Remote sensing: Scope & research options

OJ Botai

Department of Geography, Geoinformatics & Meteorology
University of Pretoria

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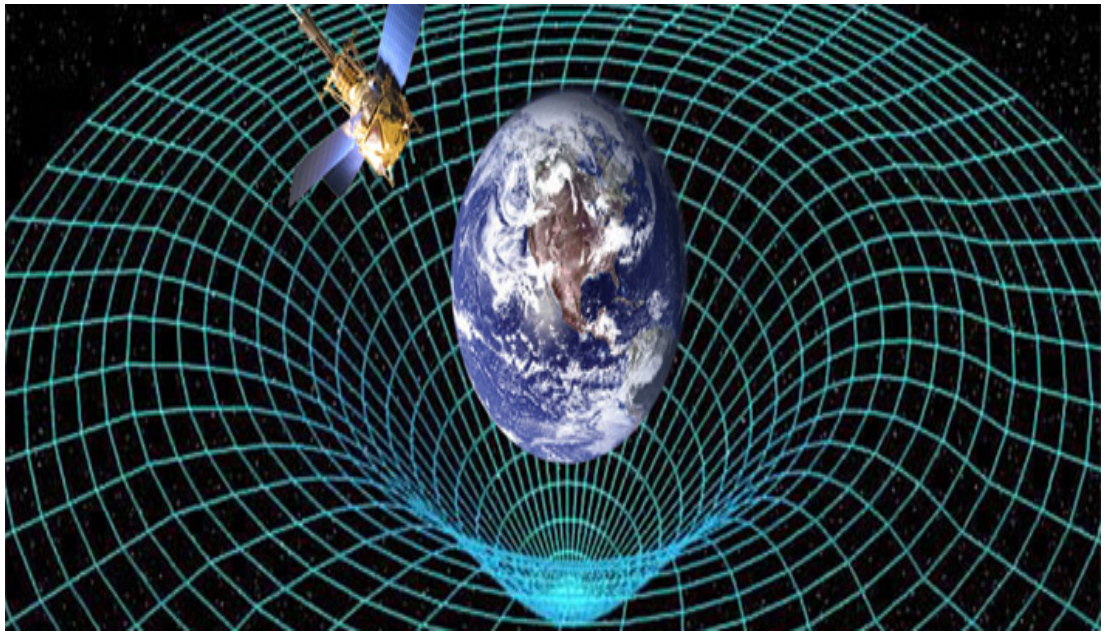
Outline

Objectives of the present talk



- Provide a general description of remote sensing[a]
- Cite some examples of applications of remote sensing (see Philemon's presentation)

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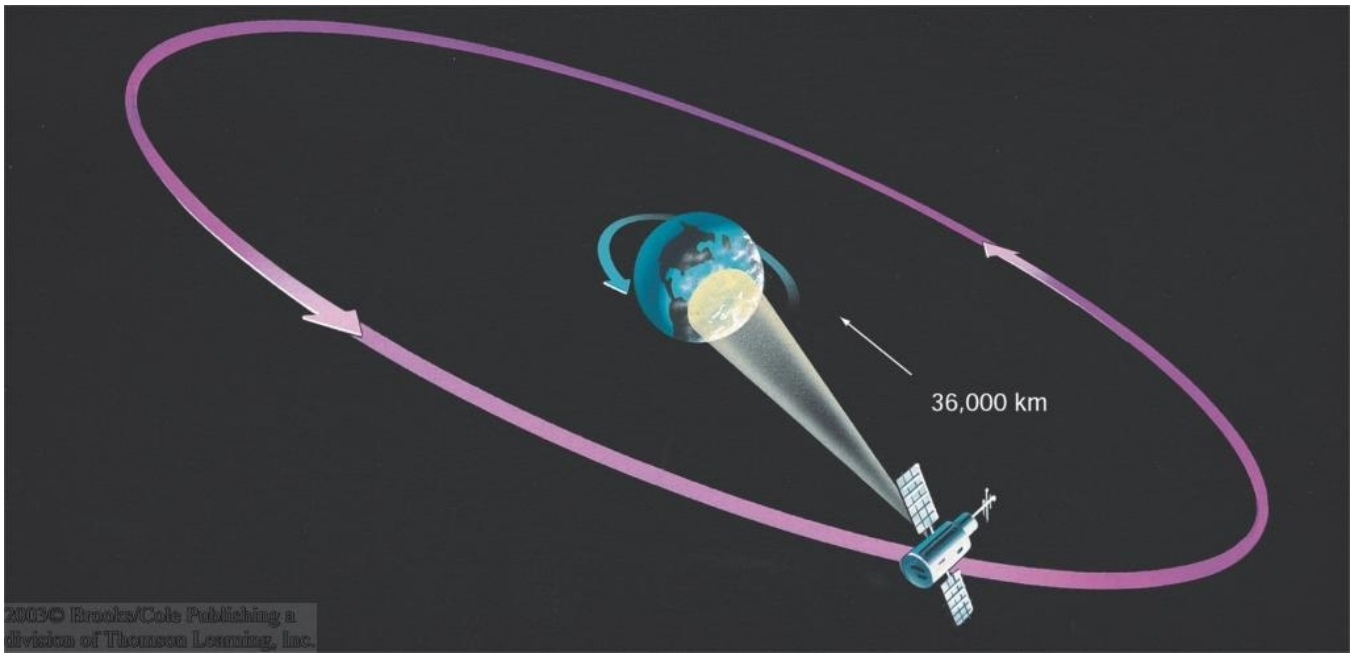
a

- What is a satellite?
- What is satellite remote sensing?

Albert Einstein ...

I want to know how God created this world. I am not interested in this or that phenomenon, in the spectrum of this or that element. I want to know His thoughts; the rest are details ....



Geostationary satellites are able to view earth from above[a] →:

[a] Acquisition & analysis of information ∼ objects or phenomena from a distance.

Why do we care?

- Remote sensing is interdisciplinary(widely used across many disciplines) .e.g., GIS, Environmental science, Geography, Meteorology, Astronomy, etc
- Source of employment in various fields[1]
- Strengths: synoptic, global, all-weather, all terrain, safe, cheap (after initial investment),non-destructive, change detection
- Weaknesses: calibration/validation needed, initial high cost/risk, high data rates/volumes,indirect

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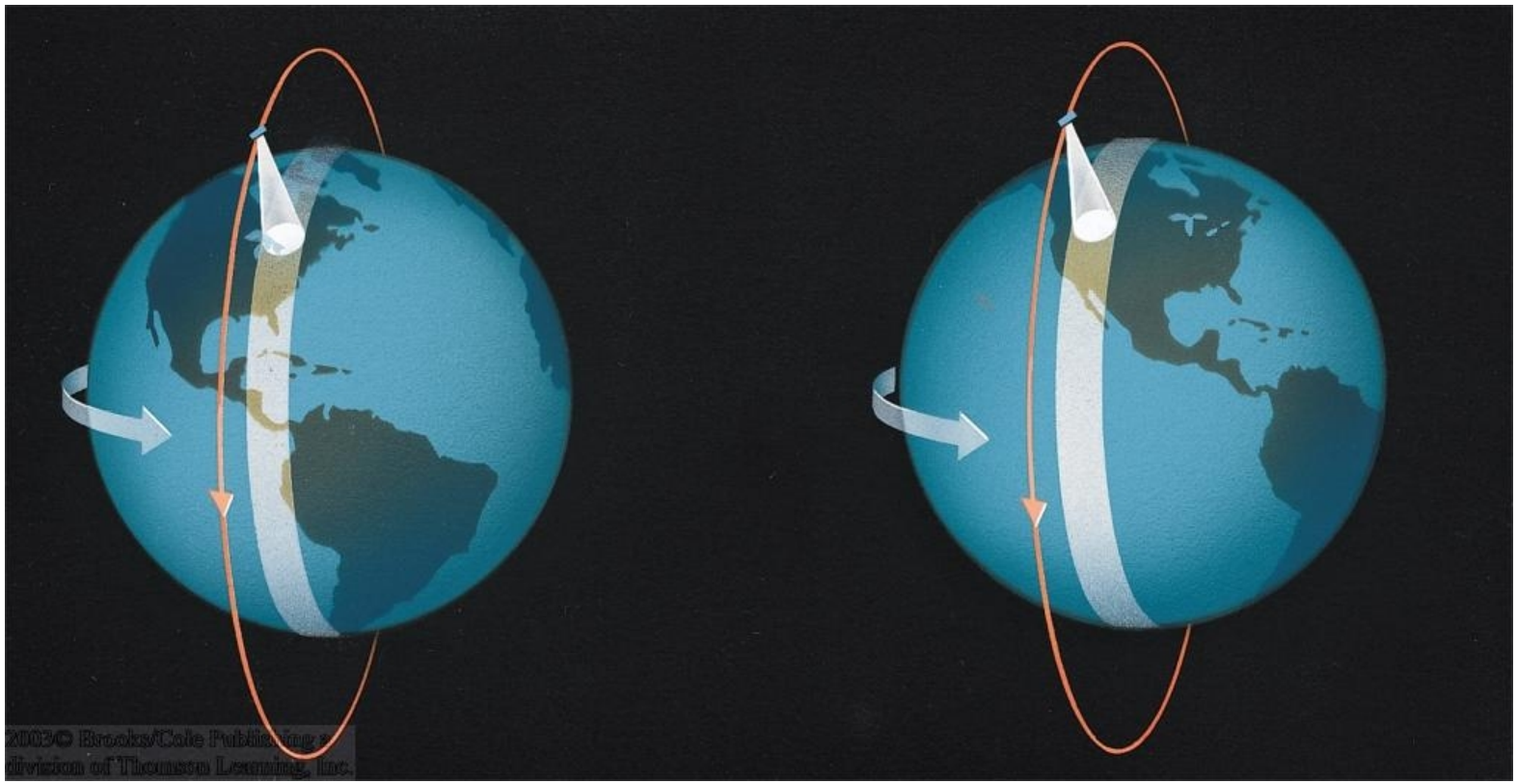
- Researcher: Earth system science, atmosphere & Astronomer etc
- Policy formulation & implementation: Government Depts, NGOs, International Organizations: UNDP

Definition of remote sensing

- Measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is NOT in physical contact with the object or phenomenon under study (Colwell, 1997).

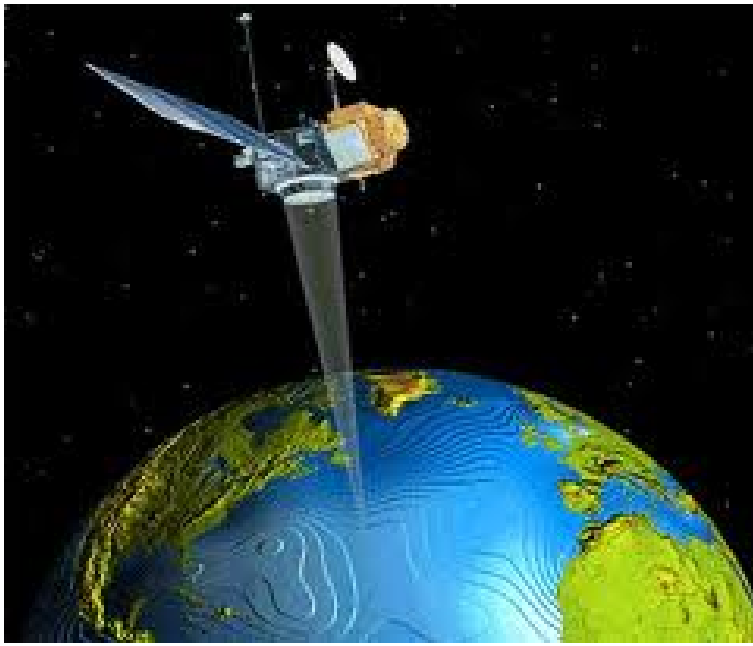


Polar Earth orbiting satellites

Definition ...

ASPRS[a] adopted a combined formal definition of photogrammetry and remote sensing as (Colwell, 1997):

- The art, science, & technology of obtaining reliable information about physical objects & the environment, through the process of recording, measuring and interpreting imagery and digital representations of energy patterns derived from noncontact sensor systems



[a] American Society for Photogrammetry & Remote Sensing

How far does the defination of remote sensing go[2]?

- Remote sensing utilises sensors onboard sub-orbital (aircraft) or orbital platforms (spacecraft/satellites) to look:

Inward onto Earth: Surface, Oceans & atmosphere

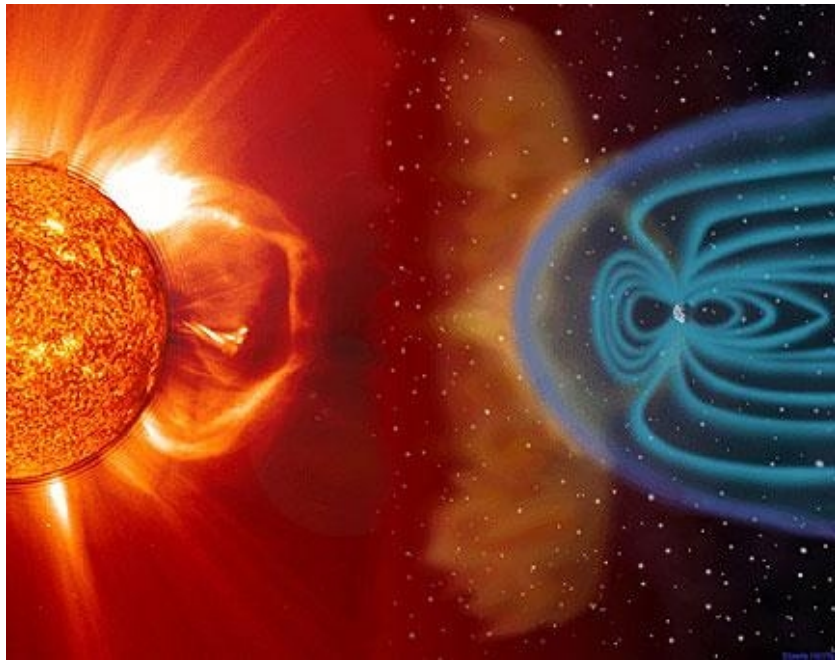
Outward: to the planets, the galaxies & even going back in time: entire universe → Cosmos

[2] As far as architecture, archaeology, medicine, industrial quality control, robotics & extraterrestrial imaging

EMR as an information carrier · · ·

- A star at the center of the solar system
- Diameter ∼700,000 km & $T_s \sim 5{,}527\ ^\circ\text{C}$
- Energy is produce by the Thermonuclear reactions
- The core is simply an inferno i.e., $T_c \sim 14{,}999{,}727\ ^\circ\text{C}$[a]

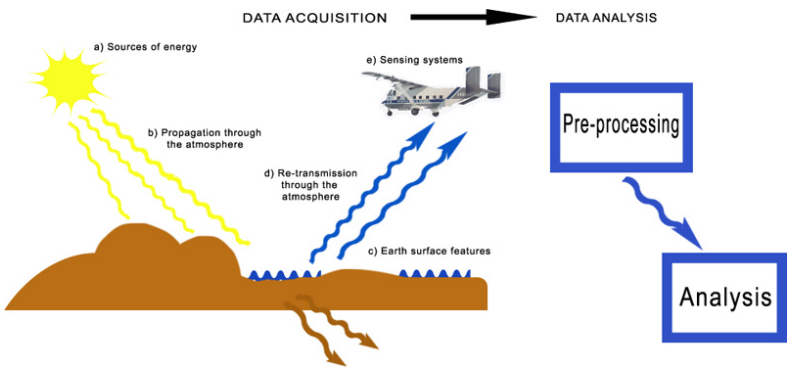
[a] Troubleshooting-1: Do you think that an atom could exist at this temperature?



Thermonuclear reaction in the sun

As a process, see DIKI: Data Information Knowledge Intelligence

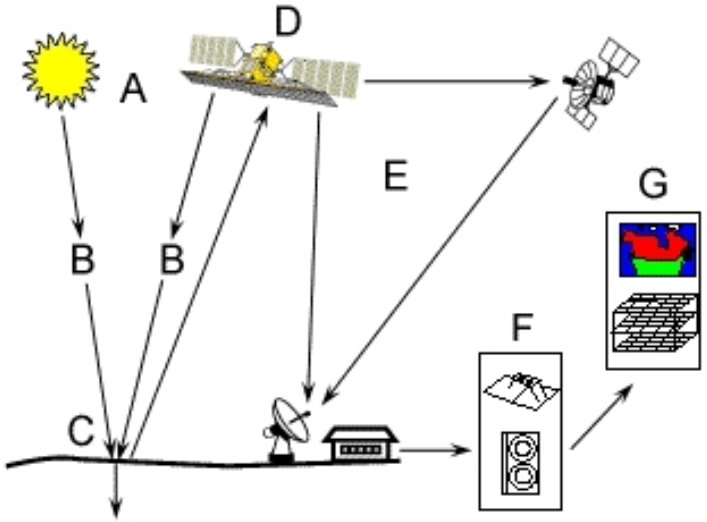
1. Data acquisition cycle
   - energy sources
   - energy through the atmosphere
   - interaction with surface features
   - retransmission
   - sensor systems
2. Data analysis: Data → information conversion
   - data processing
   - compilation
   - application



Notice that EM interacts with physical matter in different ways & in different parts of the spectrum.

Remote sensing data collection cycle

- A: Energy source/Illumination
- B: Radiation & Atmosphere
- C: Radiation interaction with target
- D: Sensor
- E: Transmission, Reception & Processing
- F: Interpretation & Analysis



- Target object & EMR interacts through a medium: the atmosphere
- Process is via systems with elements or components

Remote sensing as a Science

- Science: broad field of human knowledge concerned with facts held together by principles (rules).
- Scientists generally feel that any subject that man can study by using the scientific method[3] and other special rules of thinking may be called a science[4]

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[3] an orderly system of solving problems

[4]

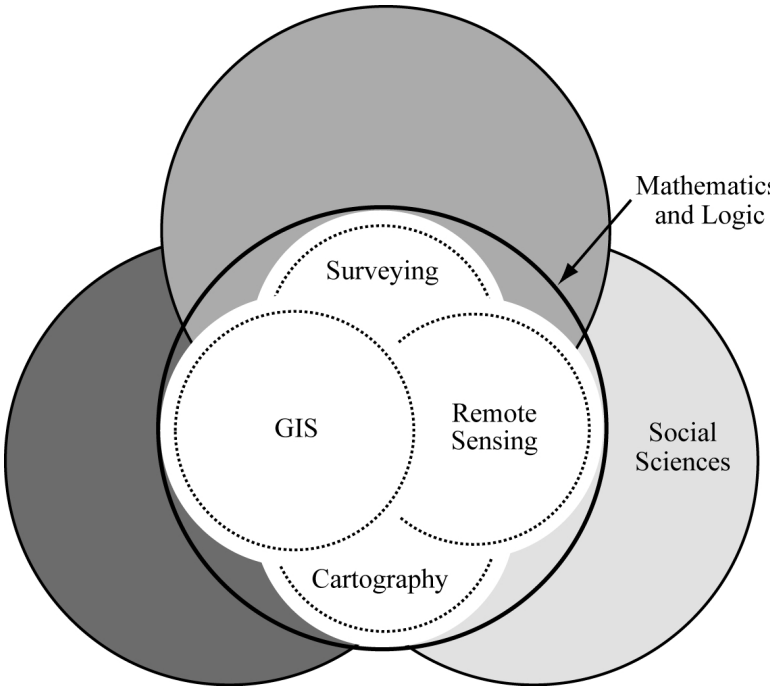
- Mathematics & logic
- Physical sciences (e.g., physics & chemistry)
- Biological sciences (e.g., botany & zoology)
- Social sciences (e.g., geography, sociology, & anthropology)

Observe that ....

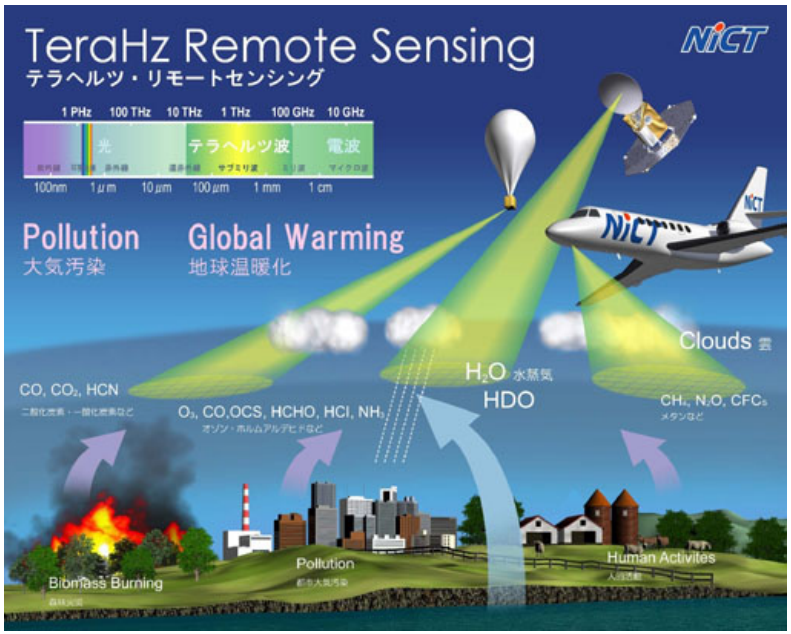
- Remote sensing is a tool or technique similar to mathematics.
- Using sensors to measure the amount of electromagnetic radiation (EMR) exiting an object or geographic area from a distance and then extracting valuable information from the data using quantitative[5] algorithms is a scientific activity.

[5] Mathematics & statistics

Interdisciplinary nature of remote sensing



Interaction model: It functions in harmony with other spatial data-collection techniques or tools of the mapping sciences

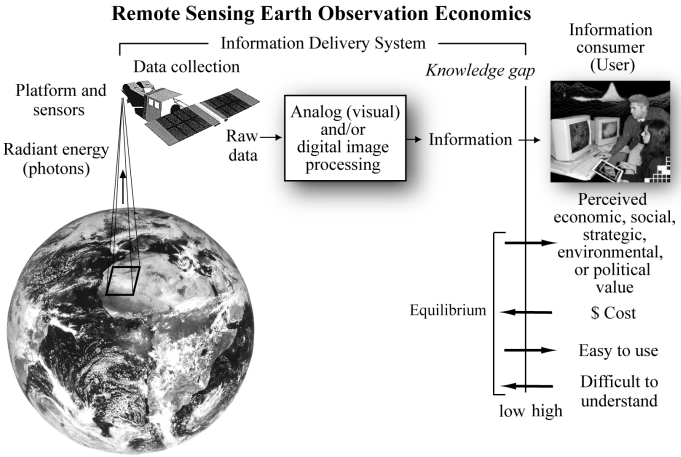


Is Remote Sensing an Art?

- Visual image interpretation brings to bear not only scientific knowledge but all of the experience that a person has obtained in a lifetime.
- The synergism of combining scientific knowledge with real-world analyst experience allows the interpreter to develop heuristic rules of thumb to extract information from the imagery.
- Thus, remote sensing image interpretation is both an art & a alertscience.

Information flow in remote sensing

- The EMR reflected, emitted, or back-scattered from an object or geographic area is used as a surrogate for the actual property under investigation.
- The EM measurements must be acalibrated and turned into information using visual & /or digital image processing techniques.



Sensors can be used to

- obtain specific information about an object (e.g., the diameter of a cottonwood tree crown) or
- geographic extent of a phenomenon (e.g., the boundary of a cottonwood stand)

Data collection and analysis procedures[6]

The Remote Sensing Process

Statement of the Problem → **Data Collection** → **Data-to-Information Conversion** → **Information Presentation**

- **Formulate Hypothesis** (if appropriate)
- **Select Appropriate Logic**
  - Inductive and/or
  - Deductive
  - Technological
- **Select Appropriate Model**
  - Deterministic
    - Empirical
    - Knowledge-based
    - Process-based
  - Stochastic

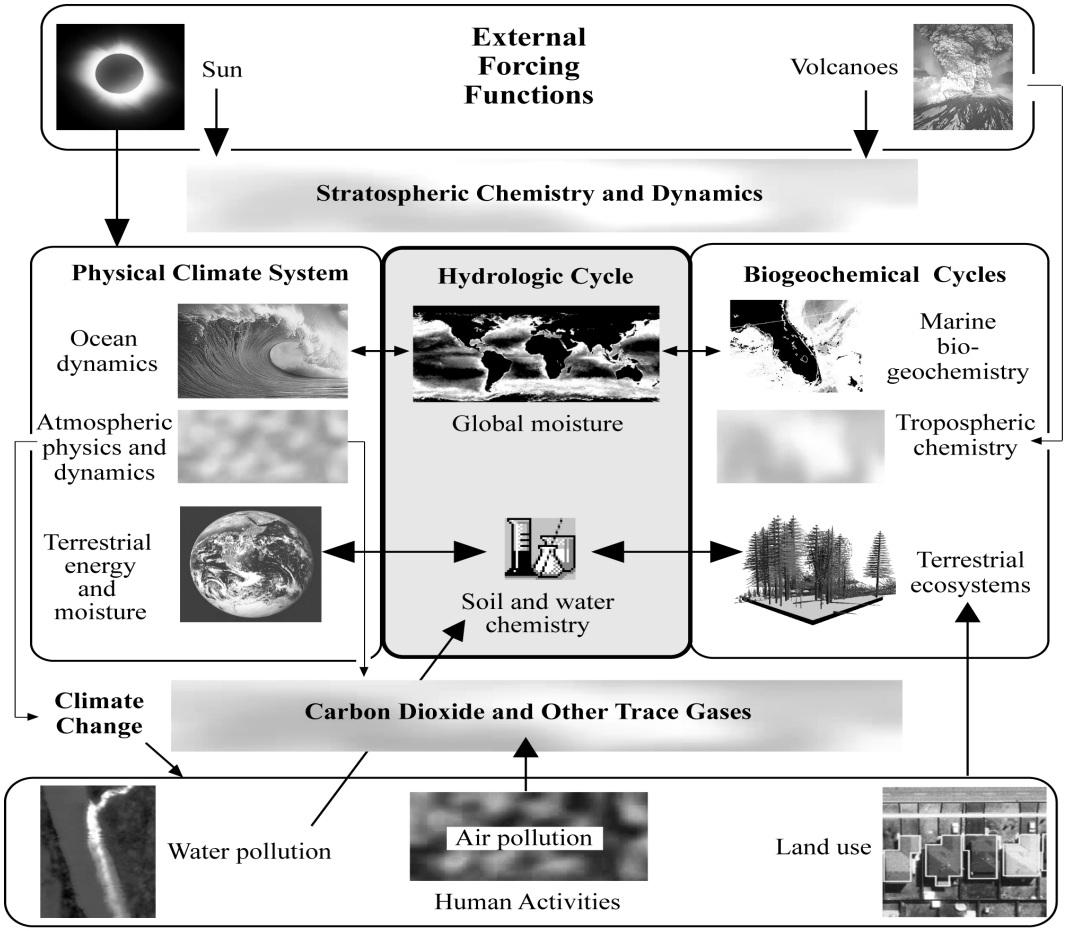
- ***In Situ* Measurements**
  - Field (e.g., *x,y,z* from GPS, biomass, reflectance)
  - Laboratory (e.g., reflectance, leaf area index)
- **Collateral Data**
  - Digital elevation models
  - Soil maps
  - Surficial geology maps
  - Population density, etc.
- **Remote Sensing**
  - Passive analog
    - Frame camera
    - Videography
  - Passive digital
    - Frame camera
    - Scanners
      - Multispectral
      - Hyperspectral
    - Linear and area arrays
      - Multispectral
      - Hyperspectral
  - Active
    - Microwave (RADAR)
    - Laser (LIDAR)
    - Acoustic (SONAR)

- **Analog (Visual) Image Processing**
  - Using the *Elements of Image Interpretation*
- **Digital Image Processing**
  - Preprocessing
    - Radiometric Correction
    - Geometric Correction
  - Enhancement
  - Photogrammetric analysis
  - Parametric, such as
    - Maximum likelihood
  - Nonparametric, such as
    - Artificial neural networks
  - Nonmetric, such as
    - Expert systems
    - Decision-tree classifiers
    - Machine learning
  - Hyperspectral analysis
  - Change detection
  - Modeling
    - Spatial modeling using GIS data
    - Scene modeling
  - Scientific geovisualization
    - 1, 2, 3, and *n* dimensions
- **Hypothesis Testing**
  - Accept or reject hypothesis

- **Image Metadata**
  - Sources
  - Processing lineage
- **Accuracy Assessment**
  - Geometric
  - Radiometric
  - Thematic
  - Change detection
- **Analog and Digital**
  - Images
    - Unrectified
    - Orthoimages
  - Orthophotomaps
  - Thematic maps
  - GIS databases
  - Animations
  - Simulations
- **Statistics**
  - Univariate
  - Multivariate
- **Graphs**
  - 1, 2, and 3 dimensions

[6] Are often implemented in a systematic fashion referred to as the remote sensing process

Remote Sensing for Earth System Science[7]



- see Philemon's talk

[7] Are often implemented in a systematic fashion referred to as the remote sensing process

For Further Reading I

[1] J. R. Jensen,
Remote sensin of the environment, An Earth resource perspective,
second edition, Pearson, Prentice Hall, N. J., 2007.

[2] Lillesand et al.,
Remote sensing and image interpretation,
sixth edition, John Wiley & Sons, Inc., 2008.

[3] W. G. Rees,
Physical principles of remote sensing,
second edition, Cambridge University press, 2001.

[4] Other-1,
Any book sensing book,
Library or e-book.

For Further Reading II

[5] Other-2,
Any book sensing resources,
Online archives.