APPLICATION OF REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM IN CIVIL ENGINEERING

INSTRUCTOR

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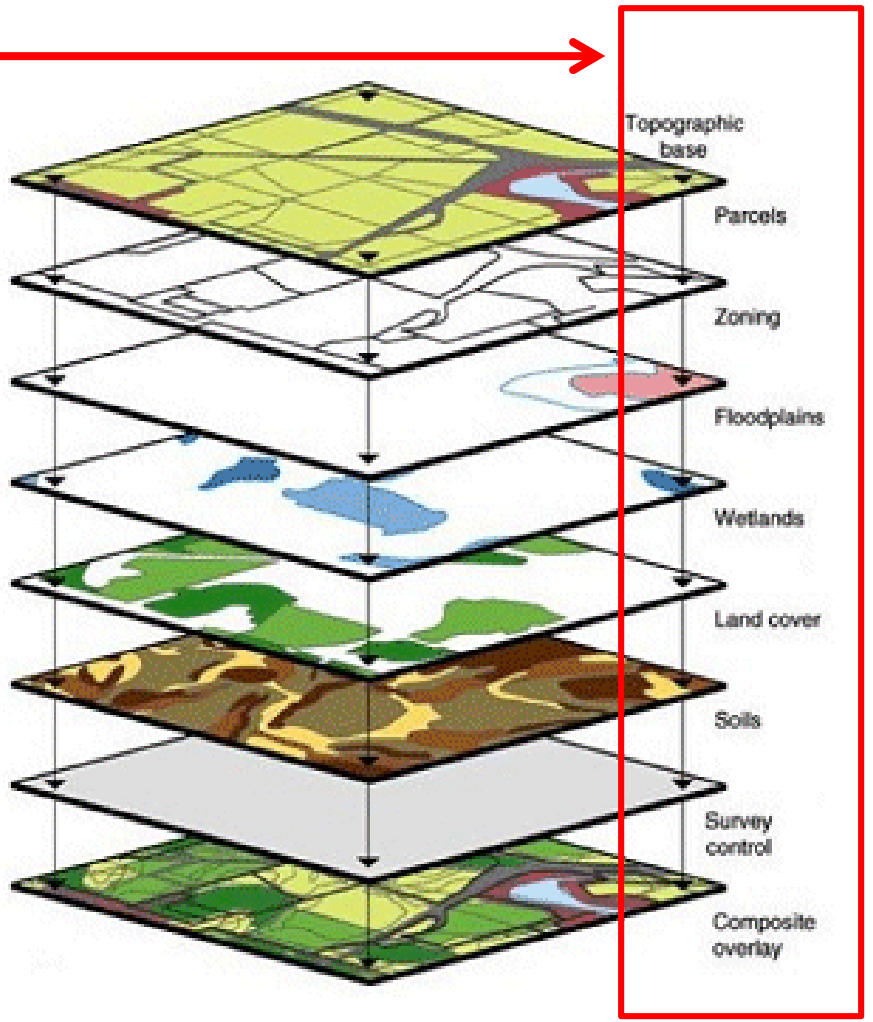
Date:

Application of Remote Sensing and Geographical Information System in Civil Engineering

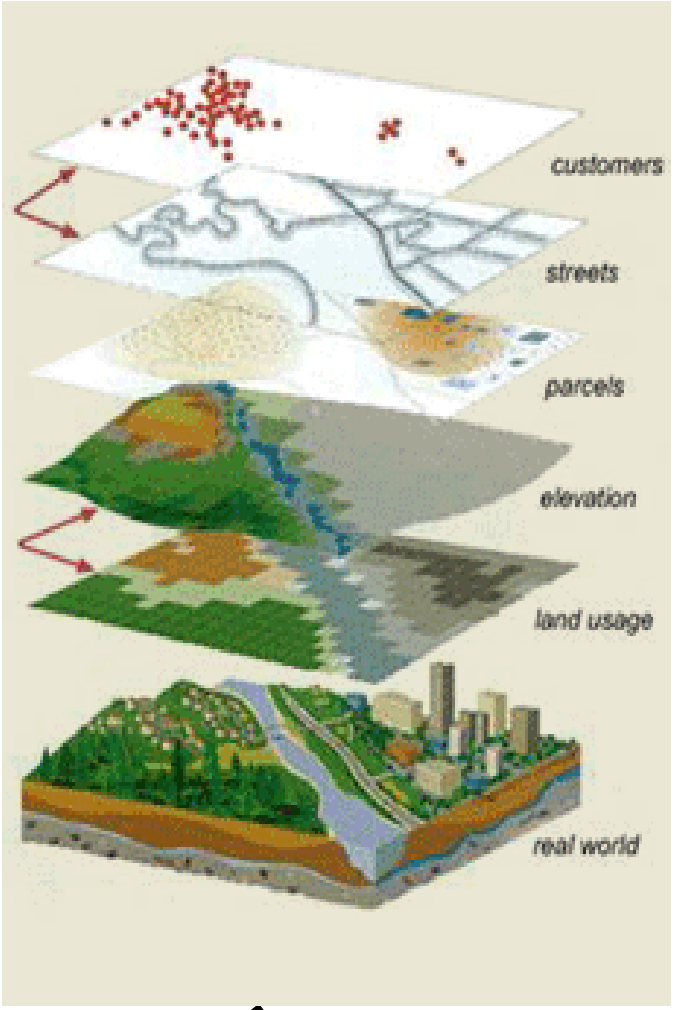
- **Remote Sensing (RS)**
  - Remotely sensing the useful information of object (earth)

- **Geographic Information System (GIS)**
  - A system that deals with all types of geographically referenced data

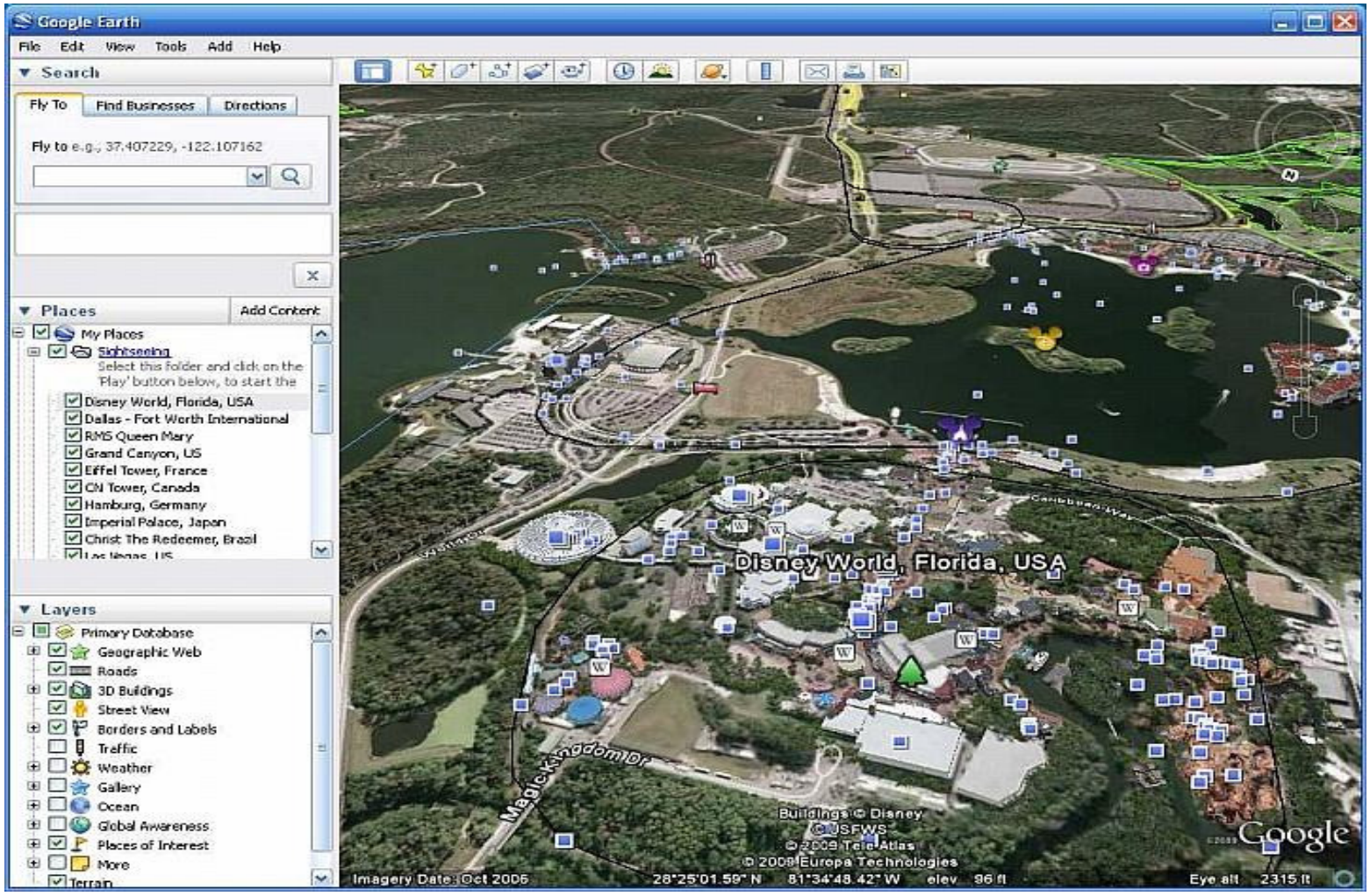


Application of Remote Sensing and Geographical Information System in Civil Engineering

- **Remote Sensing (RS)**
  - Remotely sensing the useful information of object (earth)
  - Process of recording, measuring and interpreting imagery and digital representations of energy patterns derived from **noncontact sensor systems**
- **Geographic Information System (GIS)**
  - A system designed to capture, store, manipulate, analyze, manage, and present all types of geographically referenced data



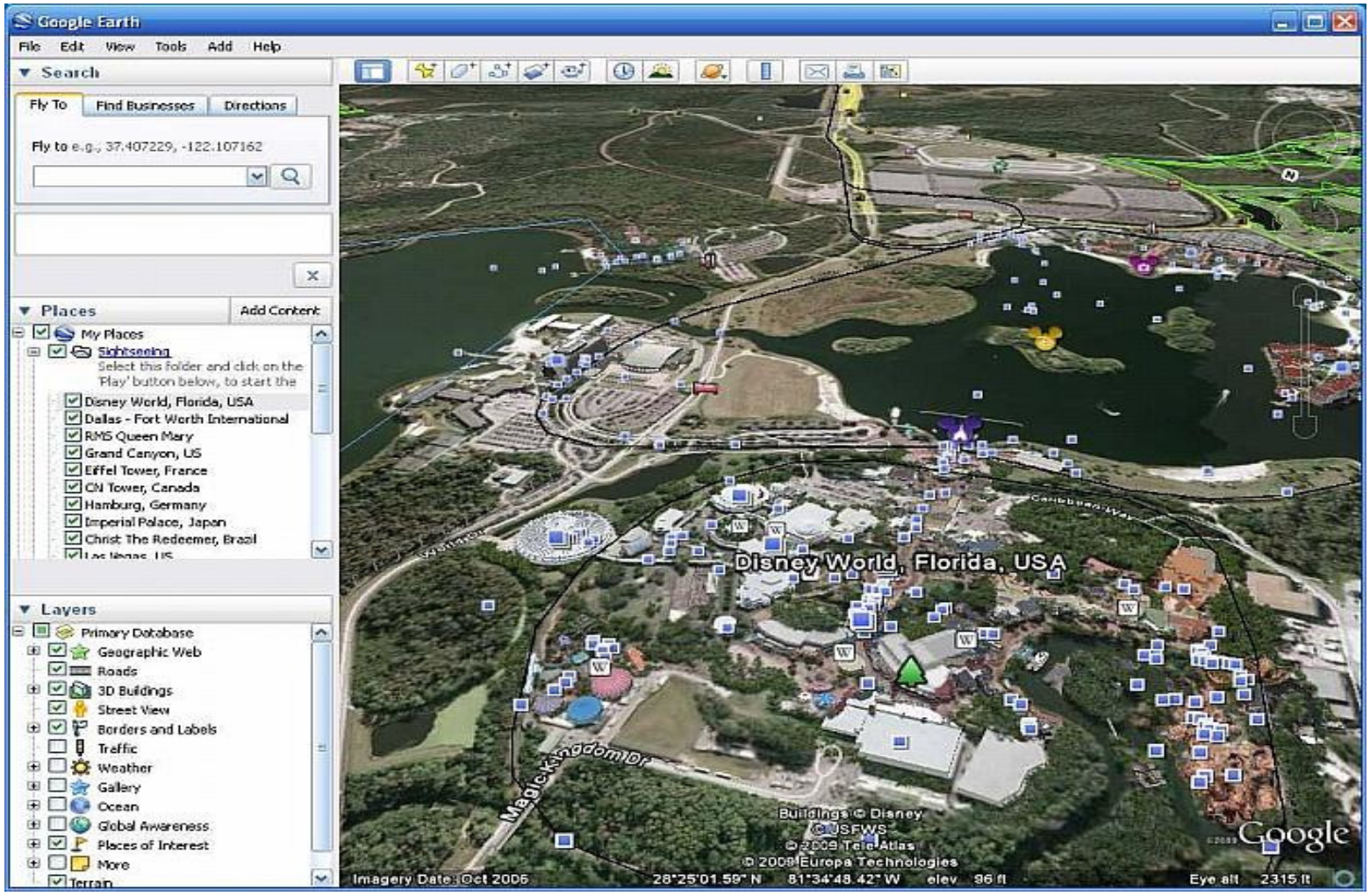
Can you recall Google Earth ?



The information in the Google earth is obtained through Remote Sensing

While its representation and management on geographical locations is made possible through GIS

Can you recall Google Earth ?



Lets look at small movies about Google earth to learn more about the remotely sensed information and its geographical referencing of the information

Remote Sensing

- Remote sensing has been variously defined but basically it is the art or science of **telling something** about an object **without touching** it. (Fischer et al., 1976, p. 34)
- Remote sensing is the **acquisition of physical data** of an **object** without **touch or contact.** (Lintz and Simonett, 1976, p. 1)
- Remote sensing is the **observation** of a **target** by a device separated from it by **some distance.** (Barrett and Curtis, 1976, p. 3)
- The term "remote sensing" in its broadest sense merely means "**reconnaissance** at a **distance.**" (Colwell, 1966, p. 71)
- Remote sensing is the art, science and technology of **obtaining reliable information** about physical **objects and the environment,** through the process of recording, measuring and interpreting imagery and digital representations of **energy patterns** derived from **noncontact sensor systems** (Lecture Note by Wataru, 2009)

Remote Sensing

- Remote sensing is the **science of deriving information** about an **object** from **measurements** made at a **distance** from the object, i.e., **without actually coming in contact with it**. The quantity most frequently measured in present-day remote sensing systems is the **electromagnetic energy** emanating from objects of interest, and although there are other possibilities (e.g., seismic waves, sonic waves, and gravitational force), our attention . . . is focused upon systems which measure electromagnetic energy. (D. A. Landgrebe, quoted in Swain and Davis, 1978, p. 1)

- *Remote sensing is the practice of **deriving information** about the **Earth's land** and water surfaces using images acquired from an **overhead perspective**, using **electromagnetic radiation** in one or more regions of the electromagnetic spectrum, **reflected or emitted** from the Earth's surface.* (James B. Campbell, Randolph H. Wynne (2011): Introduction to Remote Sensing)

Is remote sensing limited to use of electromagnetic radiation !!!?

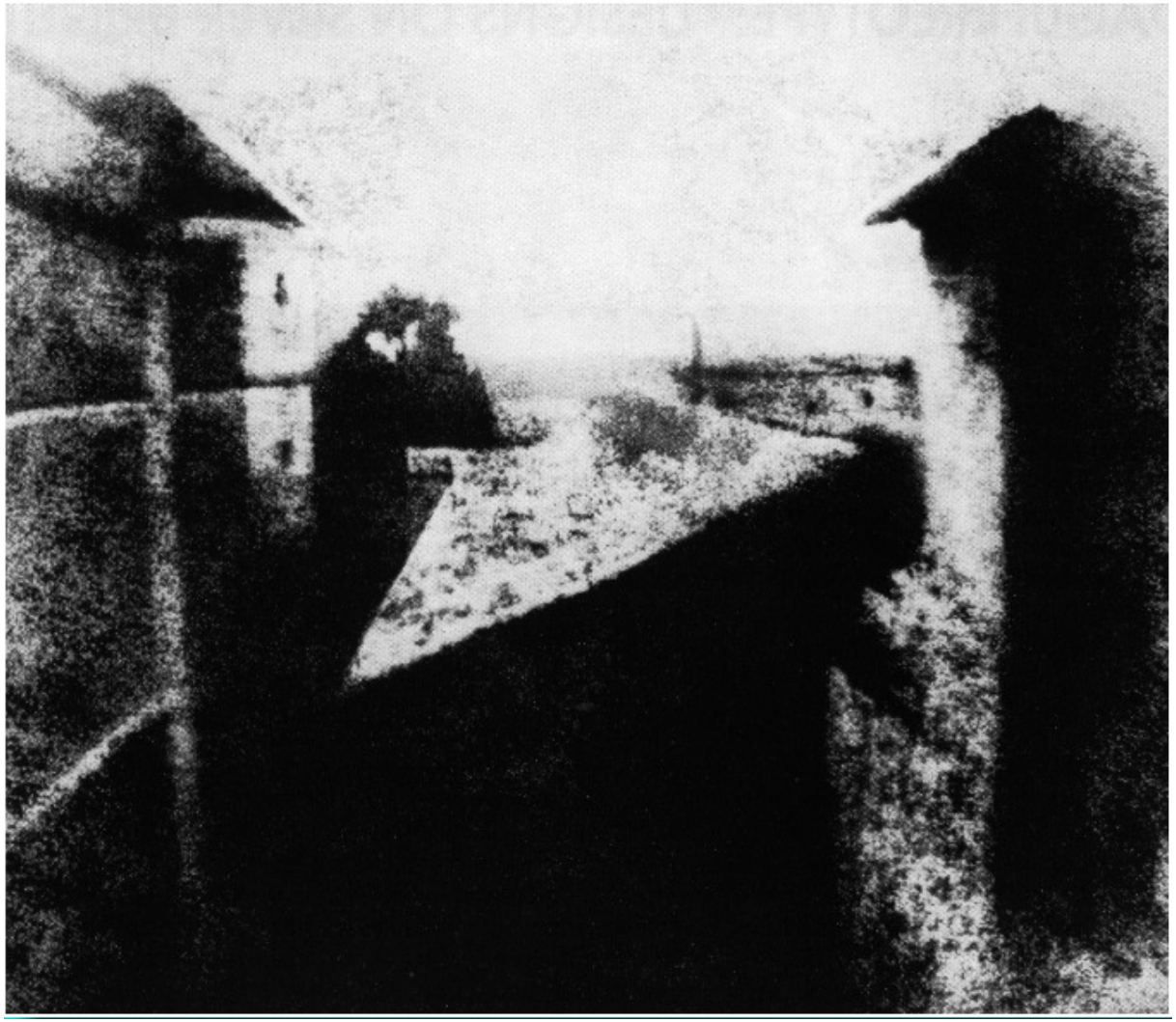
History of Remote Sensing

- **Natural:**
  - Oldest Compound Eyes
- **Artificial:**
- 1800: Discovery of infrared by Sir William Herschel
- 1826: Joseph Niepce takes first photograph
- 1839: Beginning of practice of photography
- 1850–1860: Photography from balloons
- 1858: Gaspard Tournachon takes first aerial photograph from a balloon
- 1847: Infrared spectrum shown by A. H. L. Fizeau and J. B. L. Foucault to share properties with visible light
- 1873: Theory of electromagnetic energy developed by James Clerk Maxwell
- 1909: Photography from airplanes
- 1914-1918 World War I: Aerial reconnaissance
- 1920–1930: Development and initial applications of aerial photography and photogrammetry

History of Remote Sensing

- 1929–1939: Economic depression generates environmental crises that lead to governmental applications of aerial photography
- 1930–1940: Development of radars in Germany, US, and UK
- 1939–1945: World War II: applications of nonvisible portions of electromagnetic spectrum; training of persons in acquisition and interpretation of airphotos
- 1950–1960: Military research and development
- 1956 Colwell's research on plant disease detection with infrared photography
- 1960–1970: First use of term *remote sensing* TIROS weather satellite Skylab remote sensing observations from space
- 1972: Launch of Landsat 1
- 1970–1980: Rapid advances in digital image processing
- 1980–1990: Landsat 4: new generation of Landsat sensors
- 1986: SPOT French Earth observation satellite
- 1980s: Development of hyperspectral sensors
- 1990s: Global remote sensing systems, lidars

History of Remote Sensing

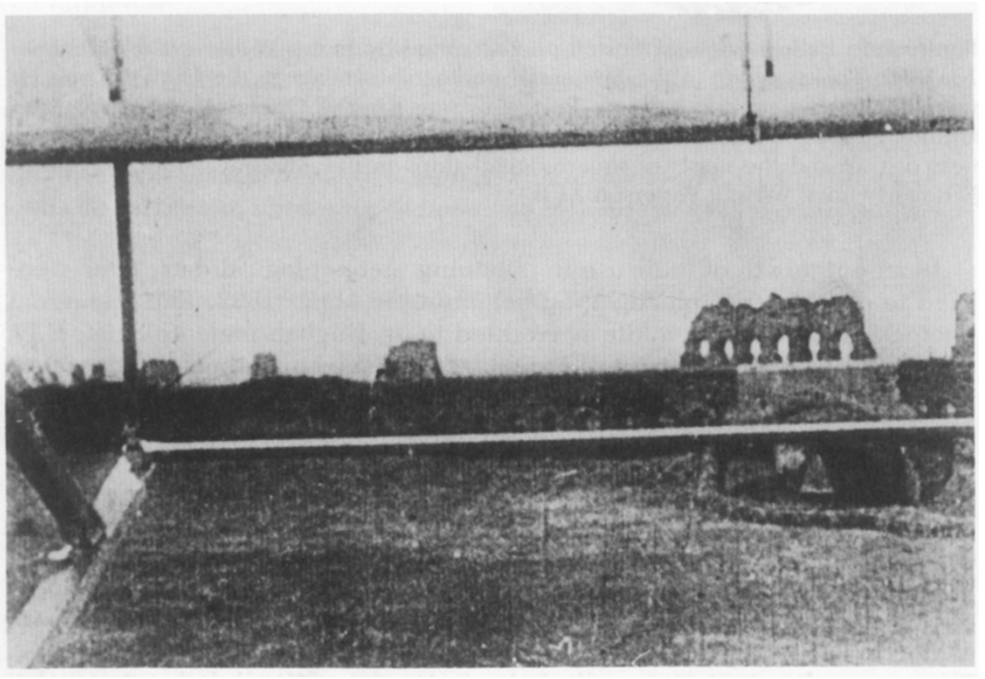


(copyright Gernsheim Collection, U-Texas)

Joseph Niepce

History of Remote Sensing

The first photo taken from balloon (1858)



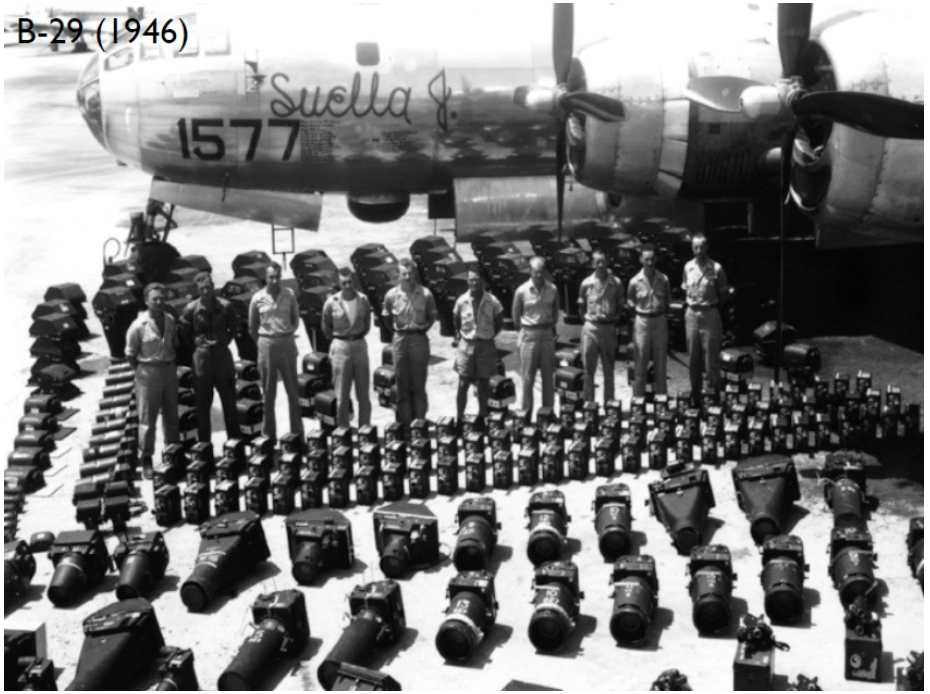
First Aerial Photograph from Airplane: Italy 24-04-1909 (Oblique view of walls of Centocelli Italy, by Wibur Wright)

History of Remote Sensing

Early aerial photography by the U.S. Navy, 1914. This photograph illustrates difficulties encountered in early efforts to match the camera with the airplane

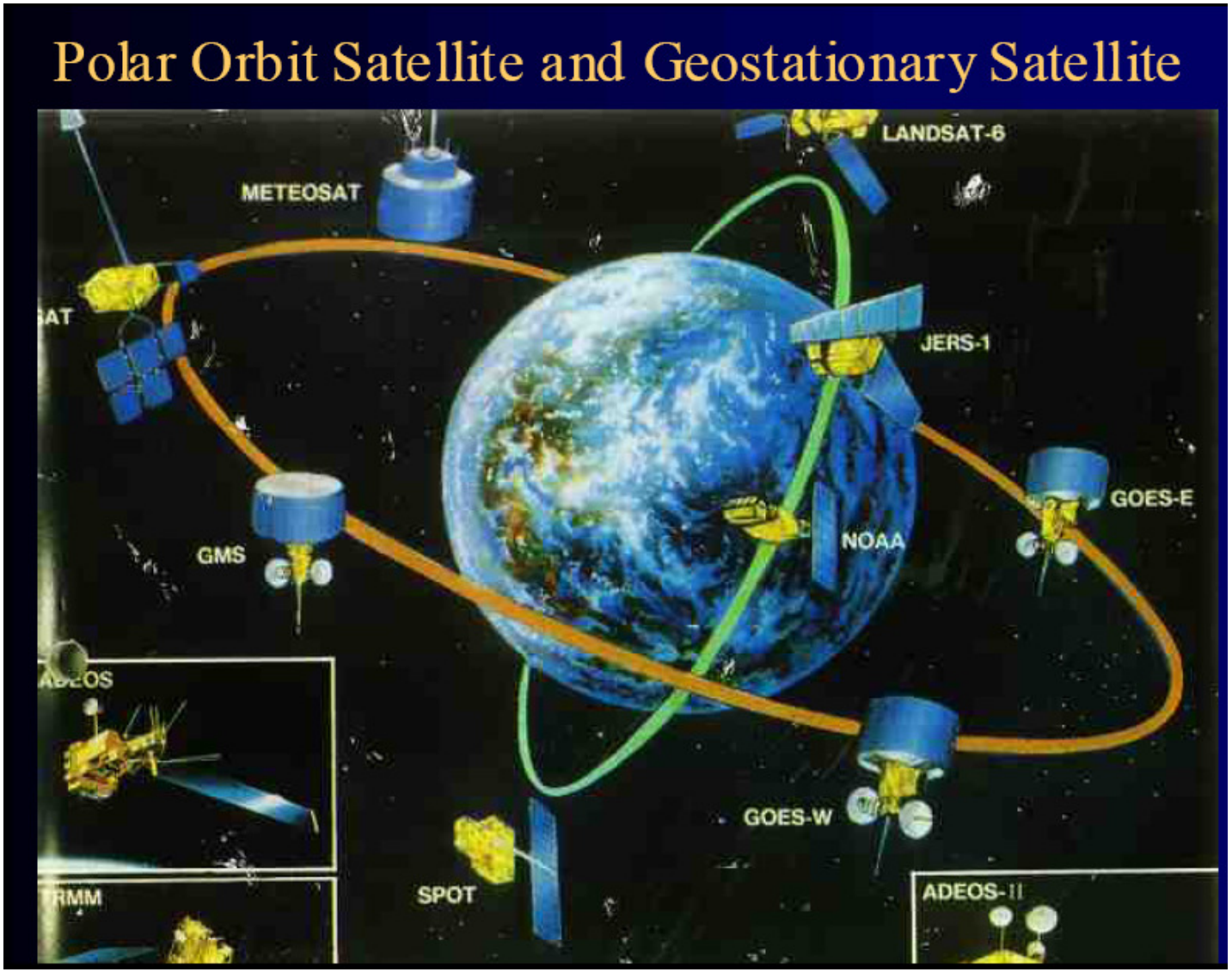
History of Remote Sensing

Aerial photography, World War I



Aerial photography, World War II

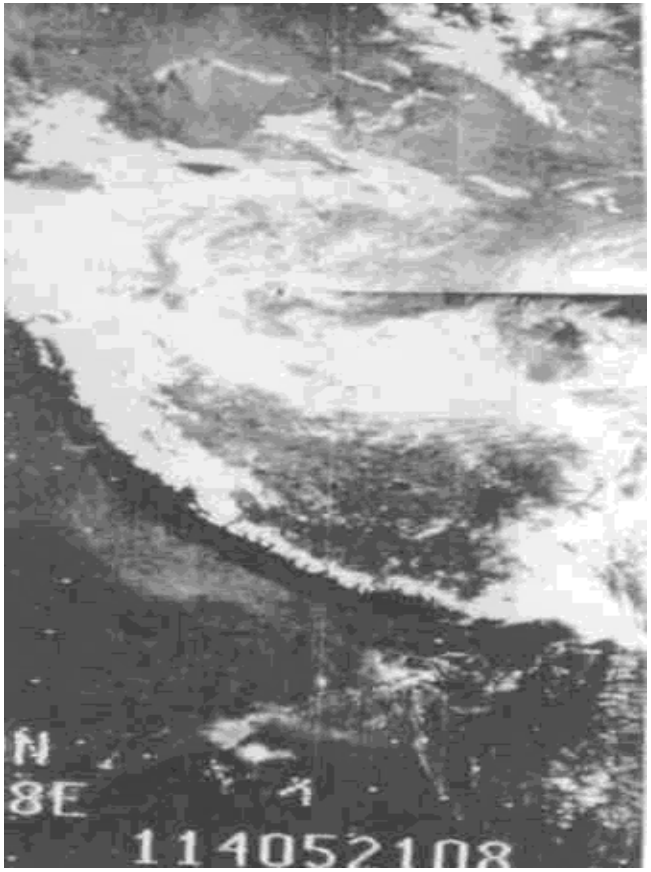
History of Remote Sensing



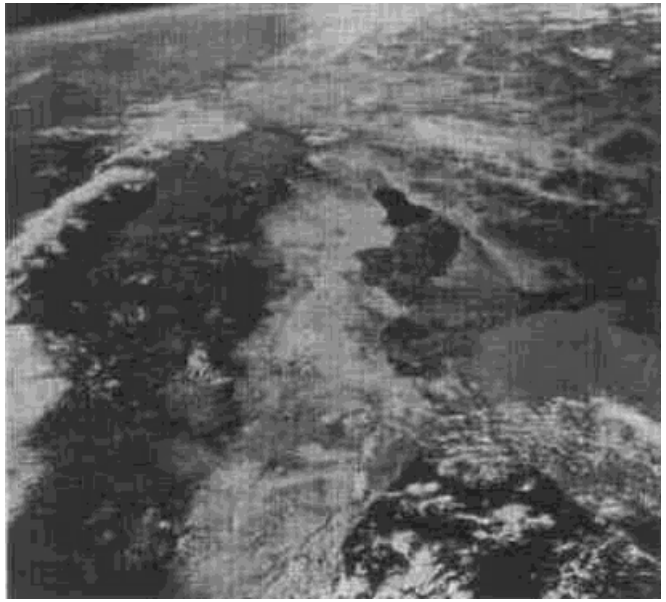
Modern day remote sensing using satellites

Early Pictures of Satellites

Saudi Arabia



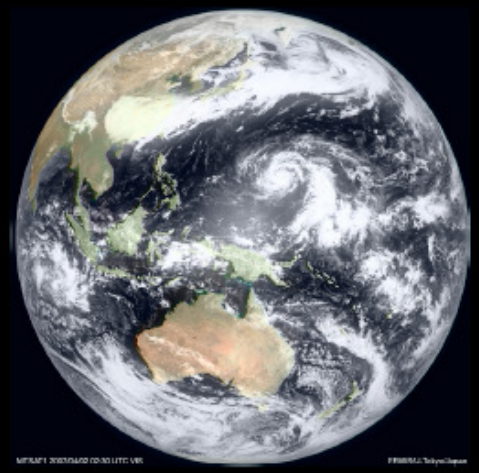
Eastern India, Bangladesh & Himalayas (20N, 88E)



Gulf of California and Southern California

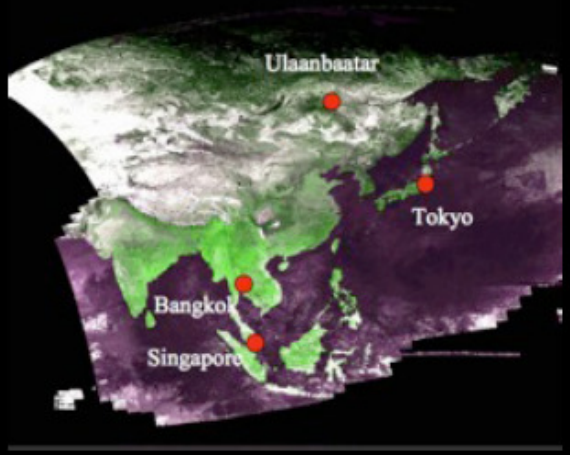
History of Remote Sensing: Satellites

1



GMS, MTSAT (~4km)

2



AVHRR, MODIS (~1km)

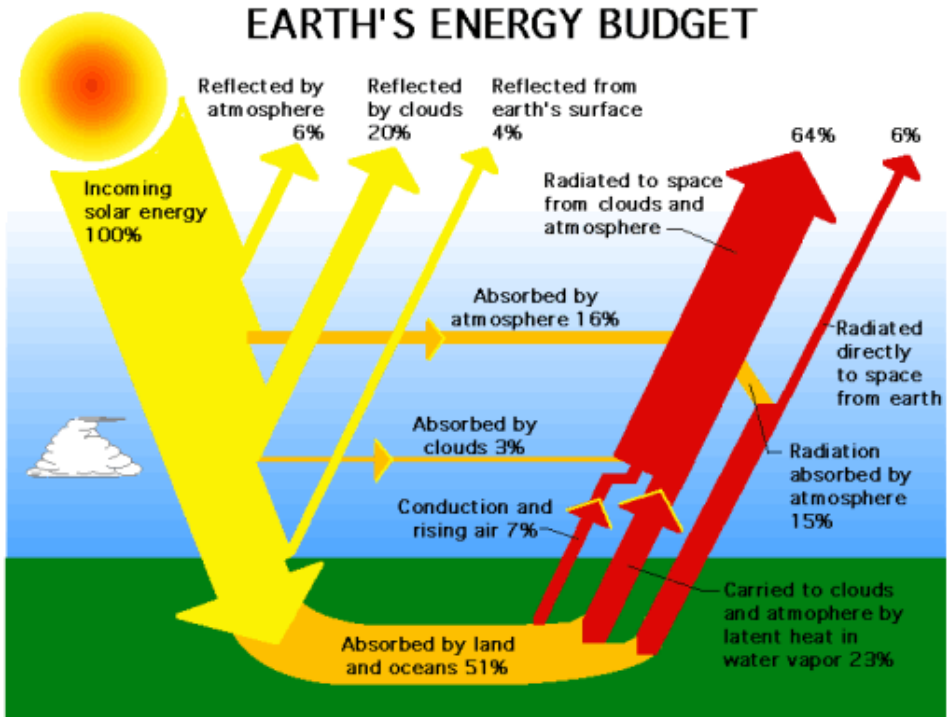
4

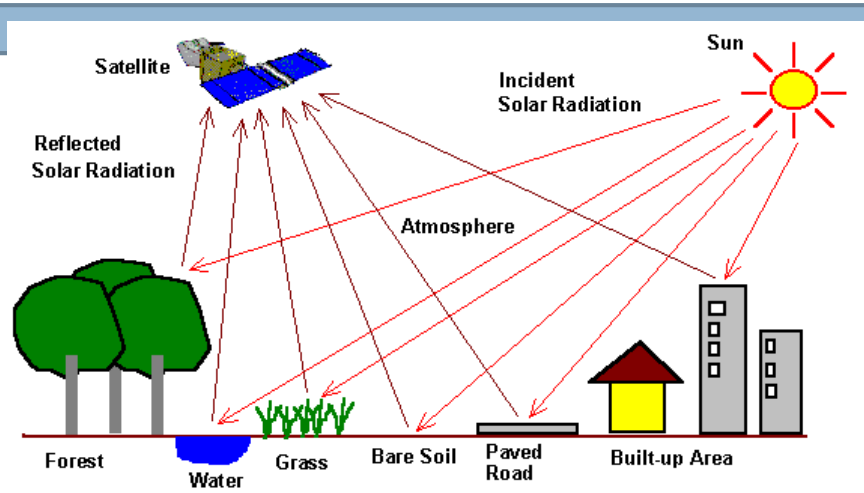
Aerialphoto (~1m)

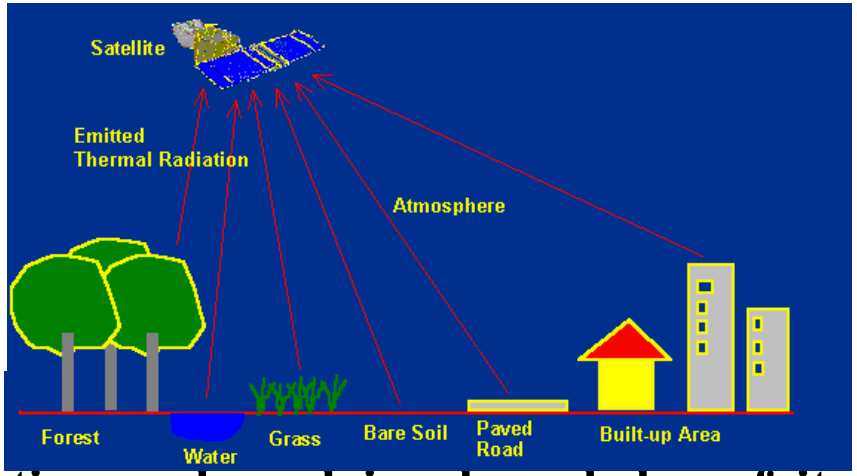
3

Landsat, ASTER (~100m)

What do we sense in Remote Sensing

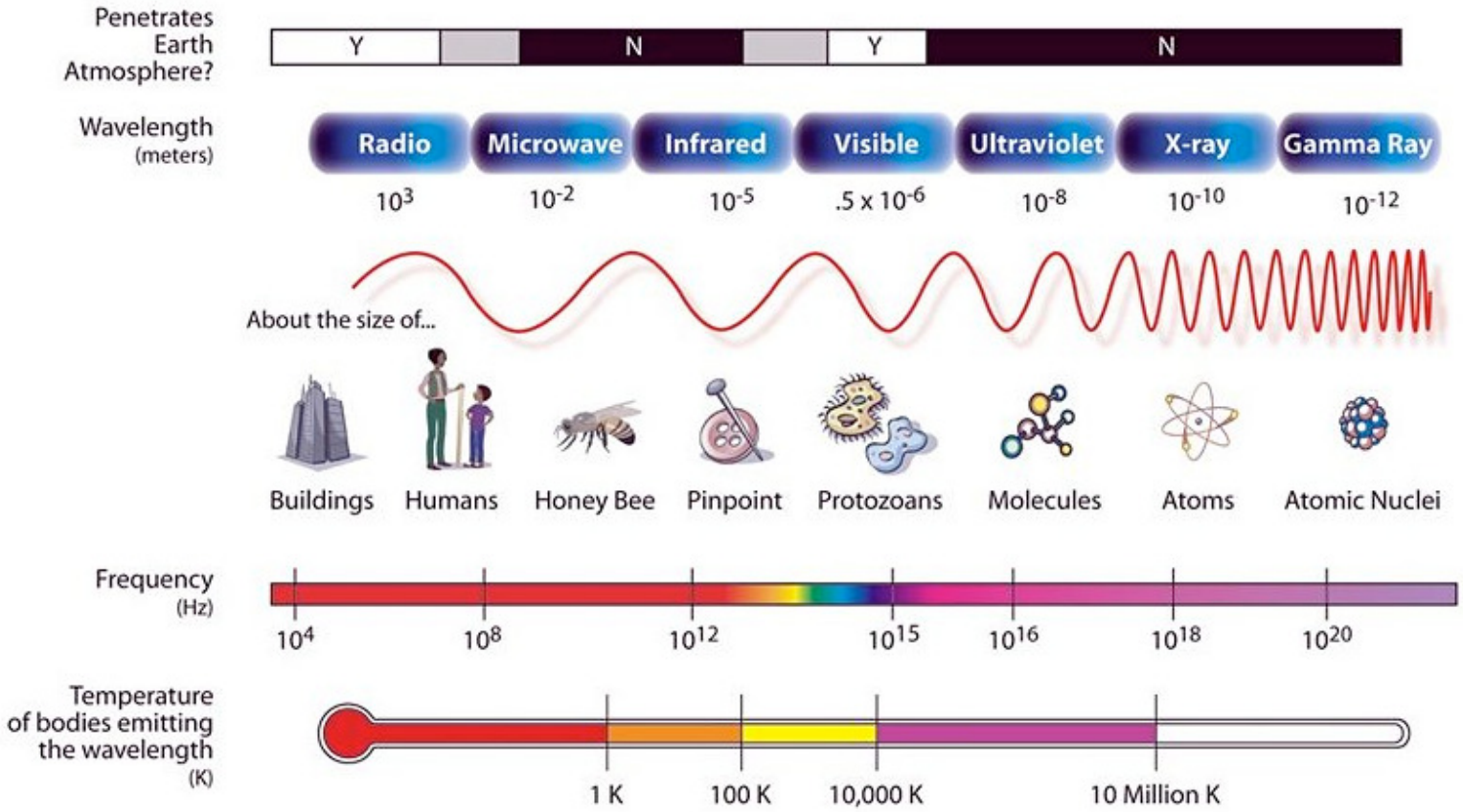






By recording emitted or reflected radiation and applying knowledge of its behaviour as it passes through the Earth's atmosphere and interacts with objects, remote sensing analysts develop knowledge of the character of features such as vegetation, structures, soils, rock, or water bodies on the Earth's surface.

Electromagnetic (EM) Spectrum

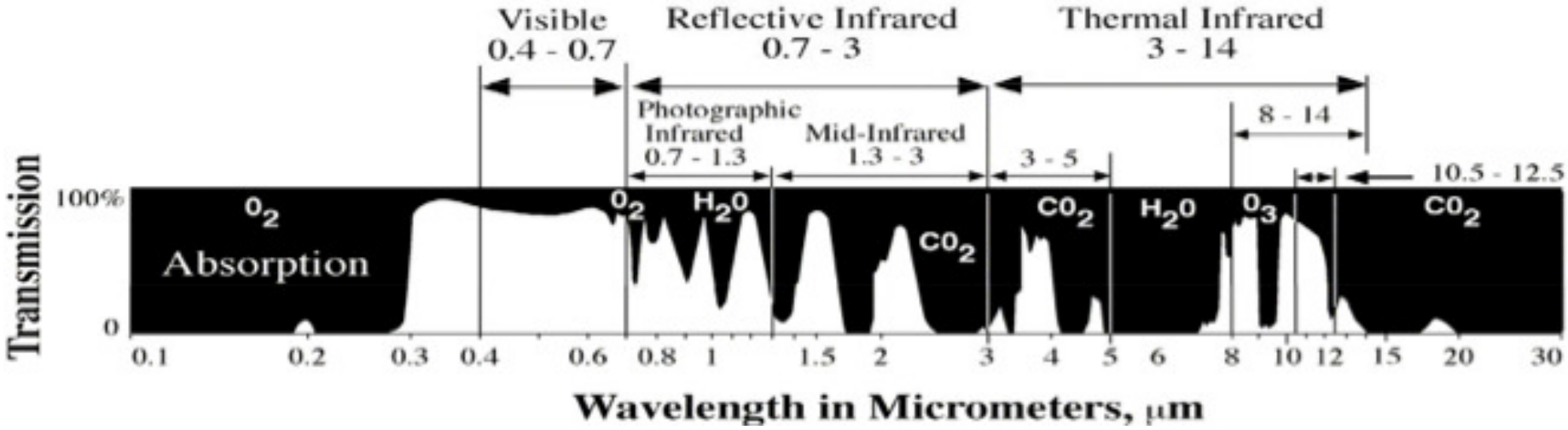


The most familiar form of EMR is visible light, which forms only a small (but very important) portion of the full EM spectrum.

The large segments of this spectrum that lie outside the visible range require our special attention because they may behave in ways that are quite foreign to our everyday experience with visible radiation.

Atmospheric Windows

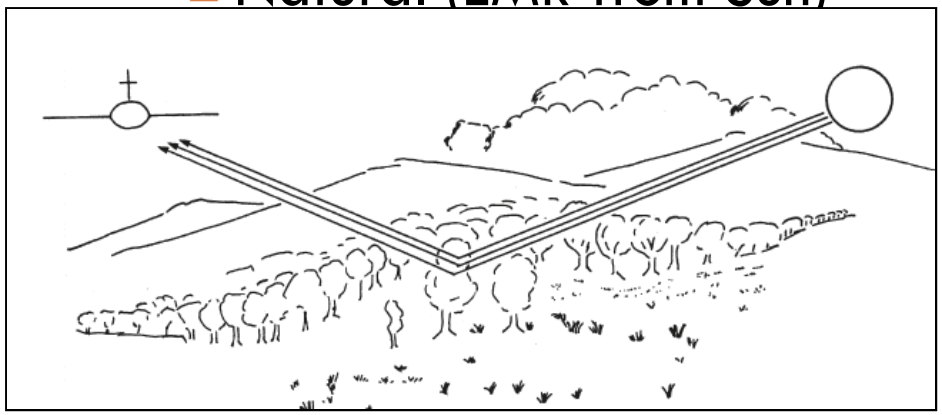
- Earth's atmosphere is by no means completely transparent to electromagnetic radiation because the gases (O3, O2, CO2 & H2O) together form important barriers to transmission of electromagnetic radiation through the atmosphere
- Atmosphere selectively transmits energy of certain wavelengths; those wavelengths that are relatively easily transmitted through the atmosphere are referred to as *atmospheric windows*



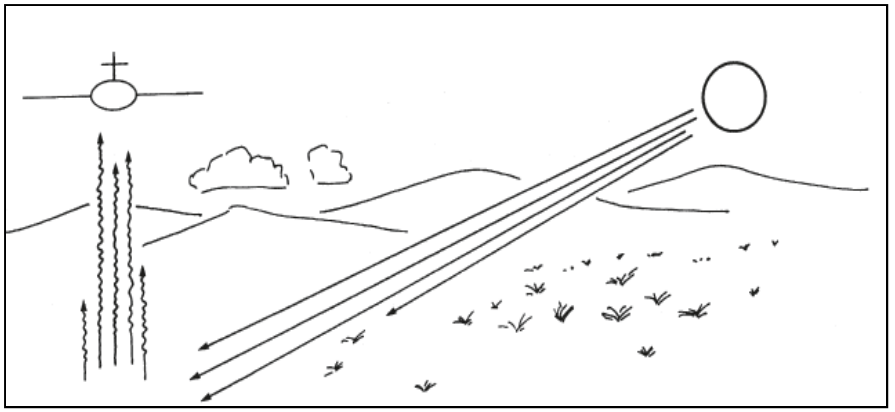
Atmospheric windows are vitally important to the development of sensors for remote sensing

Type of Remote Sensing (RS)

- **Passive RS**
  - Natural (EMR from Sun)

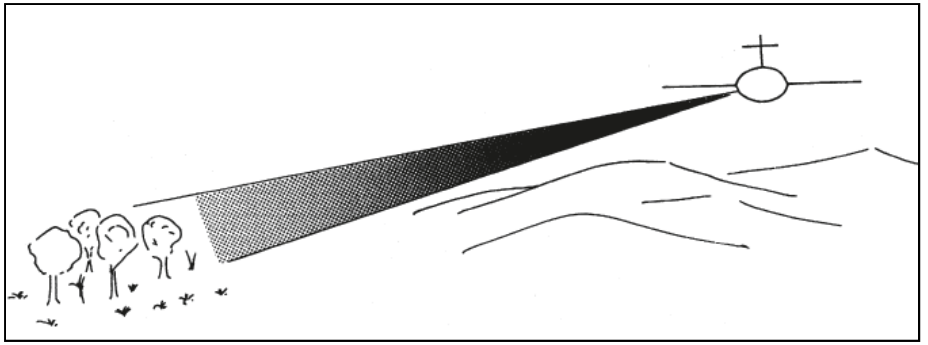


RS using reflected solar radiation



RS using emitted terrestrial radiation

- **Active RS**
  - Technological Assisted Radiation

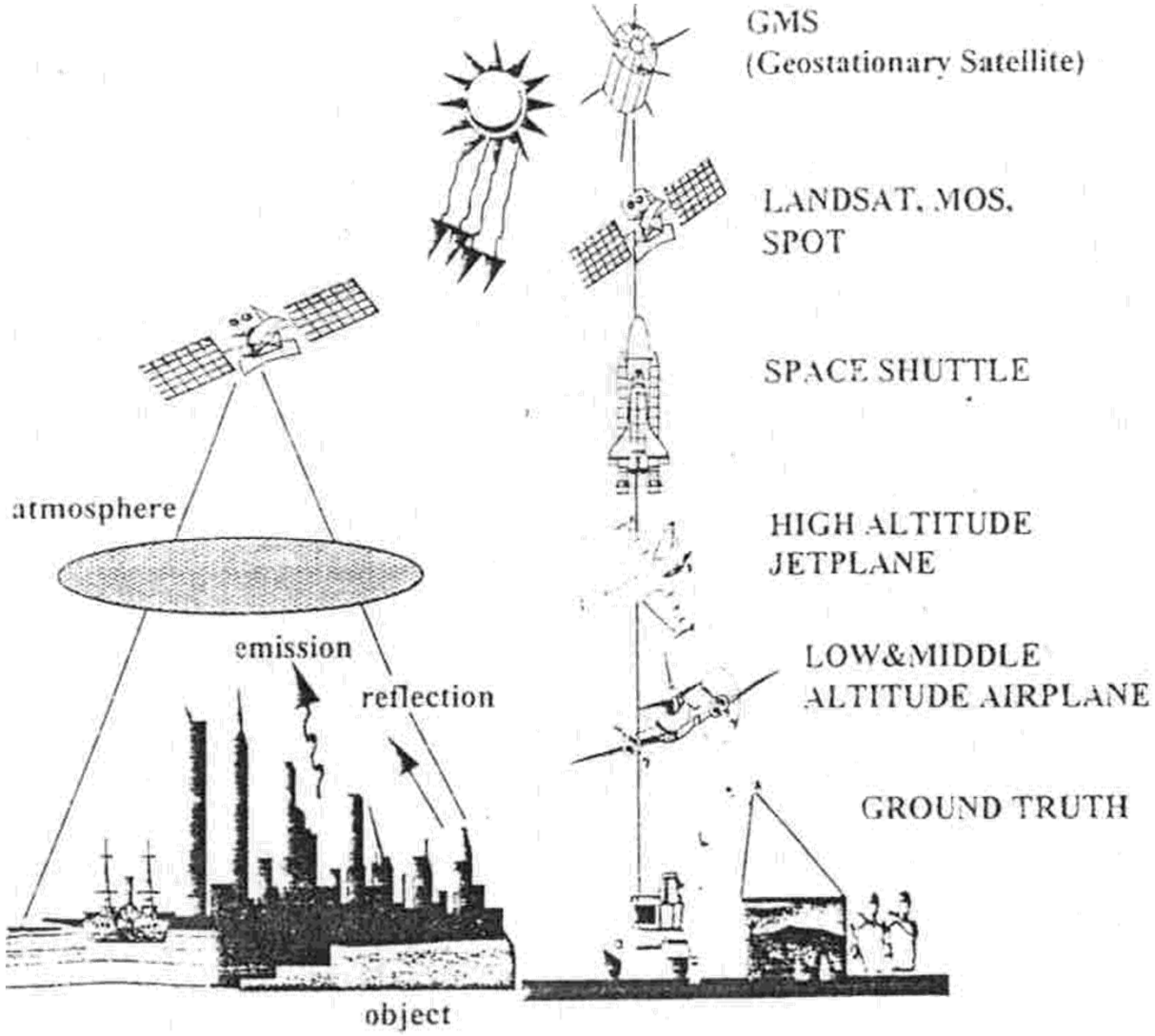


RS using senor's transmitted radiation

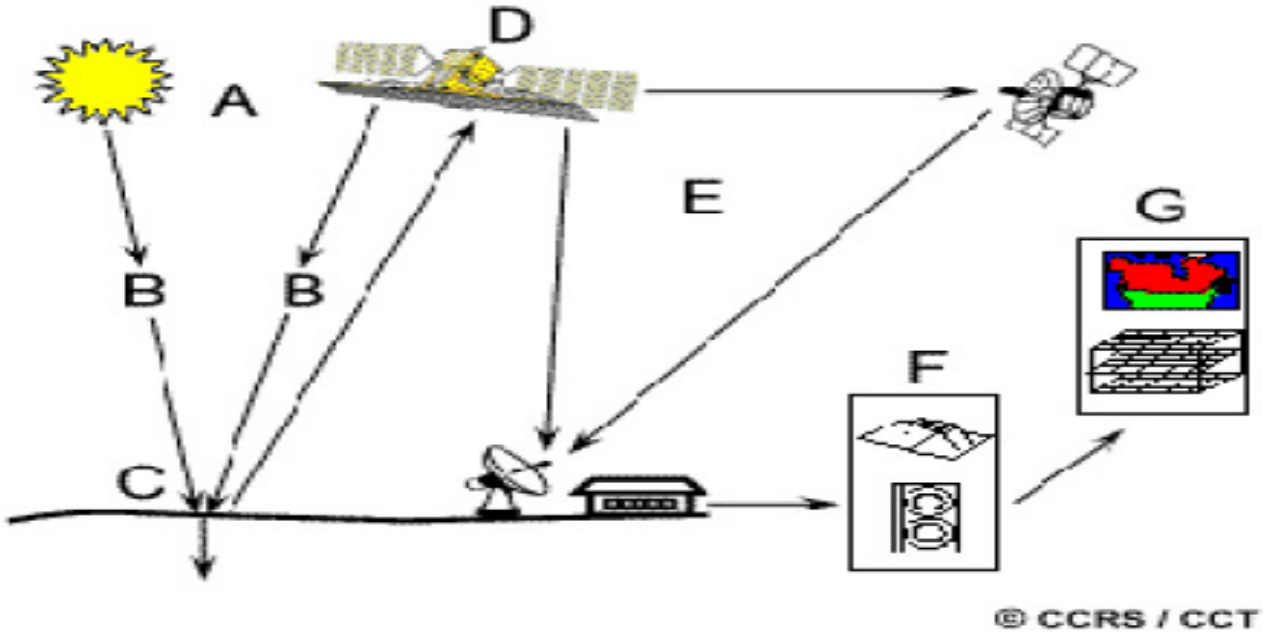
Technological Assisted Remote Sensing

- Force Field
  - (Gravitational and Magnetic)
- Acoustical Energy
  - For Sonar Survey
- Electromagnetic Energy
  - Pass through free space
  - Pass through atmosphere
  - Variety in Behaviour
  - Can be exploited in different ways

Various Platforms of RS to record EM spectrum

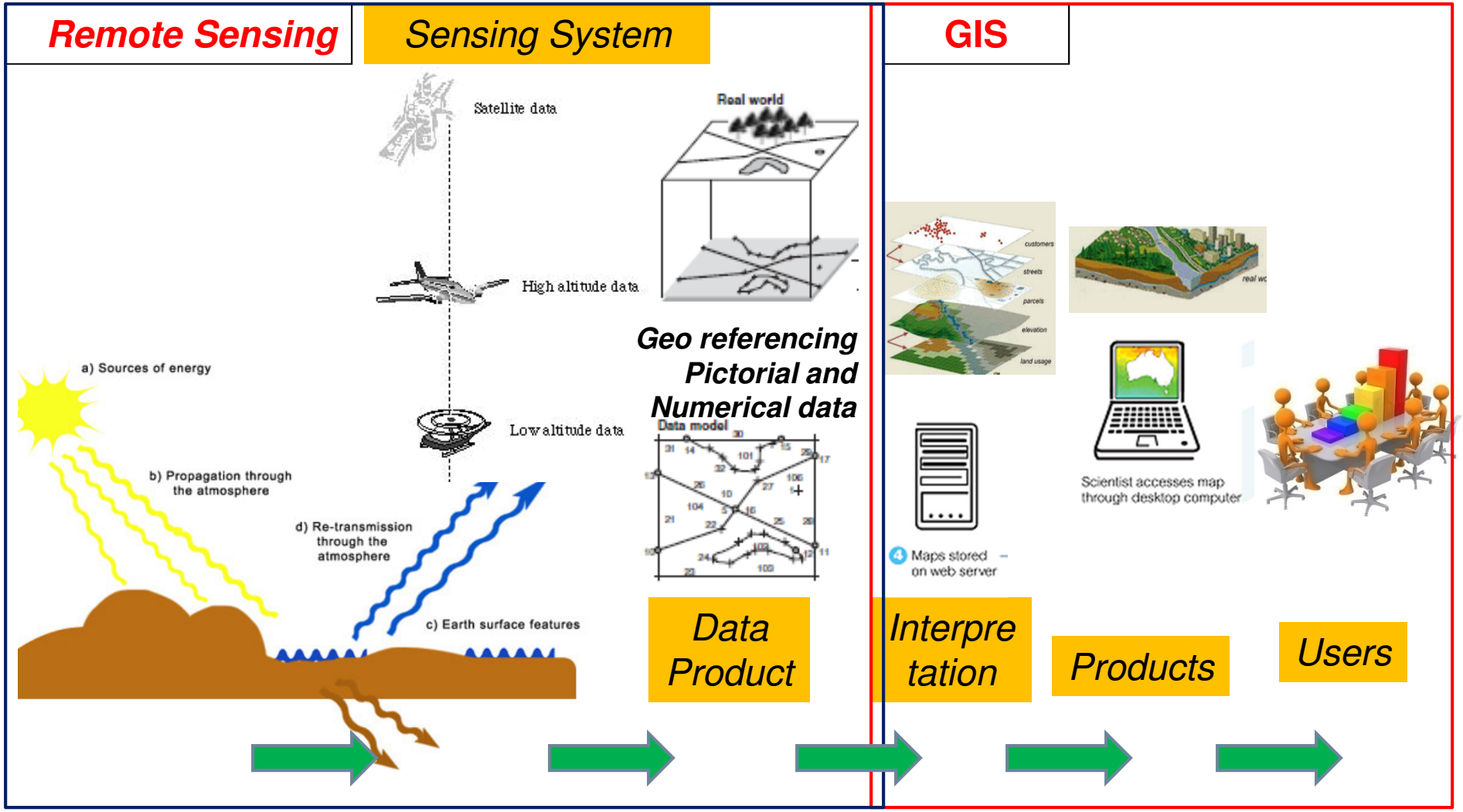


Various Steps in RS



(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

RS and GIS of Earth Resources



Electromagetic remote sensing of earth and its processing

Geographic Information System (GIS)

- **Geographic Information Systems** (GIS) system designed to capture, store, manipulate, analyze, manage, and present all types of geographically referenced data
- GIS are computerized systems designed for the storage, retrieval and *analysis* of geographically referenced data
- GIS uses advanced analytical tools to explore at a scientific level the spatial relationships, patterns, and processes of cultural, biological, demographic, economic, geographic, and physical phenomena

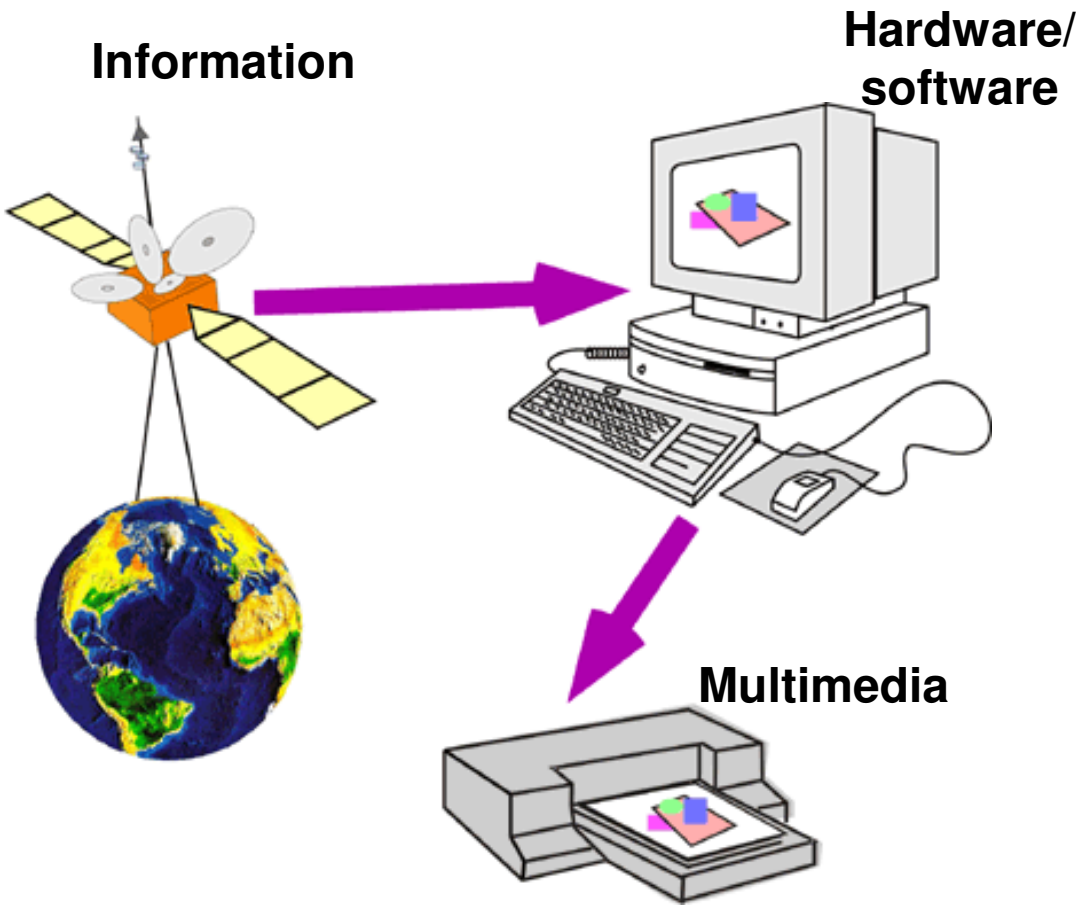
Unique capabilities of GIS

- GIS stores related geographic features in separate collections of files called map layers
- Map layers can be reused easily and assembled into any number of map compositions and overlaid for analysis

Geographic Information System (GIS)

Tools for GIS

- Information
  - Remote sensing data
  - Geographic data
- Hardware
  - Computer
  - Digitizer
  - Scanner
  - Printer/Plotter
- Software
  - Desktop GIS
  - Internet GIS
  - CAD Software
  - Database Software
- Multimedia (photos, videos, 3D models)

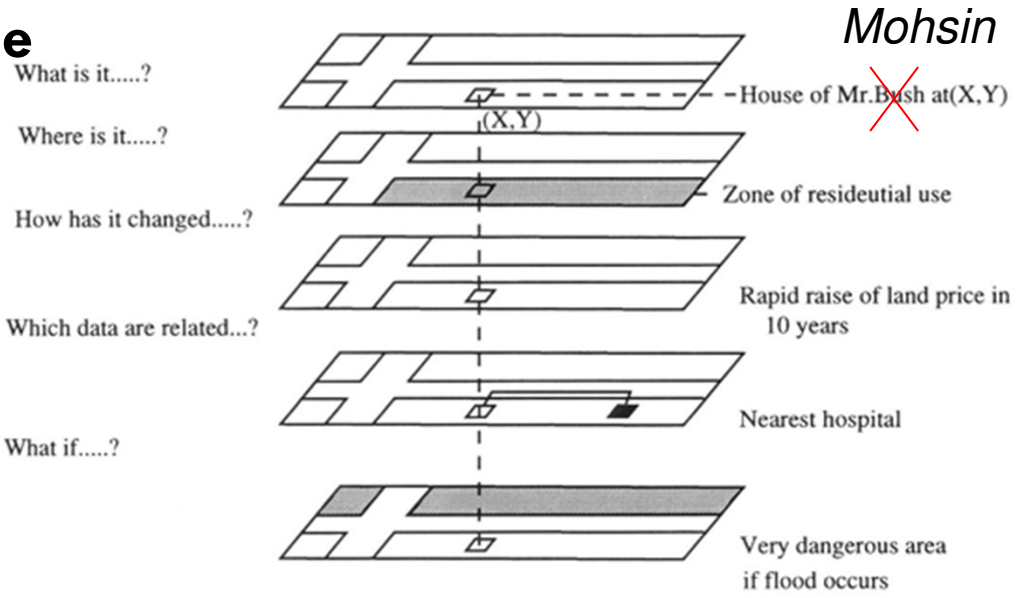


GIS answers the following

- **Location:** What is at...? Where is it...?
  - (Location question ; what exists at a particular location)
- **Condition:** Status of features...?
  - (Conditional question ; which locations satisfy certain conditions)
- **Trends:** What has changed since...?
  - (Trendy question ; identifies geographic occurrence or trends that have changed or in the process of changing)
- **Patterns:** What spatial patterns exist...?
  - (Relational question : analyzes the spatial relationship between objects of geographic features)
- **Modeling:** What if...?
  - (Model based question ; computers and displays an optimum path, a suitable land, risky area against disasters etc. based on model)

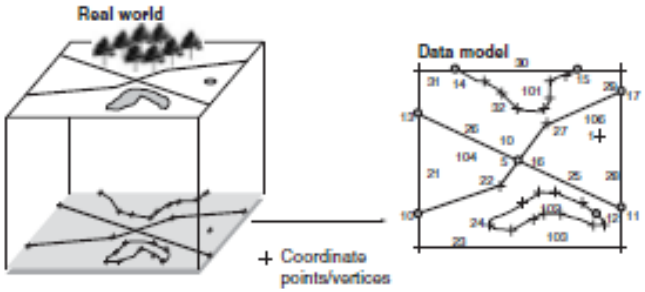
GIS answers the following

- **Location:** What is at…? Where is it…?
- **Condition:** Status of features…?
- **Trends:** What has changed since…?
- **Patterns:** What spatial patterns exist…?
- **Modeling:** What if…?

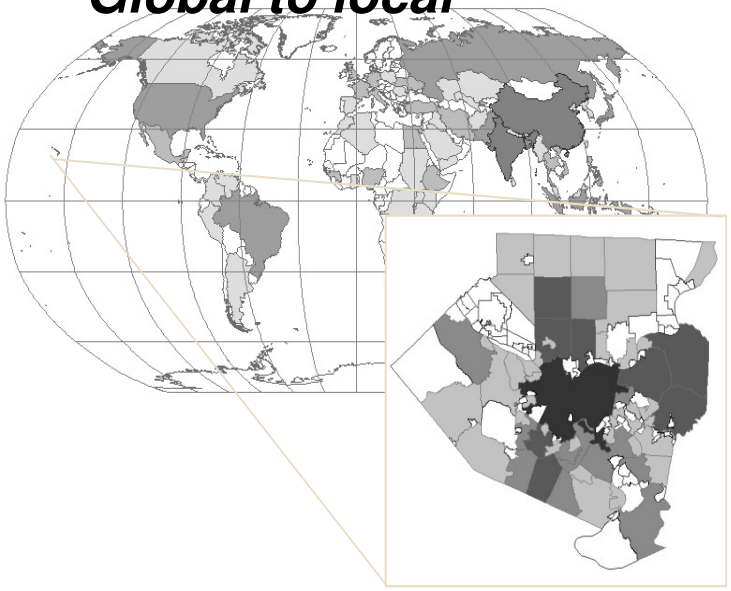


Basic data manipulation in RS & GIS

One of the most common products of a GIS is a map



Global to local

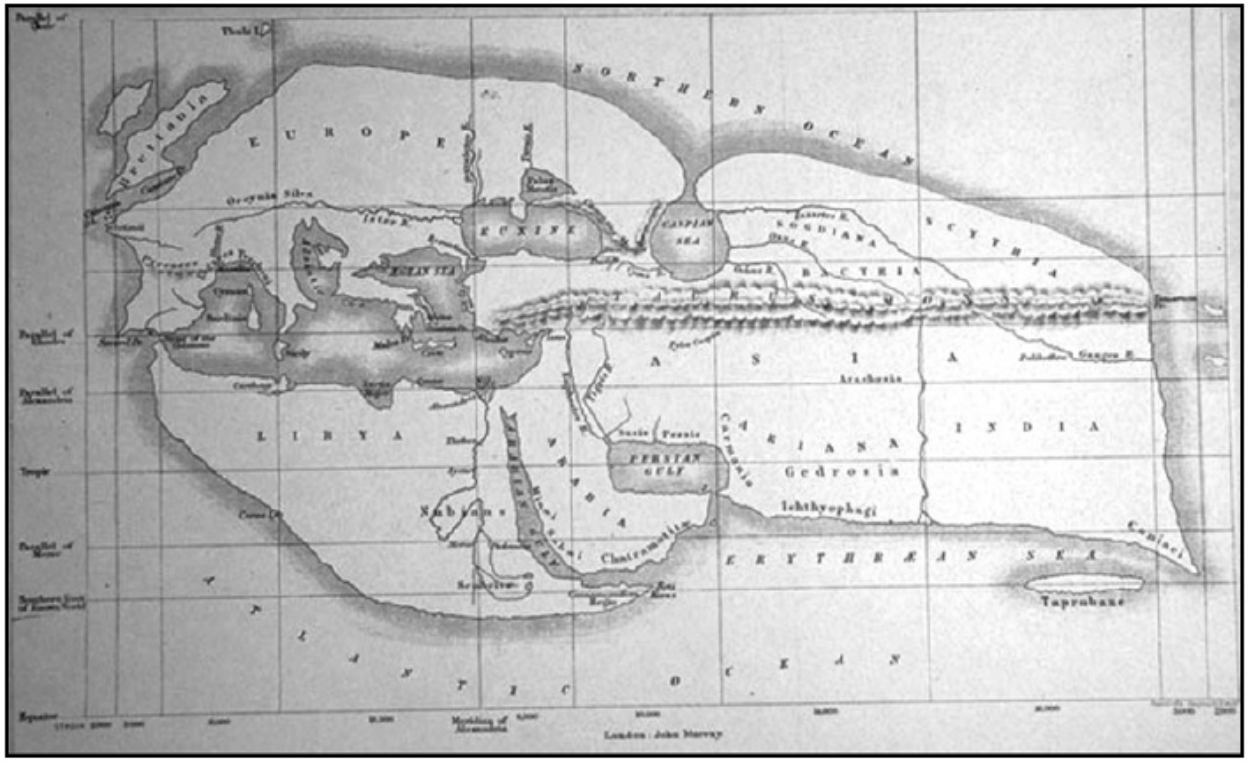


The raster view of the world	Happy valley spatial entities	The vector view of the world
	Points: hotels	
	Lines: ski lifts	
	Areas: forest	
	Network: roads	
	Surface: elevation	

Raster and vector data models. *(Adapted from Heywood et al. 1998; used with permission from Prentice Hall.)*

History and Development of GIS

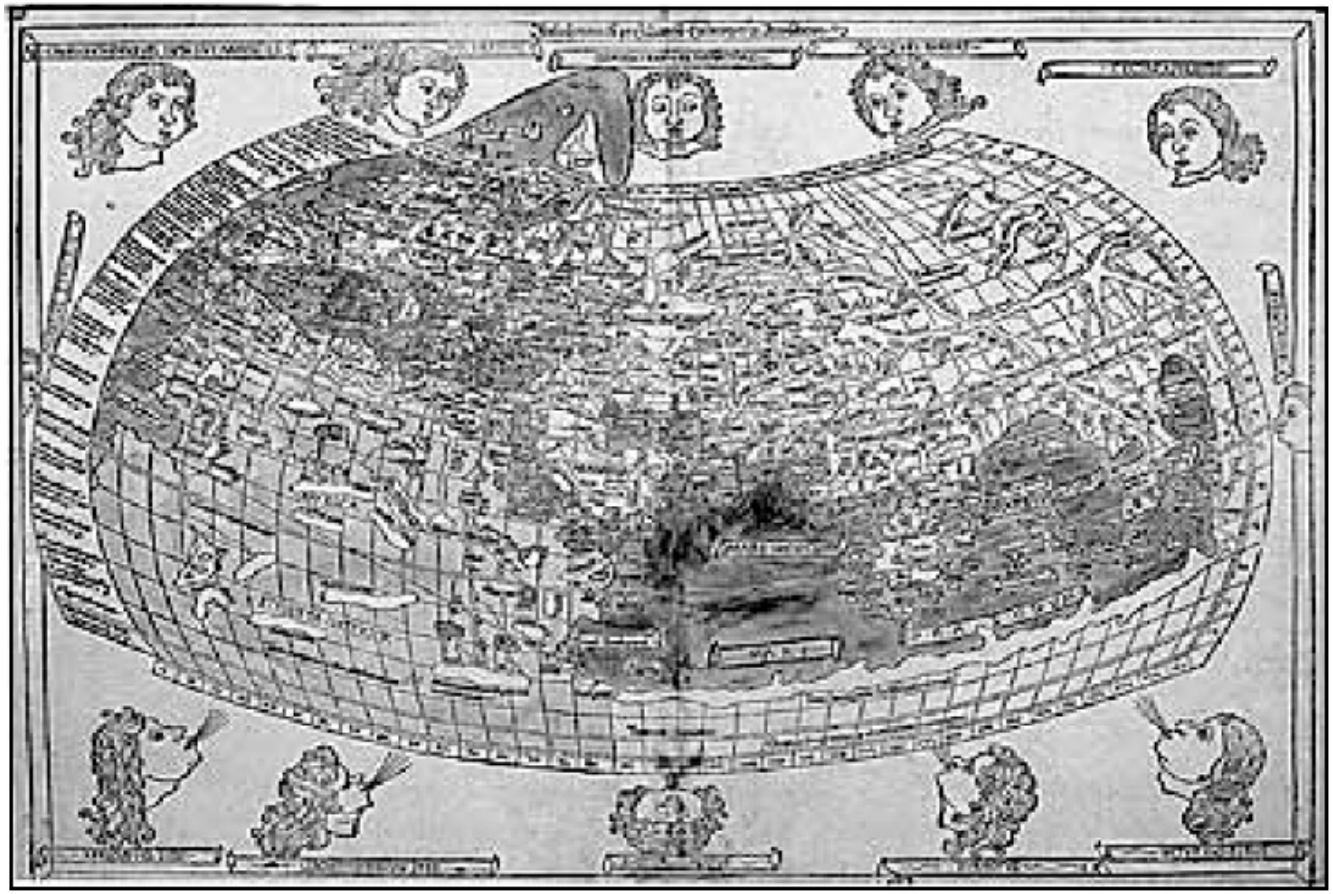
- Geographical information systems evolved from centuries of mapmaking and the compilation of spatial data



Map prepared by Eratosthenes

The Greek mathematician, astronomer, and geographer Eratosthenes (ca. 276 – 194B.C.) laid the foundations of scientific cartography

History and Development of GIS



Ptolemy's map of the world, about A.D. 150, republished in 1482. Notice the use of latitude and longitude lines and the distinctive projection of this map

History and Development of GIS

Al-Idrisi's map of the world, 1456. He completed a map of the known world in the 12th century. Drawn with south at the top, this later example has been inverted for easier viewing.

Important Milestones in The Development of GIS

Stage	Period	Description	Characteristics
The Era of ***Beginning***	*1960 – 1975*	*Pioneering*	• ***individual personalities important*** • ***mainframe-based systems dominant***
The Era of ***Innovation***	*1975 – 1980*	*Experiment and practice*	• ***local experimentation and action*** • ***GIS fostered by national agencies*** • ***much duplication of efforts***
The Era of ***Commercialization***	*1980 – 2000*	*Commercial dominance*	• ***increasing range of vendors*** • ***workstation and PC systems becoming common*** • ***emergence of GIS consultancies***
The Era of ***Exploitation***	*2000 onwards*	*User dominance* *Vendor competition*	• ***embryonic standardization*** • ***increasing use of PC and networked systems*** • ***systems available for all hardware platforms*** • ***internet mapping launched***

Source: *Adopted from Heywood, Cornelius and Carver, 2004.*

Application of RS and GIS

- **Agriculture and Soil**
  - Precision Agriculture, Crop Acreage and Production Estimation, Soil and Land Degradation Mapping
- **Forest, Biodiversity and Environment**
  - Forest Cover and Type Mapping, Biodiversity Characterisation, Environmental Impact Studies, Monitoring of Environmental Sensitive Area, Monitoring of Wetland Areas, Forest Fire and Risk Mapping
- **Engineering and Geology**
  - Mineral Potential Mapping, Groundwater Potential Zoning, Infrastructure Planning
- **Regional/ Land Development**
  - Town and Country Planning, Land Alienation, Solid Waste Disposal

Application of RS and GIS

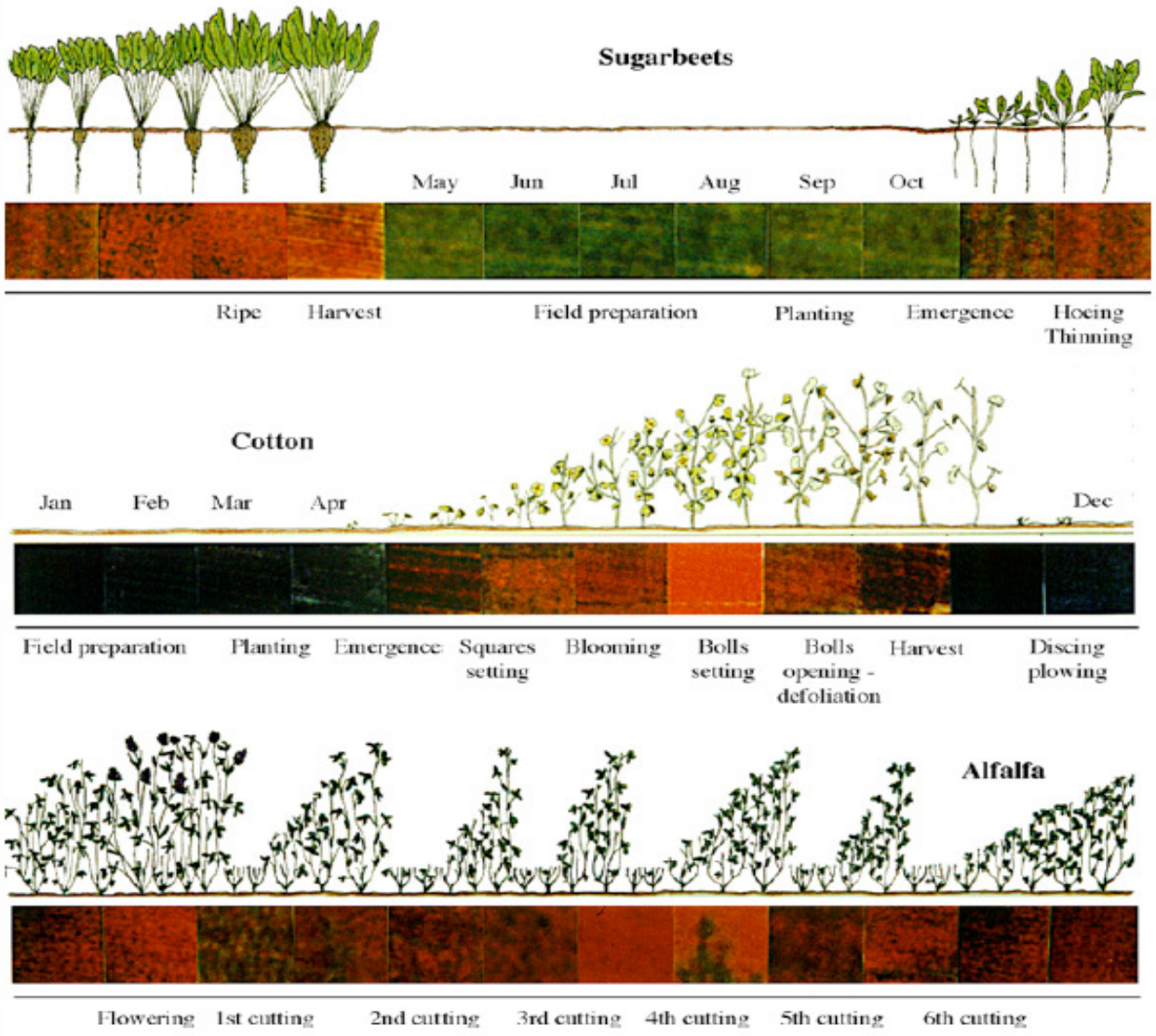
- **Marine and Oceanography**
  - Potential Fishing Zone (PFZ), Coastal Zone Mapping, Marine Resources, Physical Oceanography
- **Disaster Management**
  - Monitoring and Mapping of Disaster Areas (Forest fire, Flood and Landslide), Landslide Hazard Zonation, Flood Damage Assessment, Forest Fire
- **Meteorology**
  - Extended Range Monsoon Forecasting, Ocean State Forecasting
- **Water**
  - Potential Drinking Water Zones, Monitoring of Catchment and Reservoir Areas, Surface Water, Watershed Development

Application of RS and GIS

- **Environmental Health**
  - Dengue Risk Mapping Zoning, Children Malnutrition Study, Air Pollution Study, Tick Borne Disease
- **Landuse Monitoring**
  - Landuse/ Land Cover Mapping, Wasteland Mapping, Topography and Geographic Positioning, Urban Development, Geology
- **National Security**
  - Intelligence, Territorial Security Management, Mapping and Rescue Planning, Strategic and Tactical, Ground Mobility

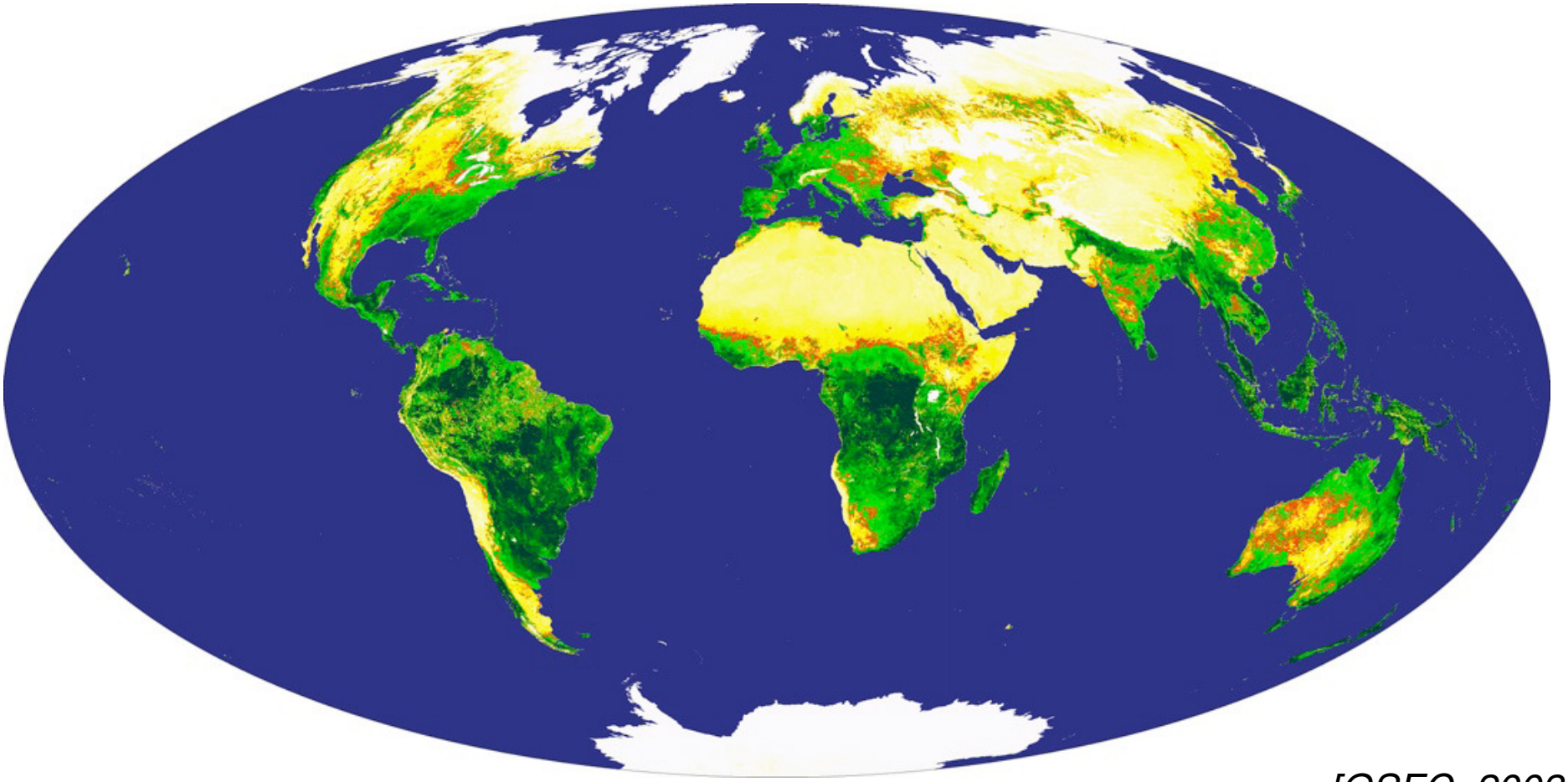
Application of RS: Crop Growth Monitoring

Phenological cycles of crops and Landsat image



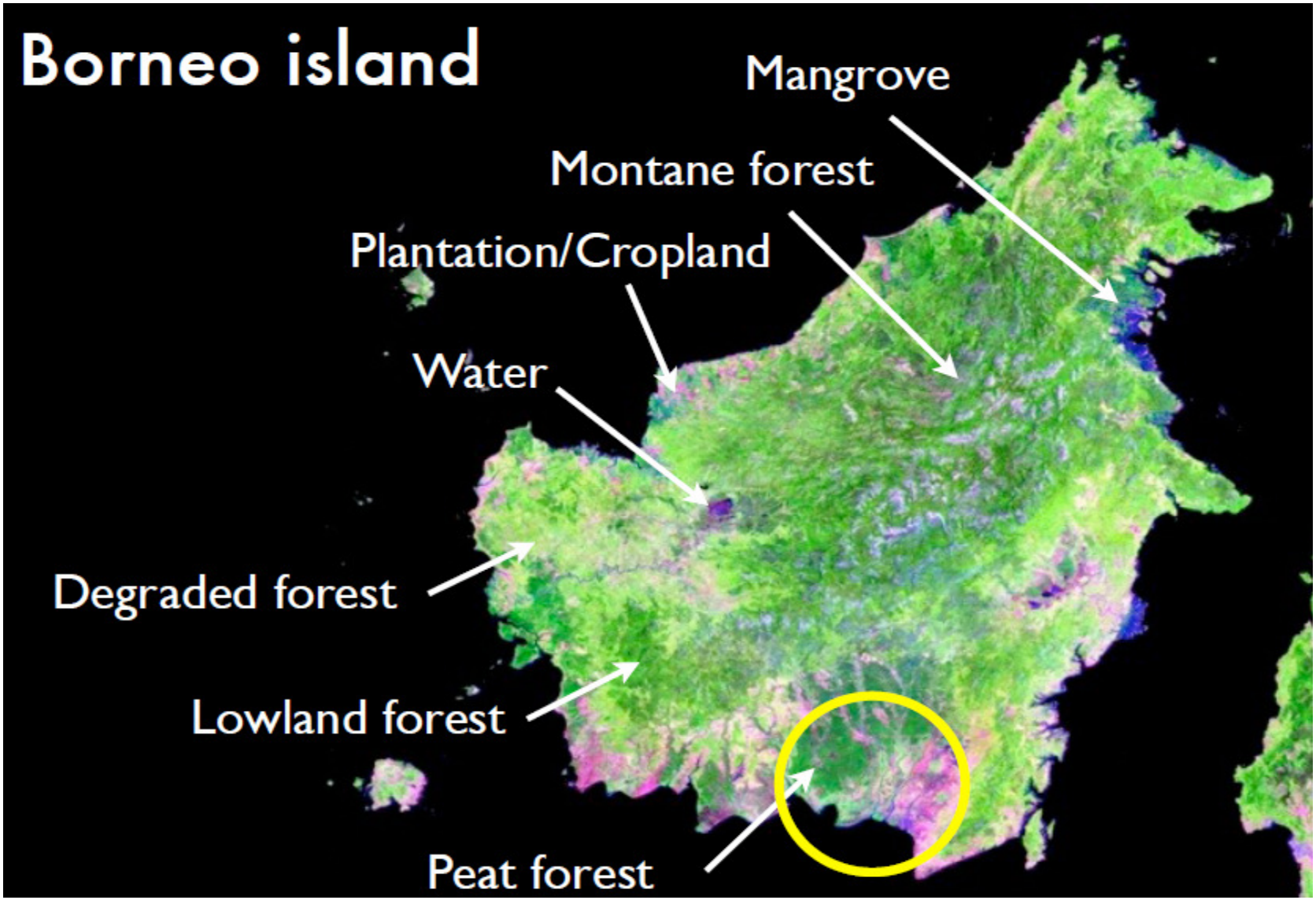
Application of RS: Crop Growth Monitoring

- Global Normalized difference vegetation index (NDVI) map by MODIS (2003)

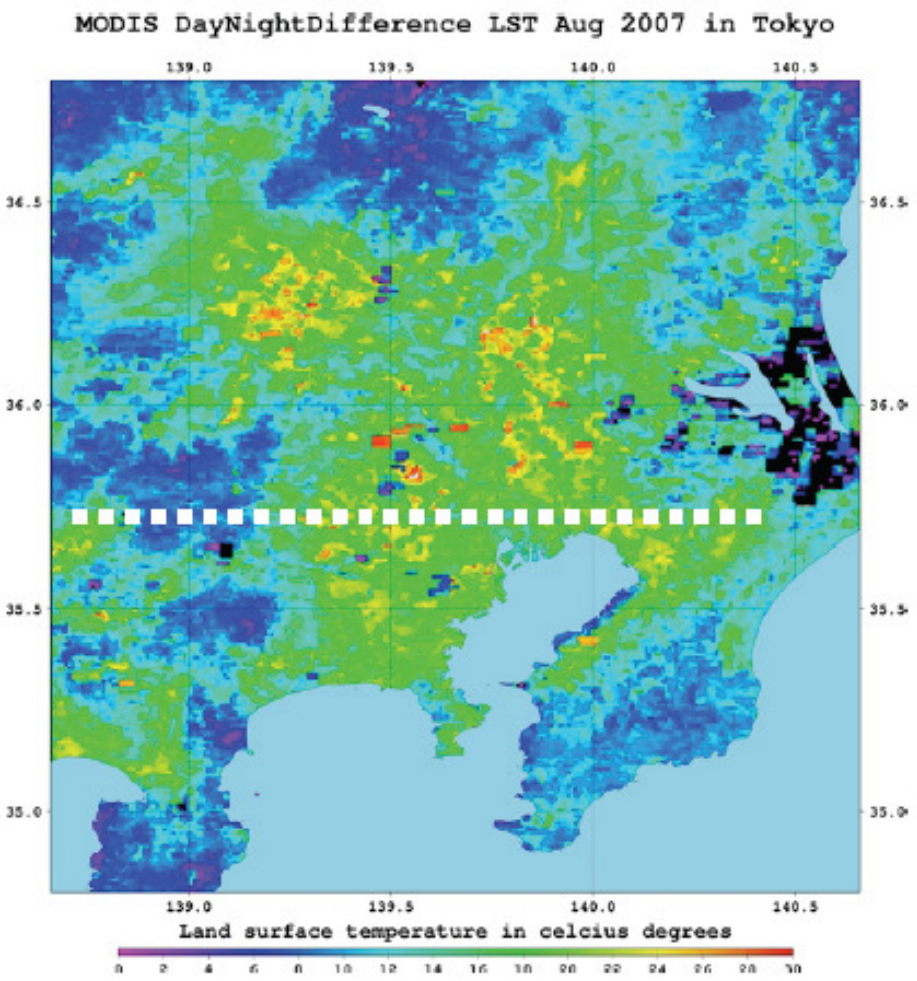


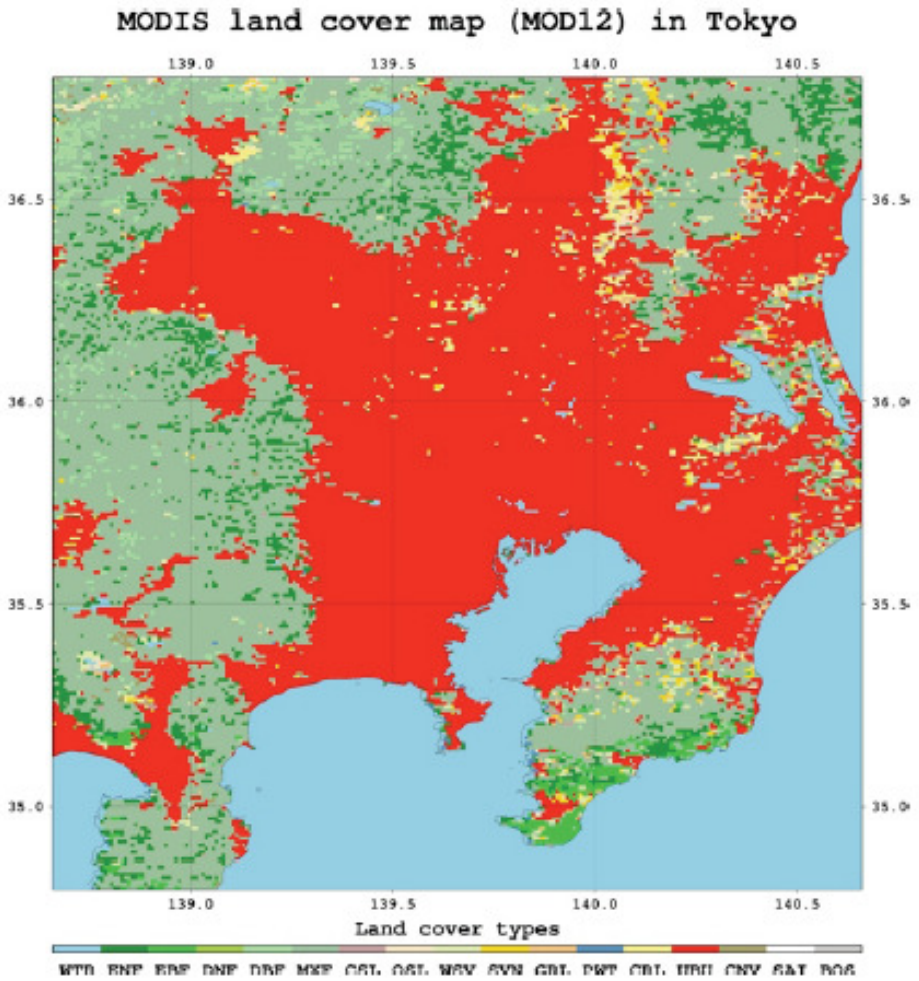
[GSFC, 2003]

Application of RS: Forest Monitoring



Application of RS: Urban Heat Island Monitoring

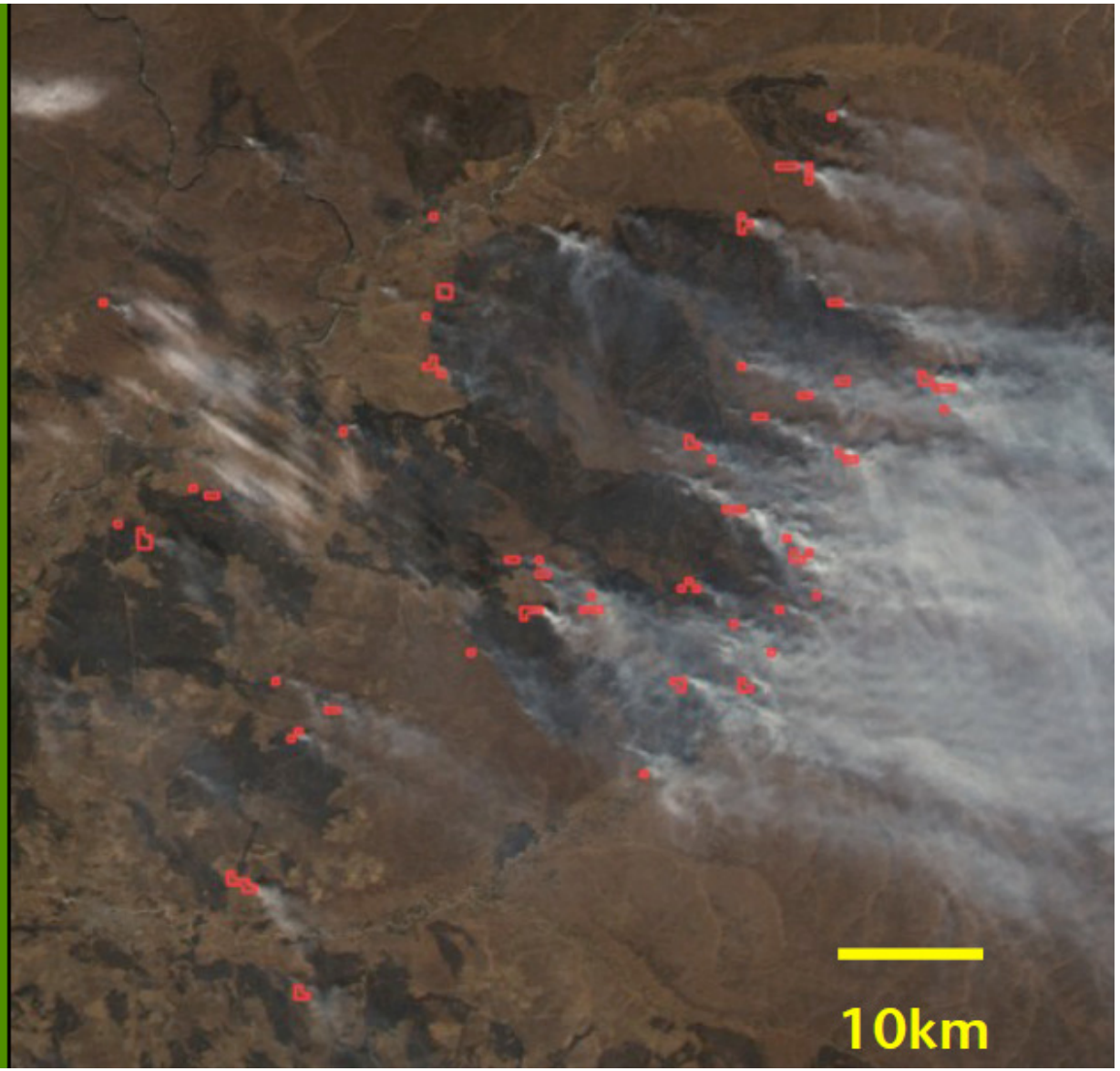




Land Surface temperature is clearly enhanced by land cover

Application of RS: Wild Fire Monitoring

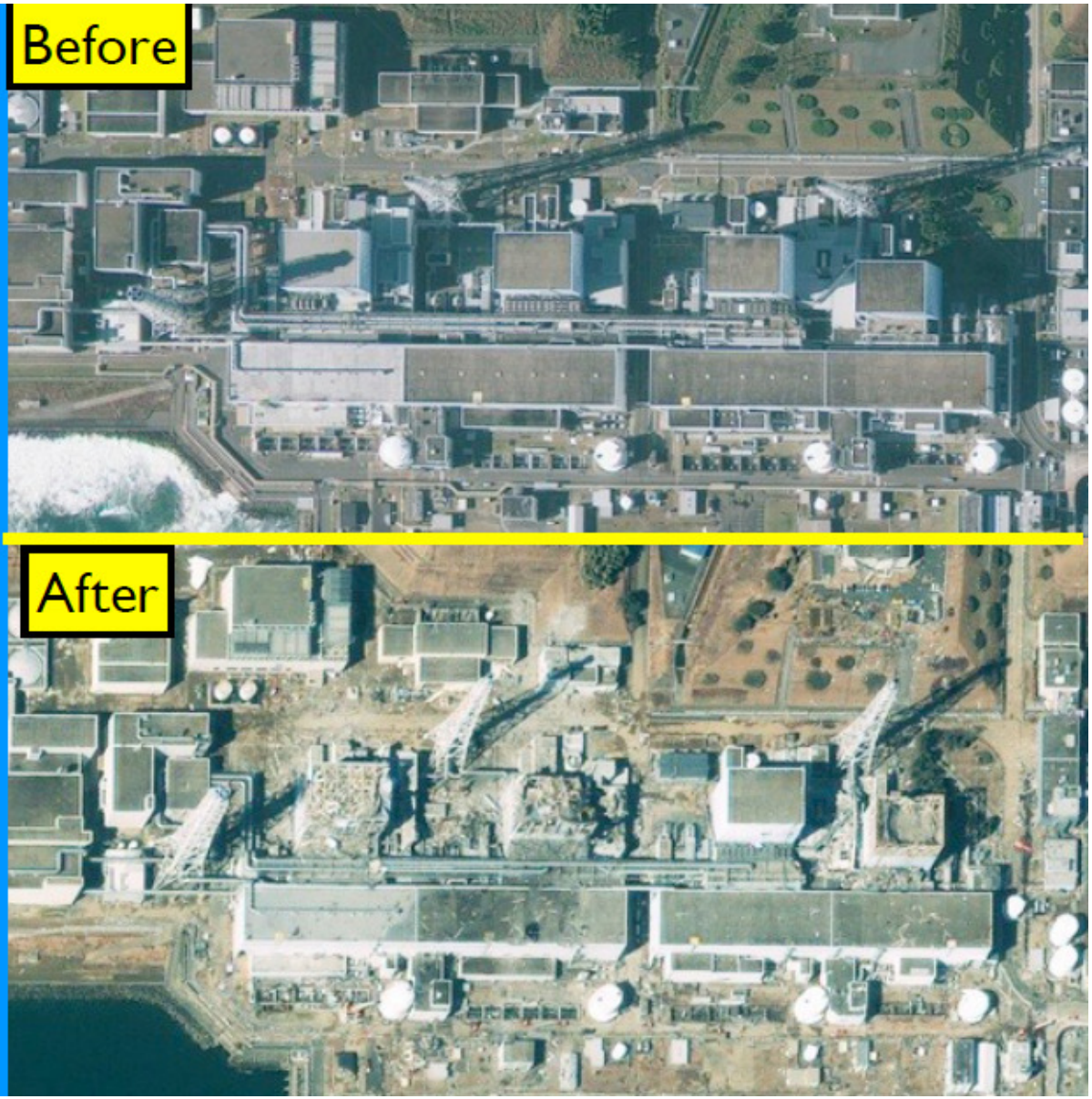
Fires in Siberia close-up



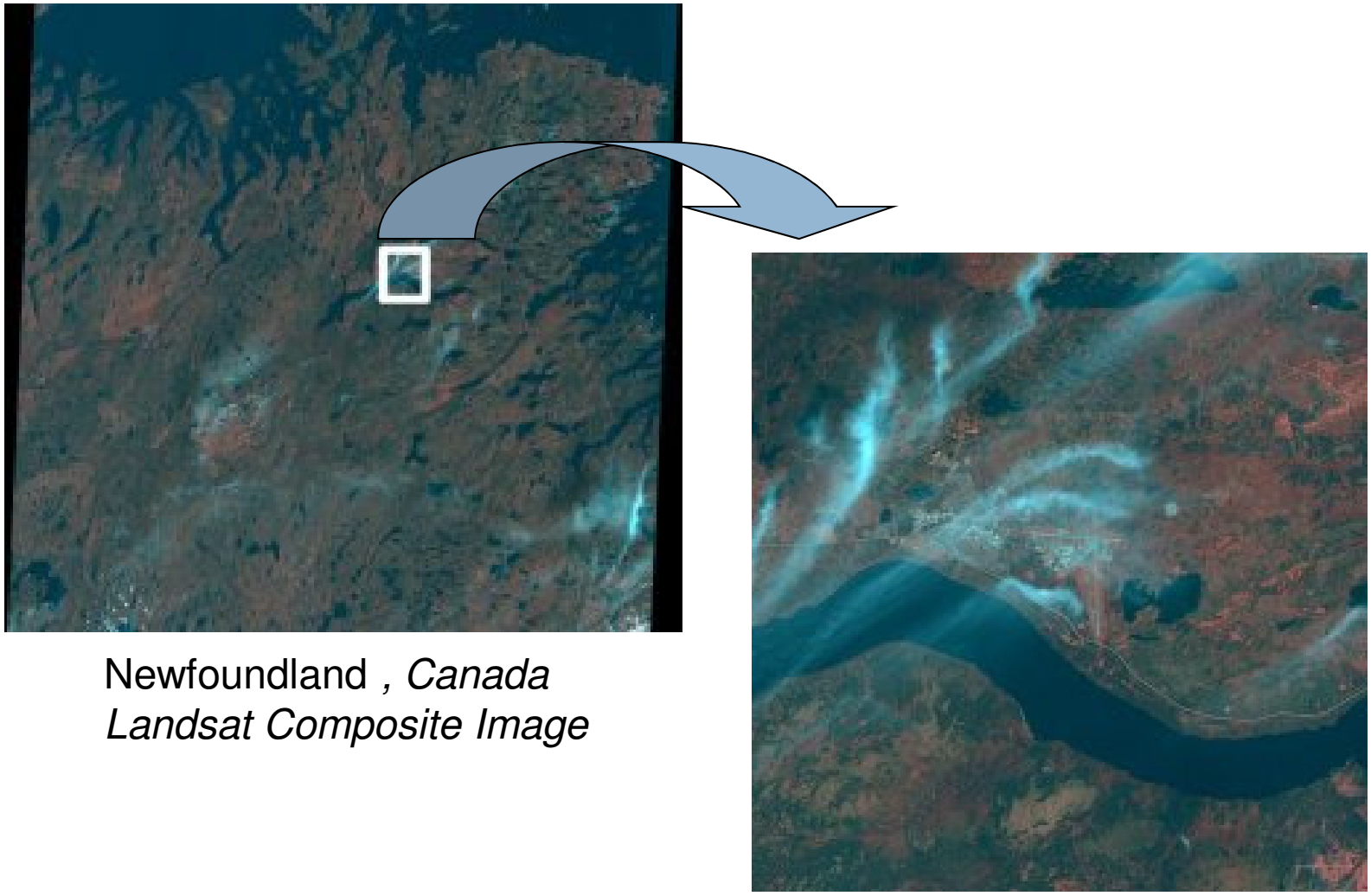
Active burning spot is shown by red rectangles.

Application of RS: Disaster Management

Fukushima nuclear power plant (GeoEye)

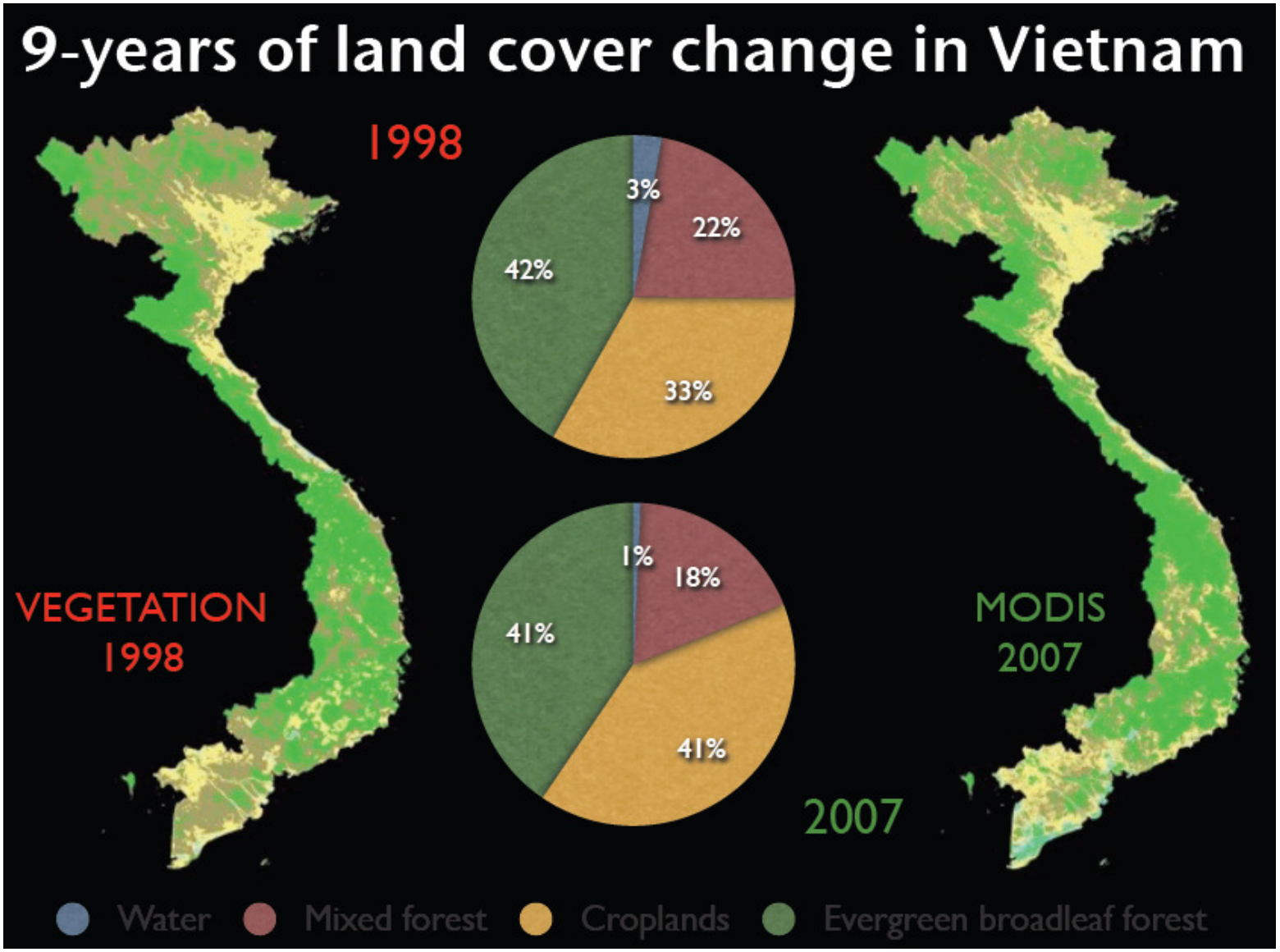


Application of RS: Land Uses



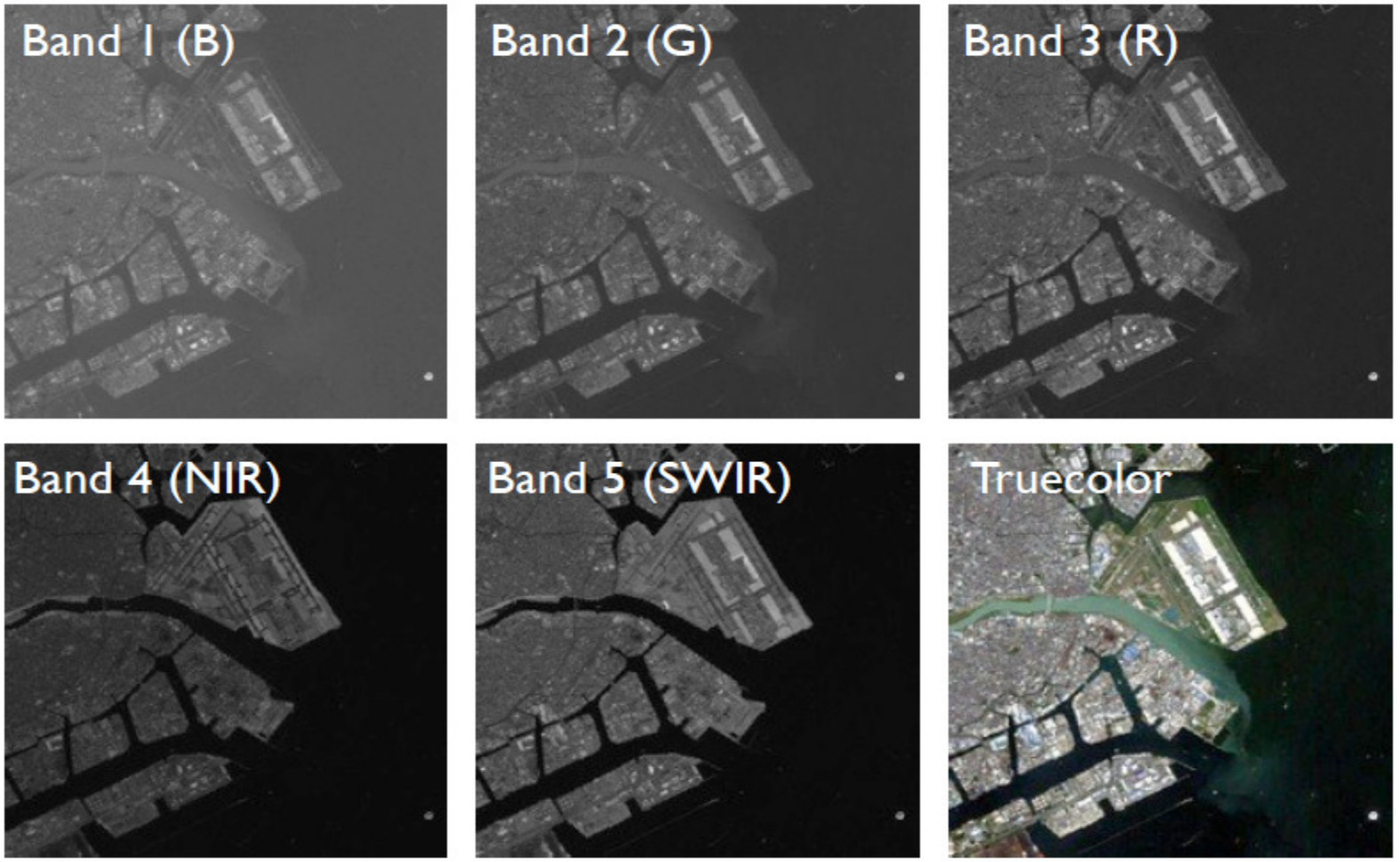
Newfoundland , *Canada*
Landsat Composite Image

Application of RS: Land Use change



Application of RS: Water

Water penetration



Application of RS: Flood Mapping

satellite image of St. Louis on **July 4, 1988**, during normal river levels.

St. Louis on **July 18, 1993**, during the height of the flooding.

Application of RS: Military Use

Application of RS: Military Use

HI-511: Application of Remote Sensing and Geographical Information System in Civil Engineering

- Contact Hours (2+2)
- Credit Hours (1)

Distribution of Course Contents

GIS

DR. HABIB UR REHMAN
PROFESSOR

REMOTE SENSING

DR. MOHSIN SIDDIQUE
ASSISTANT PROFESSOR

Tentative Course Schedule (Remote Sensing)

Lecture No	Description	Seminar
1	**Remote Sensing:** Introduction and Significance	
2	**Remote Sensing:** Principles, Spectral Signatures, Spectral range in Remote Sensing, Types of Remote Sensing (Passive and active), Spectrum of Solar radiation	
3	**Optical Remote Sensing:** Principles, Sensors and Data processing	
4	**Optical Remote Sensing** : Sensor Performances: Spatial characteristics (Resolution, Coverage), Spectral Characteristics (Range, resolutions, number of bands), Radiometric Characteristics (dynamic range, Quantizing level), Temporal Resolution	
5	**Optical Remote Sensing:** Platforms (Satellite systems, Aircraft, Space Shuttle and others), Imaging System (Camera, push broom scanner, whisk broom scanner)	

Tentative Course Schedule (Remote Sensing)

Lecture No	Description	Seminar
6	**Optical Remote Sensing:** Resolving Power and Spatial Performances, Dispersing Systems (filter, dispersing element, spectrometer, prism, grating)	
7	**Microwave Remote Sensing**: Principles, Sensors and data processing	
8	**Introduction to Image Processing** (e.g. WinASIAN) software, Data Analysis, Image Enhancement, Classification	

Tentative Course Schedule (GIS)

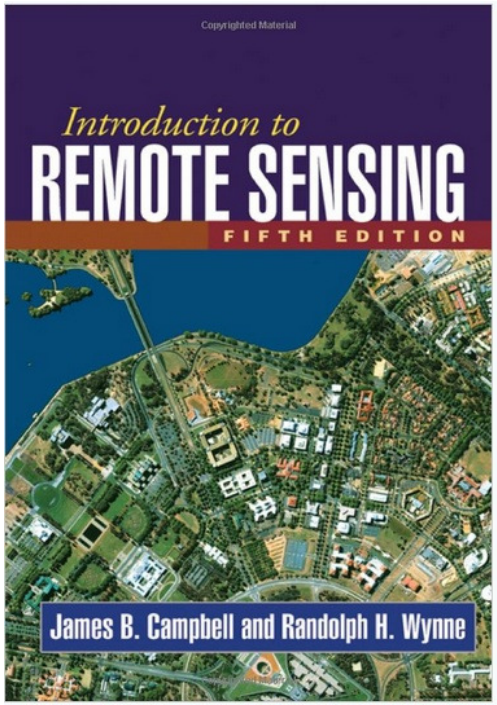
Lecture No	Description	Seminar
1	**Geographic Information System (GIS):** Introduction, Basic data operations and data structures for GIS	
2	**Geographic Information System (GIS):** Concept and theories of Database, Representation of Geo-objects	
3	**Geographic Information System (GIS):** Basic data structure and data operations, Advanced data models/structures.	
4	**Introduction of GIS software:** (ArcGIS/ArcView/ArcInfo), Data input and transformation	
5	**Introduction of GIS software:** Spatial query and analysis: Spatial query and related data structures	
6	**Introduction of GIS software:** Spatial Operations and analysis	
7	**Practice Sessions:** Data generation for Hydrological Modeling: Filling DEM, Flow direction map, Flow accumulation map, Catchment boundaries, River network generation, Slope etc grids.	

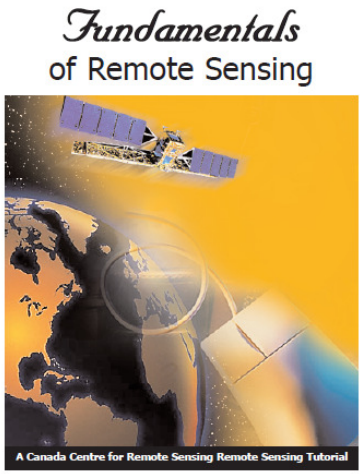
Goal of the Course

- Provide the student with a basic understanding of the science and technology of remote sensing and geographic information system
- Enable the student to understand the differences between the various satellite remote sensing systems in existence today
- Enable the student to differentiate between the different types of information provided by these systems
- Enable the student to understand the integration of remote sensing and GIS
- Provide the student with basic understanding of GIS systems and their processing of remote sensing and geographic data
- Enable the student to perform basic manipulatation of data using commercial software such as ArcGIS etc

Books and Tutorials

- Books on Remote sensing





Natural Resources Canada | Ressources naturelles Canada

Canada

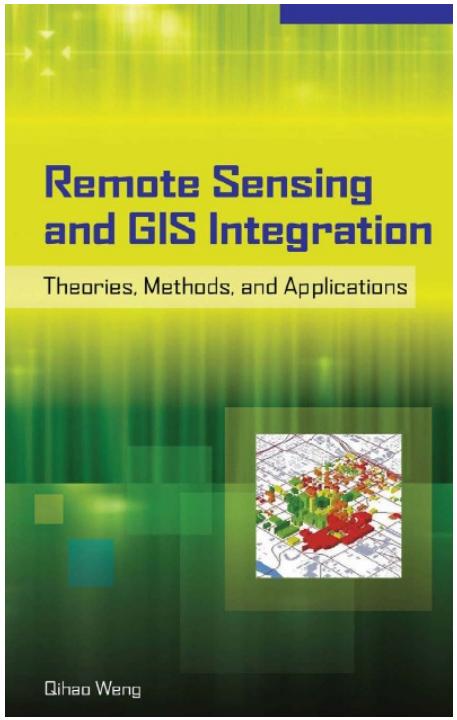
James B. Campbell, Randolph H. Wynne (2011): Introduction to Remote Sensing, Fifth Edition

Canada Centre for Remote Sensing Fundamentals of Remote sensing

Thomas M. Lillesand (eds.), 2007. Remote sensing and image interpretation, Willey.

Books and Tutorials

- Books on Remote Sensing and GIS

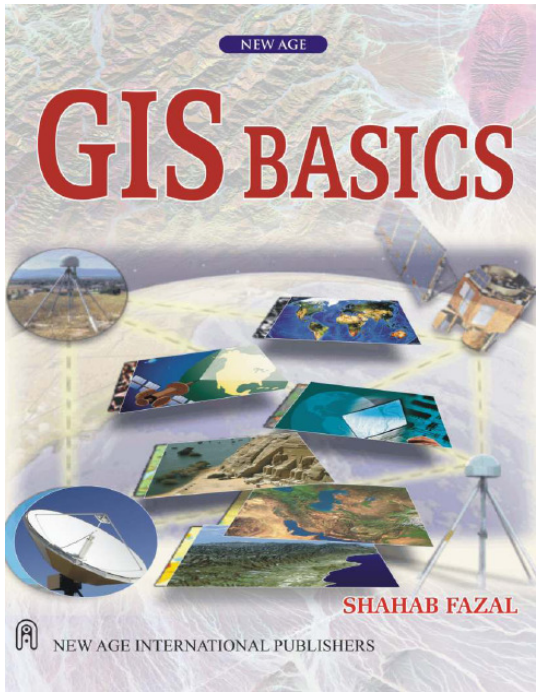


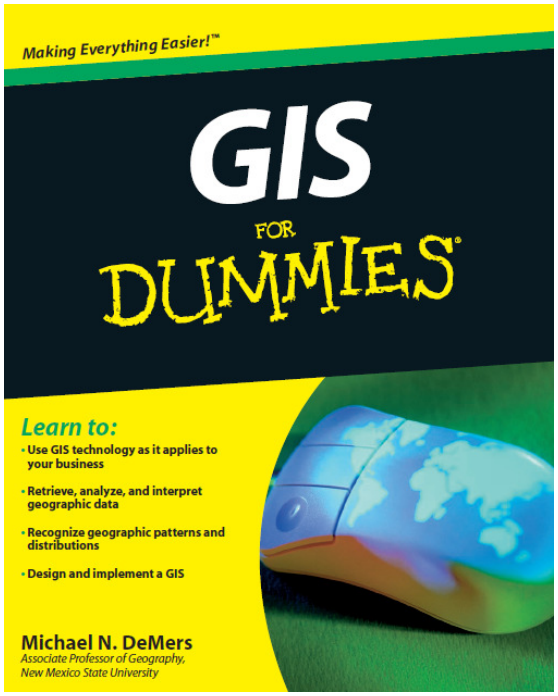
Paul R. Wolf (eds.), 2000. Elements of photogrammetry with applications in GIS, McGraw-Hill Science.

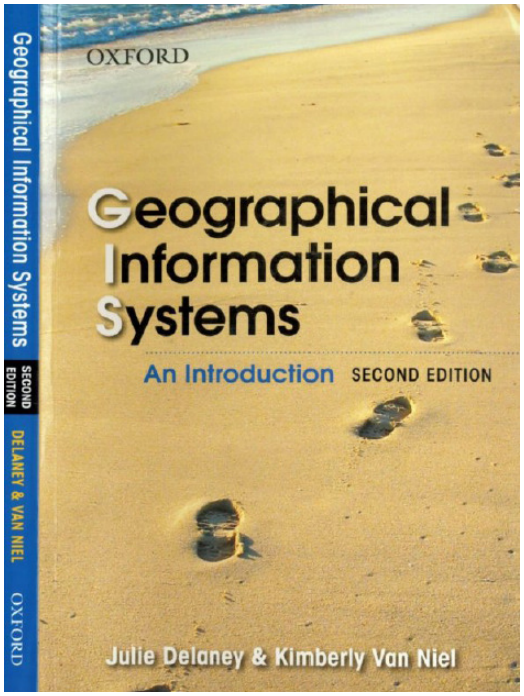
Qihao Weng, Remote Sensing and GIS Integration, Theory, Methods and Applications

Books and Tutorials

- Books on GIS







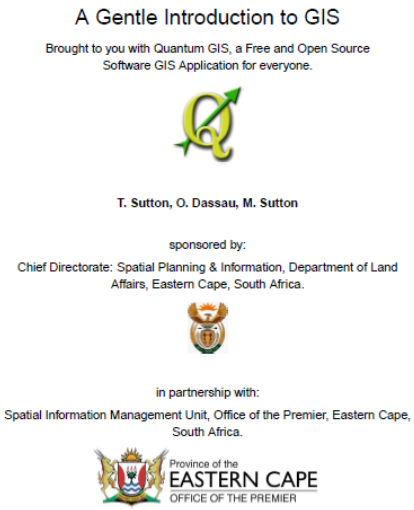
Shahab Fazal, GIS Basics

Michael N. DeMers, GIS for Dummies

Julie Delaney & Kimberly Van Niel, Geographic Information system An introduction

Books and Tutorials

- Books on GIS


A Gentle Introduction to GIS

Brought to you with Quantum GIS, a Free and Open Source Software GIS Application for everyone.

T. Sutton, O. Dassau, M. Sutton

sponsored by:

Chief Directorate: Spatial Planning & Information, Department of Land Affairs, Eastern Cape, South Africa.

in partnership with:

Spatial Information Management Unit, Office of the Premier, Eastern Cape, South Africa.

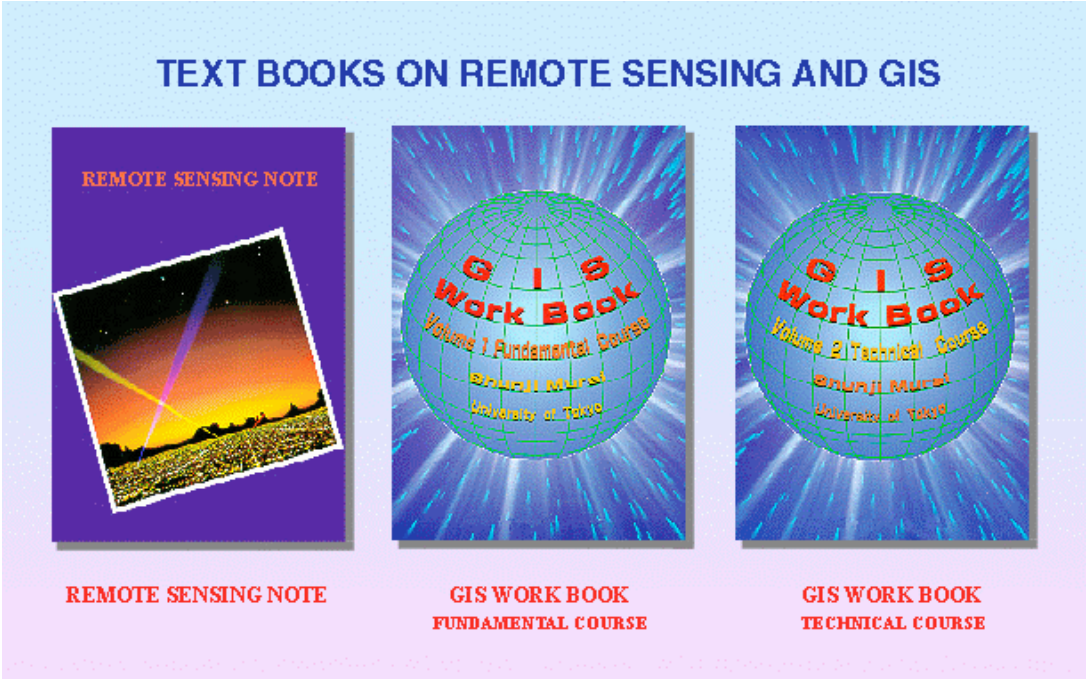
Province of the EASTERN CAPE OFFICE OF THE PREMIER

To be added with the help of Sir Google ….☺

T. Sutton, O. Dassau, M. Sutton, A gentle introduction to GIS

Books and Tutorials

- Tutorial on Remote Sensing and GIS



Remote Sensing and GIS Tutorial by JARS/JAXA/AIT/RESTEC
(http://stlab.iis.u-tokyo.ac.jp/~wataru/lecture/rsgis/)

Remote Sensing Tutorial by GSFC/NASA:
(http://rst.gsfc.nasa.gov/)

History of Remote Sensing by GSFC/NASA
(http://stlab.iis.u-tokyo.ac.jp/~wataru/lecture/rsh/)

Other Sources

- **Lecture Notes**
  - Dr. Takauchi Wataru
    - http://stlab.iis.u-tokyo.ac.jp/~wataru/
  - Dr. Ryosuke Shibasaki
  - Dr. Noor Muhammad Khan
  - Dr. Nagesh Kumar
  - etc etc
- **Web Sources**
  - www.google.com
  - www.youtube.com
  - www.wikipedia.org
  - etc etc

Seminars Assignments

- A seminar type assignment is being planned in which each student is required to choose his favorite topic related to RS and GIS
- The schedule of seminar/presentation will be decided in next week

Assignment

- Search and Install Google earth or Use Google Maps to locate you home
- The purpose is to get interaction with remotely sensed information and its processing using internet GIS systems
- No formal submission is required. However, you have to report about your interaction with Google earth or Google Map
- Deadline: Jan 09, 2012 (In next class)

Thank you !

Comments….

Questions….

Suggestions….

I am greatly thankful to all the information sources (regarding remote sensing and GIS) on internet that I accessed and utilized for the preparation of present lecture.

Feel free to contact