Shahrood University of Technology

Introduction to GIS and Remote Sensing

Lectures 1 and 2: Introduction to RS

Mansour Ziaii

Shahrood University of Technology

mziaii@shahroodut.ac.ir

Lecture 1 Topics

Course Structure
- History of RS
- Components of remote sensing
- Introduction to understanding RS images
- Summary

Course Structure

Part 1: 4 weeks intensive

– Lectures- Mansour Ziaii

– Seminar

– Computer Practical Sessions

– Coursework (50%)

Part 2: 4 weeks 2-3 times per week – Mahdi Ziaei

– Computer Practical Sessions

– Coursework (50%)

Reading

Key Texts

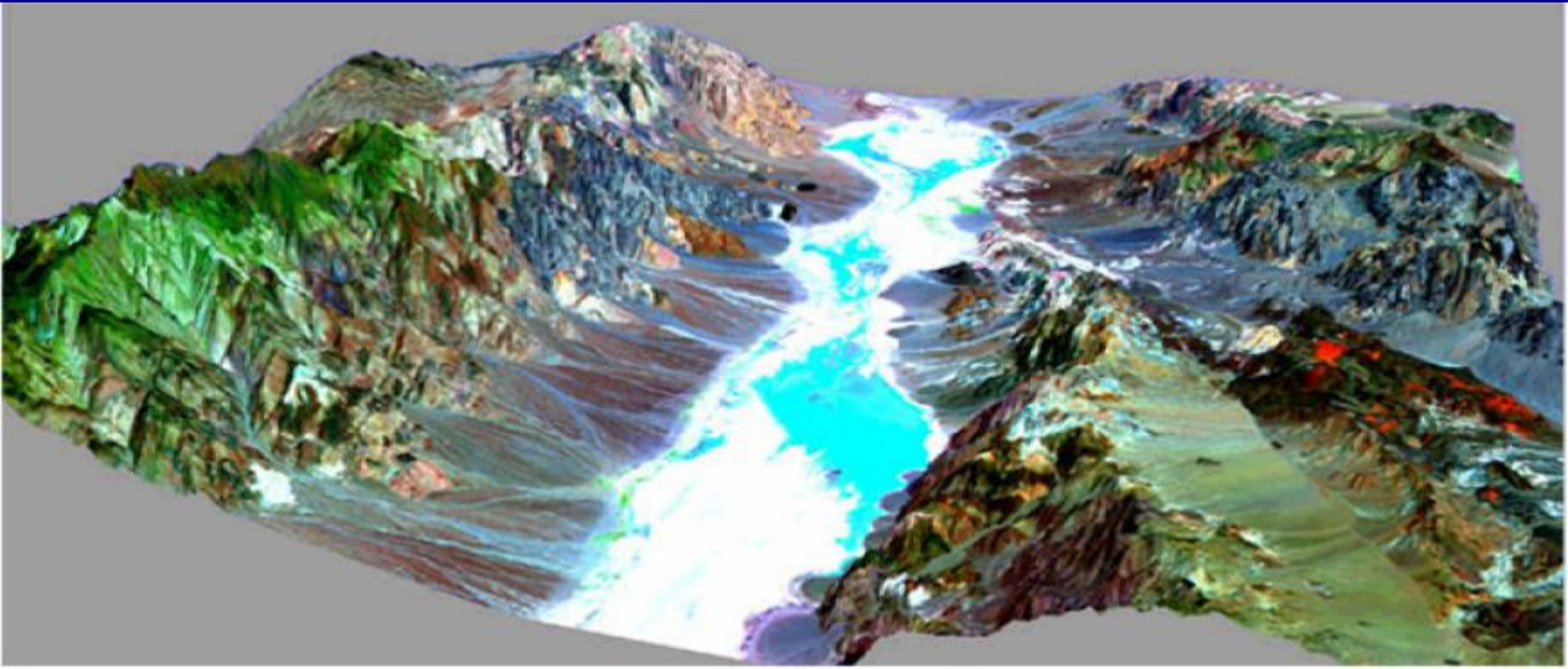
- *Remote sensing and image interpretation* , Lillesand, Thomas M., New York; Chichester : Wiley, c2000, 1994 and 2000 (in Farsi)
- *Introduction to remote sensing*, Campbell, James B., London : Taylor & Francis, 3rd 2002
- *Principles of Remote Sensing*, Curran, P. J., Longman, Harlow, 1985
- *Introduction to the Physics and Techniques of Remote Sensing, 2006* Charles E. and Jakob van Z., *by John Wiley & Sons*

Journals for General Reference

– International Journal of Remote Sensing

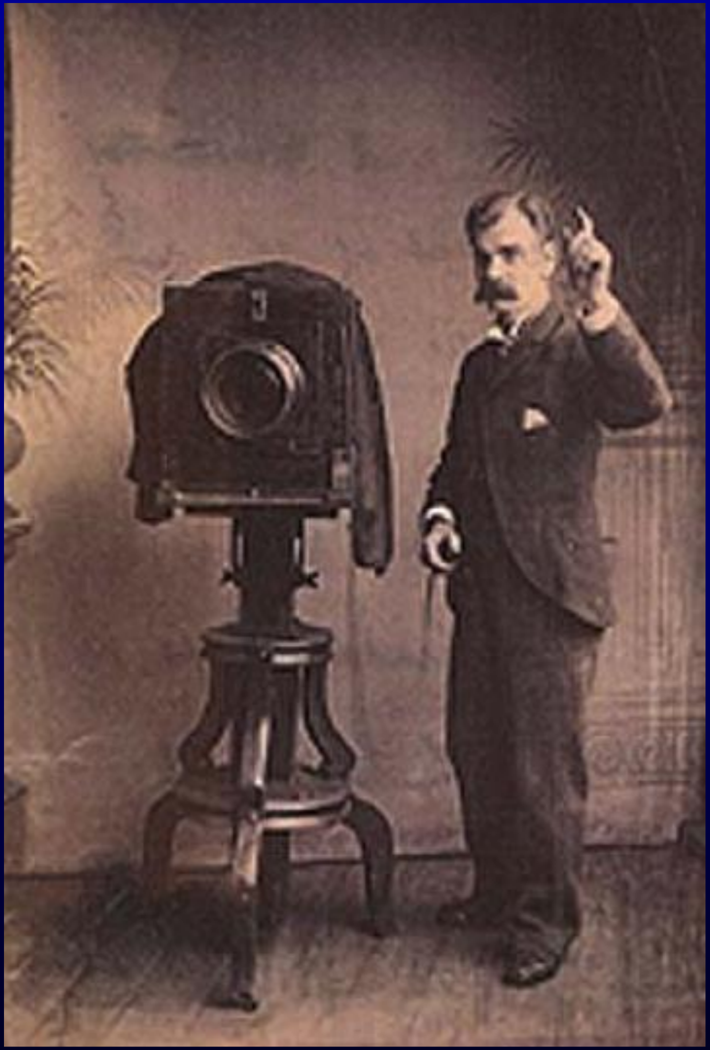
– Photogrammetric Engineering and Remote Sensing

– Remote Sensing of Environment



History of remote sensing

First photographs taken in 1839



Boston by Black and King (1860)

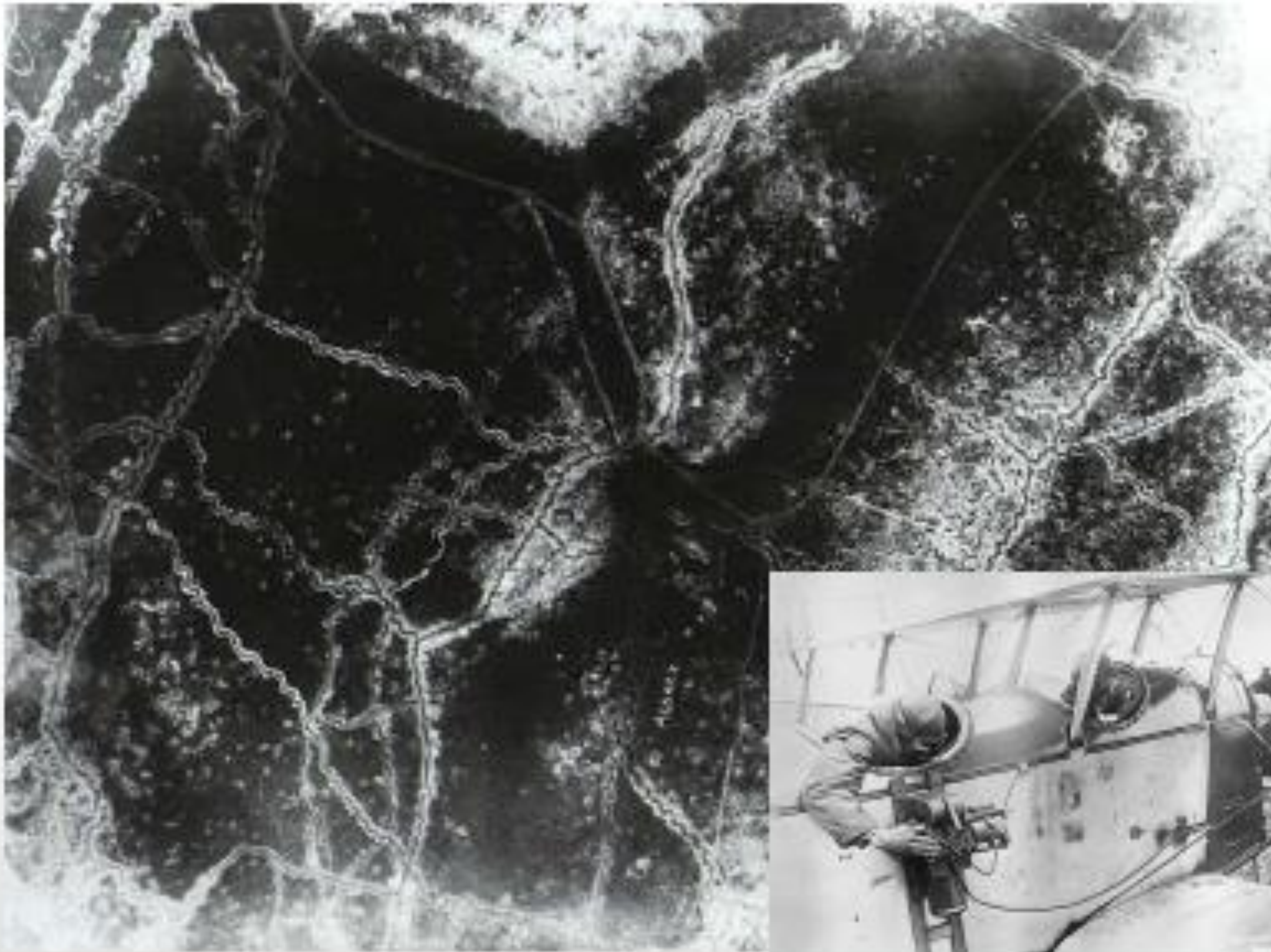
1858 Gasper Felix Tournachon "Nadar" takes photograph of village of Petit Bicetre in France from a balloon

Photos such as these helped Allies to understand the nature of reported new German "secret weapons" research. Arrow indicates V-2 rocket lying on its side.

After the war the technology was in place to begin large scale aerial surveys

Picture taken by the Pigeons of a Bavarian castle
(the irregular objects on either side are the flapping wings)

World War One was a major impetus to development of aerial photography



The zigzag pattern of World War I trench systems could be viewed best from the air.
From the National Archives.

A Brief Chronology of Remote Sensing

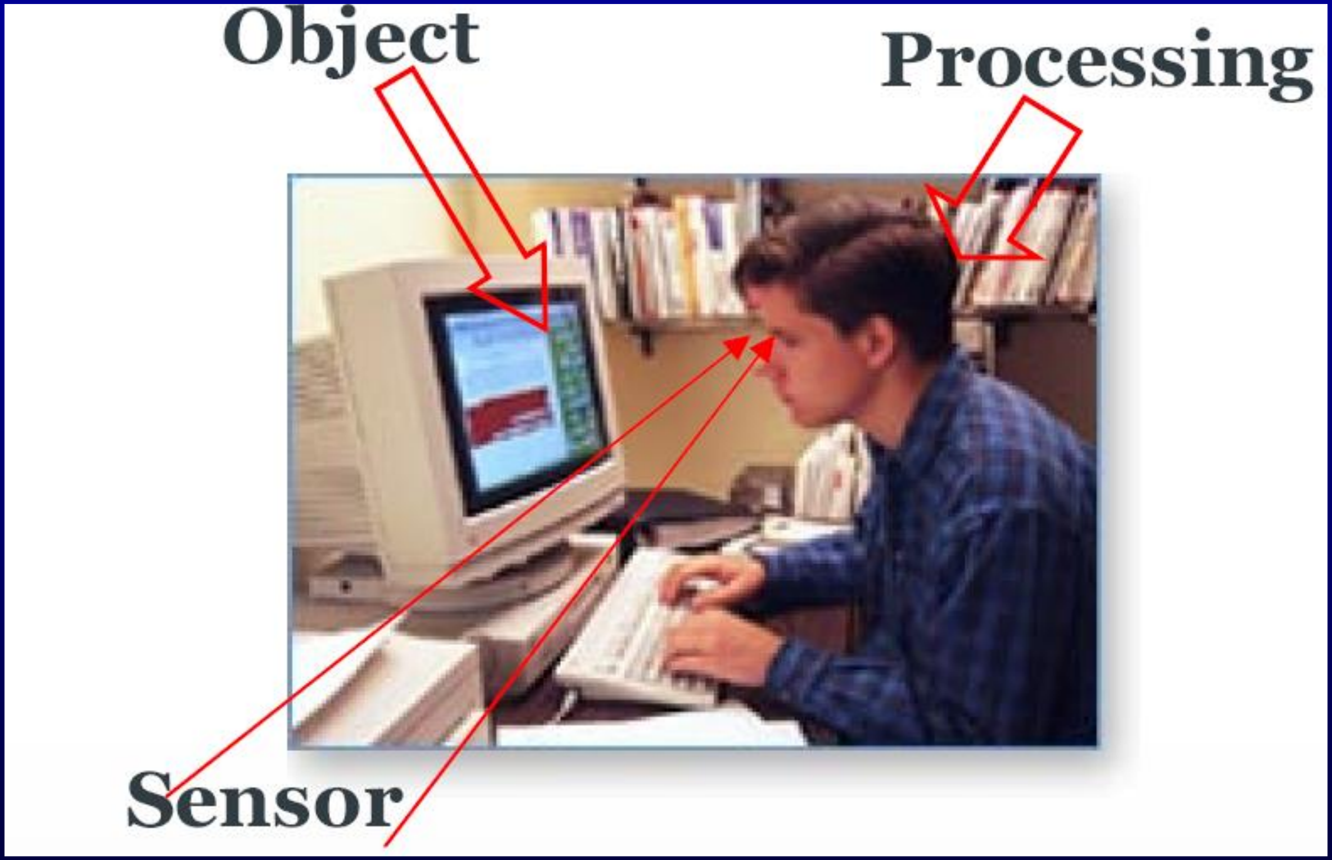
- **1960's** First meteorological satellites (TIROS-1)
  - **1970's** Launch of the first generation of Earth resource satellites (Landsat-1) Setting up of International Remote Sensing Bodies. Digital analysis was born.
- **1980's** Setting up of Specific Remote Sensing Journals

  Continued deployment of Earth Resource satellites by NASA

  Development of the hyperspectral sensor (200 + band)
- **1990's** Launch of earth resource satellites e.g. Terra-1 by national space agencies and commercial companies
- **2000's** Cheap targeted satellites

What is remote sensing?

A common observation: Human vision



“The use of electromagnetic radiation sensors to record images of the environment, which can be interpreted to yield useful information” (Curran, 1985)

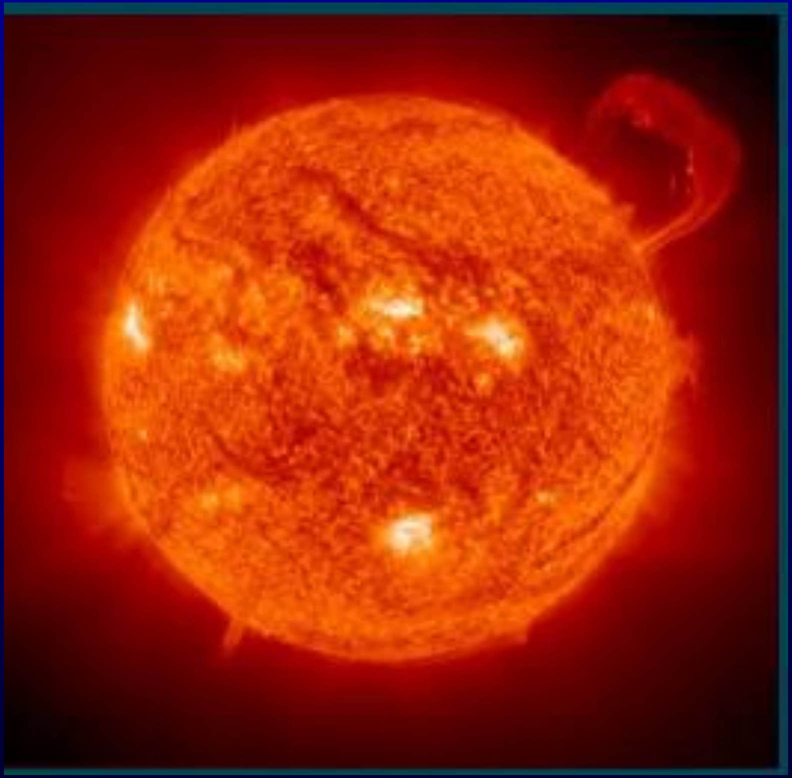
What is remote sensing?

Has 4 main Components

- Source
- Atmospheric interaction
- Interaction with Earth's surface
- Sensor

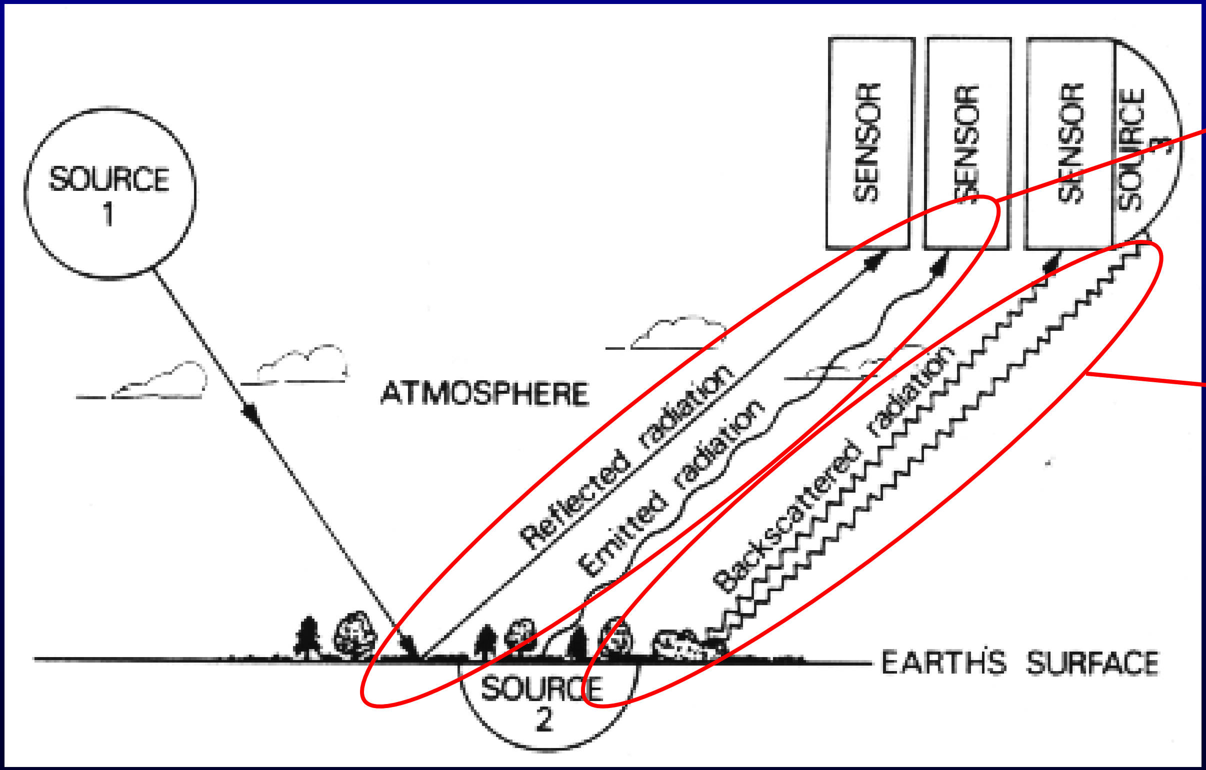
Source

بازگشت



The Remote Sensing Process: II

- Collection of information about an object without coming into physical contact with that object



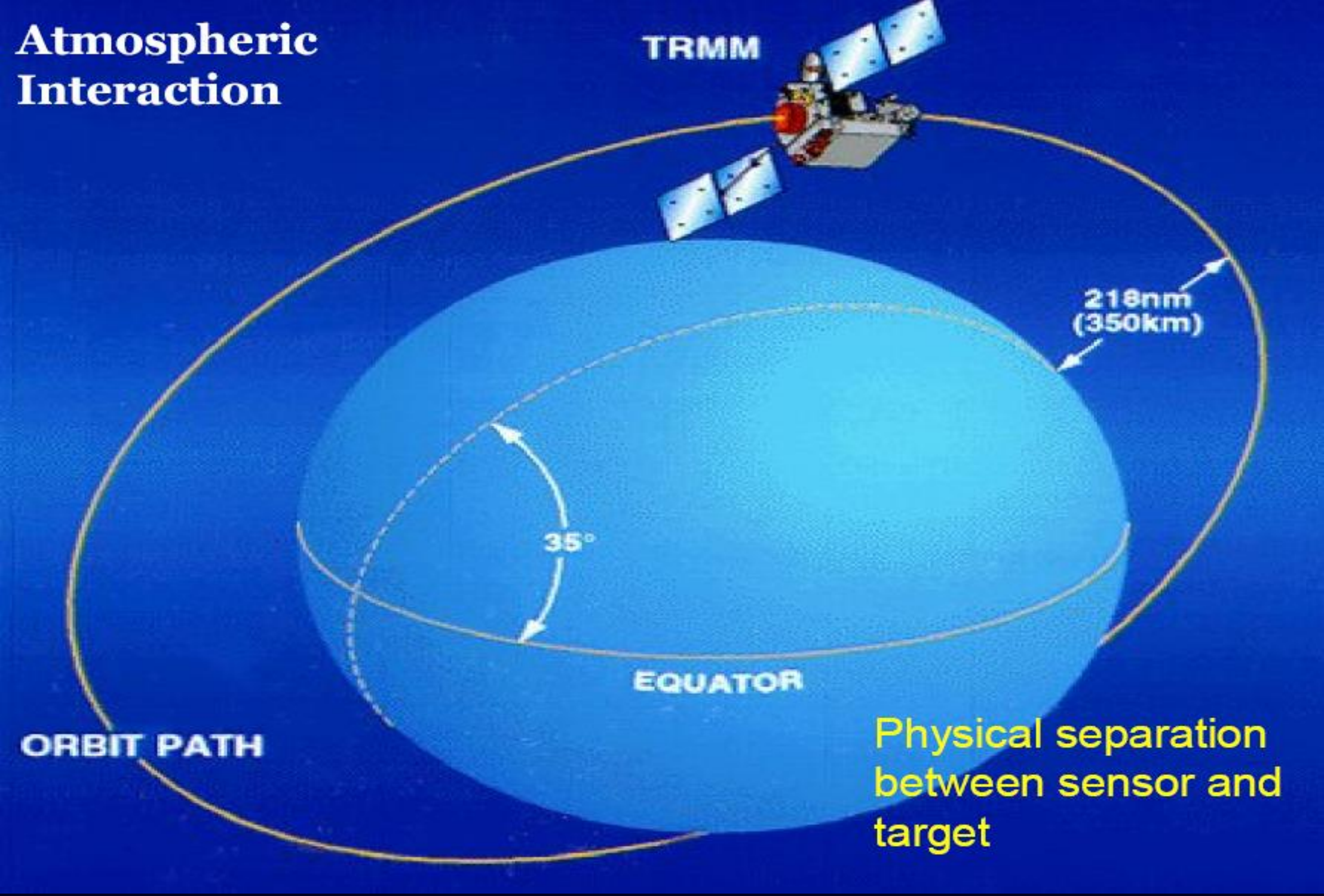
Passive: solar reflected/emitted

Active:RADAR (backscattered); LiDAR (reflected)

The Remote Sensing Process: III

- What are we collecting?
  - Electromagnetic radiation (EMR)
- What is the source?
  - Solar radiation
    - passive – reflected (vis/NIR), emitted (thermal)
  - OR artificial source
    - active - RADAR, LiDAR

Atmospheric Interaction



Physical separation between sensor and target

بازگشت

EO and the Earth "System"

External forcing

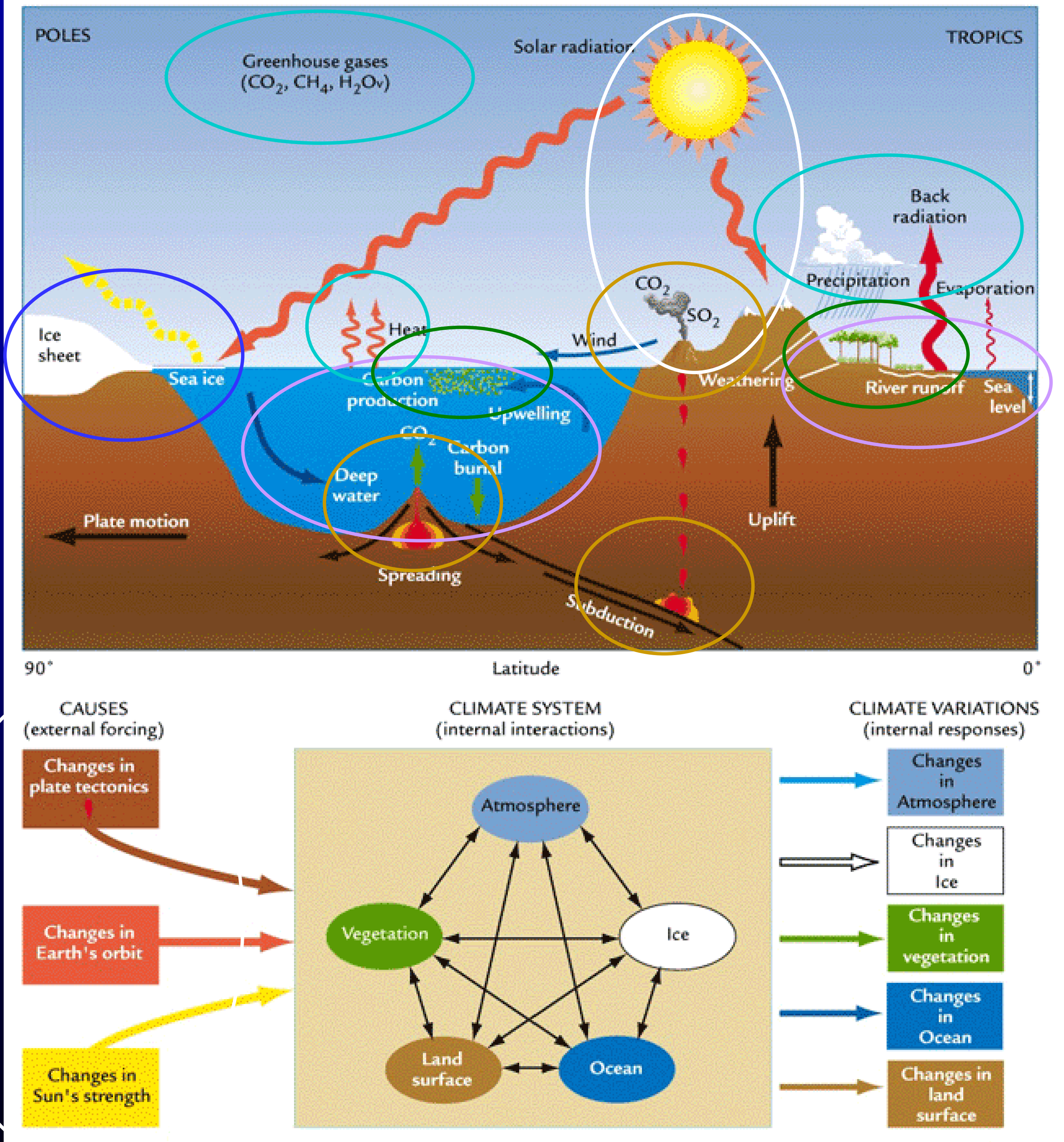
Hydrosphere

Cryosphere

Atmosphere

Geosphere

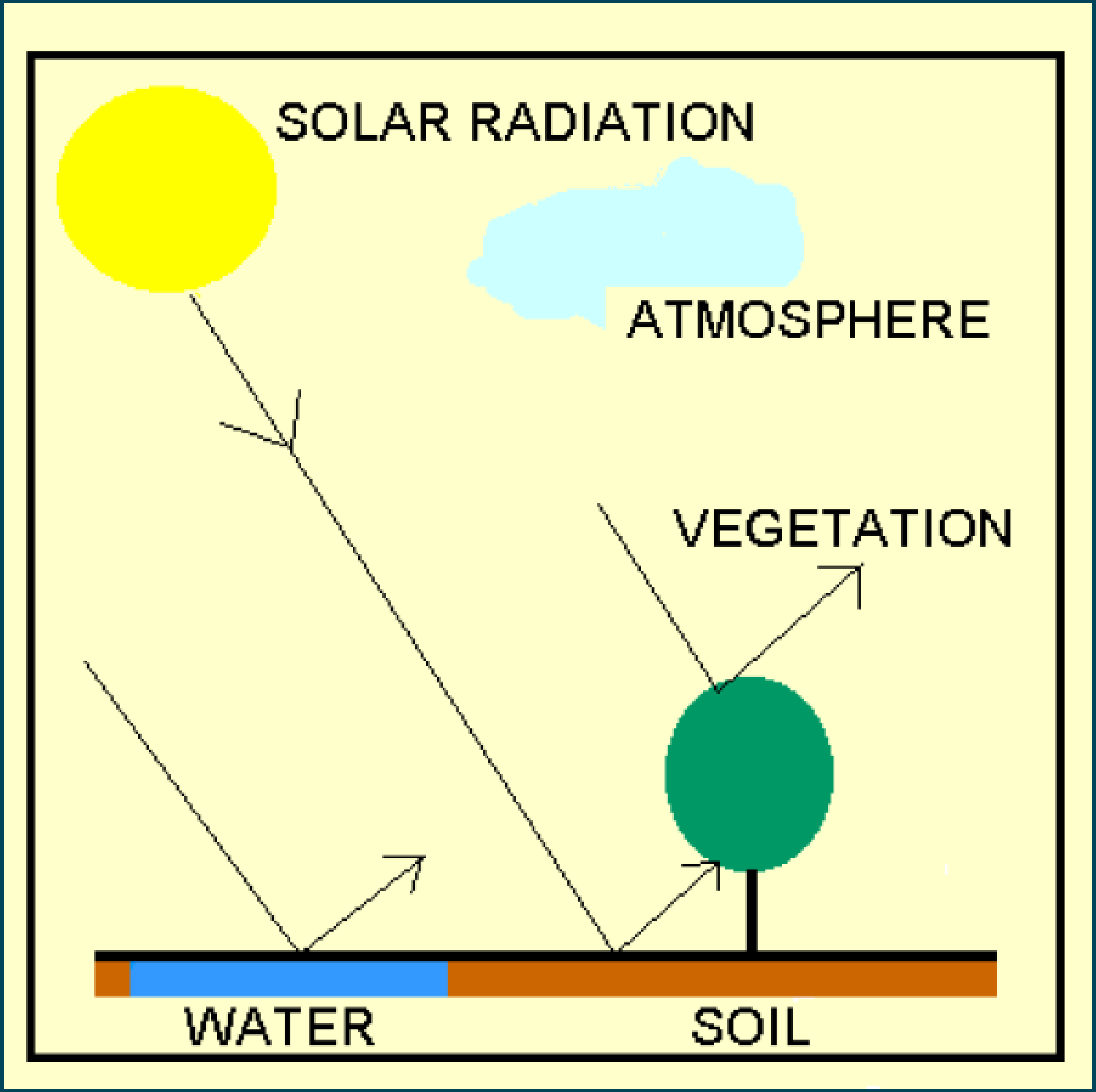
Biosphere



From Ruddiman, W. F., 2001. Earth's Climate: past and future.

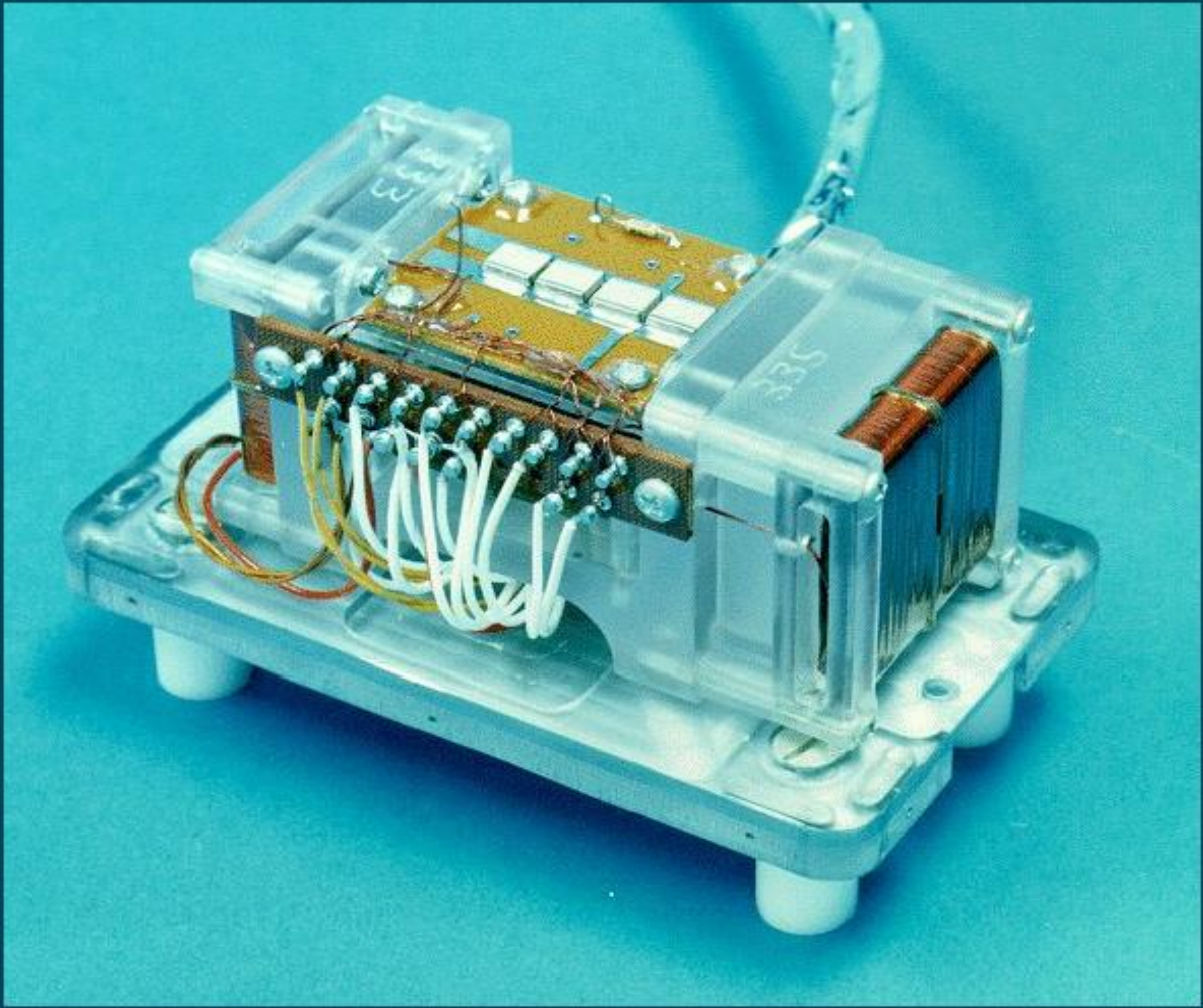
Interaction with the Earth's surface

بازگشت



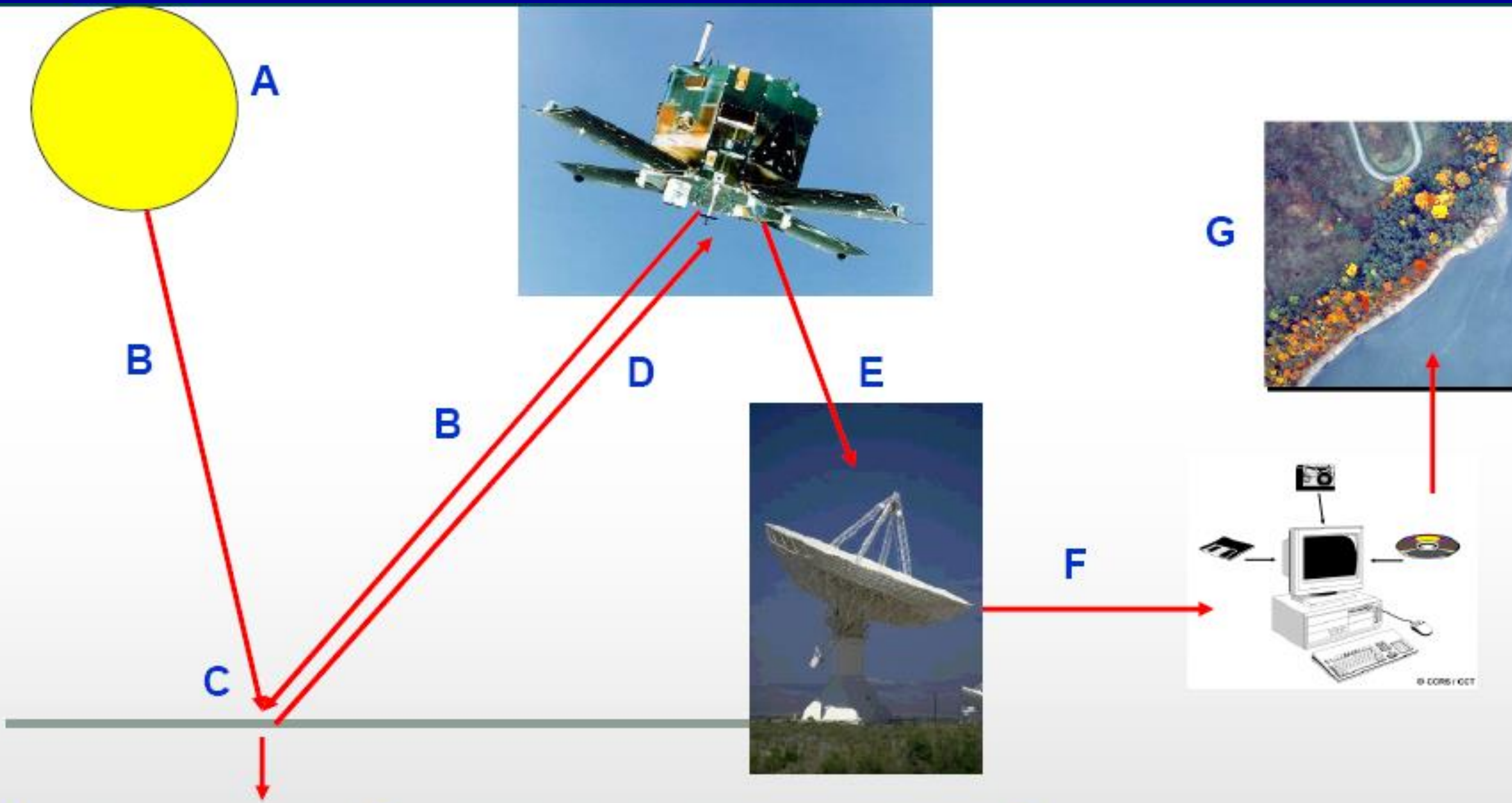
Sensor

بازگشت



Device to sample and measure radiation

Main components of remote sensing



A = Energy Source, B = Radiation and the atmosphere, C = Interaction with the target, D = Recording of energy by the sensor, E = Transmission, reception and processing, F = Interpretation and analysis, G = Application

Understanding remote sensing images

Interpretation of imagery requires understanding of:

- The physical property that Earth observation is measuring
- The source of magnitude of this physical property
- How this physical property is modified before measurement
- How this physical property interacts with the Earth's surface
- How this physical property is manipulated to produce a digital image of the Earth's surface

Summary

- EO can acquire spatially extensive samples of the Earth's surface at regular time intervals

- They are data and NOT information *per se*

- In order to understand RS images we need to know

1. How EMR interacts with Earth's surface features
2. How different types of Earth observed images are acquired
3. How these different types of images can be processed by computers

What information can RS provide?

- What is there?
- How much is there?
- What type of details can we get?

Agriculture land → Variety of crop → Weekly crop condition

Multi concept

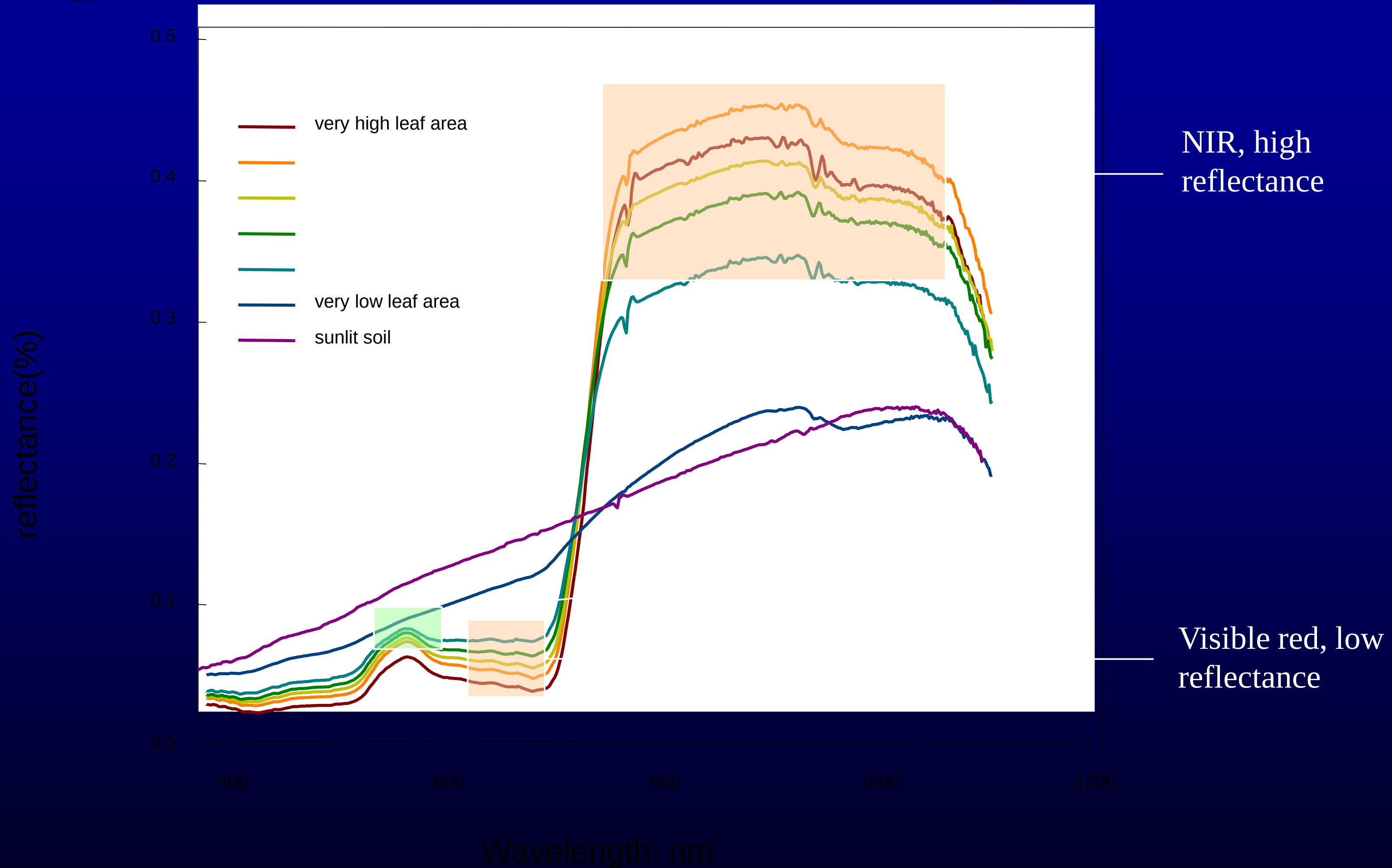
Remote sensing can be

- Multi-stage
- Multi-view
- Multi-spectral
- Multi-temporal
- Multi-use or multi-theme

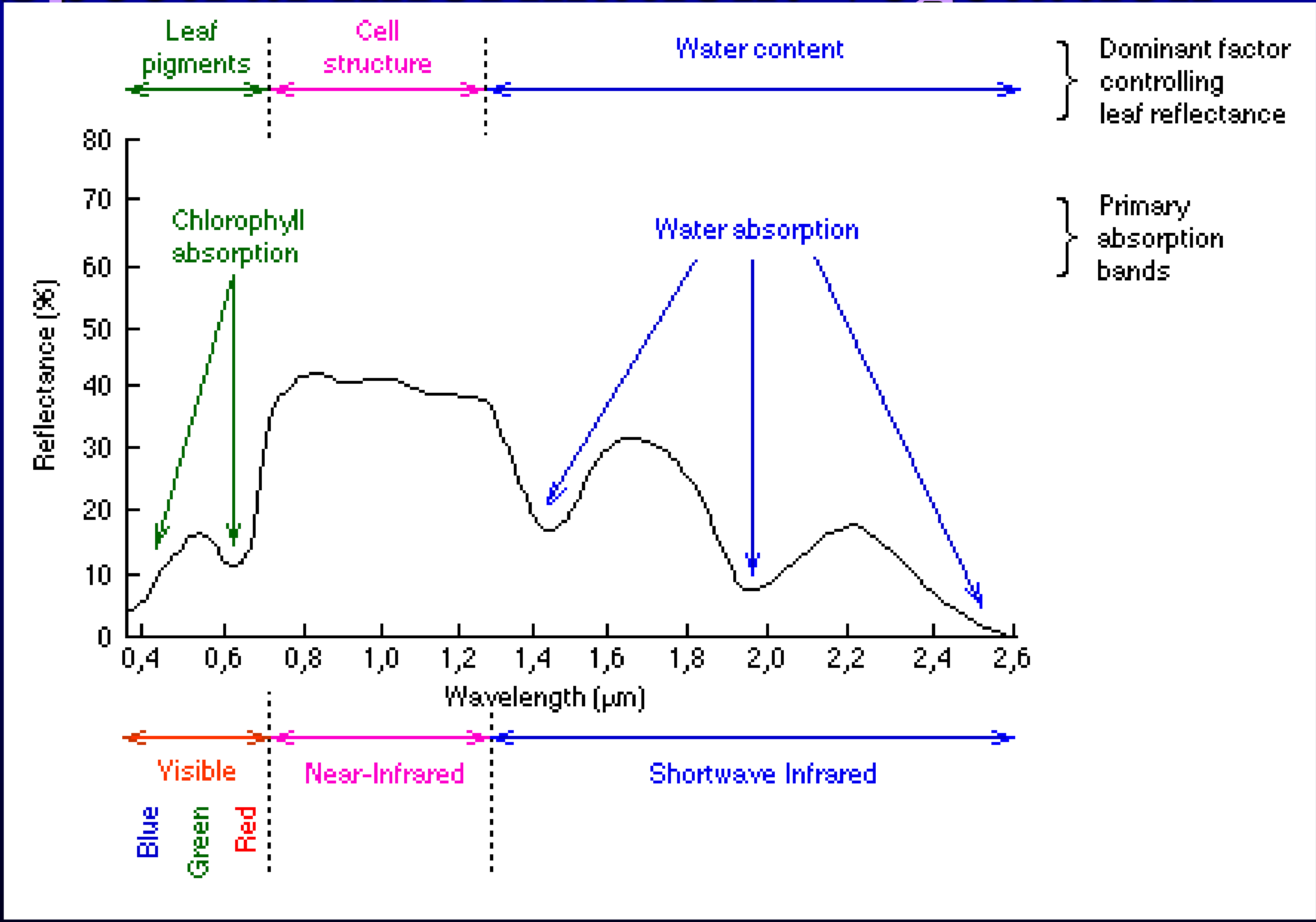
Information

- What type of information are we trying to get at?
- What information is available from RS?
  - Spatial, spectral, temporal, angular, polarization, etc.

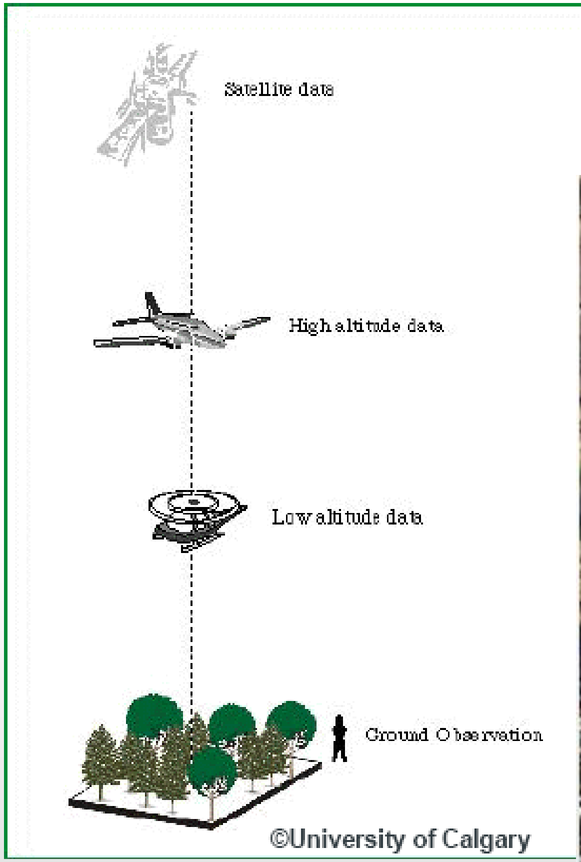
Spectral information: vegetation



Spectral information: vegetation



Multi stage



Spatial resolution

بازگشت

Colour Composites: temporal

‘False Colour’ composite

- many channel data, much not comparable to RGB (visible)
  - e.g. Multi-temporal data
  - but display as spectral

  - AVHRR MVC 1995

April

August

September

Multi view

- Same thing from a different angle
- Provide information about dimension (buildings, trees etc)

Area and the shape of object changes

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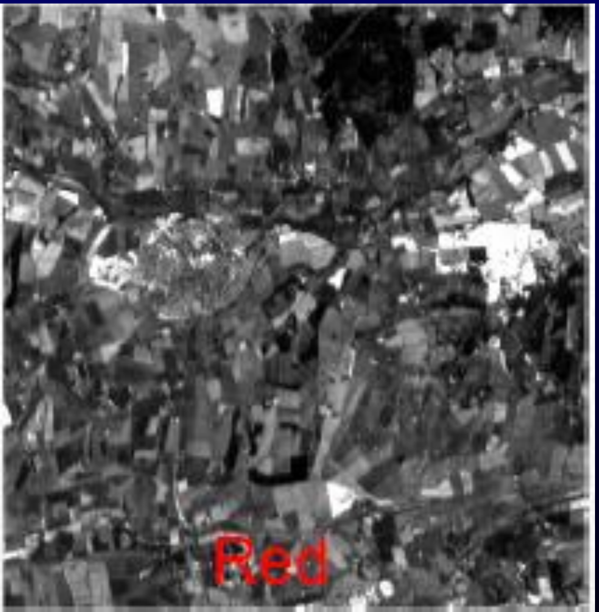
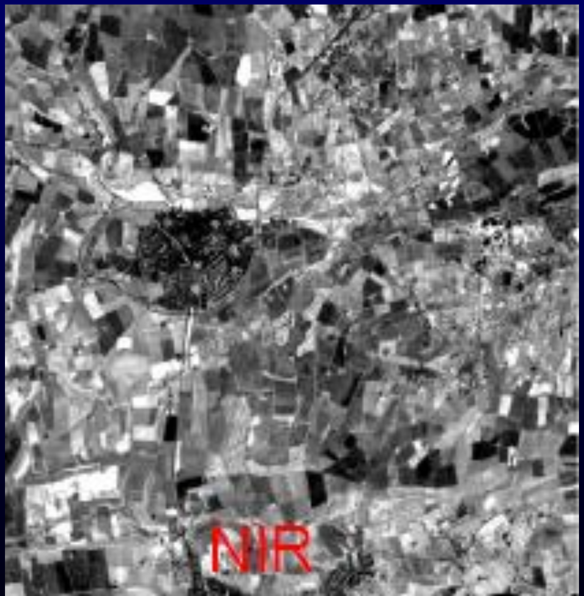
Image: ESA SPARC

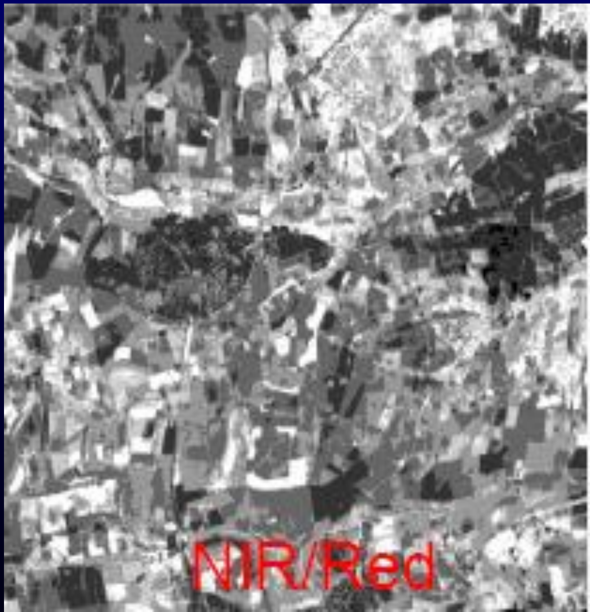
Multi-spectral

- More than one spectral band
- Basis of most remote sensing applications

بازگشت

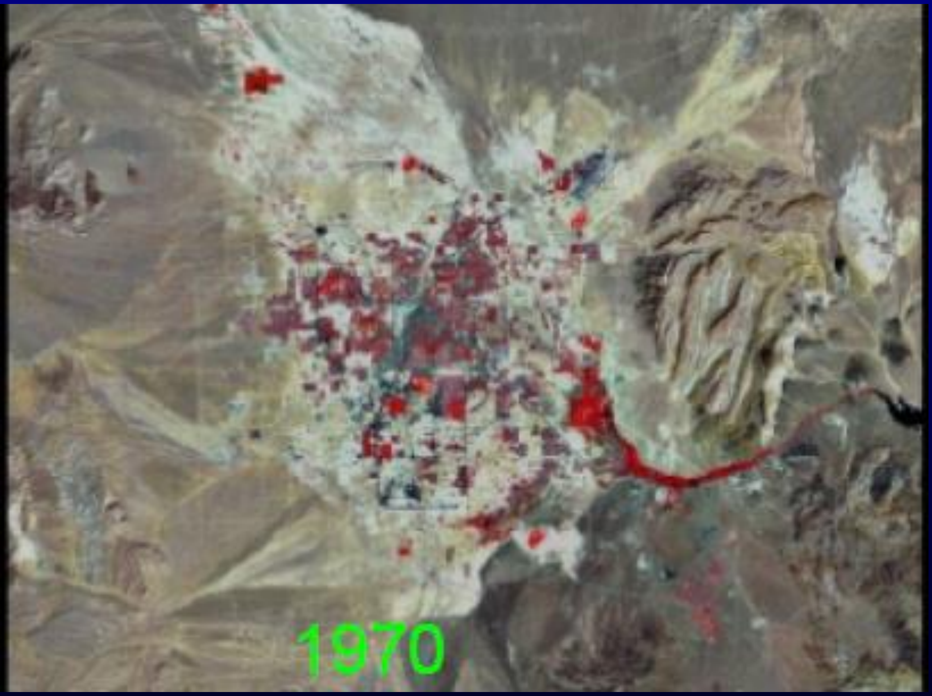


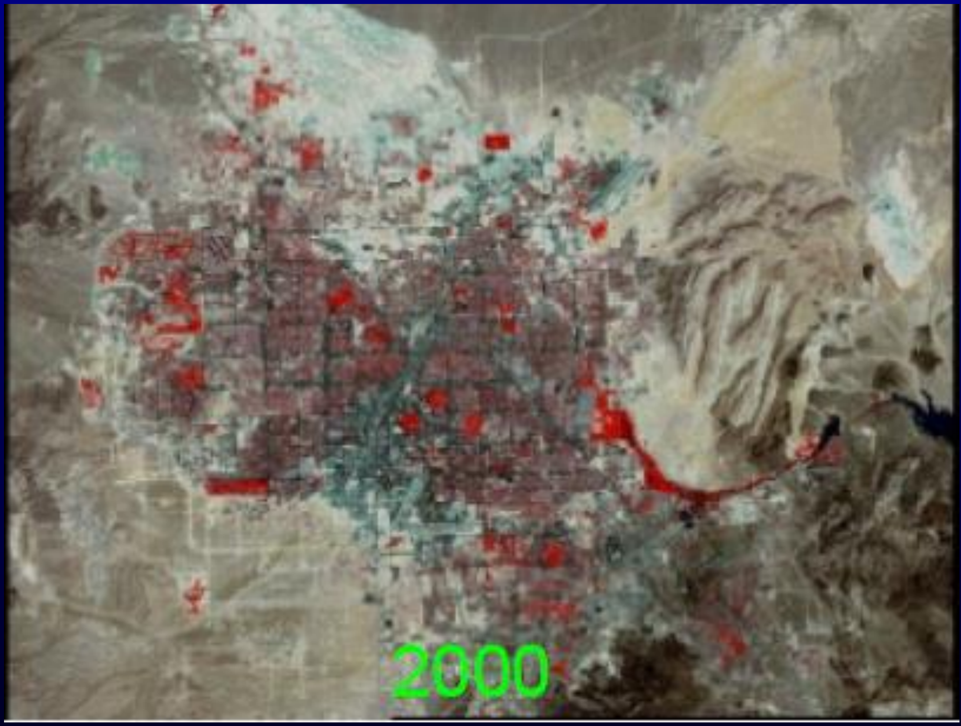




Multi-temporal

- Same object at different time
- Monitor changes occurring with time (urban growth, change in vegetation, natural disaster)





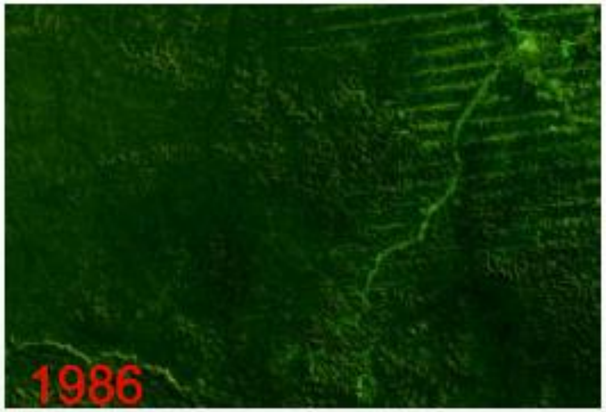
بازگشت

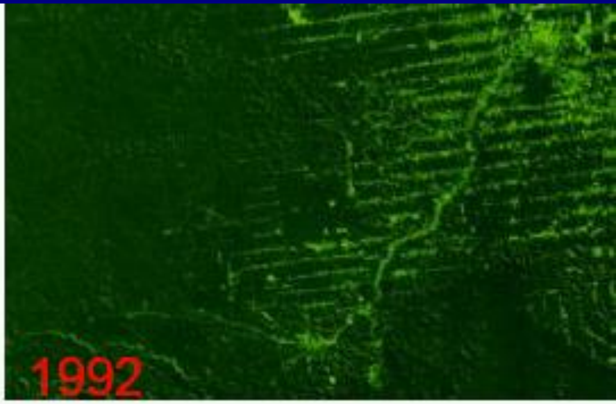
Urban growth in Las Vegas

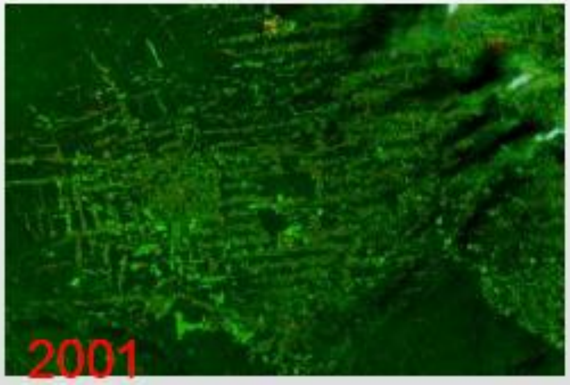
Multi-temporal

Rondonia,
Brazil deforestation

- Same object at different time
- Monitor changes occurring with time (urban growth, change in vegetation, natural disaster)







بازگشت

Multi-temporal

- Same object at different time
- Monitor changes occurring with time (urban growth, change in vegetation, natural disaster)

Indian ocean Tsunami, 2004

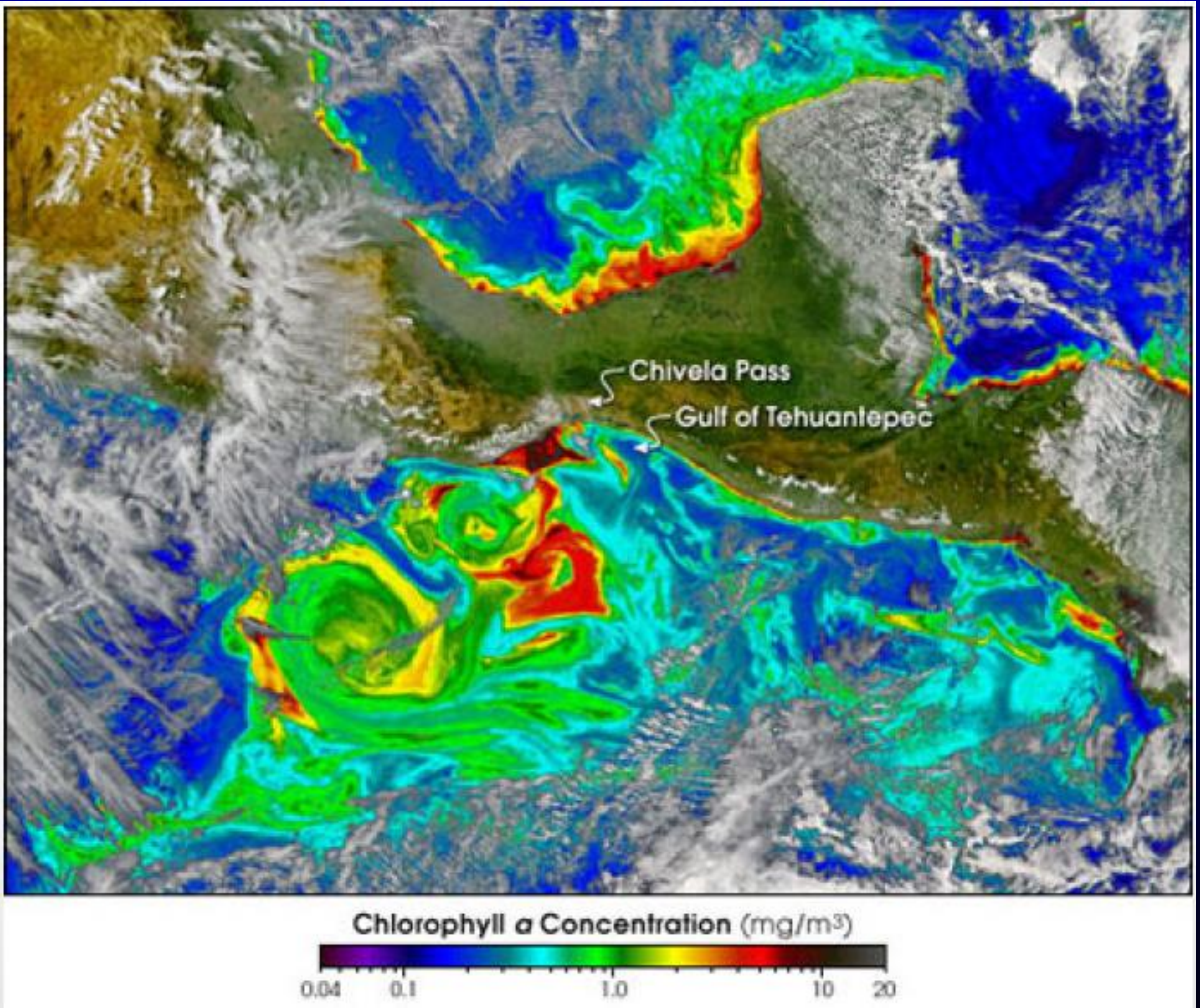
بازگشت

Multi-use or multi-theme

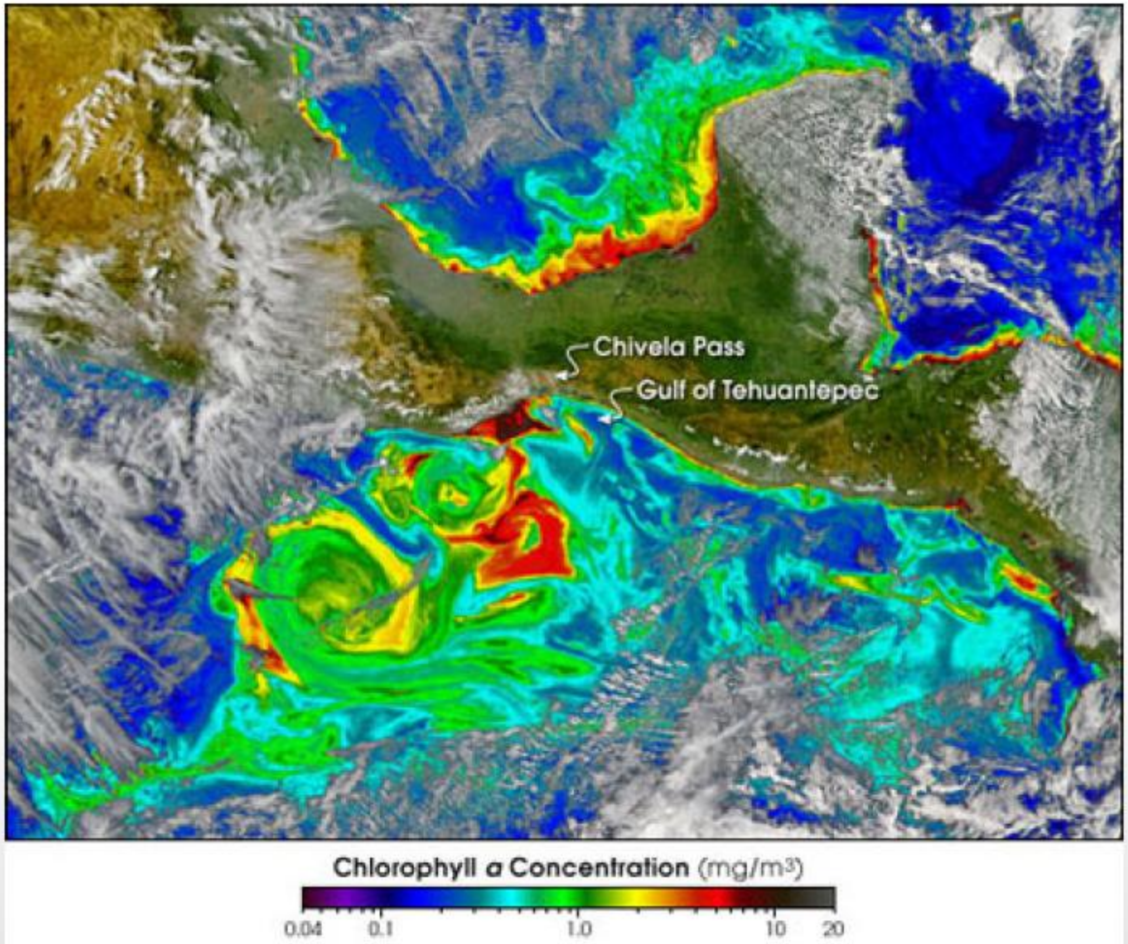
- Meteorology Weather forecasting, Climate studies, Global change
- Hydrology Water balance, Energy balance, Agrohydrology
- Soil science Soil mapping
- Biology/conservation Vegetation mapping/monitoring
- Forestry Inventories, mapping, de/re-forestation, forest fires
- Enviromental studies Sources/effects of pollution
- Agriculture Land use development, water management, erosion
- Planning Physical planning scenarios
- Land surveying Topography, spatial data models, GIS

بازگشت

Ecological forecasting

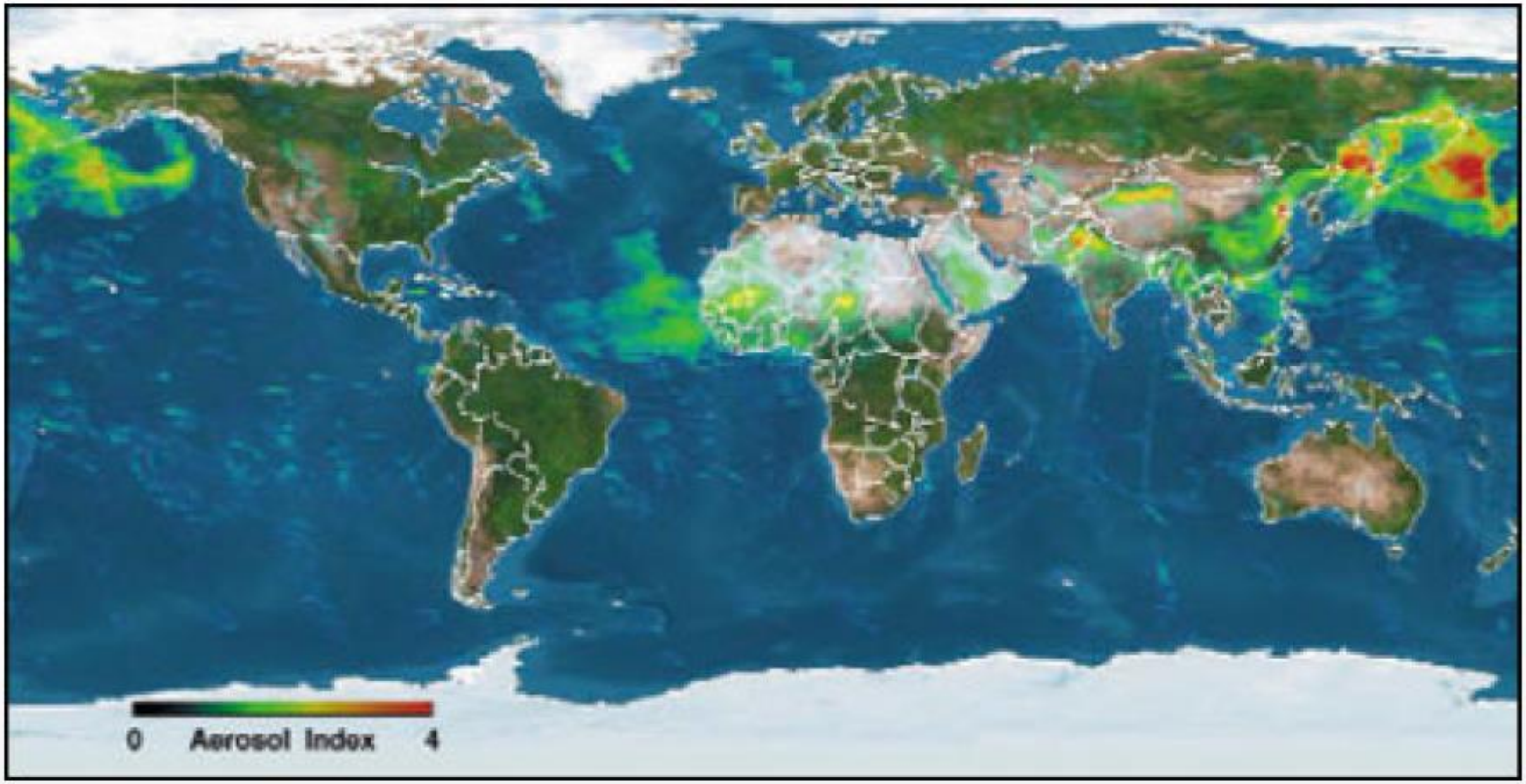


Ecological forecasting



This satellite image from the Sea-viewing Wide Field-of-View Sensor (SeaWiFS) shows the effect of the Tehuano winds on the ocean's plant life on December 9, 2003. Winds blowing southwest from the Gulf of Mexico (top center) toward the Gulf of Tehuantepec (bottom left) churned up the water and initiated an algal bloom that is shown in the image in rainbow colours. The colours represent how much plant chlorophyll SeaWiFS detected in the surface water. Highest concentrations are dark red and lowest concentrations are blue. Source: NASA – Looking at Earth from space

Air Quality



Aerosols affect climate both directly by reflecting and absorbing sunlight and indirectly by modifying clouds. The TOMS aerosol index is an indicator of smoke and dust absorption. The image shows aerosols crossing the Atlantic and Pacific oceans. Dust from the Sahara desert is carried westward toward the Americas. Asian dust and pollution travel to the Pacific Northwest. Credit: Jay Herman (NASA GSFC)

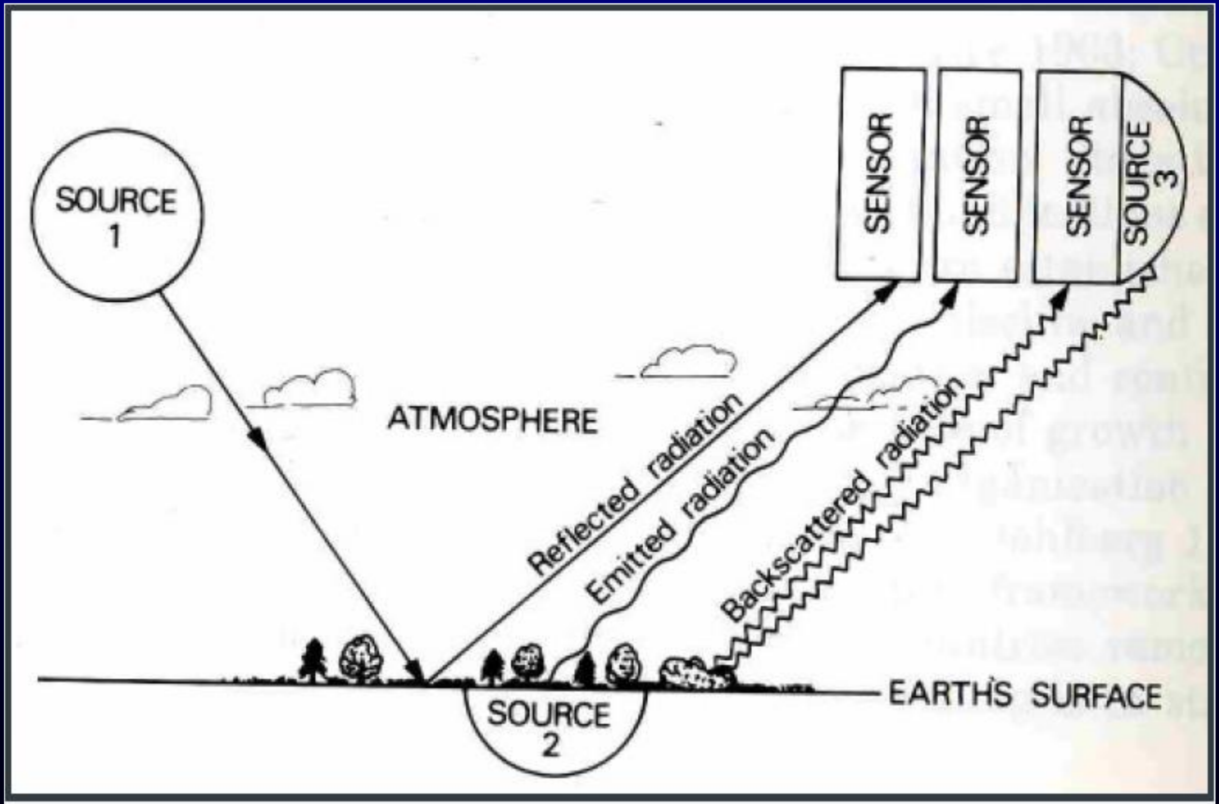
Any questions?

- Additional reading:

CURRAN, P. J., 1987, Remote sensing methodologies and geography. *International Journal of Remote Sensing*, **8**, 1255-1275.

The remote sensing system

- Source
- Atmospheric interaction
- Interaction with earth surface
- Sensor

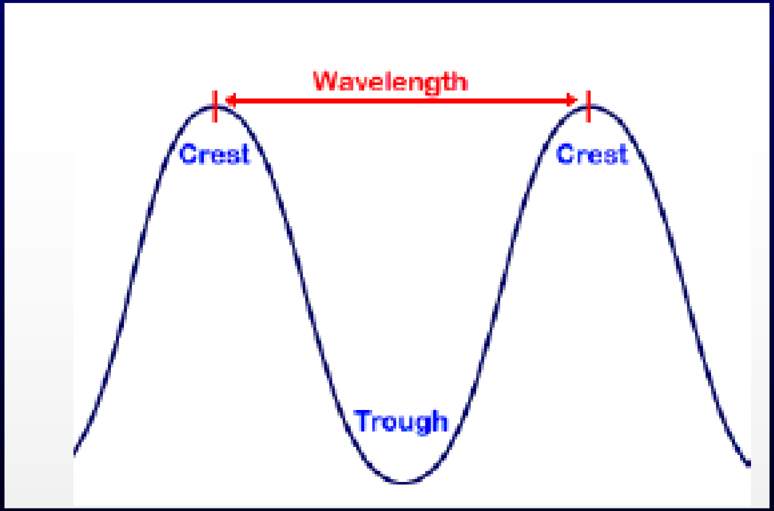


Source: Electromagnetic radiation

What do sensor actually record?

• Provides link between various remote sensing components

What are waves?Source: Electromagnetic radiation



بازگشت

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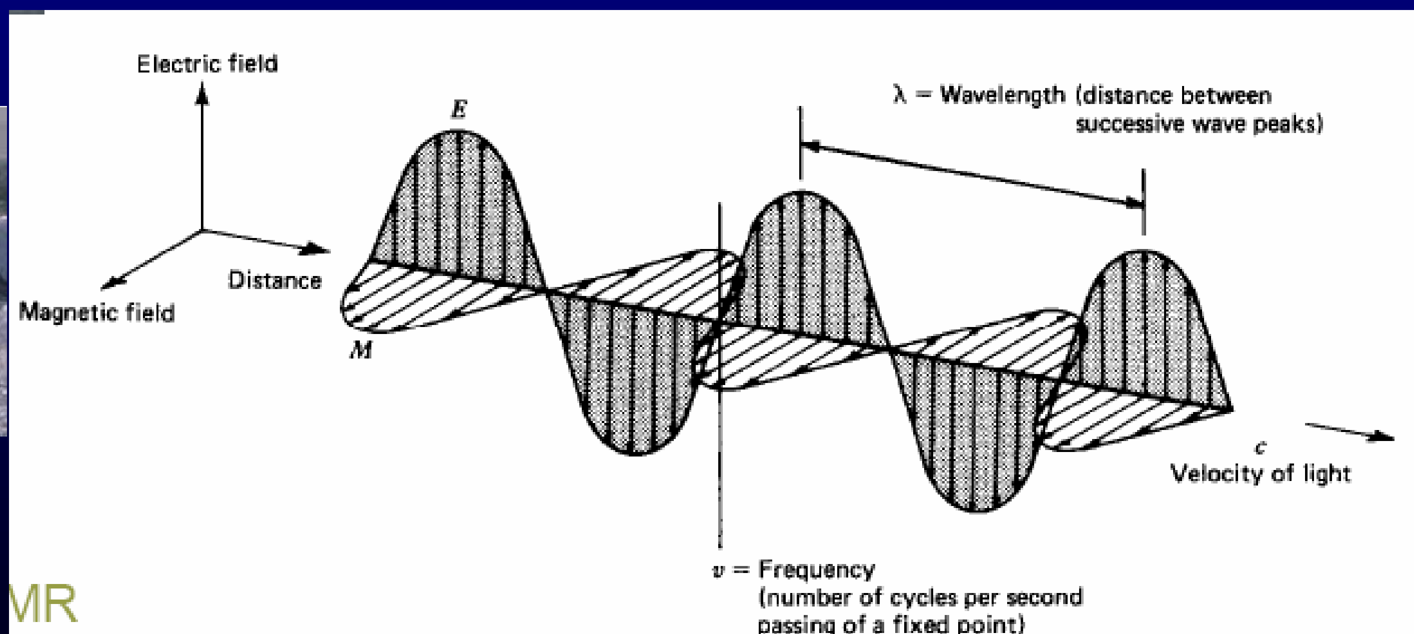
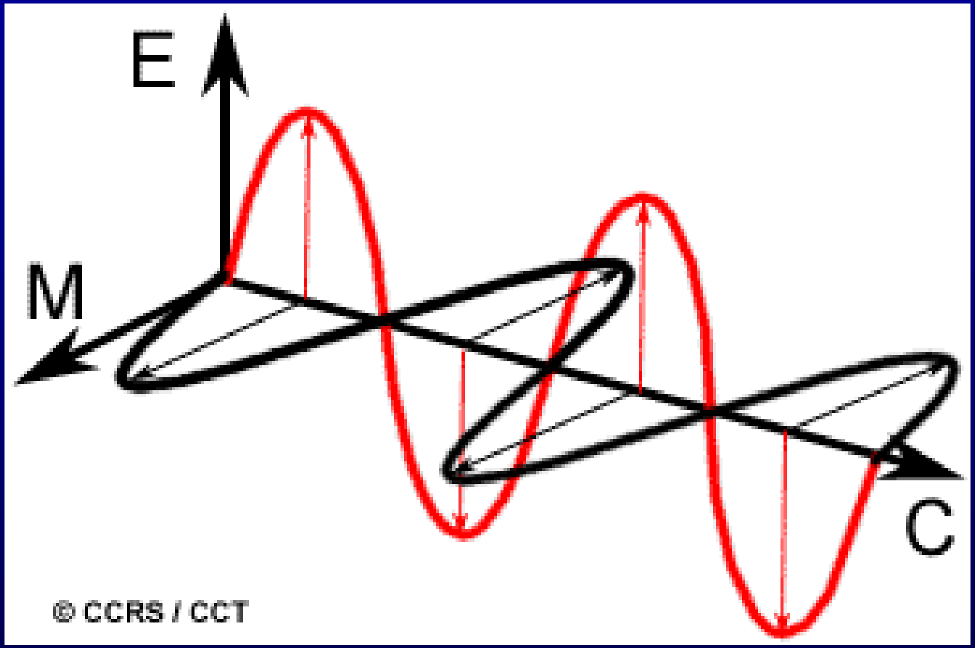


The wave picture of EMR

بازگشت

Electromagnetic radiation?

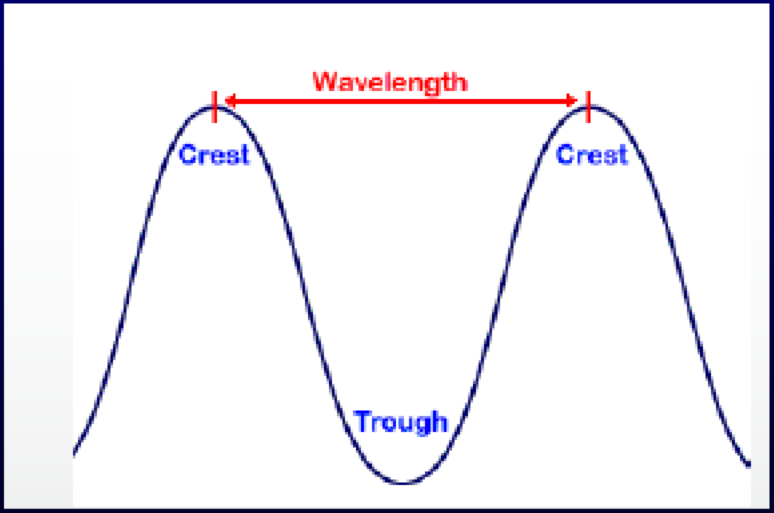
- Electric field (E)
- Magnetic field (M)
- Perpendicular and travel at velocity, c ($3x10^8$ ms^{-1})



Source: Electromagnetic radiation

Wavelength

- The wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crests. Wavelength is usually represented by the Greek letter lambda .

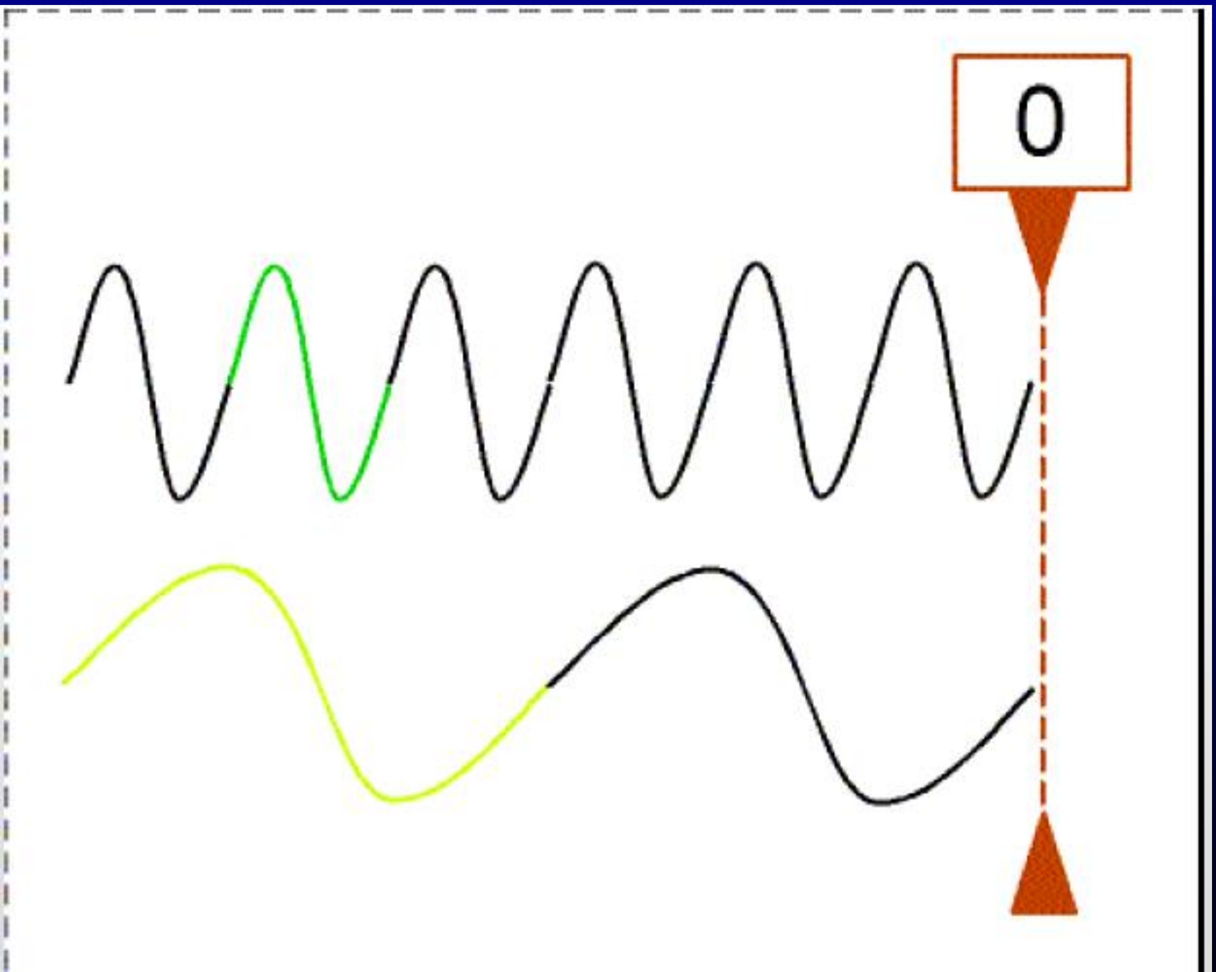


بازگشت

Source: Electromagnetic radiation

What is the frequency?

- Number of wave peaks passing though a fixed point in space though unit time

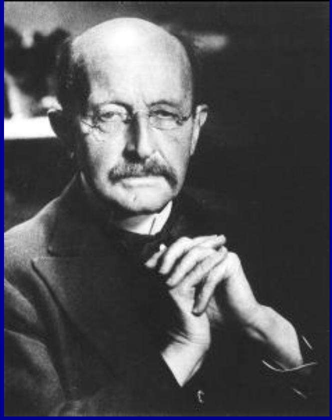


High frequency

Low frequency

بازگشت

Source: Electromagnetic radiation



Speed

- EM energy can be characterised by either frequency or wavelength

- In vacuum EM energy travels with speed of light (C) = 3x108m s-2

$$C=\lambda .v$$

- Particle (Quantum) theory suggests that EM radiation is composed of many discrete units called photons or quanta.

- Energy contained in quanta is proportional to their wavelength and (or frequency)

- Therefore a single quantum of shorter wavelength EMR is more energetic that a single quantum of longer wavelength EMR

بازگشت

Source: Electromagnetic radiation

1. Wavelength (λ)

- Micrometres (µm) = 10^{-6} metres or 1/1000,000th of a metre (old unit was the 'micron')
- Nanometres (nm) = 10^{-9} metres or 1/1000,000,000th of a metre (e.g. 0.5 µm = 500nm)
- How many nm in 1 µm ? **1 µm=1000 nm**

2. Intensity of EMR

- Measured by a sensor : Radiance $Wm^{-2}sr^{-1}$

(Units : Watts per square metre per steradian)

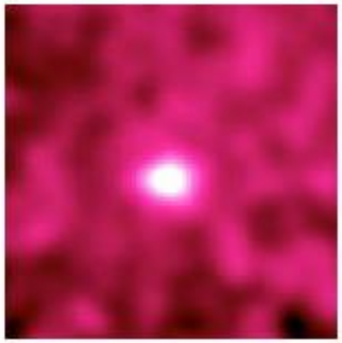
- Falling on a surface : Irradiance Wm^{-2}

بازگشت

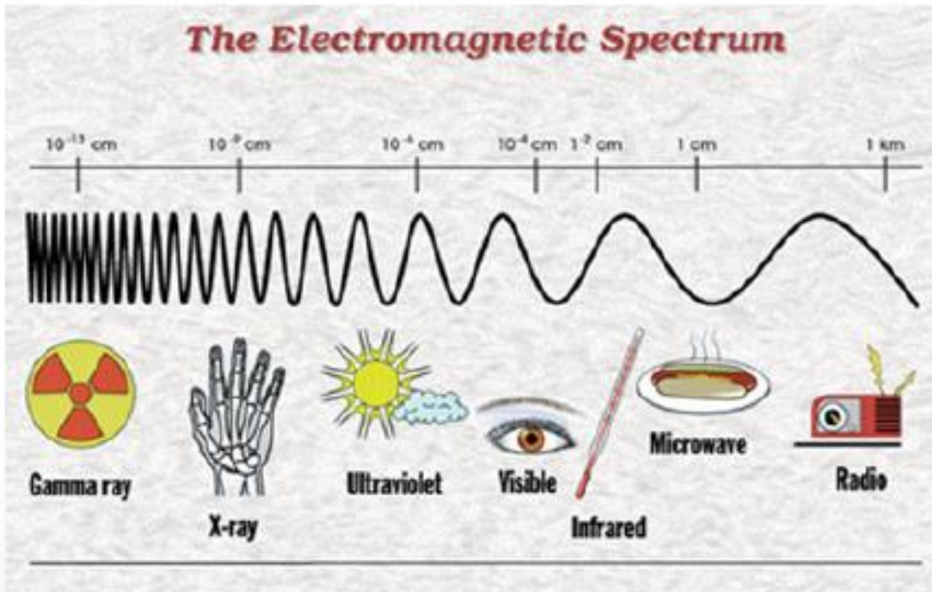
Source: Electromagnetic radiation

بازگشت

The electromagnetic spectrum is constituted of waves of different wavelengths



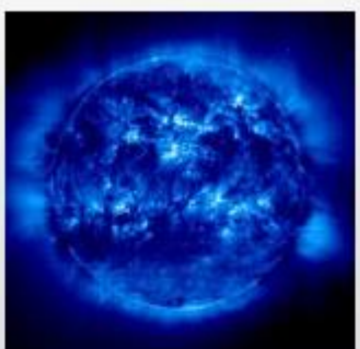
High in energy



Carry signals

Radar

Astronomy



Sunburn

We can see

Plants reflect more

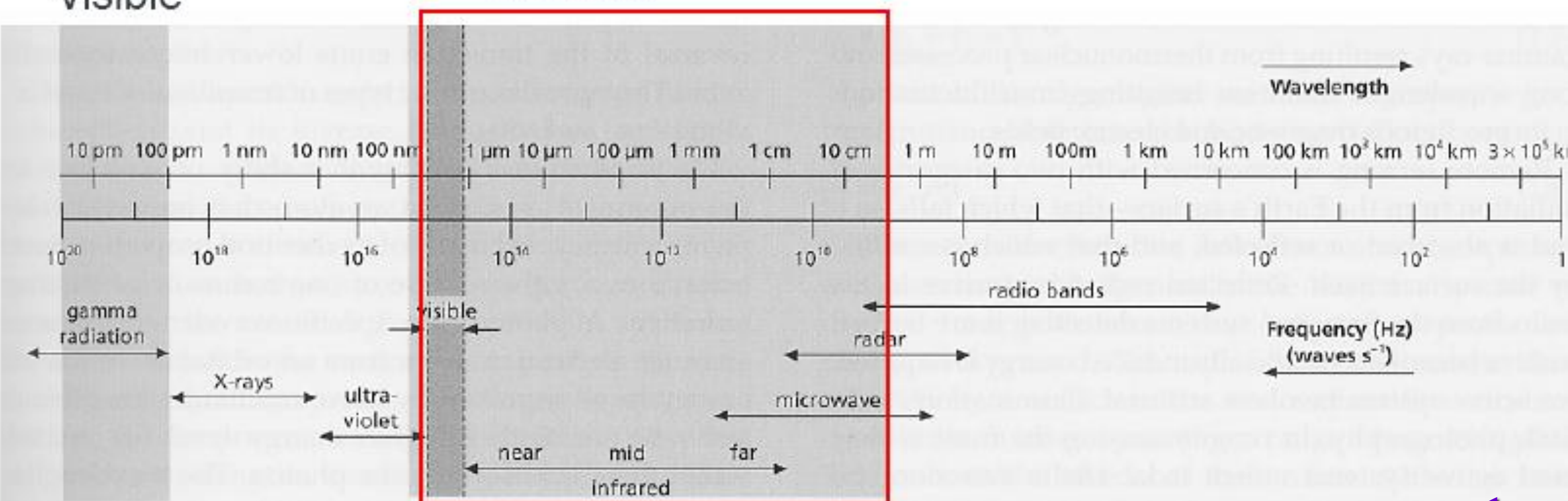
Source: Electromagnetic radiation

Which are of interest to remote sensing?

visible

Infrared

microwave



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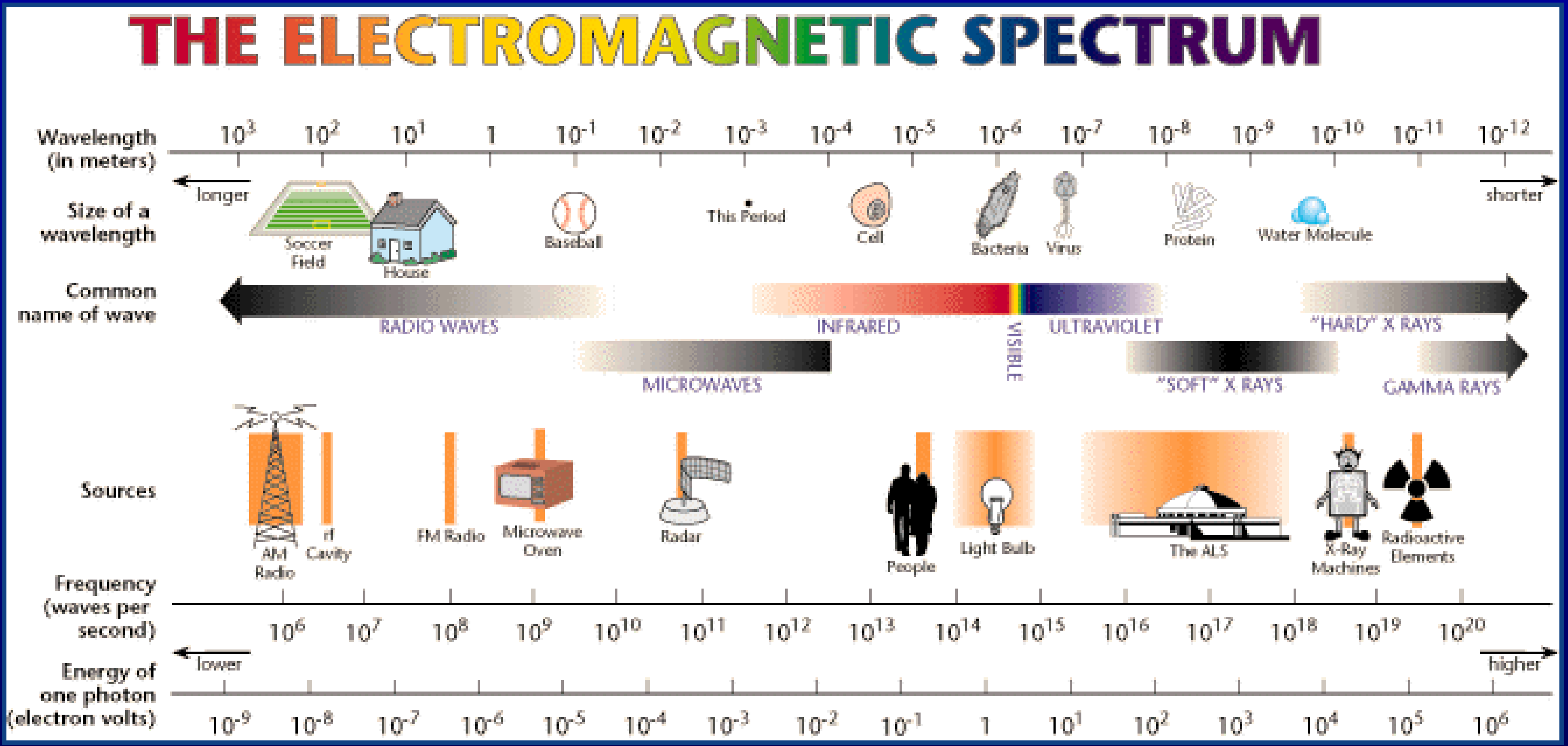


- Energy radiated from sun (or active sensor)
- Energy ∝ 1/wavelength (1/λ)
  - shorter λ (higher f) == higher energy
  - longer λ (lower f) == lower energy

from http://rst.gsfc.nasa.gov/Intro/Part2_4.html

Source: Electromagnetic radiation

Visible spectrum

- The small part of the EM spectrumthat can be detected by the humaneye

Blue (0.4-0.5 Em)

Green (0.5-0.6 Em)

Red (0.6-0.7 Em)

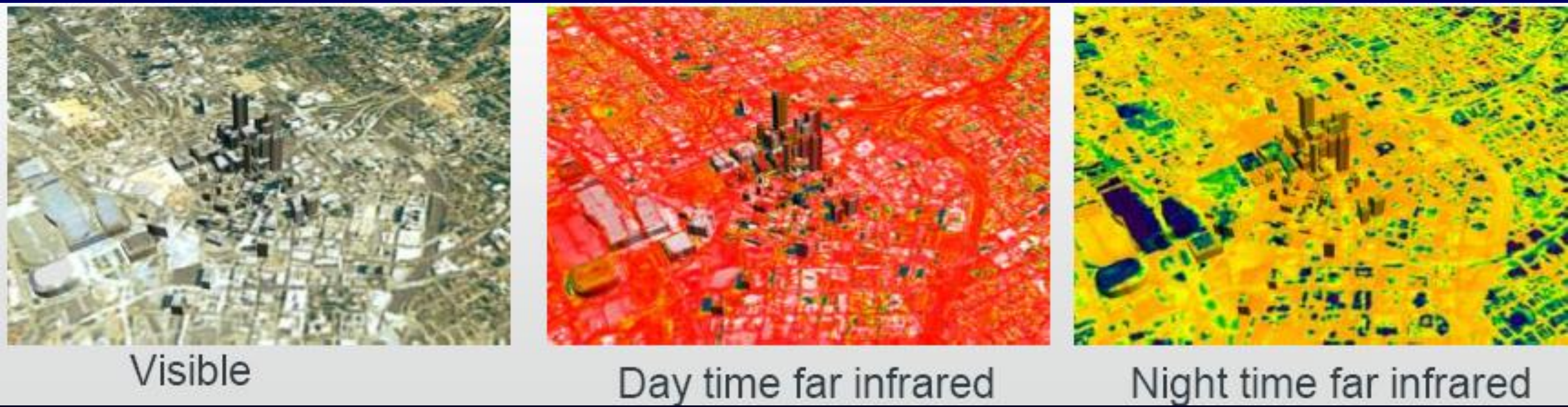
Optical remote sensing an provideus with true colour

بازگشت

Source: Electromagnetic radiation

Infra red spectrum

- Wavelengths are longer than visible red
- Subdivided into
  - Near infrared (NIR) 0.7 – 1.3 Pm
  - mid infrared (MIR) 1.3 – 3. 0 Pm
  - far infrared 3 Pm – 1 mm



بازگشت

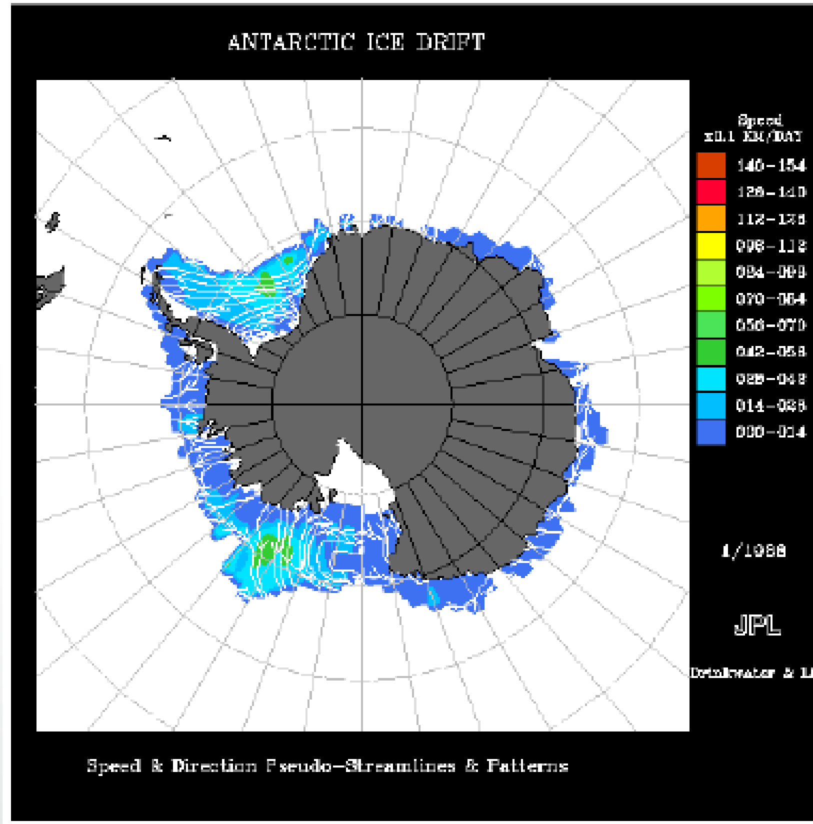
Source: Electromagnetic radiation

Microwave spectrum

- Wavelengths longer than Infra red
- **Microwaves (passive)**
- Passive microwave sensor detect

naturally emitted microwave energy

- All weather capability
- Requires antennas rather than optics
- Passive microwave RS is closely related to thermal sensors



SSM/I images of sea ice concentrations around Antarctica

بازگشت

Source: Electromagnetic radiation

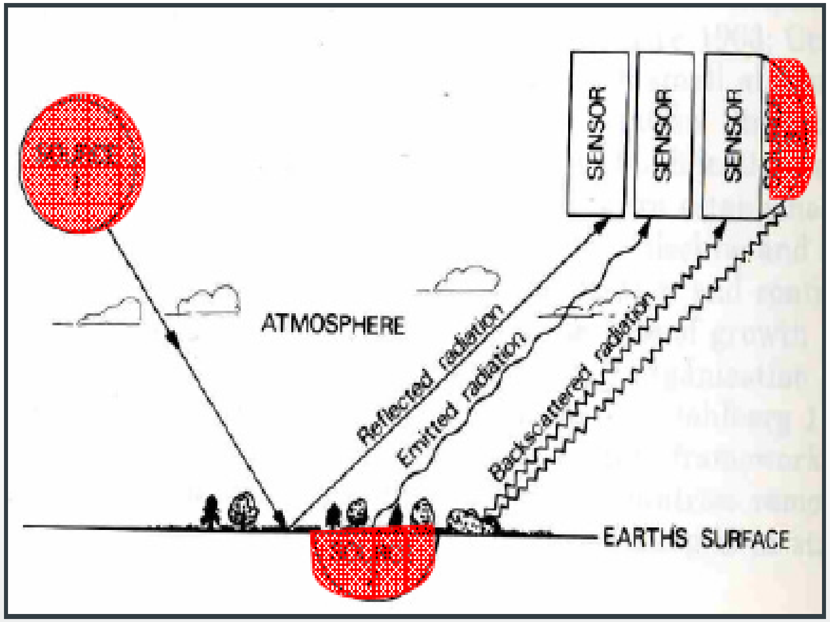
بازگشت

Microwave spectrum

- Wavelengths longer than Infra red
- **Microwaves (active)**
- Radarsat image of the Western part of theRoss Sea, Antarctica

Source: Electromagnetic radiation

- The multi concept in remote sensing make it a valuable tool for a number of applications
- A remote sensing system constitutes 4 components: a source, Atmospheric interaction, Interaction with objects and a sensor.
- Electromagnetic energy is the link between each component in a remote sensing system.
- Visible, Infrared and the microwave radiation are of greatest interest to remote sensing.



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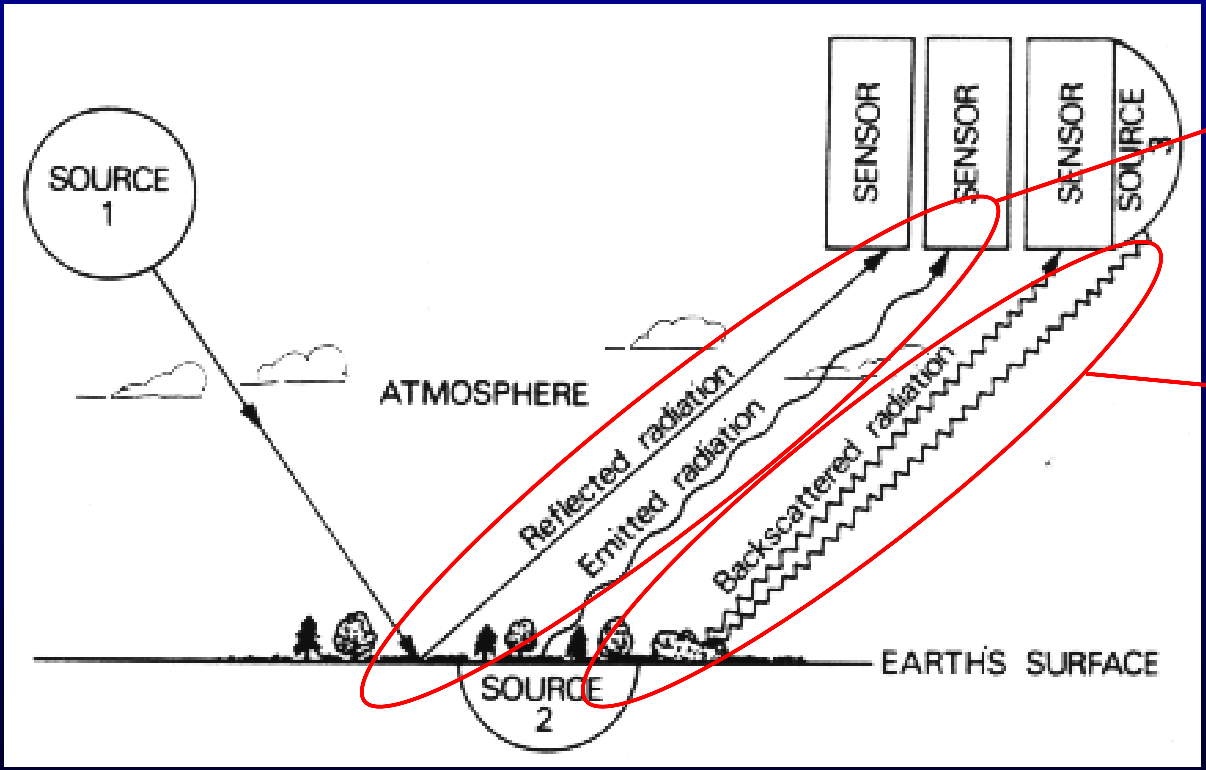

Passive: solar reflected/emitted

Active:RADAR (backscattered); LiDAR (reflected)

Issue No1

Remote sensing and GIS course

"**Types and Methods of Data Analysis for Earth Sciences**"

* I suggest selecting a series of short case studies to illustrate 2000 word maximum

* Fully referenced your work or use " " to show direct quotation

* Ensure references are up to date (last 10 years(

The coursework will be due to be submitted by 6 pm on 28 th February 2007

e-mail: m.ziaii47@gmail.com

Recommended Reading for Issue No1:

Borradaile G (2003), Statistics of Earth Science Data - Their Distribution in Time, Space and Orientation. Springer, Berlin Heidelberg New York

Carr JR (1995), Numerical Analysis for the Geological Sciences. Prentice Hall, Englewood Cliffs, New Jersey

Davis JC (2002), Statistics and data analysis in geology, third edition. John Wiley and Sons, New York

Mardia KV (1972), Statistics of Directional Data. Academic Press, London

Middleton GV (1999), Data Analysis in the Earth Sciences Using MATLAB. Prentice Hall

Press WH, Teukolsky SA, Vetterling WT (1992) Numerical Recipes in Fortran 77. Cambridge University Press

Press WH, Teukolsky SA, Vetterling WT, Flannery BP (2002) Numerical Recipes in C++.Cambridge University Press

Swan ARH, Sandilands M (1995), Introduction to geological data analysis. Blackwell Sciences

Upton GJ, Fingleton B (1990) Spatial Data Analysis by Example, Categorial and Directional Data. John Wiley & Sons

Martin H. Trauth, (2006) MATLAB® Recipes for Earth Sciences, Springer-Verlag Berlin Heidelberg , Printed in The Netherlands, Web: www.mathworks.com

Issue No 2

Remote sensing and GIS course

"Pattern Recognition and Bayesian approach in Mining Geochemistry and Mining Geology "

* I suggest selecting a series of short case studies to illustrate 2000 word maximum
* Fully referenced your work or use " " to show direct quotation
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e-mail: m.ziaii47@gmail.com
Recommended Reading for Issue No1

Koutroumbas K., Theodoridis S., 2006, Pattern Recognition, Third Edition

Ziaii Mansour, Pouyan Ali, Ziaei Mahdi, Neuro-Fuzzy modelling in mining geochemistry: Identification of geochemical anomalies. J. Geochemical Exploration, Volume 100, Issue 1, January 2009, Pages 25-36**.** (ScienceDirect Topic Alert: Earth Sciences - VnGG Geoscience Publications).

Mansour.Ziaii, A.Pouyan, Mahdi Ziaii, Geochemical anomaly recognition using fuzzy C-means cluster analysis, J.Wseas transactions on systems, P.2424-2430, Oct. 2006.

Ziaii M., Abedi A. and Ziaei M. 2009. Geochemical and mineralogical pattern recognition and modeling with a Bayesian approach to hydrothermal gold deposits. Special issue of Applied Geochemistry

Ziaii Mansour, Pouyan Ali, Ziaei Mahdi., 2009. A Computational Optimized Extended Model for Mineral Potential Mapping Based on WofE Method, American Journal of Applied Sciences 6 (2): 200-203.