number of values is defined by the number of bits (binary numbers)
- An 8 bit representation has 256 grey values, a 16 bit (ERS satellites) representation 65.536 grey values

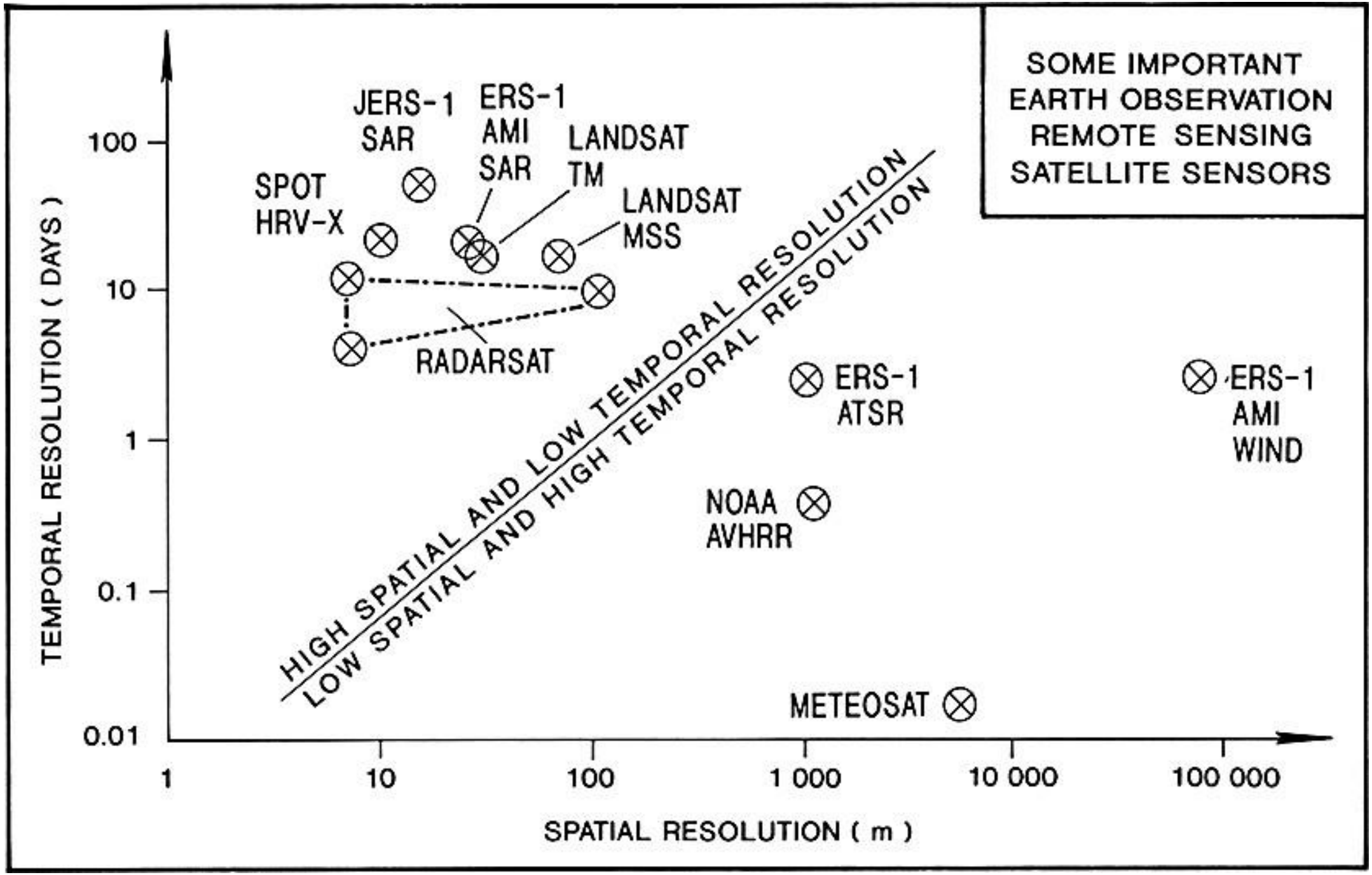
Radiometric resolution (cont.)

- Radiometric resolution depends on the wavelengths and the type of the spectrometer

✓ LANDSAT-TM (from LANDSAT 4-5) & SPOT-HRV

8 bits (256 grey values)

✓ IKONOS & QuickBird: 11 bits


SOME IMPORTANT
EARTH OBSERVATION
REMOTE SENSING
SATELLITE SENSORS
JERS-1
SAR
ERS-1
AMI
SAR
LANDSAT
TM
SPOT
HRV-X
LANDSAT
MSS
RADARSAT
HIGH SPATIAL AND LOW TEMPORAL RESOLUTION
LOW SPATIAL AND HIGH TEMPORAL RESOLUTION
ERS-1
ATSR
ERS-1
AMI
WIND
NOAA
AVHRR
METEOSAT
TEMPORAL RESOLUTION (DAYS)
100
10
1
0.1
0.01
1
10
100
1 000
10 000
100 000
SPATIAL RESOLUTION (m)

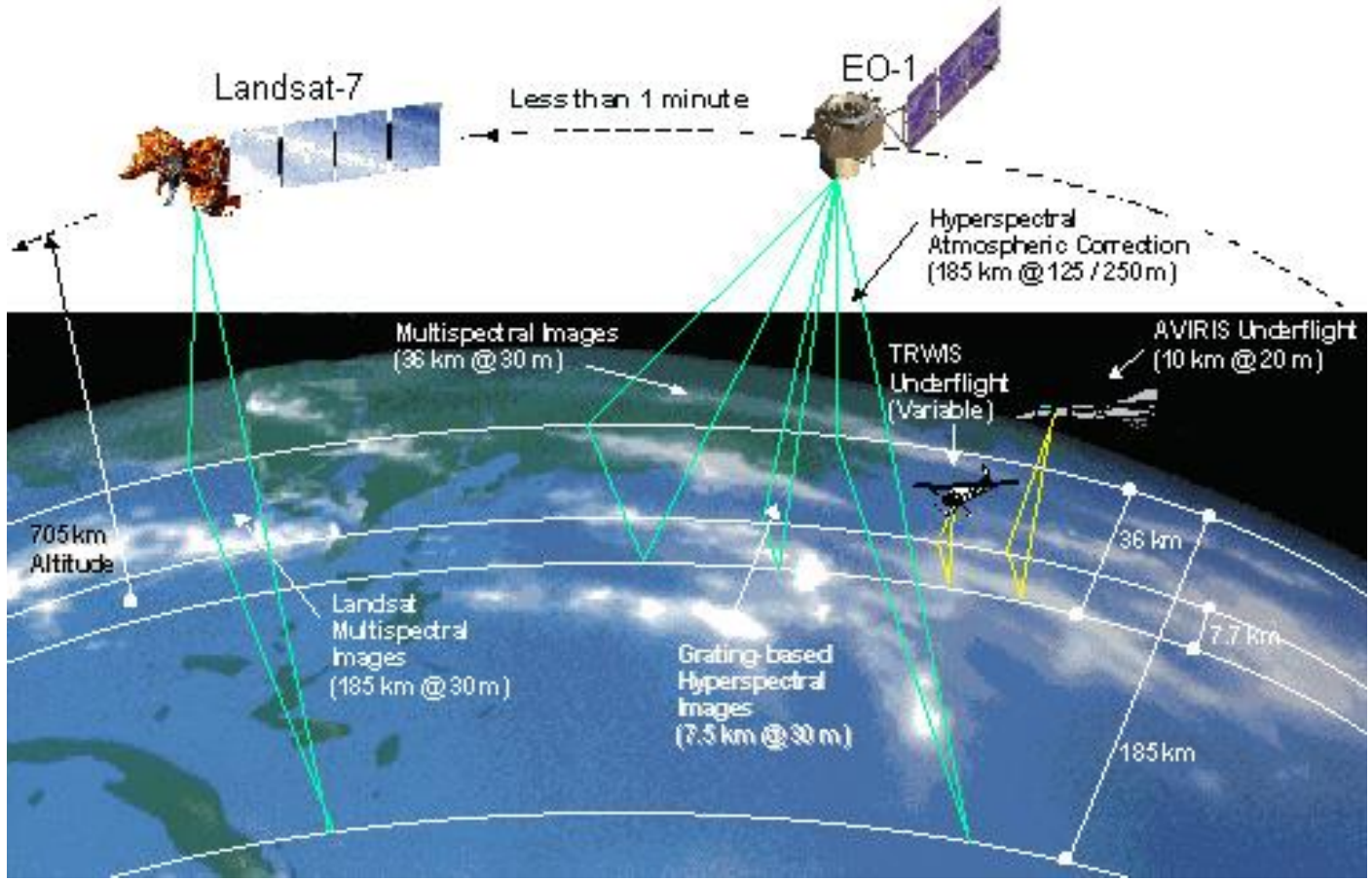
The best spatial resolution?

Resolution Trade-Off

- The different spatial, temporal and spectral resolutions are the limiting factor for the utilization of the satellite image data for different applications.
- Unfortunately, because of technical constraints, satellite remote sensing systems can only offer the following relationship between spatial and spectral resolution: a high spatial resolution is associated with a low spectral resolution and vice versa.

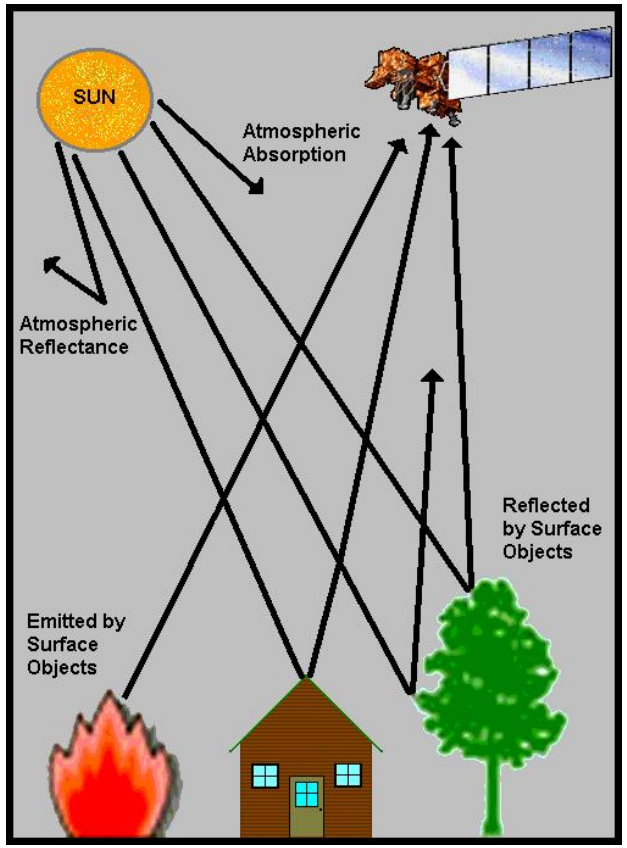
Satellites and Sensors

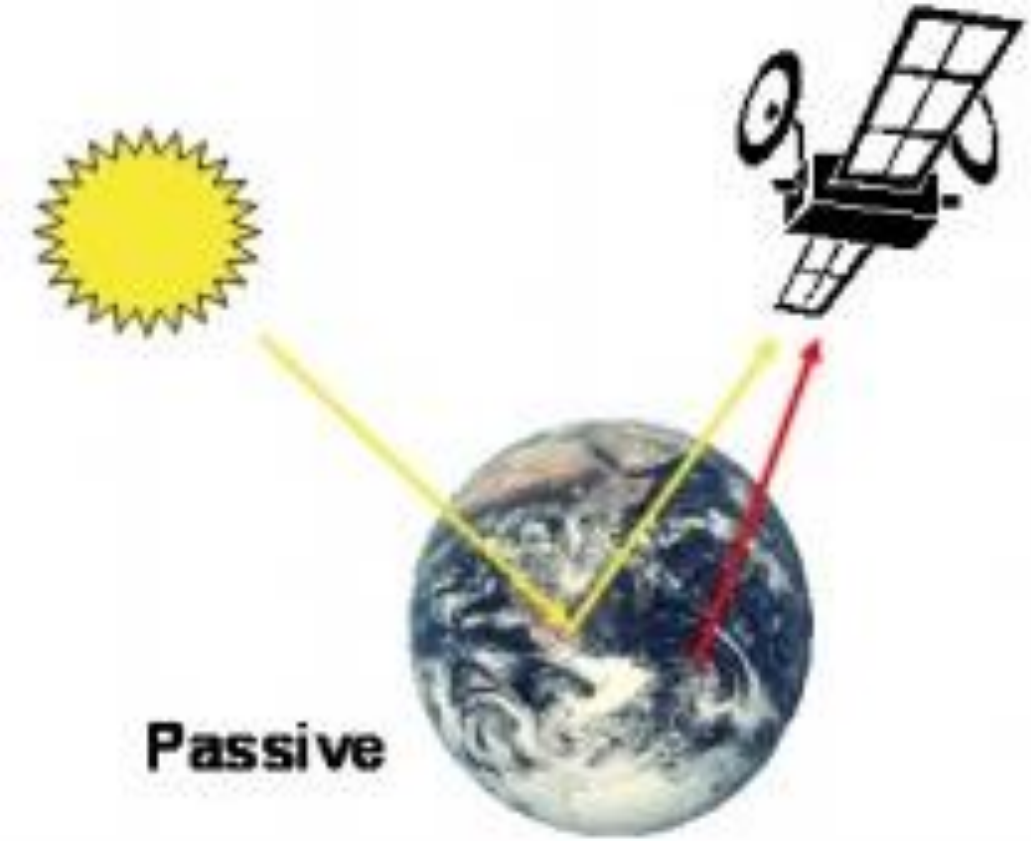
1. Passive Sensor Systems
2. Active Sensor Systems



1. Passive System

- **Needs an external energy source**
  - ✓ Most cases this source is the sun
  - ✓ These sensors generally detect reflected and emitted energy wave lengths from a phenomenon





Satellites and Sensors

Passive and Active Sensor Systems

1. Passive Sensor Systems

- ✓ The most popular sensors
- ✓ Used in are the camera, image plane scanning sensors, such as TV cameras and multispectral scanners coving
- ✓ Along-track scanning systems (SPOT 1-7) and Across-track scanning sensors, such as multispectral scanners (LANDSAT 1-8: MSS, TM; optical-mechanical scanner), QuickBird, RapidEye, and Thaichote or THEOS.

Comparison of The Passive Sensor Satellites

Comparing High- and Medium-Resolution Commercial Imaging Satellites

Satellite	Launch Date	Swath Width (kilometers) [1]	Native GSD (meters)[2]	Output Resolution (meters)	Max View Scale[3]	Native Accuracy (meters)[4]	Bands	Bit Depth	Stereo
IKONOS	Sept. 24, 1999	11.3	0.82 x 3.20	1 x 4 [5]	1:2,500	15	pan + 4 MS	11	yes
QuickBird	Oct. 18, 2001	18[6]	0.65 x 2.62	0.6 x 2.4	1:1,500	23	pan + 4 MS	11	no
SPOT-5	May 3, 2002	60	5 x 10 x 20	2.5 x 5 x 10 x 20[7]	1:5,000	48	pan + 4 MS	8	yes
WorldView-1	Sept. 18, 2007	17.7	0.5	0.5	1:1,250	5	pan only	11	yes
RapidEye	Aug. 29, 2008	77	6.5	5	1:12,500	23- 45[8]	5 MS (no pan)	12	no
GeoEye-1	Sept. 6, 2008	15.2	0.41 x 1.65	0.5 x 2	1:1,250	5	pan + 4 MS	11	yes
WorldView-2	Oct. 8, 2009	17.7	0.46 x 1.85	0.5 x 2	1:1,250	5	pan + 8 MS	11	yes
Pléiades 1	Dec. 16, 2011	20	0.70 x 2.4	0.5 x 2	1:1,250	to be determined	pan + 4 MS	12	yes

2. Active Sensor Systems

- **Provides its own energy source.**

  ✓ A radar sensor sends out sound waves and records the reflection waves coming back from the surface**.**

  ✓ An active scanning and imaging sensor can be a LIDAR or RADAR. For example synthetic aperture radar (SAR), which can produce high resolution imagery, day or night, even under cloud cover such as **RADARSAT, ALOS, and Sentinel 1-3**.

Comparison of the Active Sensor Satellites

Commercial Radar Remote Sensing Satellites						
Satellite Mission	**Launch Date**	**Band**	**Resolution**	**Swath Width**	**Repeat Rate**	**Comment**
TerraSAR-X / TanDEM-X	2007 / 2010	X Band	1-18 meters	5 - 150 km	11 days	A German mission carried out under a public-private-partnership with the German Aerospace Center and EADS Astrium. Both satellites used as radar interferometer for WorldDEM.
COSMO-SkyMed	2007 / 2008	X Band	1-100 meters	10 - 200 km	16 days	Italian constellation of four satellites
RADARSAT-1 / RADARSAT-2	1995 / 2007	C Band	3-100 meters	20 - 500 km	24 days	Canadian commercial mission
PAZ	2013	X Band	1-18 meters	5 - 150 km	11 days	Spanish dual-use mission, constellation with TerraSAR-X and TanDEM-X envisioned

Active sensors for mapping terrain

1. Radar

- Transmits microwaves in pulses
- Determines distance to objects and their angular position (from side)

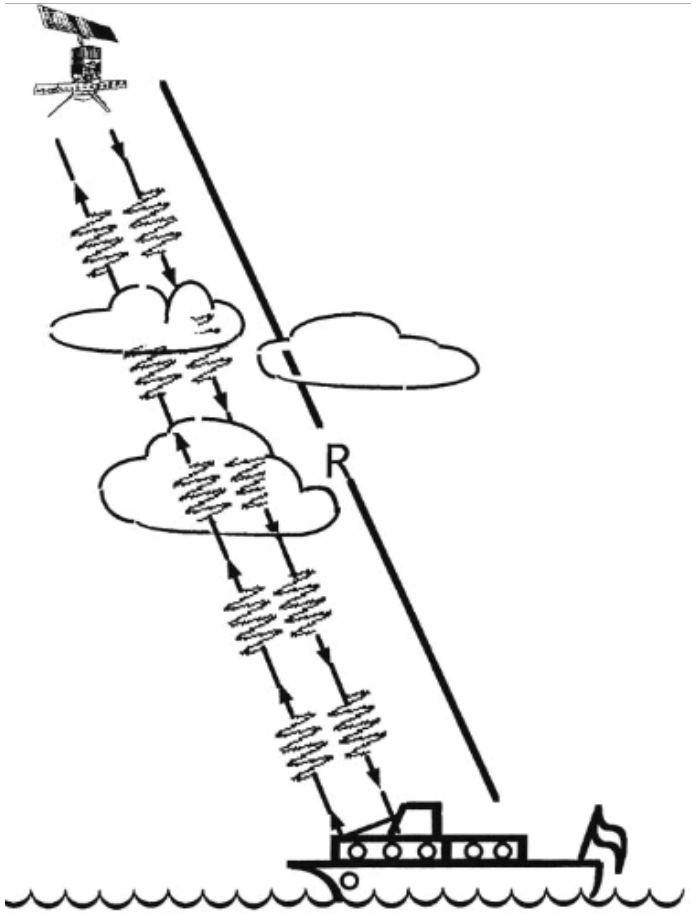
2. LiDAR

- Transmits optical laser light in pulses
- Determines distance to objects

Radar

- Radio Detection and Ranging

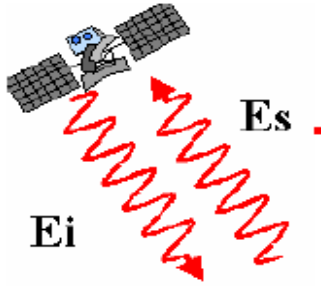
- Transmits microwaves in pulses
- Determines distance to objects and their angular position



What determines radar backscatter from vegetation?

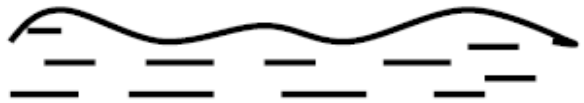
- System Parameters (Sensor)
- Wavelength/Frequency (X, C, L, and P bands)
- Polarization (HH, VV, and HV)
- Incidence angle
- Resolution

Scattering mechanisms



Surface scattering

water



Surface scattering

soil, rock

Volume scattering if penetration

Volume scattering

vegetation

Volume surface scattering

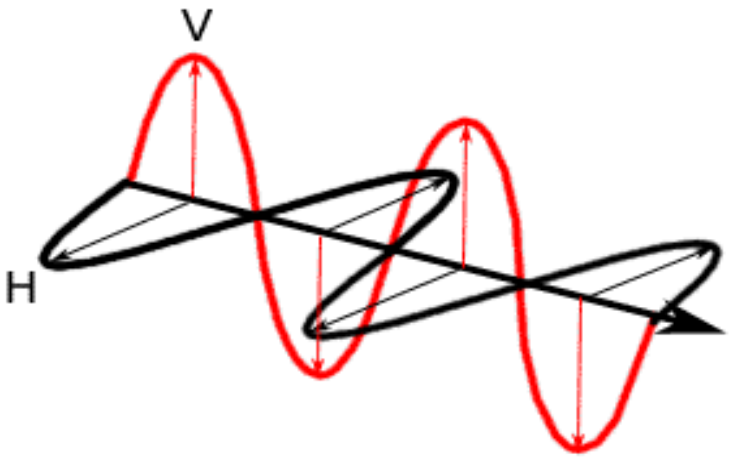
Surface scattering

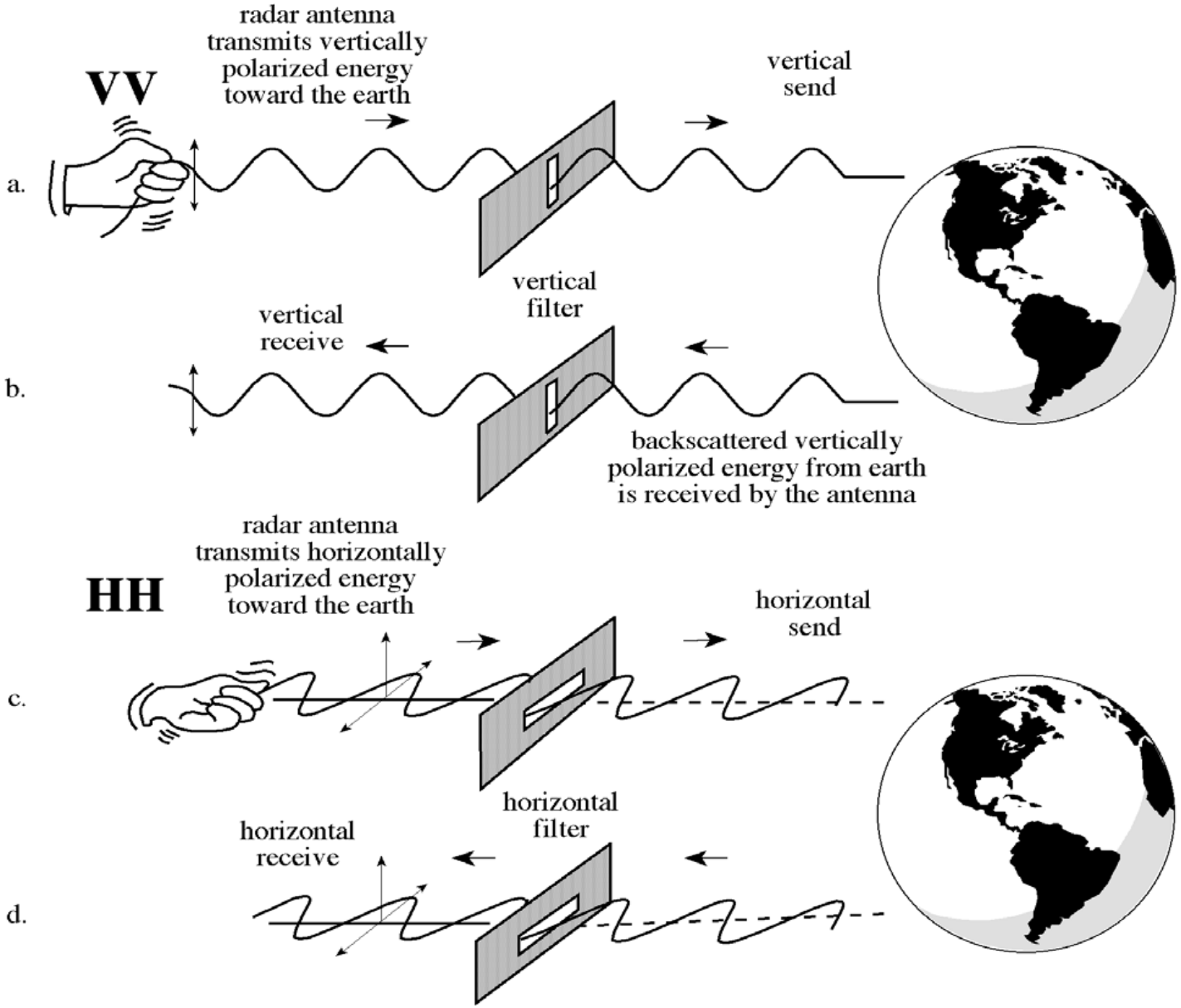
Volume scattering

snow

Surface scattering

Polarization

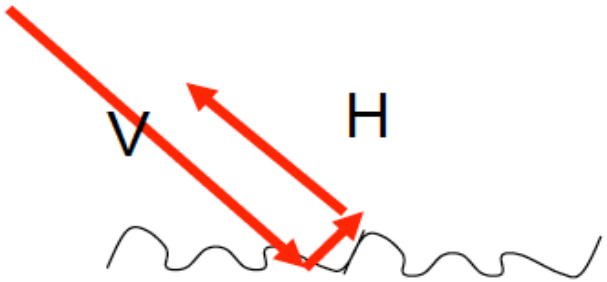




Smooth surface

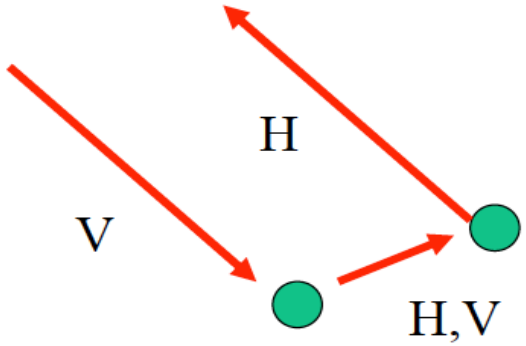
No Depolarization

Rough surface



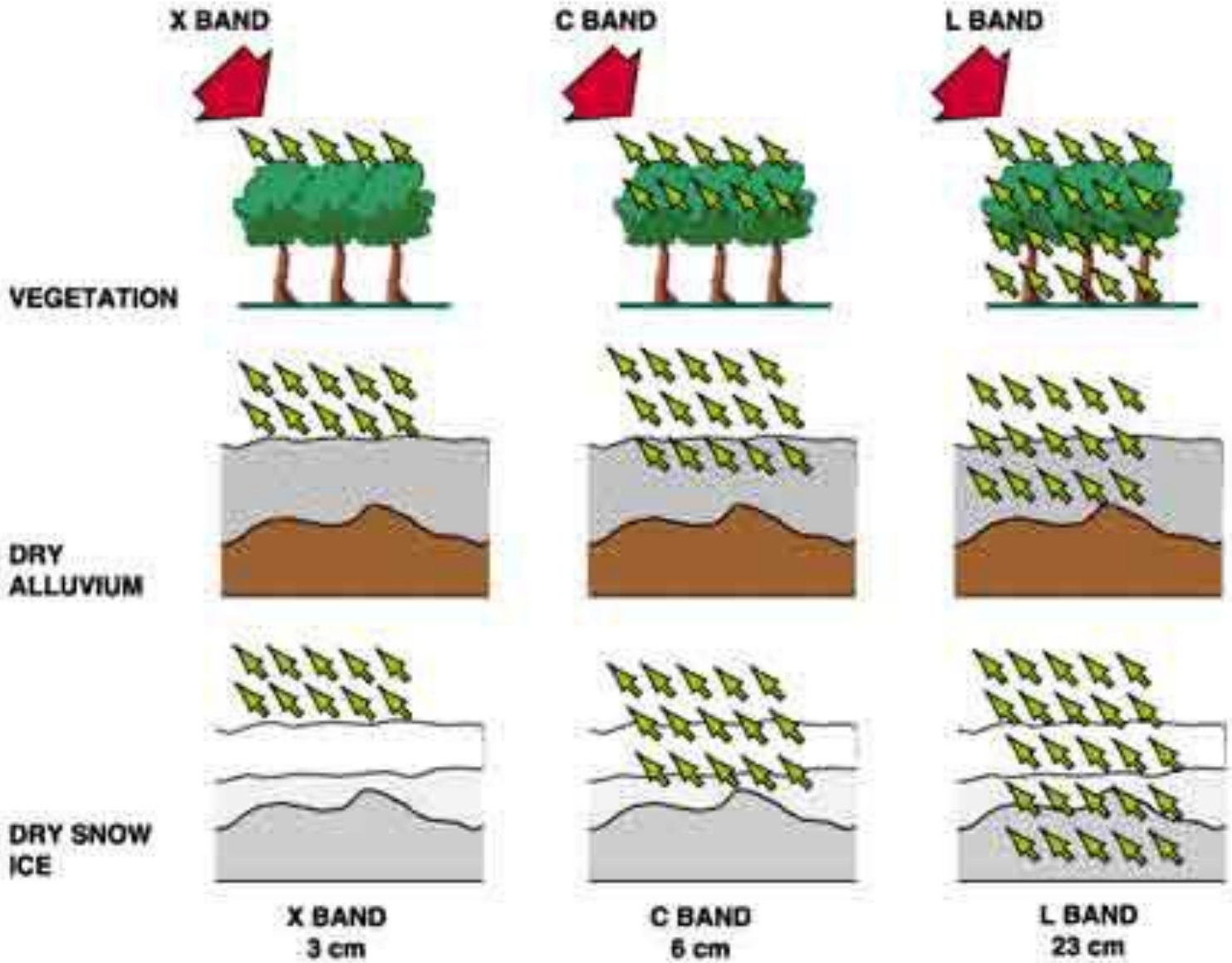
Little Depolarization

Multiple scattering



-> depolarisation

Depolarization occurs mainly over vegetation, hardly over open ground. Cross polarization (HV or VH) is very sensitive to vegetation parameters

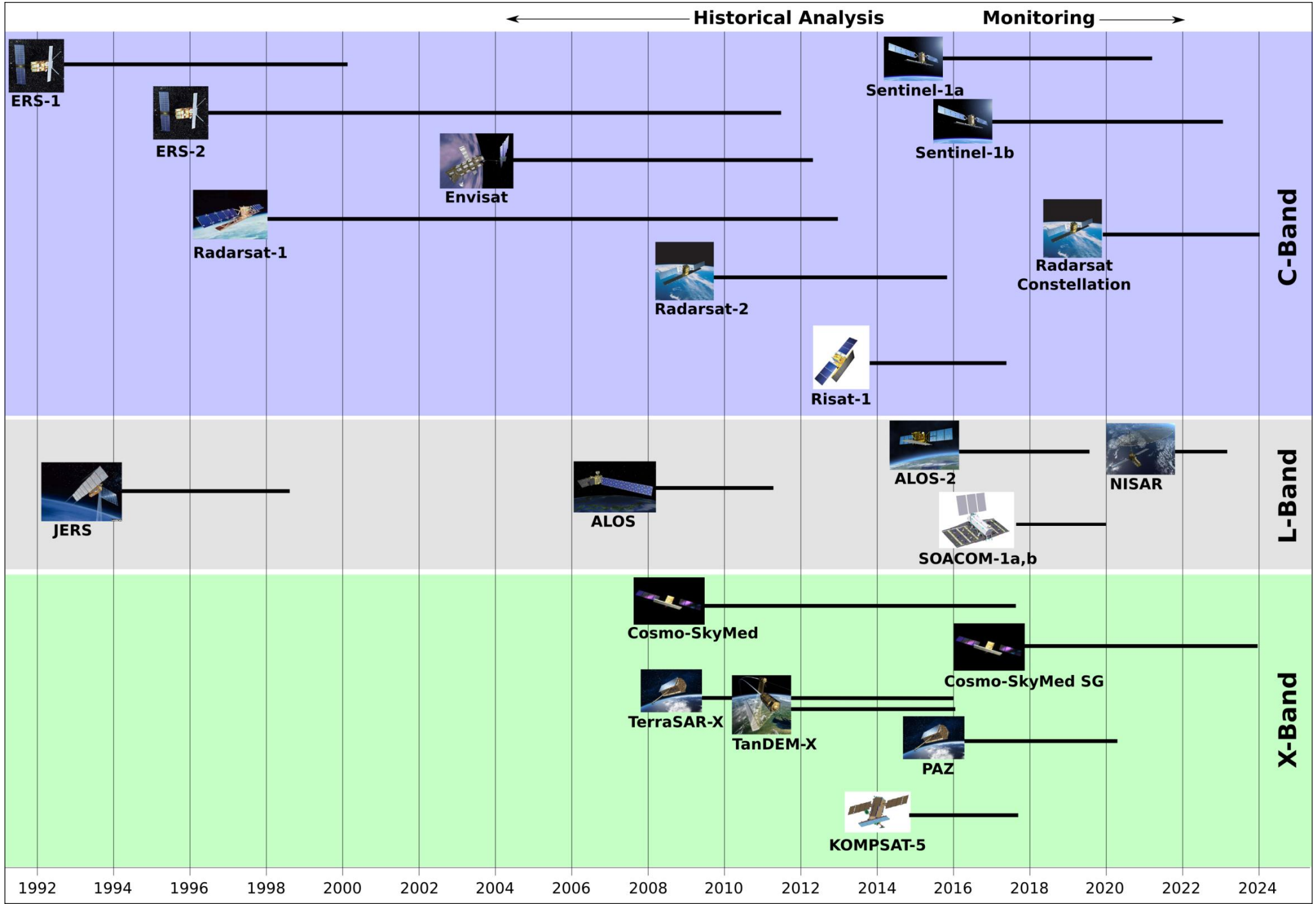

X BAND
C BAND
L BAND
VEGETATION
DRY
ALLUVIUM
DRY SNOW
ICE
X BAND
3 cm
C BAND
6 cm
L BAND
23 cm

SAR

✓ Synthetic Aperture RADAR

✓All imaging RADAR sensors used for remote sensing are Synthetic Aperture Radars.

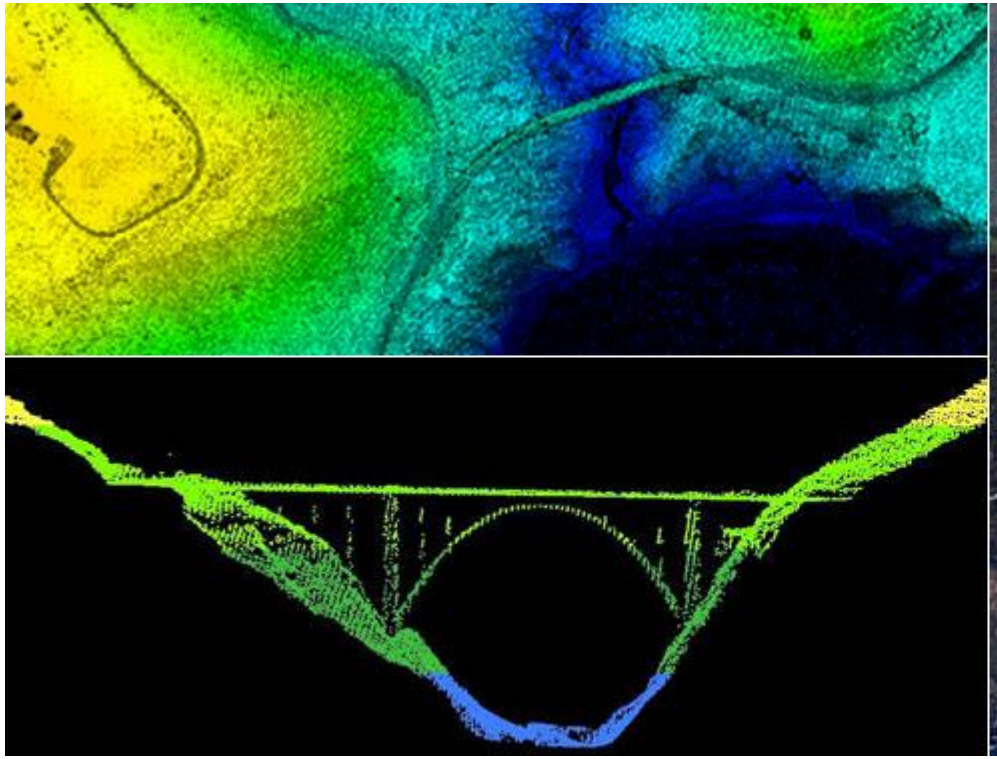
- Microwave pulses are transmitted by an antenna towards the earth surface
- The microwave energy scattered back to the spacecraft is measured
- The SAR makes use of the radar principle to form an image by utilising the time delay of the backscattered signals


Historical Analysis
Monitoring
ERS-1
ERS-2
Envisat
Radarsat-1
Sentinel-1a
Sentinel-1b
Radarsat-2
Radarsat Constellation
Risat-1
C-Band
JERS
ALOS
ALOS-2
NISAR
SOACOM-1a,b
L-Band
Cosmo-SkyMed
Cosmo-SkyMed SG
TerraSAR-X
TanDEM-X
PAZ
KOMPSAT-5
X-Band
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024

LiDAR

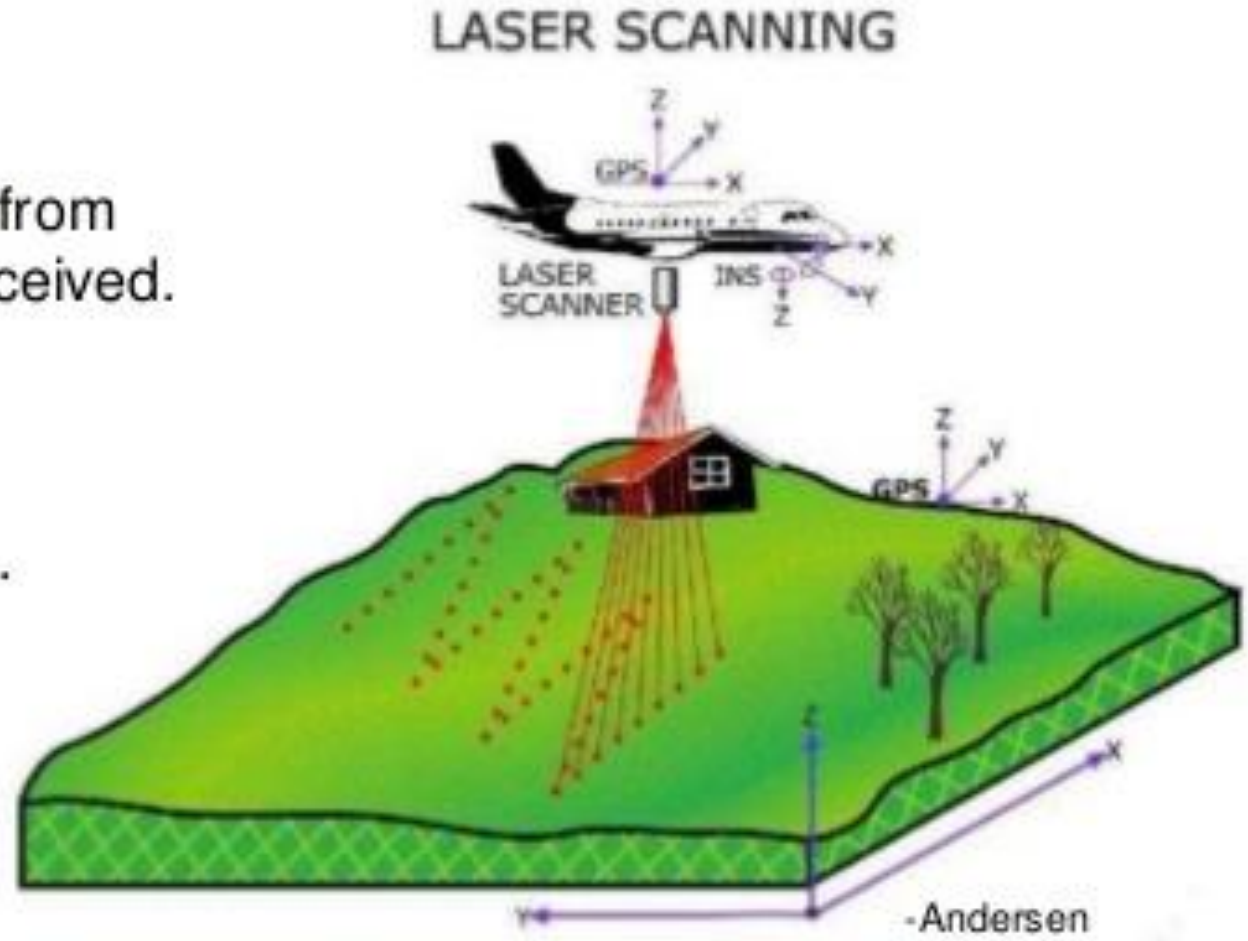
- **Light Detection and Ranging**

  - Transmits optical laser light in pulses
  - Determines distance to objects

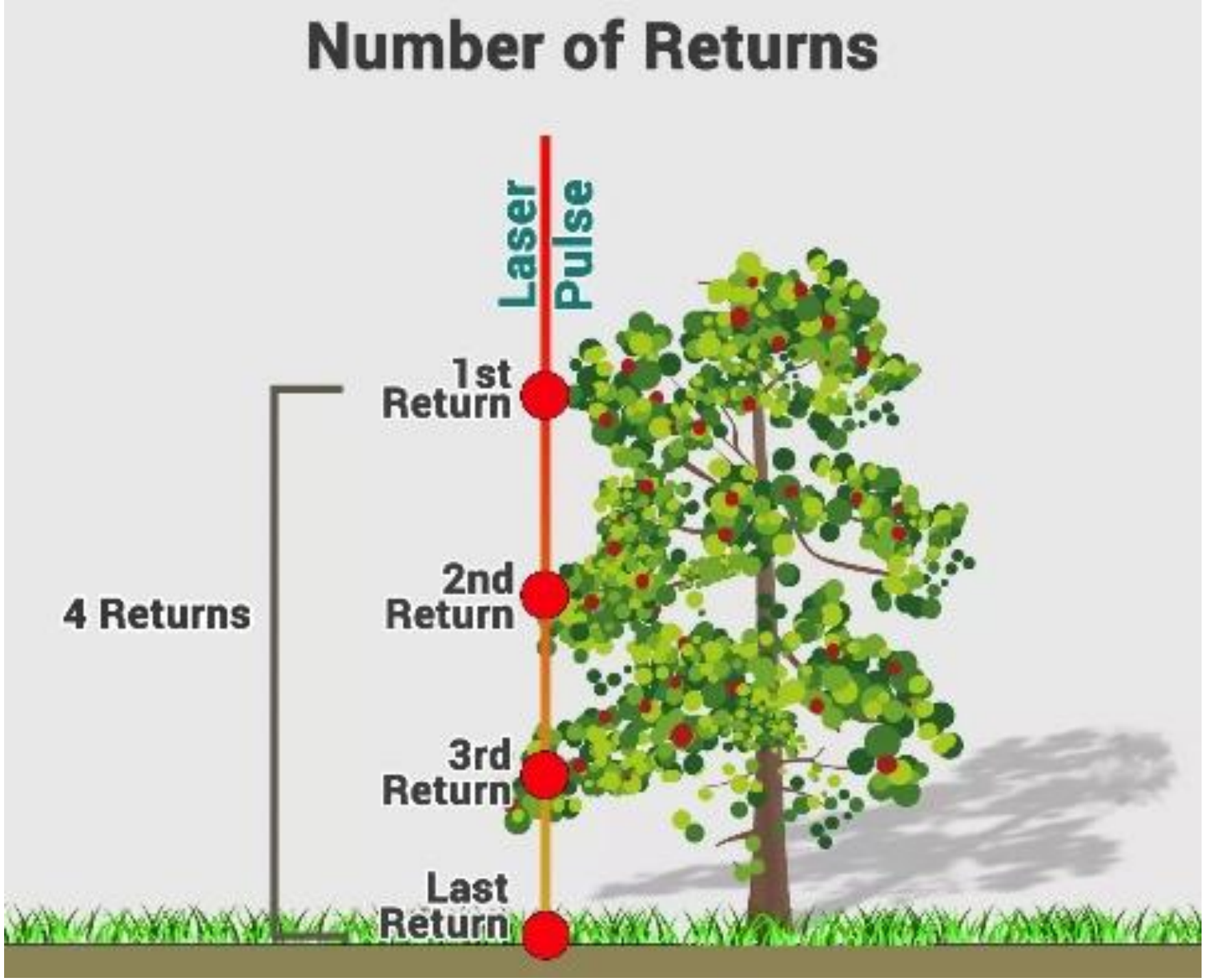


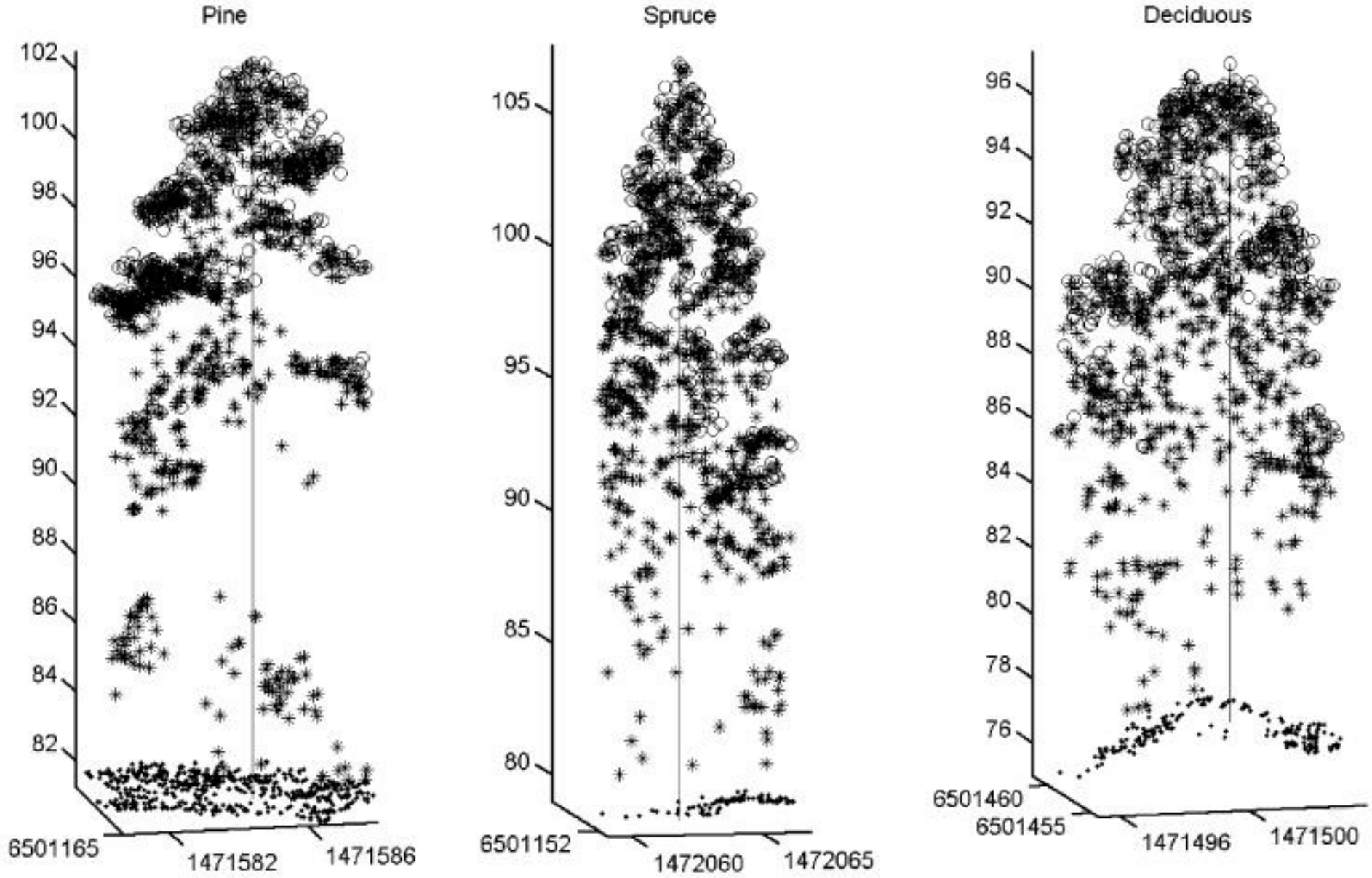
The process:

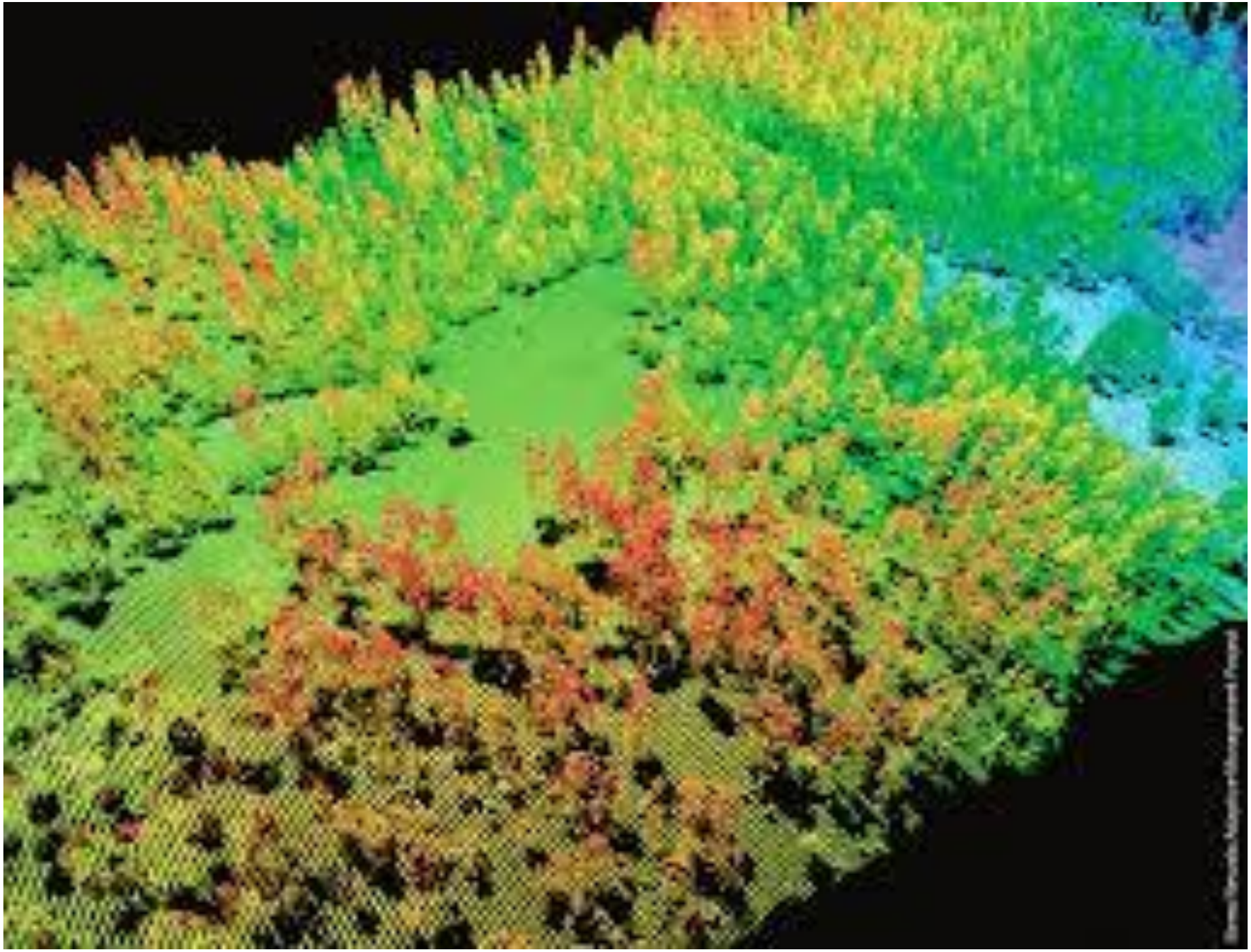
- LIDAR sensor measures time from when pulse sent to when received.
- This translates to distance from sensor to object.
- GPS knows location of sensor.
- Coordinates (X,Y,Z) are assigned to each pulse.



- Result is a "cloud of points" each point has its own coordinates & height.


Number of Returns
Laser Pulse
1st Return
2nd Return
3rd Return
Last Return
4 Returns


Pine
102
100
98
96
94
92
90
88
86
84
82
6501165
1471582
1471586
Spruce
105
100
95
90
85
80
6501152
1472060
1472065
Deciduous
96
94
92
90
88
86
84
82
80
78
76
6501460
6501455
1471496
1471500



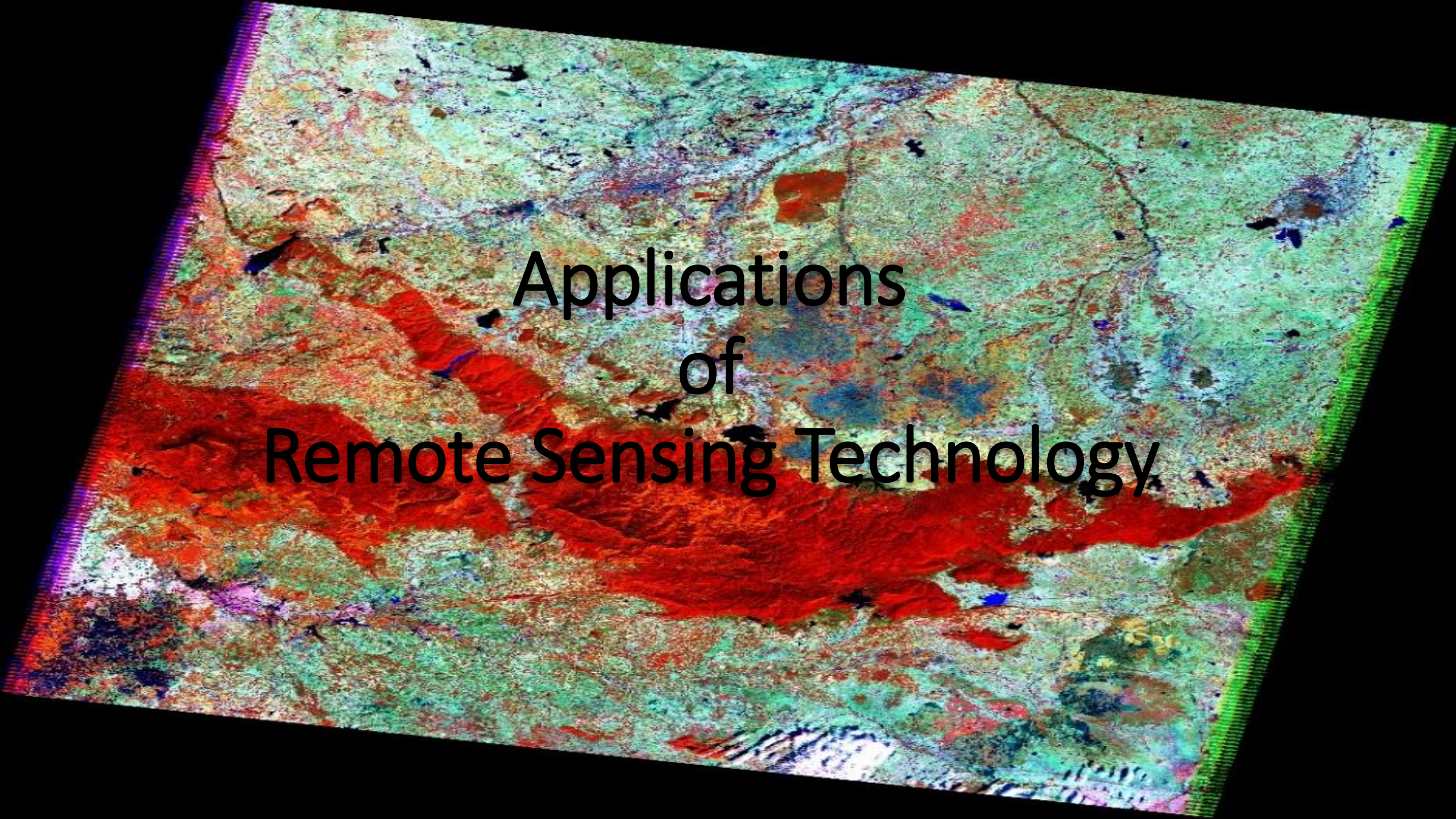
Books

- Jenson, John R. 2007. *Remote Sensing of the Environment: An Earth Resource Perspective.* Person Prentice Hall.

Websites

https://earthobservatory.nasa.gov/Features/RemoteSensing/

http://www.gistda.or.th

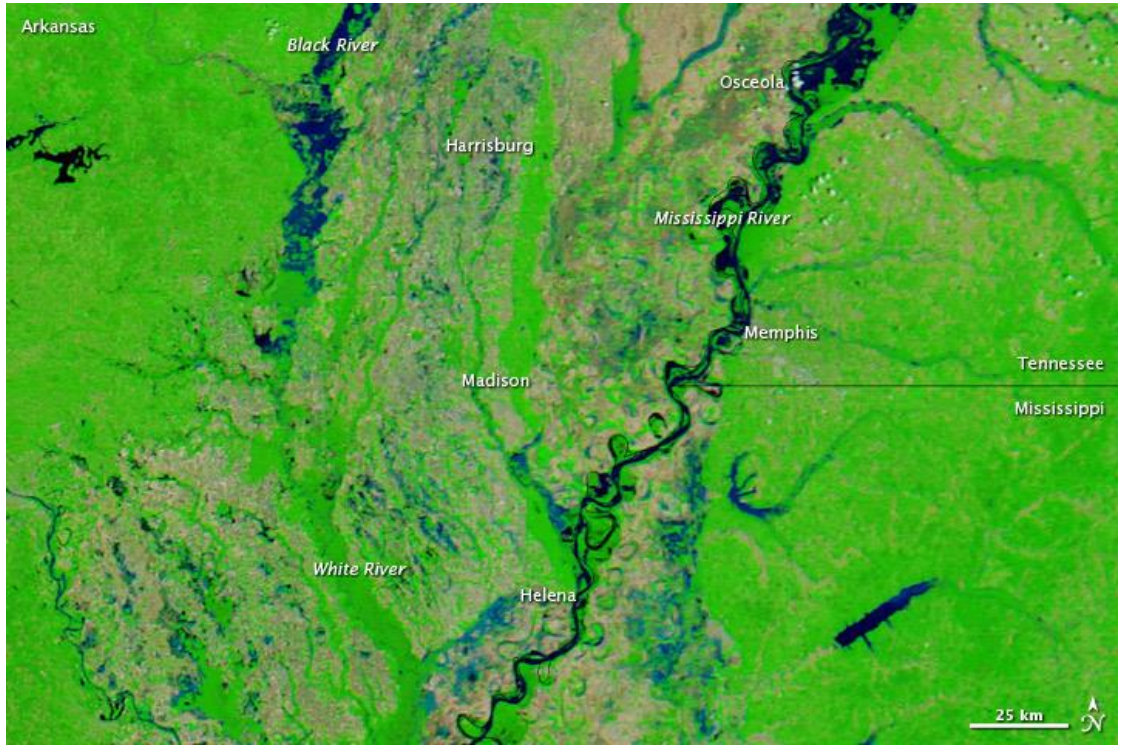

Applications
of
Remote Sensing Technology

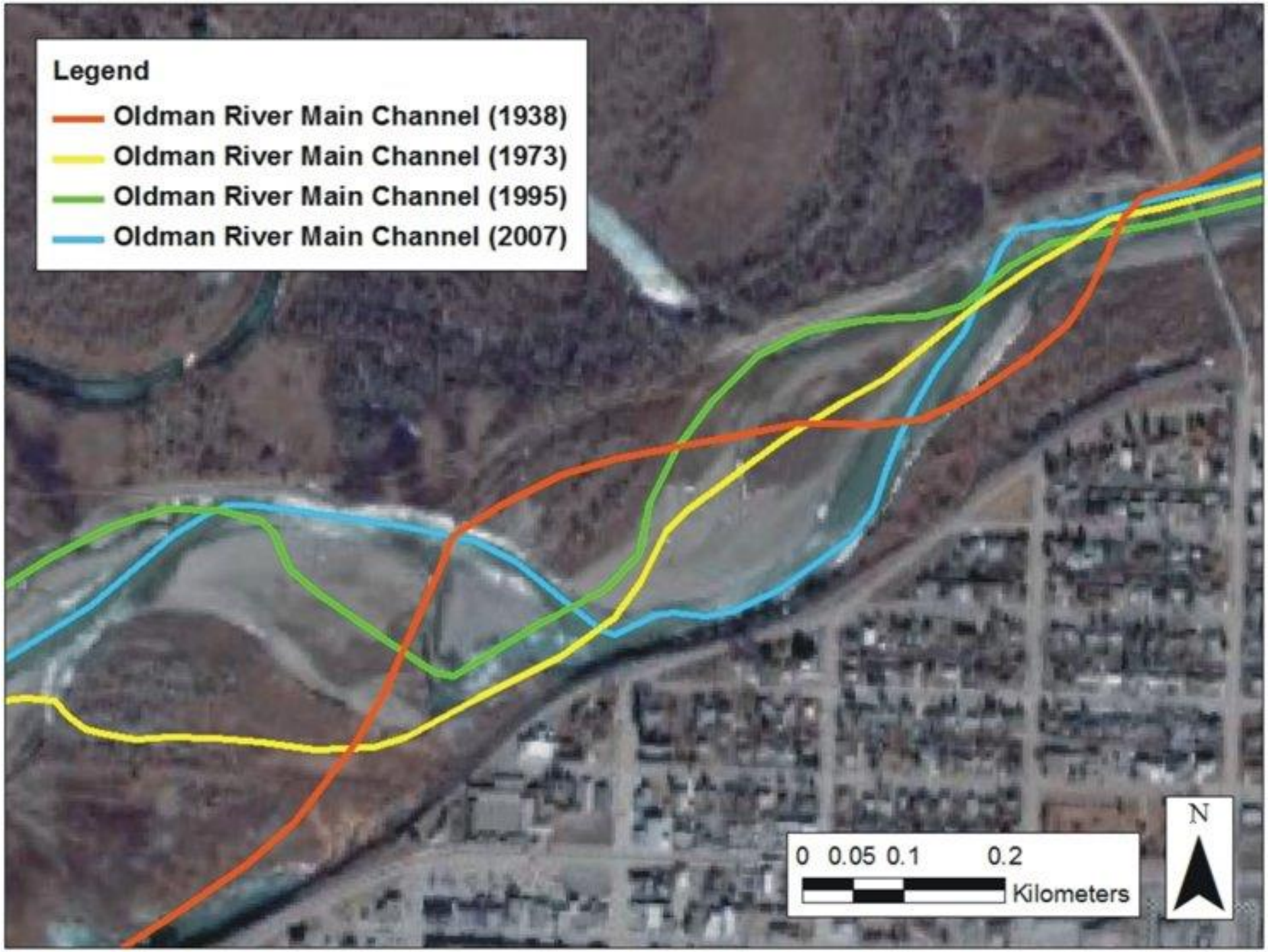
Environmental monitoring

- Remote sensing is envisaged to contribute substantially to future environmental monitoring.

- Monitoring of rapidly varying parameters (mostly but not exclusively related to the open sea and coastal zones) using satellite-based sensors providing high temporal but low spatial resolution.

- Mapping of surface cover types and monitoring of slowly varying surface parameters – River shape




Legend
Oldman River Main Channel (1938)
Oldman River Main Channel (1973)
Oldman River Main Channel (1995)
Oldman River Main Channel (2007)
0 0.05 0.1 0.2
Kilometers
N

•Disaster Relief, Rehabilitation and Reconstruction

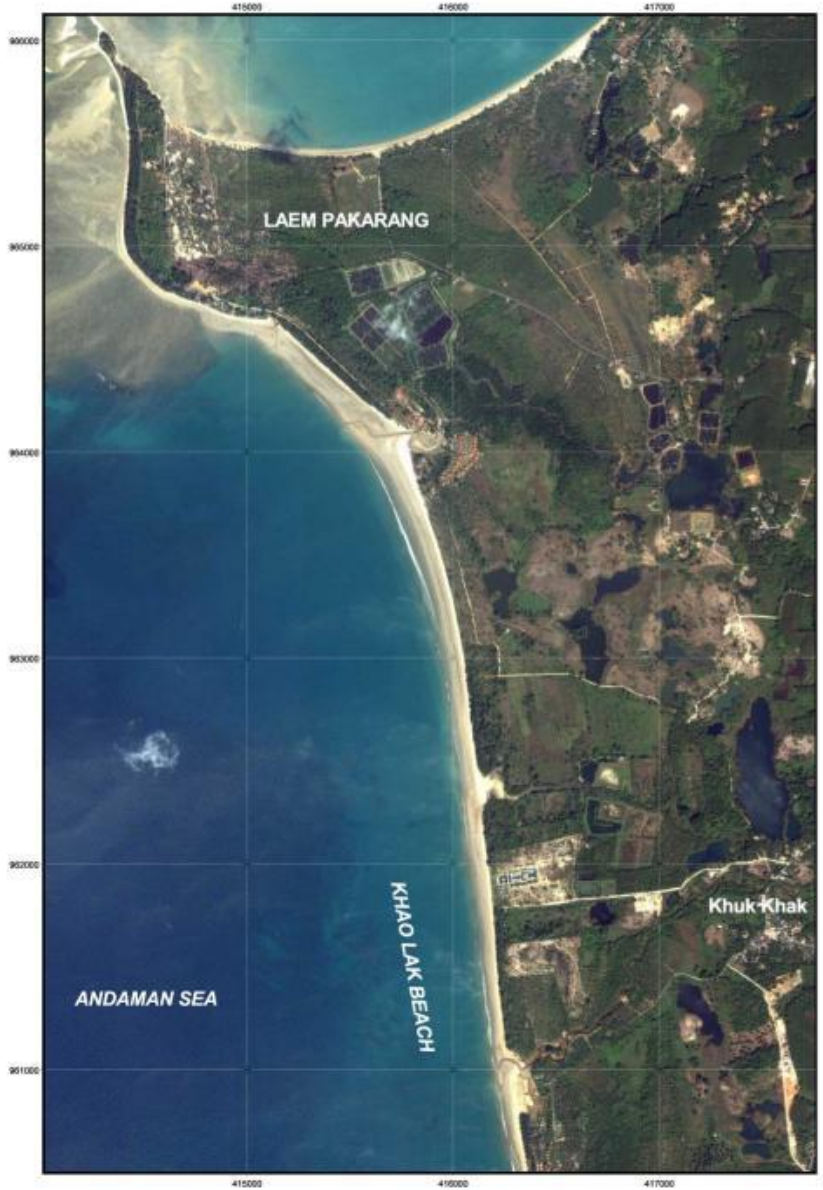
✓RS technology plays vital role in both the immediate relief and long-term development phases of disaster relief/rehab and Reconstruction.

✓ Satellite imagery assists in estimating the damaged infrastructure and analyzing the severity of vital services required to any community, undertaking detailed damage need assessments and urban development planning.

THAILAND / Northern Khao Lak Bay

1 : 12.500

IKONOS - January 30, 2003 - PRE-DISASTER IMAGE



IKONOS - December 29, 2004 - POST-DISASTER IMAGE

Center for Satellite based Crisis Information
- Emergency Mapping & Disaster Monitoring -

German Remote Sensing Data Center
German Aerospace Center
DLR

Ikonos Data

Legend

- Major Road (paved)
- Major Road (unpaved)
- Dirt Road
- Coastline before Tsunami
- Affected Area

Interpretation

The map shows the northern Khao Lak Bay,Thailand before and after the devastating Tsunami flood wave of December 26, 2004. In the northern edge the Laem Pakarang spit can be seen. The flood wave has washed away several tourist resort buildings, forest plantations and one can see how the coast lines were severely destroyed. The images were taken on January 30, 2003 and December 29, 2004, respectively. Along the shore line a strip of about 1000 m to 1500 m was washed away by the flood wave. As most parts of the Khao Lak Bay area and neighbouring beaches are of similar topographic shape is it expected that similar destruction has occurred in the surroundings.

Scale

0 250 500 750 1000 m

1 : 12.500

Projection: UTM Zone 47 N
Spheroid: WGS84
Datum: WGS 84

N

Data Source

IKONOS imagery provided through

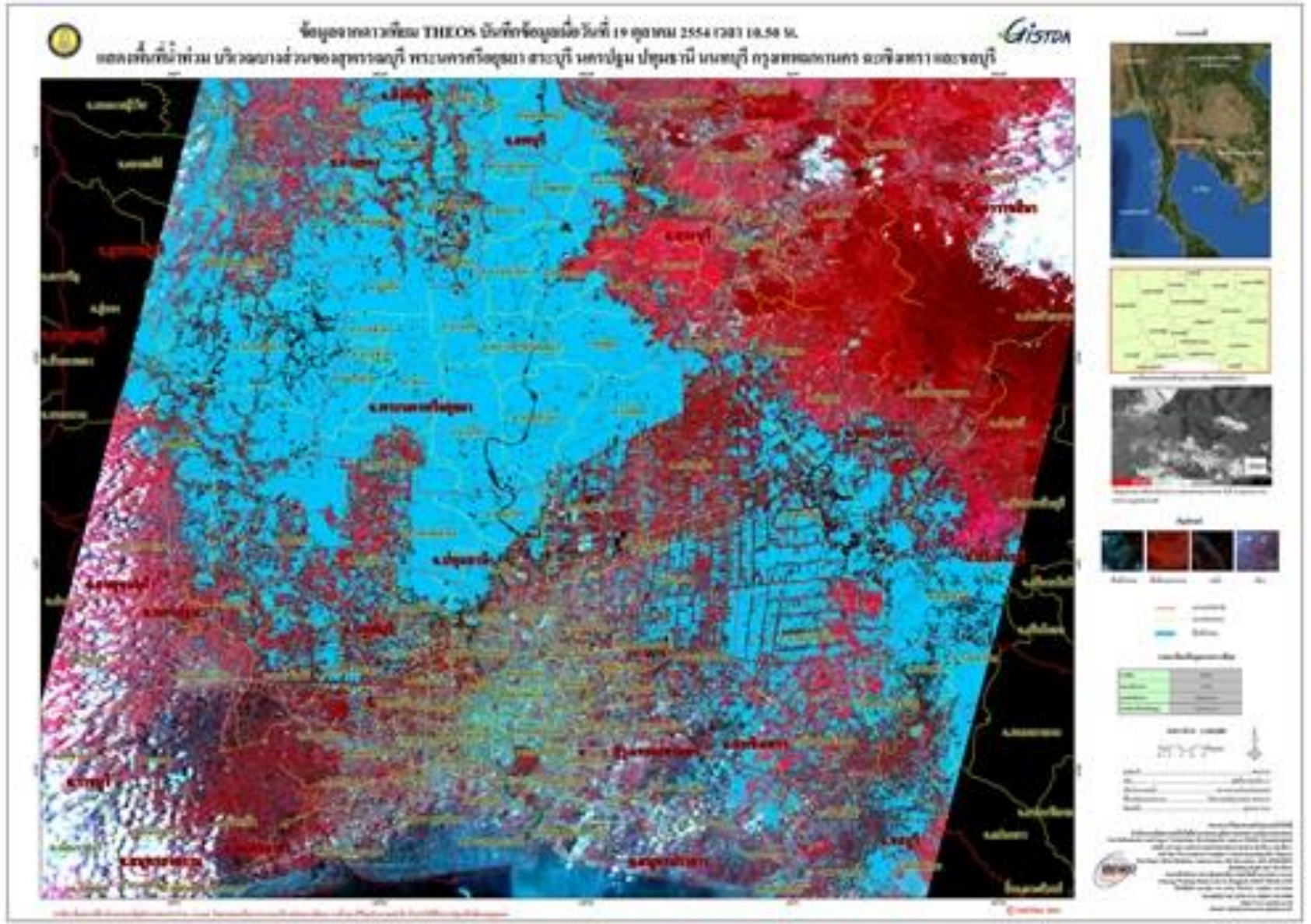
Centre for Remote Imaging, Sensing and Processing (CRISP)

SPACE IMAGING
Visual Information. Visible Results.

Map created December 31, 2004 by ZKI@DLR.DE
updated January 2, 2004 by ZKI@DLR.DE (Version 02)

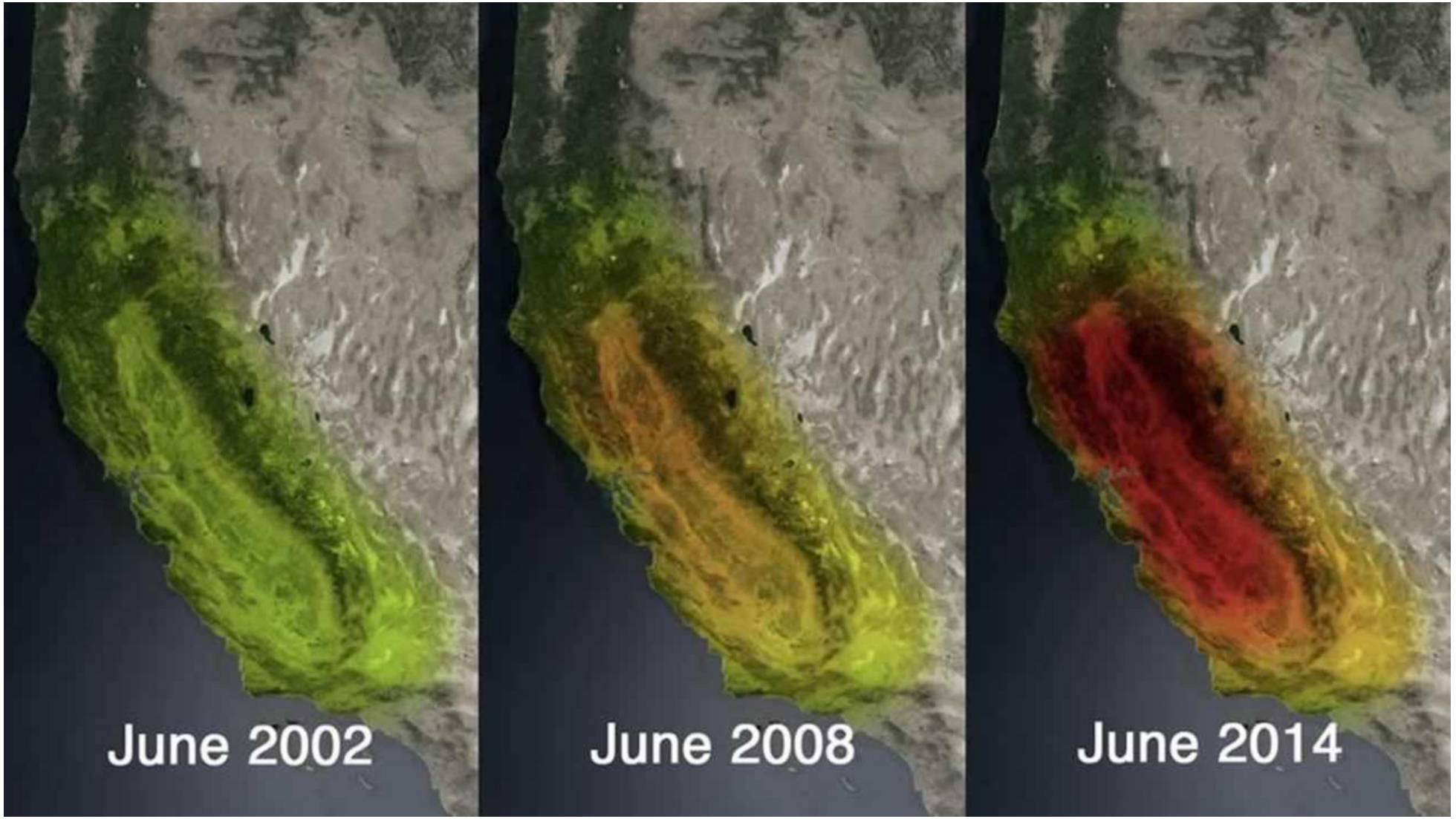
- Flood

✓ Mapping flood-prone areas
✓ delineating flood-plains
✓ land-use mapping



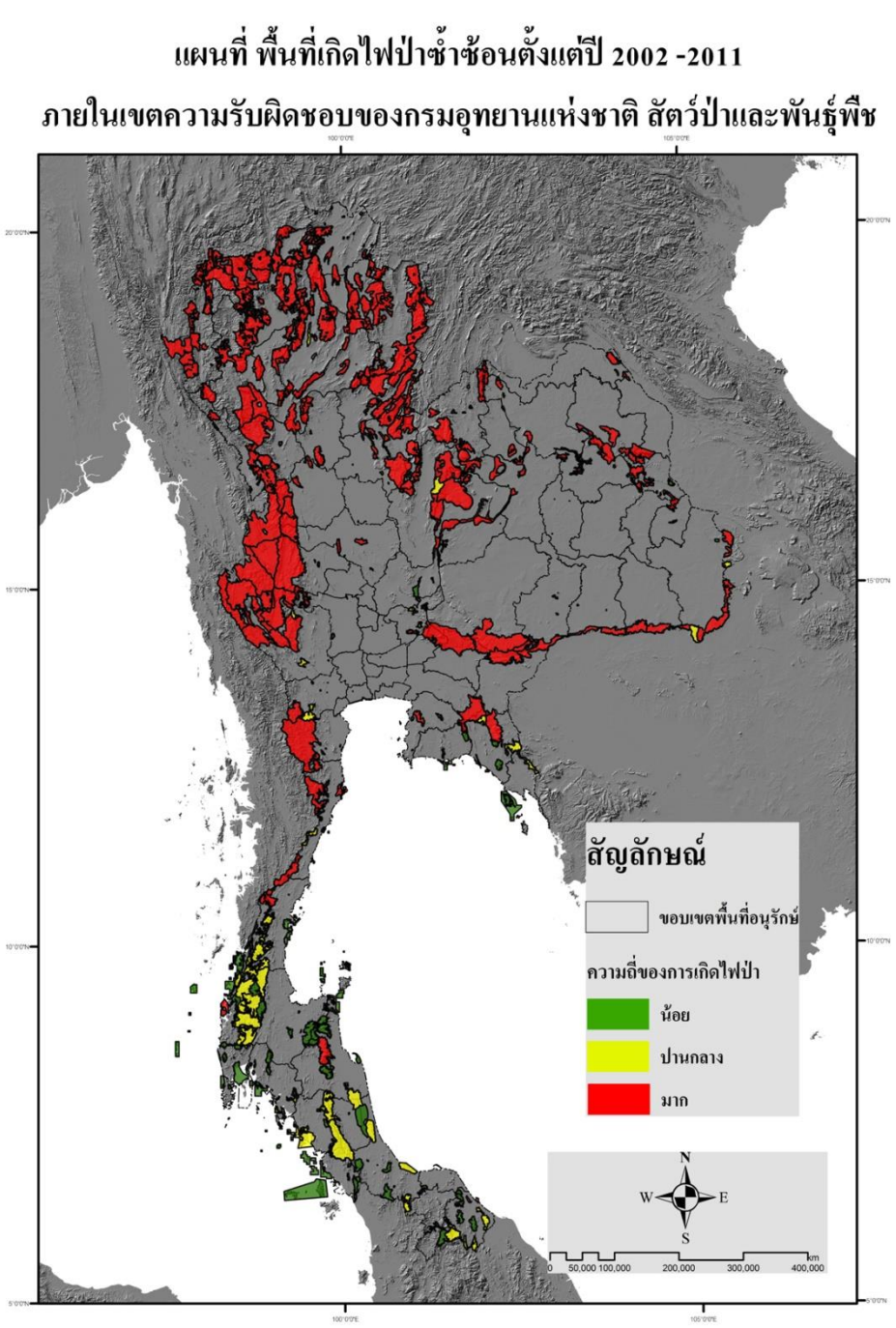
•Drought

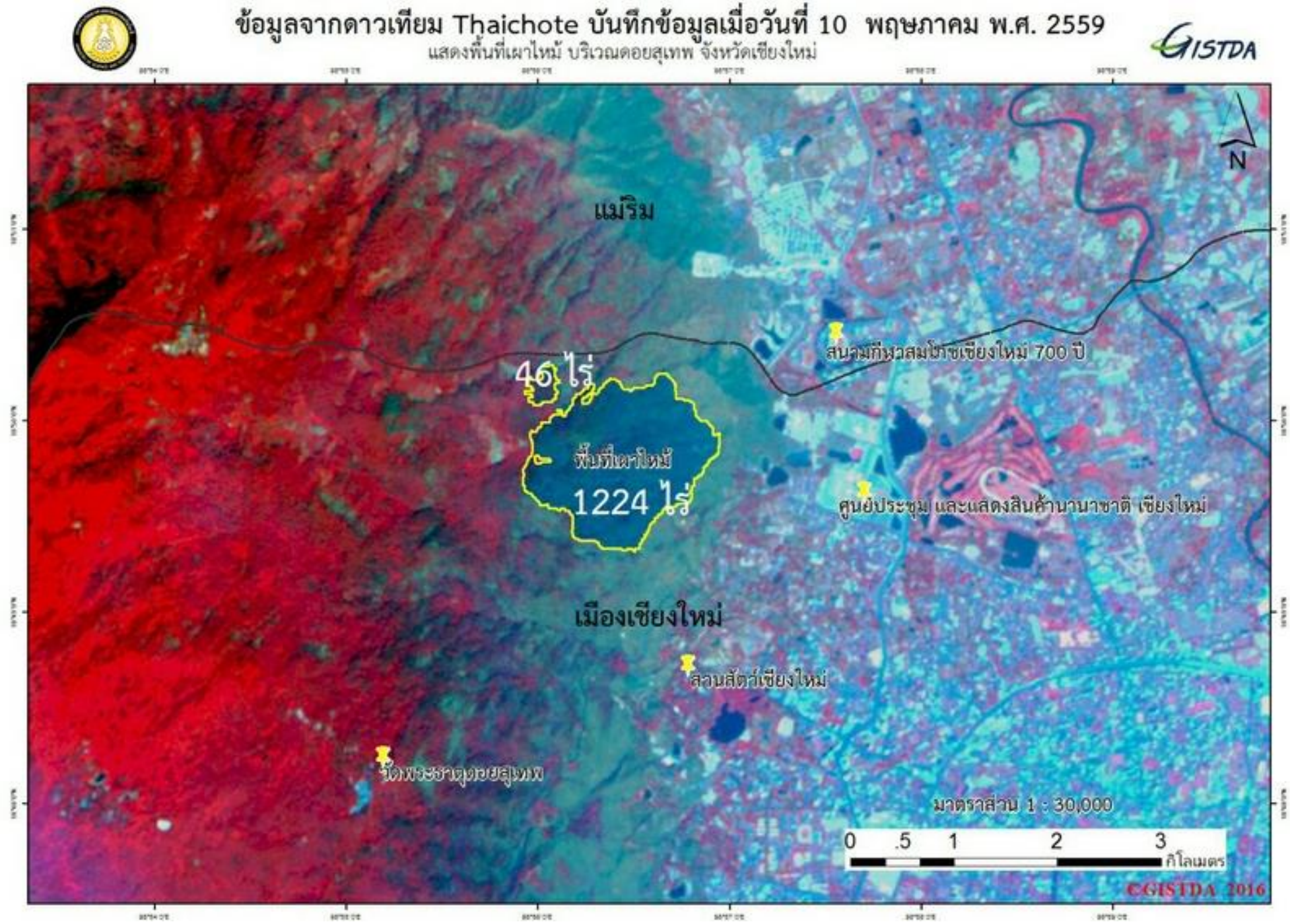
✓ Monitor desert encroachment, overgrazing and depletion in biomass



• Forest Fire

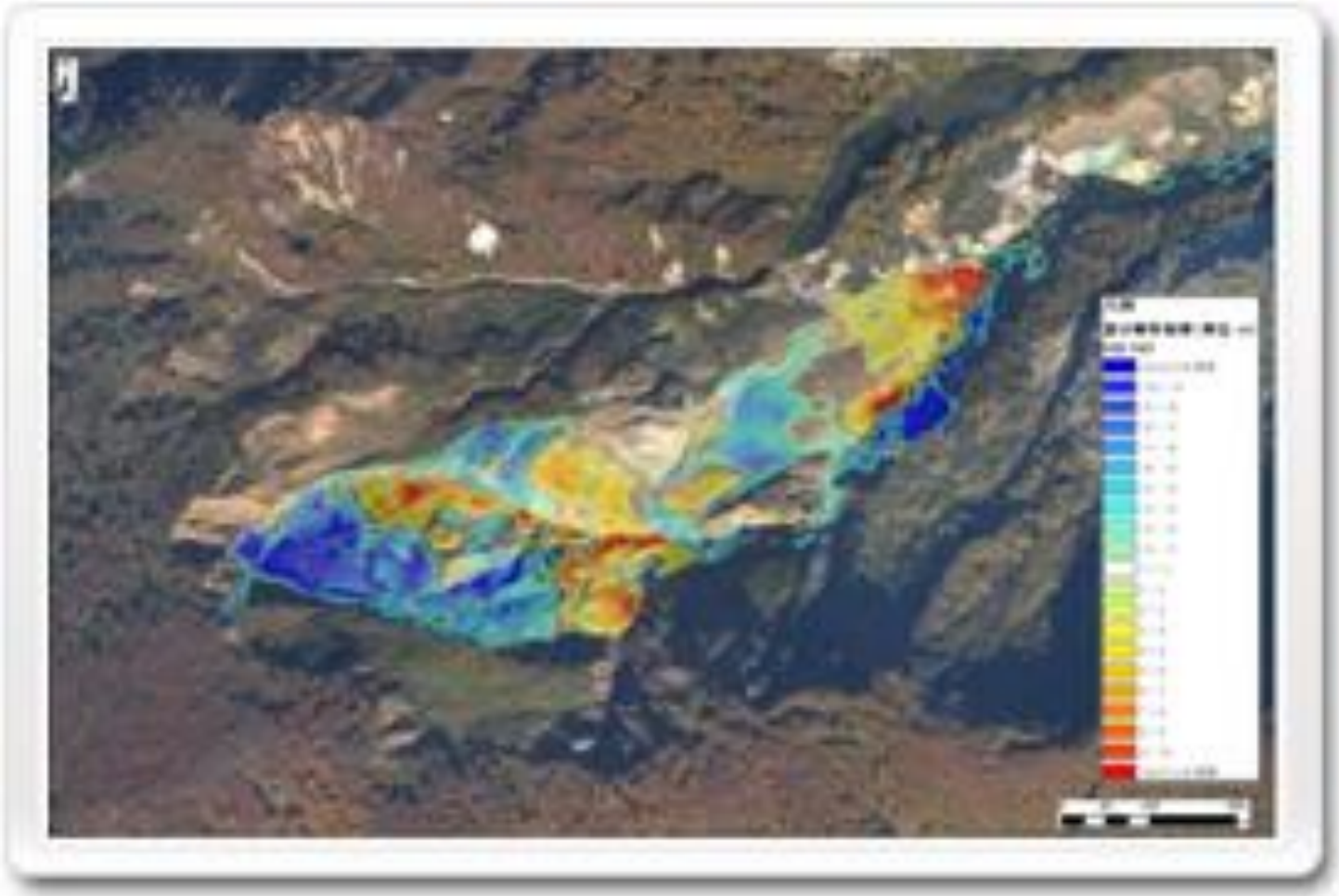
- ✓ Classify forest resources extending to inaccessible areas
- ✓ AVHRR; The Advanced Very High-Resolution Radiometer
- ✓ NOAA
- ✓ Hot spot; Infrared, IR




ข้อมูลจากดาวเทียม Thaichote บันทึกข้อมูลเมื่อวันที่ 10 พฤษภาคม พ.ศ. 2559
แสดงพื้นที่เผาไหม้ บริเวณดอยสุเทพ จังหวัดเชียงใหม่
GISTDA
N
แม่ริม
40 ไร่
พื้นที่เผาไหม้
1224 ไร่
สนามกีฬาสมโภชเชียงใหม่ 700 ปี
ศูนย์ประชุม และแสดงสินค้านานาชาติ เชียงใหม่
เมืองเชียงใหม่
สวนสัตว์เชียงใหม่
วัดพระธาตุดอยสุเทพ
มาตราส่วน 1 : 30,000
0 .5 1 2 3
กิโลเมตร
©GISTDA 2016

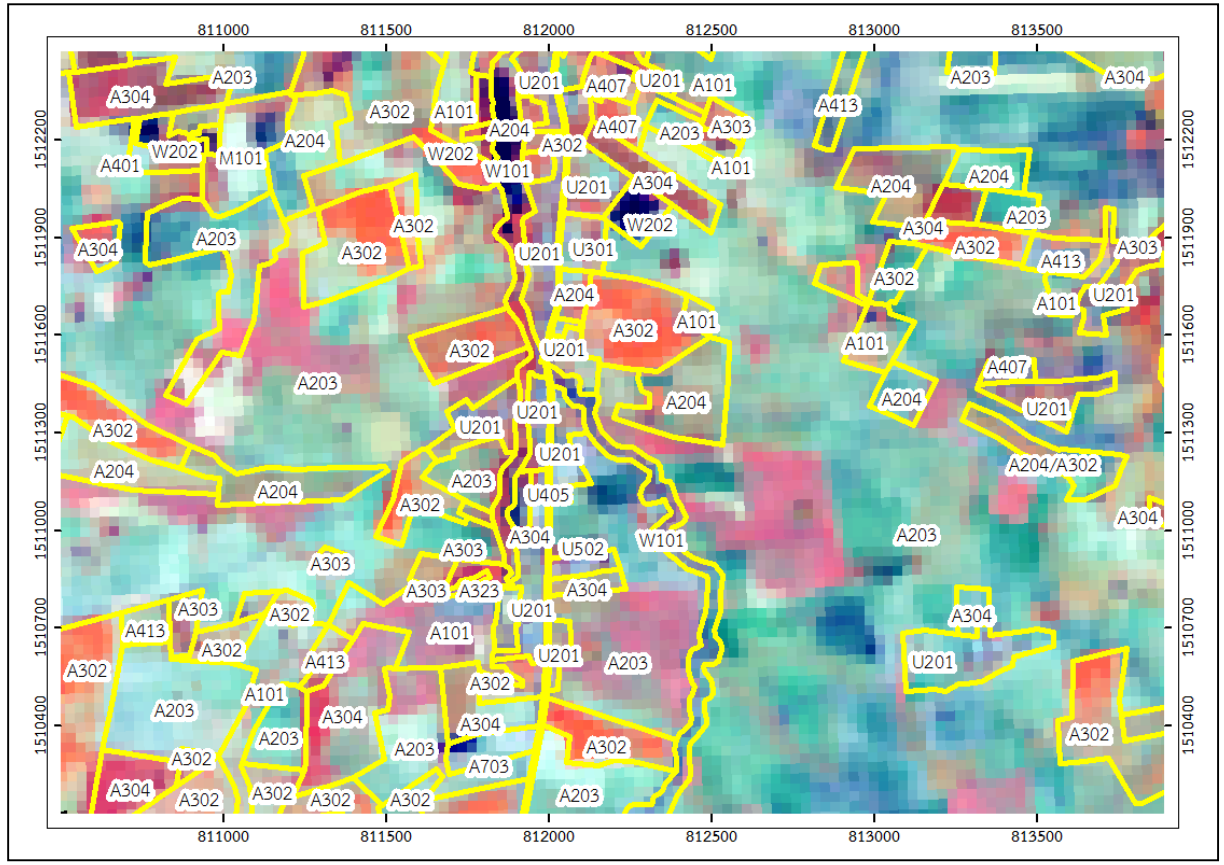
• Landslide

- ✓ Mapping landslide-prone areas
- ✓ delineating Landslide area
- ✓ land-use mapping



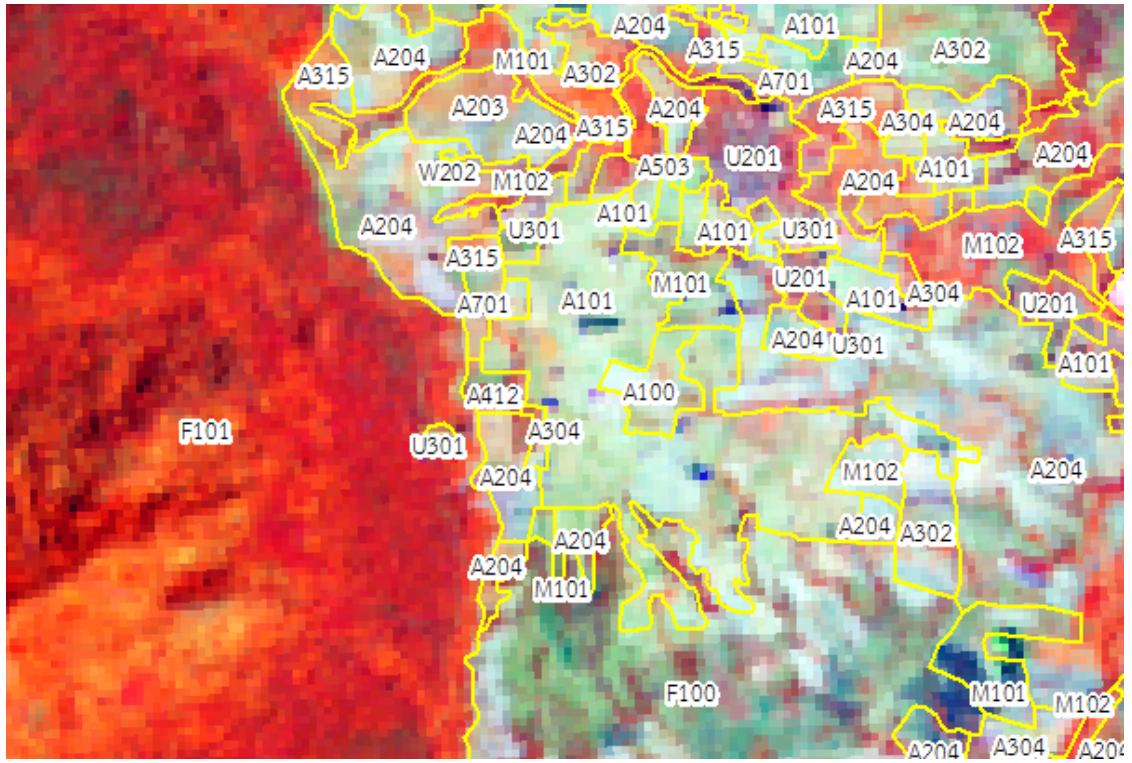
Crop types classification

- ✓ Traditional methods of obtaining this information are census and ground surveying.
- ✓ satellites is advantageous as it can generate a systematic and repetitive coverage of a large area and provide information
- ✓ The health of the vegetation.
- ✓ The data of crop is needed for agricultural agencies to prepare an inventory of what was grown in certain areas and when.
- ✓ predict grain crop yield, collecting crop production statistics, facilitating crop rotation records, mapping soil productivity, identification of factors influencing crop stress, assessment of crop damage and monitoring farming activity.



Forest mapping

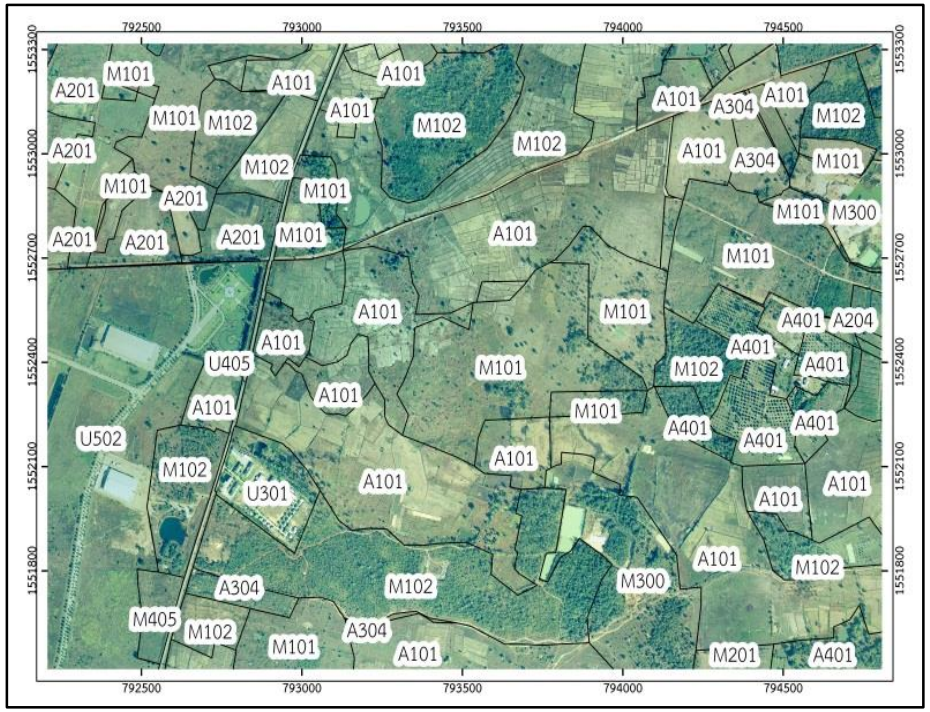
- ✓ Forest cover typing and species identification.
- ✓ Forest cover typing can consist multi-spectral images, a very high resolution data is required to get detailed species identification
- ✓ Multi-temporal images datasets contribute phenology information of seasonal changes of different species
- ✓ Hyper-spectral imagery can be used to generate signatures of vegetation species and certain stresses (e.g. infestations) on trees. Hyper-spectral data offers a unique view of the forest cover, available only through remote sensing technology
- ✓ RADAR is more useful for applications in the humid tropics because its all weather imaging capability is valuable for monitoring forest
- ✓ LiDAR data allows the 3-dimensional structure of the forest. The multiple return systems are capable of detecting the elevation of land and objects on it. The LIDAR data help estimate a tree height, a crown area and number of trees per unit area.



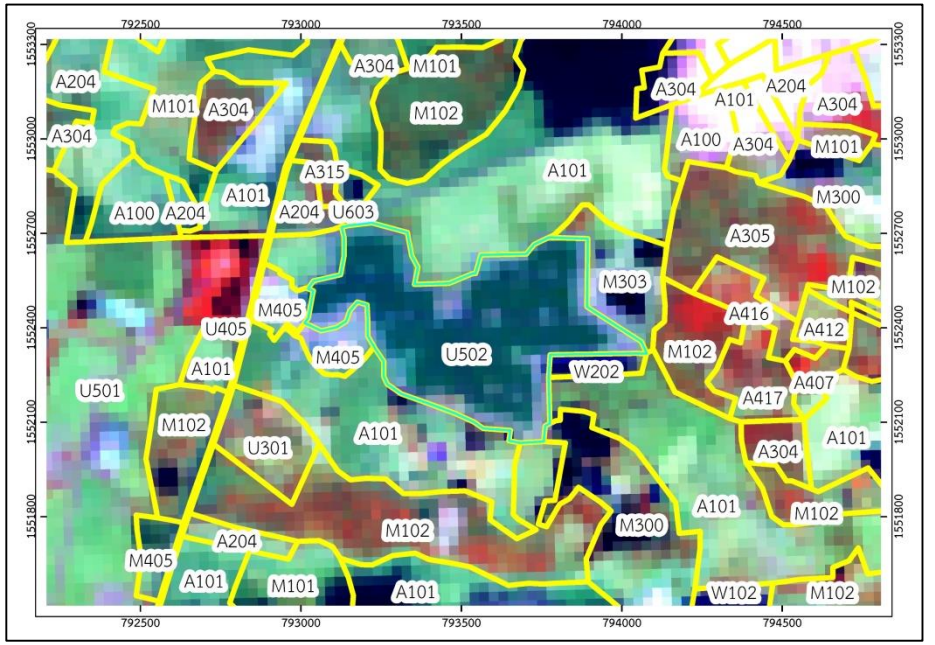
Surveying and urban planning

❖ Urban land cover/use mapping

- ✓ Digitization of planning base maps and various layout plans has facilitated updating of base maps wherever changes have taken place in terms of land development etc.
- ✓ Since information and maps are available in digital format, correlating various layers of information about a feature from satellite imagery
- ✓ Remote Sensing techniques are extremely useful for change detection analysis and selection of sites for specific facilities, such as hospital, restaurants, solid waste disposal and industry



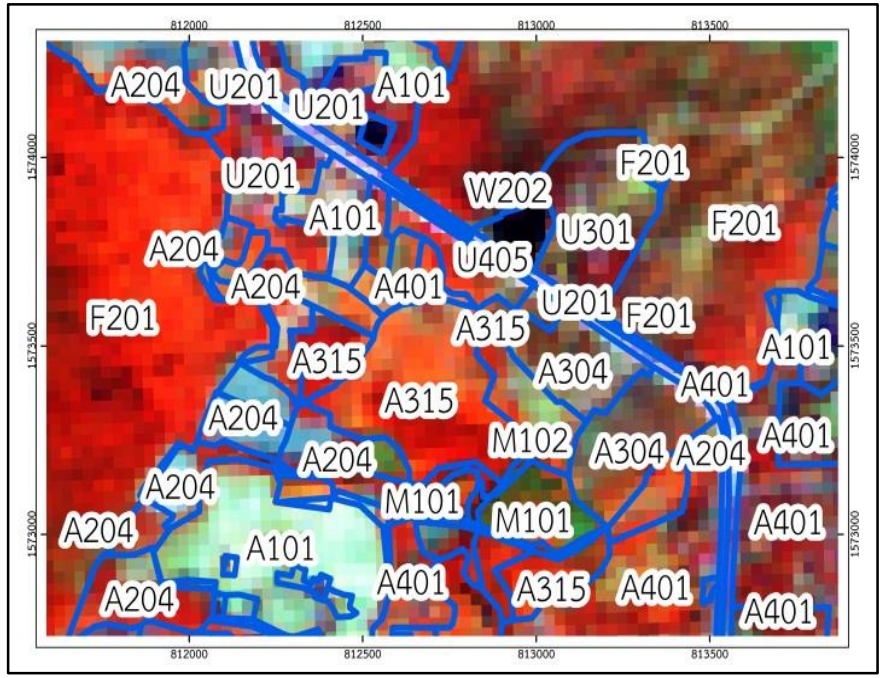
แผนที่สภาพการใช้ที่ดินปี พ.ศ. 2549 ซ้อนทับบนภาพออโธสีเชิงเลข ปี พ.ศ. 2545



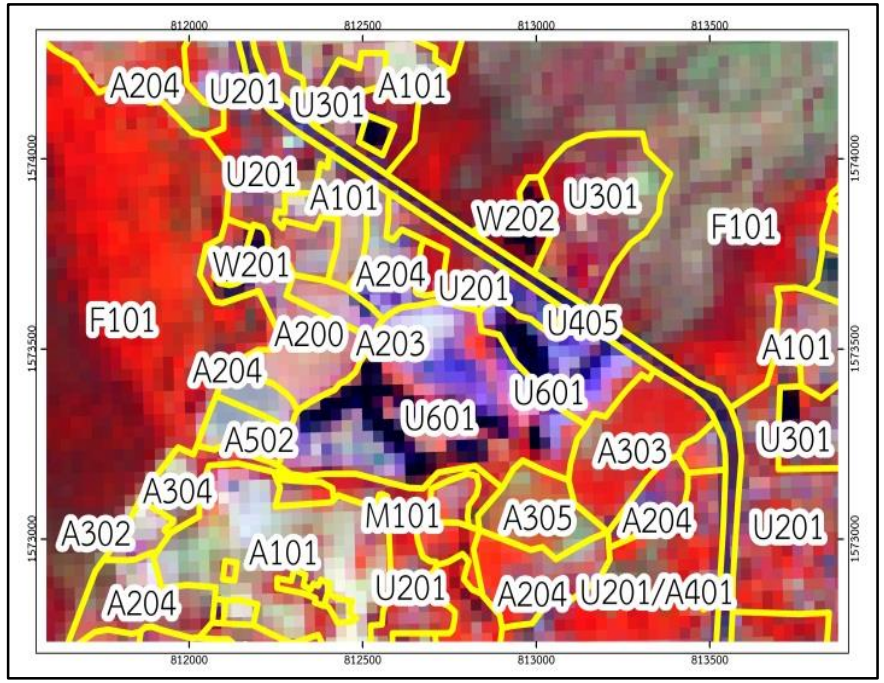
แผนที่สภาพการใช้ที่ดินปี พ.ศ. 2559 ซ้อนทับบนภาพถ่ายดาวเทียม LANDSAT 8 บันทึกภาพเมื่อวันที่ 5 เมษายน 2559

แผนที่สภาพการใช้ที่ดินปี พ.ศ.2559 ซ้อนทับบนภาพถ่ายดาวเทียมของ Google Earth

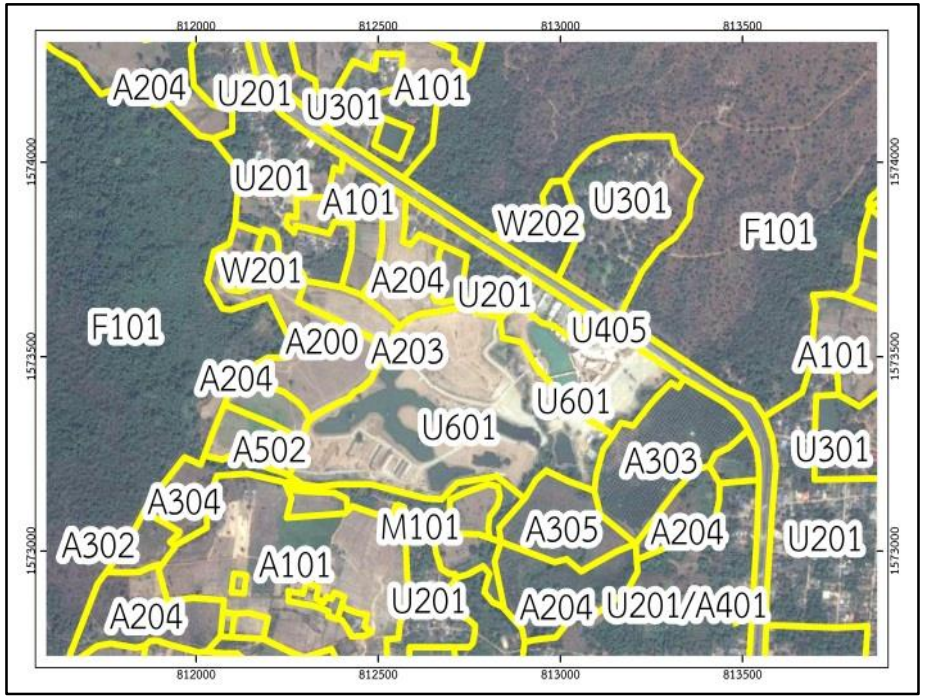
ภาพถ่ายบริเวณพื้นที่โรงงานไฟฟ้าพลังงานแสงอาทิตย์ อำเภอกบินทร์บุรี



แผนที่สภาพการใช้ที่ดินปี พ.ศ. 2549 ซ้อนทับบนภาพถ่ายดาวเทียม LANDSAT 5TM บันทึกภาพมื่อวันที่ 22 ธันวาคม 2549



แผนที่สภาพการใช้ที่ดินปี 2559 ซ้อนทับบนภาพถ่ายดาวเทียม Landsat 8 บันทึกภาพมื่อวันที่ 5 เมษายน 2559

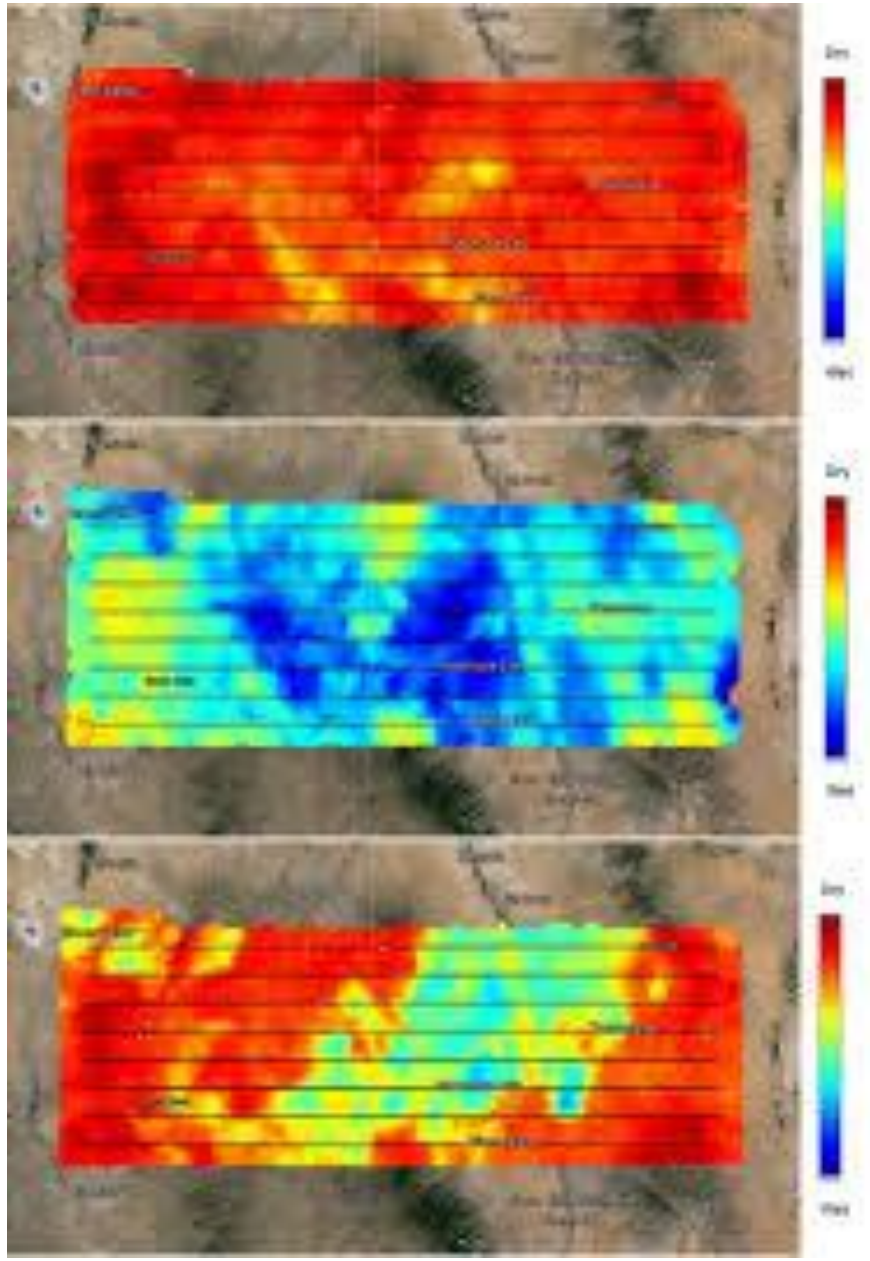


แผนที่สภาพการใช้ที่ดินปี พ.ศ. 2559 ซ้อนทับบนภาพถ่ายดาวเทียมของ Google Earth

การเปลี่ยนแปลงสภาพการใช้ที่ดินจากพื้นที่ไผ่ปลูกเพื่อการค้า (A315) เป็นสถานที่พักผ่อนหย่อนใจ (U601) โครงการเดอะเวโรน่า ทับลาน อำเภอนาดี

Soil

- mapping of soil characteristics
- mapping of soil type
- soil erosion
- soil moisture
- mapping of soil management practices
- compliance monitoring (farming practices)



Crop monitoring and damage assessment

- ✓ monitoring the health of crops
- ✓ optical (VIR) sensing advantage is that it can see the infrared, where wavelengths are highly sensitive to crop vigour as well as crop stress and crop damage.
- ✓ Remote sensing can aid in identifying crops affected by conditions that are too dry or wet, affected by insect, weed or fungal infestations or weather related damage
- ✓ Detecting damage and monitoring crop health requires high-resolution, multi-spectral imagery and multi-temporal imaging capabilities.