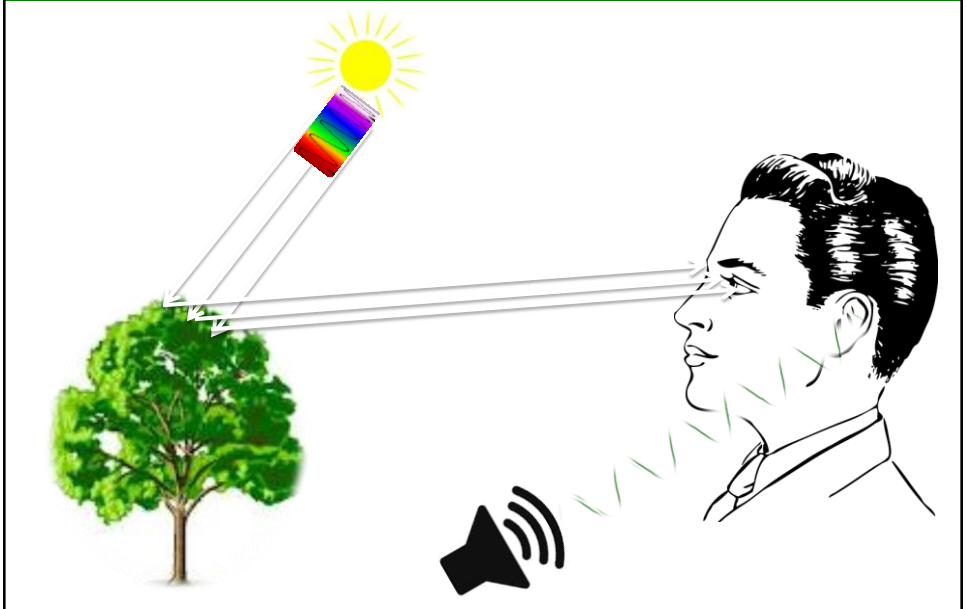
Remote Sensing in Daily Life



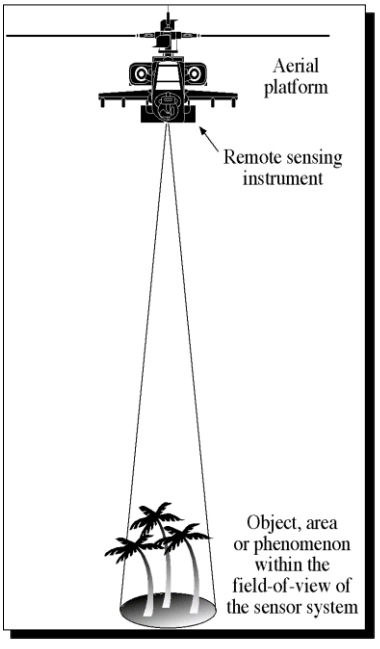
What Is Remote Sensing?

- First time term Remote Sensing was used by Ms Evelyn L Pruitt, a geographer of US in mid 1950s.
  - Minimal definition (not very useful): “remote sensing is the acquiring of data about an object without touching it.”

1892-1973

What Is Remote Sensing?

- From your text:
  - Inclusive definition (much better): “remote sensing is the noncontact recording of information from the ultraviolet, visible, infrared, and microwave regions of the electromagnetic spectrum by means of instruments such as cameras, scanners, lasers, linear arrays, and/or area arrays located on platforms such as aircraft or spacecraft, and the analysis of acquired information by means of visual and digital image processing.”



Remote sensing:

“the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study” (Colwell, 1997).

Advantages of Remote Sensing

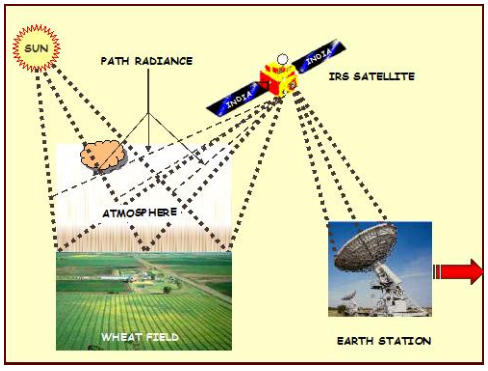
• Remote sensing is *unobtrusive* if the sensor *passively* records the EMR reflected or emitted by the object of interest. Passive remote sensing does not disturb the object or area of interest.

• Remote sensing devices may be programmed to collect data systematically, such as within a 9 × 9 in. frame of vertical aerial photography. This systematic data collection can remove the sampling bias introduced in some *in situ* investigations.

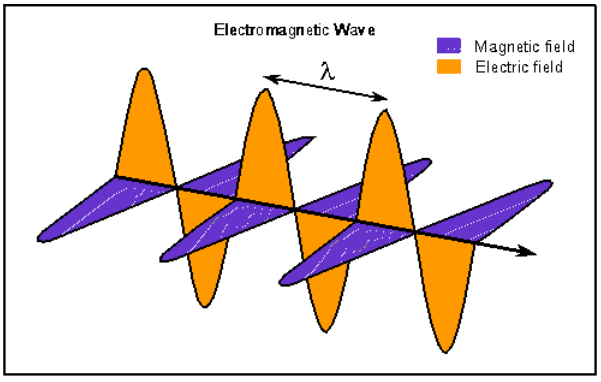
• Under controlled conditions, remote sensing can provide fundamental biophysical information, including *x*,*y* location, *z* elevation or depth, biomass, temperature, and moisture content.

• Remote sensing–derived information is now critical to the successful modeling of numerous natural (e.g., water-supply estimation; nonpoint source pollution) and cultural (e.g., land-use conversion at the urban fringe; water-demand estimation; population estimation) processes.

Process of Image Acquisition



Wave model of electromagnetic Radiation



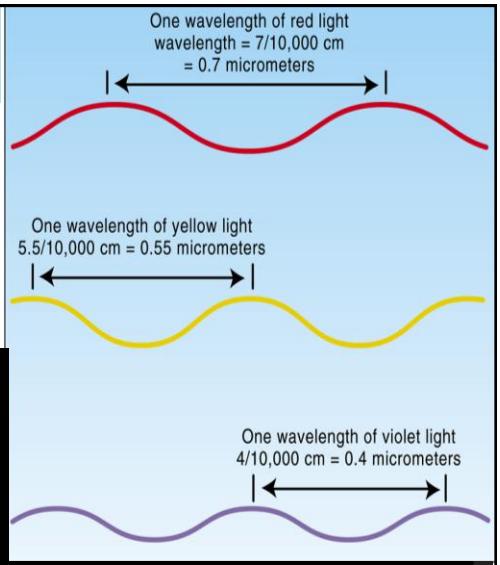
Light as Waves

Light as a wave
Color = different wavelengths

Wavelength
Distance from a given point on one wave to the same point on the next wave
Example – peak to peak

Measured in micrometers for metrology, 1 millionth of a meter symbol is µm or called micron

Ultraviolet, 0.01µm; Violet, 0.4µm; Yellow, 0.55µm; Red light, 0.7µm
Infrared, 10 µm

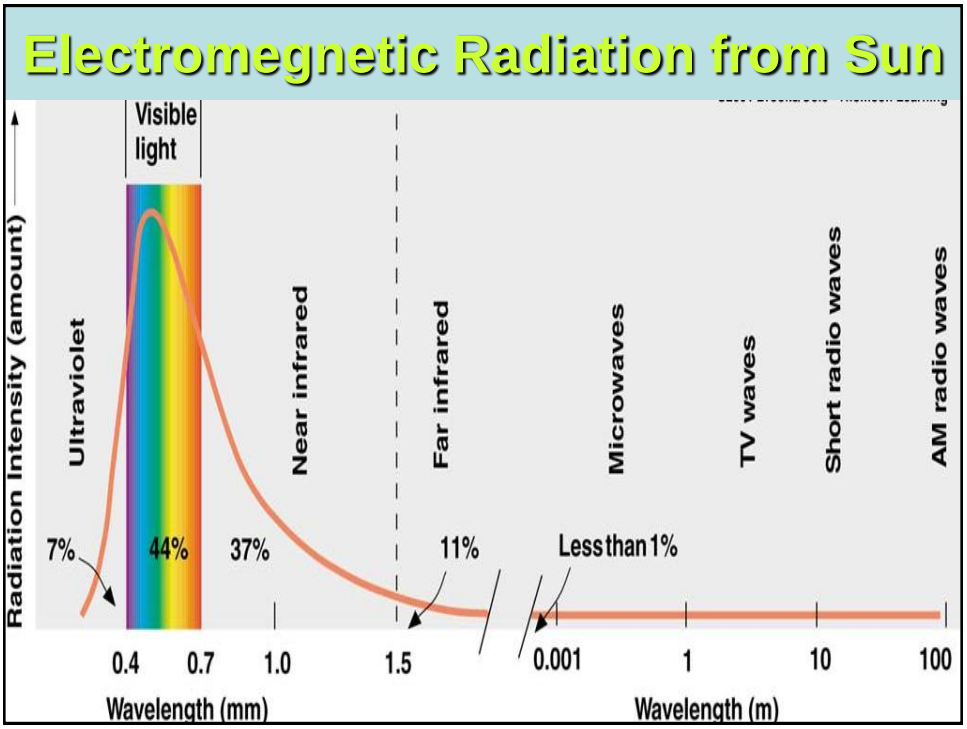


Wave equation (in a vacuum)

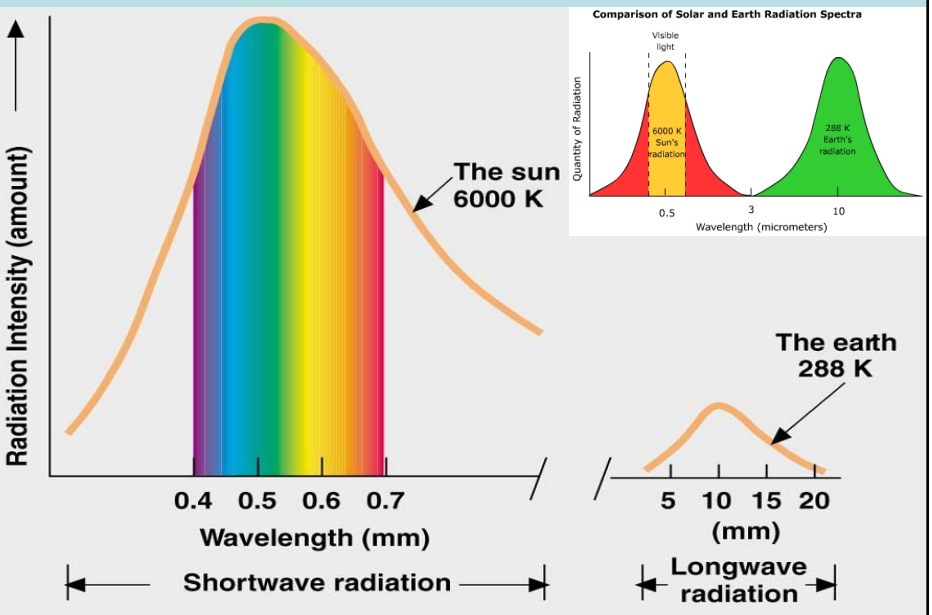
$$C = \lambda v$$

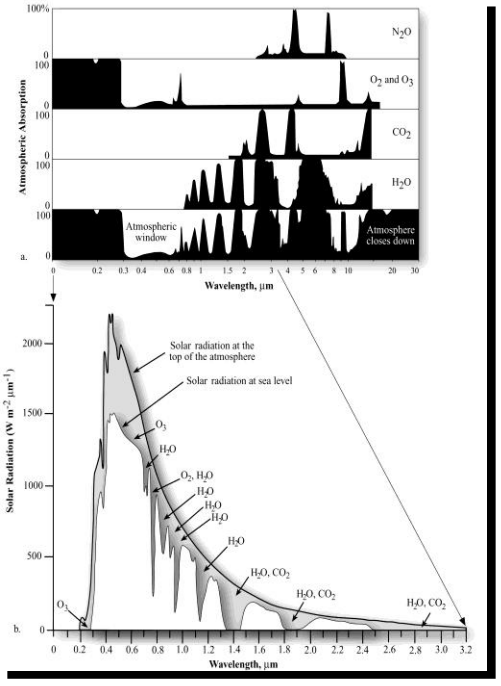
$$V = c/\lambda$$

$$\lambda = c/v$$



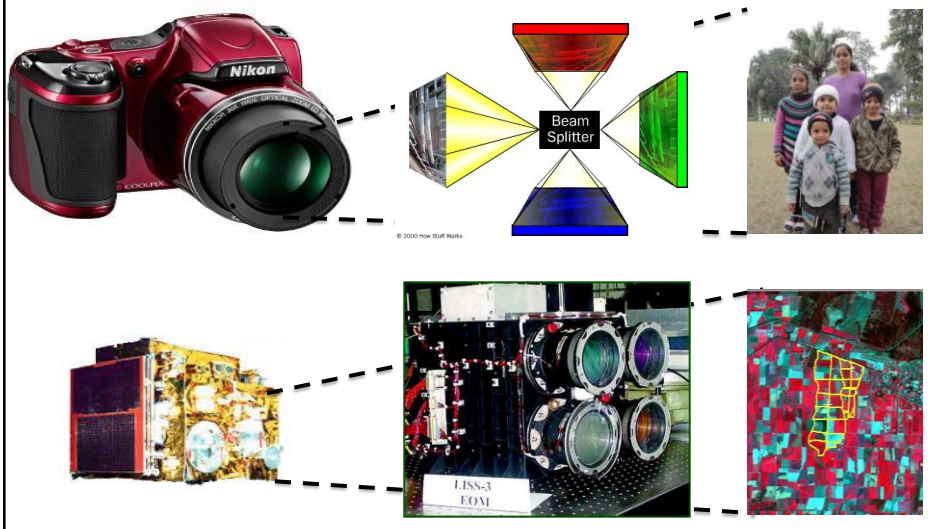
Radiation from Sun and Earth





a) The *absorption* of the Sun's incident electromagnetic energy in the region from 0.1 to 30 μm by various atmospheric gases. The first four graphs depict the absorption characteristics of N_2O, O_2 and O_3, CO_2, and H_2O, while the final graphic depicts the cumulative result of all these constituents being in the atmosphere at one time. The atmosphere essentially "closes down" in certain portions of the spectrum while "atmospheric windows" exist in other regions that transmit incident energy effectively to the ground. It is within these windows that remote sensing systems must function.
b) The combined effects of atmospheric absorption, scattering, and reflectance reduce the amount of solar irradiance reaching the Earth's surface at sea level.

RS vs Digital Camera



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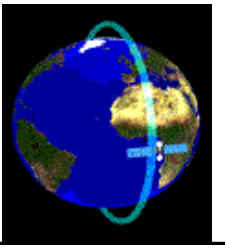
Remote Sensing Satellites

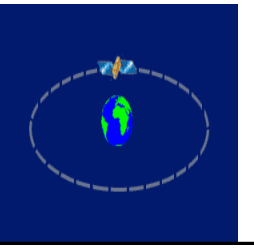
Polar Orbits

Orbiting at an altitude of 700 to 800 km, these satellites cover best the parts of the world most difficult to cover in situ (on site). These satellites operate in a sun-synchronous orbit. The satellite passes the equator and each latitude at the same local solar time each day, meaning the satellite passes overhead at essentially the same solar time throughout all seasons of the year. This feature enables regular data collection at consistent times as well as long-term comparisons. Ex- **SPOT, LANDSAT, IRS (1A, 1B, 1C, 1D), Resourcesat, Cartosat, RISAT**

Geostationary Orbits

A geostationary (GEO=geosynchronous) orbit is one in which the satellite is always in the same position with respect to the rotating Earth. The satellite orbits at an elevation of approximately 36000 km because that produces an orbital period (time for one orbit) equal to the period of rotation of the Earth (23 hrs, 56 mins, 4.09 secs). By orbiting at the same rate, in the same direction as Earth, the satellite appears stationary (synchronous with respect to the rotation of the Earth). Geostationary satellites provide a "big picture" view, enabling coverage of weather events. This is especially useful for monitoring severe local storms and tropical cyclones. Ex- INSAT, METEOSAT, EDUSAT etc





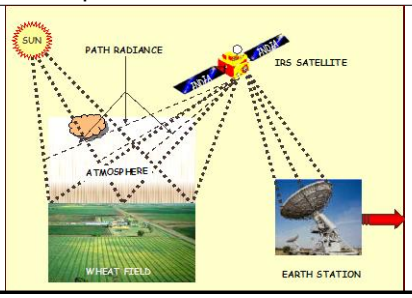
Types of remote sensing

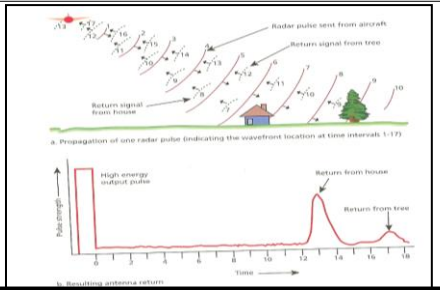
- **Passive:** source of energy is either the Sun, Earth, or atmosphere
  - Sun
    - wavelengths: 0.4-5 µm
  - Earth or its atmosphere
    - wavelengths: 3 µm -30 cm

  Advantage: Cost effective, images available in Multi-spectral Bands

- **Active:** source of energy is part of the remote sensor system
  - Radar
    - wavelengths: mm-m
  - Lidar
    - wavelengths: UV, Visible, and near infrared

  Advantages: All time weather, height detection, able to penetrate ground up to certain depth.





Landsat 8

Landsat 8-Launched February 11, 2013

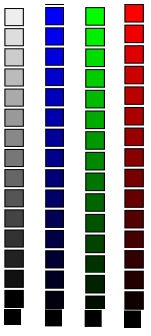
	Bands	Wavelength (micrometers)	Resolution (meters)
Operational Land Imager (OLI) and	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
Thermal Infrared Sensor (TIRS)	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

IRS-P6

Indian Remote Sensing (IRS) P6 (RESOURCESAT-1) was launched in October 2003. This satellite carries three different imaging sensors: Linear Imaging Self Scanner (LISS) 3 and 4 and an advanced Wide Field Scanner (AWiFS). The LISS 3 instrument is multispectral in the visible to mid-infrared region with a spatial resolution of 23.5m and swath width of 140km. The LISS 4 instrument has two modes that both operate at a spatial resolution of 5.8m. The multispectral (visible to near-infrared) instrument has a swath width of 24km and 70km for the panchromatic (monochrome) mode. The AWiFS has a spatial resolution of 60m and a 740km swath width. Both LISSs have 7-bit radiometric resolution, while the AWiFS has 10-bit.

	Band	Wavelength Region (µm)	Resolution (m)
AWIFS	1	0.0.52-0.59 (green)	60
	2	0.62-0.68 (red)	60
	3	0.77-0.86 (near-IR)	60
	4	1.55-1.70 (mid-IR)	60

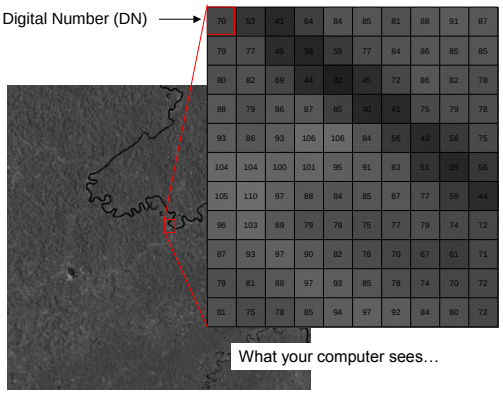
LISS-III			LISS-IV		
Band	Wavelength Region (µm)	Resolution (m)	Band	Wavelength Region (µm)	Resolution (m)
1	0.52 - 0.59 (green)	24	1	0.52 - 0.59 (green)	6
2	0.62 - 0.68 (red)	24	2	0.62 - 0.68 (red)	6
3	0.77 - 0.86 (near-IR)	24	3	0.77 - 0.86 (near-IR)	6
4	1.55 - 1.70 (mid-IR)	24	4	1.55 - 1.70 (mid-IR)	6
			pan	0.62-0.68 (red)	6



2 bit data system
$(2)^4$ = 16 level (0-15)

Digital Image Processing

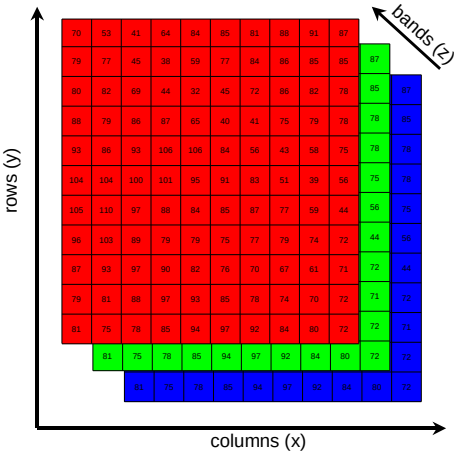
What Is A Digital Image?



Digital numbers (DNs) typically range from 0 to 255; 0 to 511; 0 to 1023, etc. These ranges are binary scales: 2^8=256; 2^9=512; 2^{10}=1024.

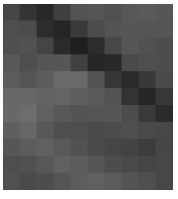
Digital Image Processing

What Is A Digital Image?



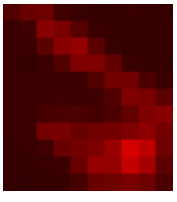
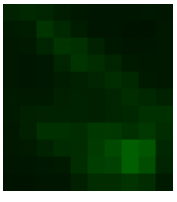
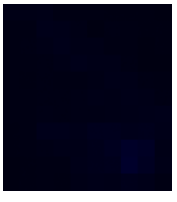
Digital Image Processing

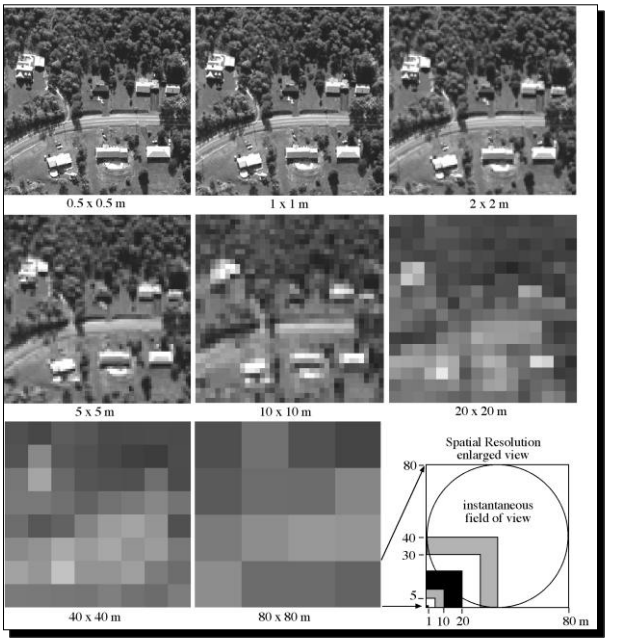
Greyscale vs. RGB



Greyscale is typically used to display a *single band*…

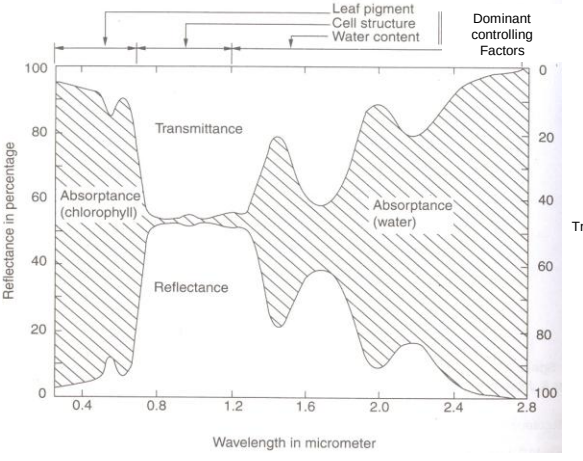
…while **RGB** ("Red", "Green", "Blue") images can display *3 bands*, corresponding to the red, green and blue phosphors on a monitor. Computer monitor colors are *additive*, meaning "true" red + green + blue = white.



Spatial Resolution

Concept of EMR Interaction

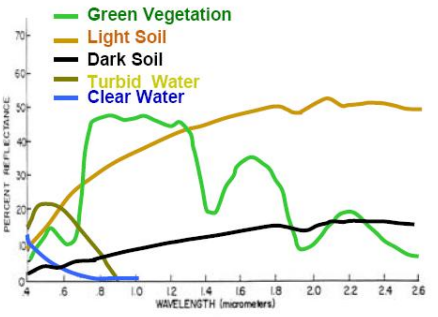


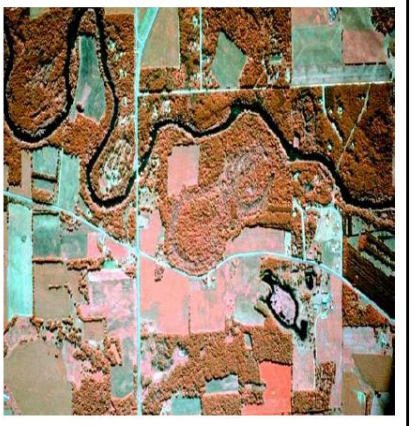
Reflection, Absorption and Transmittance spectra of a typical green leaf

Physical Basis for Remote Sensing

The distinctive character of electromagnetic radiation reflected or emitted from natural and human-made objects and scenes

Spectral Reflectance of Basic Cover Types



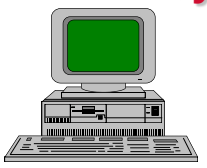


Applications in Agriculture

1) Natural Resources mapping such as river, drainage system, water province etc.,
2) To estimate the crop biomass, LAI etc.,
3) To draw information on phenology of the crop,
4) Crop Growth monitoring,
5) Nutrient management,
6) Moisture stress,
7) Pest and Disease detection and extent mapping,
8) Soil mapping,
9) Organic matter and nutrient status detection,
10) Precision Farming,
11) Cropping System Analysis,
12) Crop Yield Forecast.

What is a GIS?

Information System



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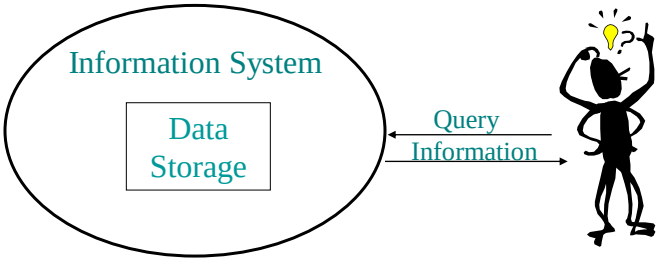
Geographic Position

A means of storing, retrieving, sorting, and comparing *spatial data* to support some analytic process.

What is an Information System?



Information systems can be very simple, such as a telephone directory.

What is an Information System?

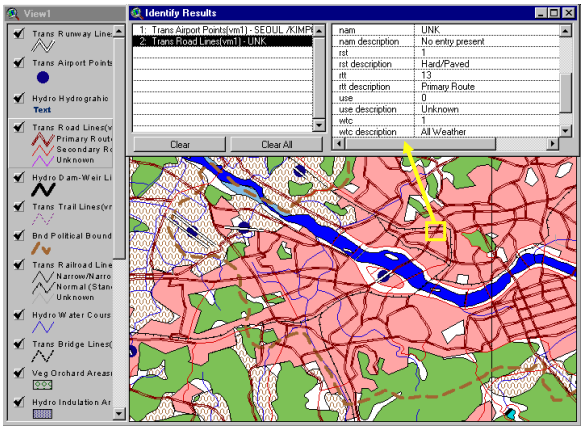
SYSTEM USED FOR:

capturing
storing
updating
manipulating
analyzing

DATA

What is a GIS?

GEOGRAPHIC Information System



GIS links graphical features (**entities**) to tabular data (**attributes**)

GIS Definition

- A GIS is a system (hardware + database engine) that is designed to efficiently, assemble, store, update, analyze, manipulate, and display **geographically referenced information** (data identified by their locations).

- A GIS also includes the **people** operating the system and the **data** that go into the system.

Data vs. Information

- Data, by itself, generally differs from information.
- Data is of little use unless it is transformed into information.
- Information is an answer to a question based on raw data.
- We transform data into information through the use of an Information System.

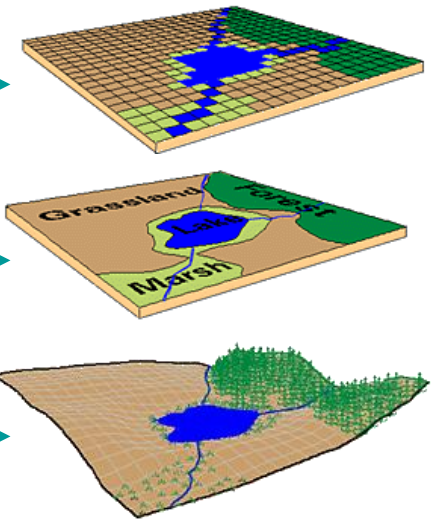
Key Functions of a GIS

Data can be:

1. Positioned by its known spatial coordinates.
2. Input and organized (generally in **layers**).
3. Stored and retrieved.
4. Analyzed (usually via a Relational DBMS).
5. Modified and displayed

Representing Spatial Elements

- RASTER →
- VECTOR →
- Real World →



Representing Spatial Elements

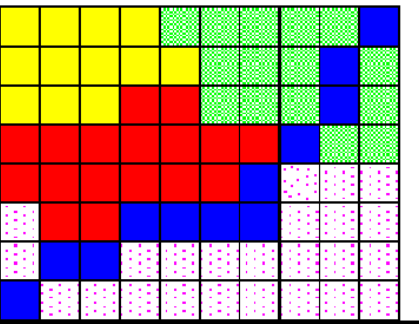
Raster

Stores images as rows and columns of numbers with a Digital Value/Number (DN) for each cell.

Units are usually represented as square grid cells that are uniform in size.

Data is classified as "*continuous*" (such as in an image), or *"thematic"* (where each cell denotes a feature type.

Numerous data formats (TIFF, GIF, ERDAS.img etc)

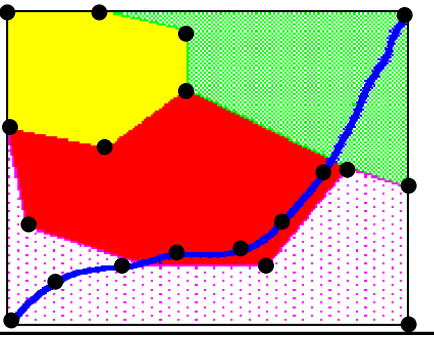


Representing Spatial Elements

Vector

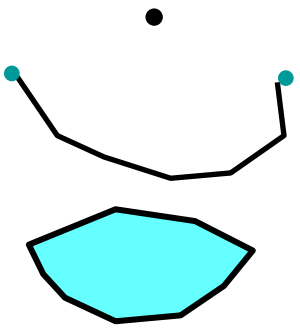
Allows user to specify specific spatial locations and assumes that geographic space is continuous, not broken up into discrete grid squares

We store features as sets of X,Y coordinate pairs.



Entity Representations

We typically represent objects in space as three distinct spatial elements:



Points - simplest element

Lines (arcs) - set of connected points

Polygons - set of connected lines

We use these three spatial elements to represent real world features and attach locational information to them.

Attributes

- In the raster data model, the cell value (Digital Number) is the attribute. Examples: brightness, landcover code, SST, etc.
- For vector data, attribute records are linked to point, line & polygon features. Can store *multiple* attributes per feature. Vector features are linked to attributes by a *unique feature number*.

Raster vs. Vector

Raster Advantages

The most common data format

Easy to perform mathematical and overlay operations

Satellite information is easily incorporated

Better represents “continuous”- type data

Vector Advantages

Accurate positional information that is best for storing discrete thematic features (e.g., roads, shorelines, sea-bed features.

Compact data storage requirements

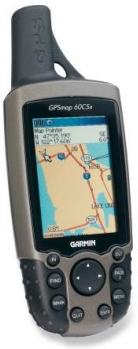
Can associate unlimited numbers of attributes with specific features

GIS Applications in Agriculture

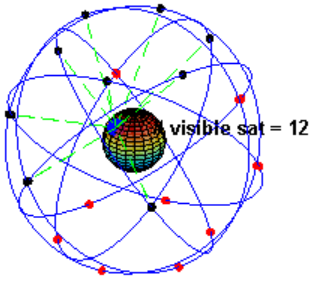
- Precision Farming
- Nutrient management
- Water management
- Suitability Analysis
- Forming homogenous zones (Agro-ecological / agro-climatic, agro-edaphic etc.)
- Pests and diseases monitoring and management
- Establishment of Agro-industries.
- Nearest site for Agro product storage like coldstorage.
- Selection of shortest route for agricultural produce transportation.

GPS

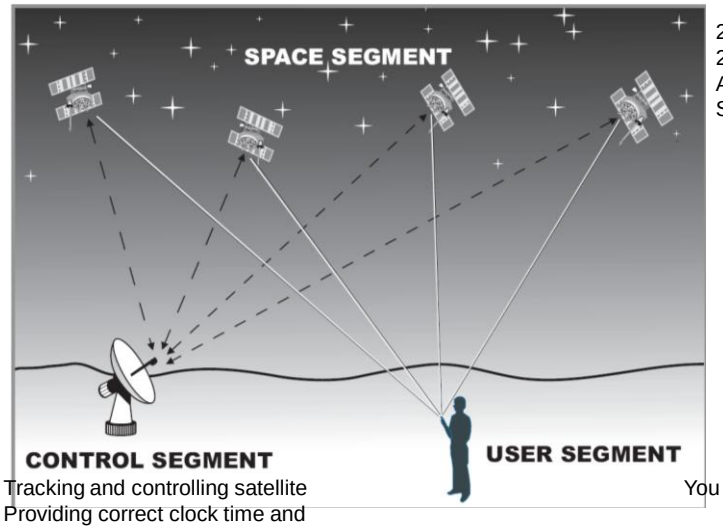
- Global Positioning System is an instrument, which provide geographic information of the object i.e. latitude, longitude and altitude



GPS



GPS: 3 Segments



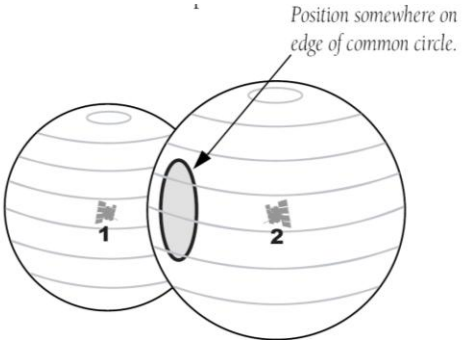
24 Satellites
21 Active and 3 spares
At 12000 miles height
Speed 7000 mph

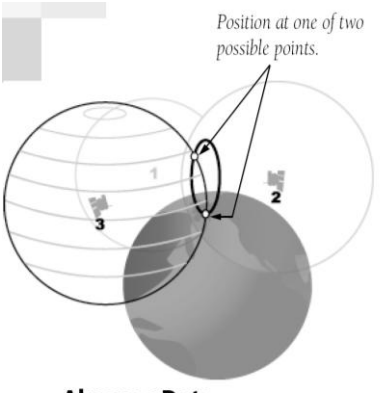
Tracking and controlling satellite
Providing correct clock time and orbital information

You and GPS Reciever

NAVSTAR: NAVigation Satellite Timing And Ranging

GPS: Functions





Almanac Data

GPS: Uses

1) To know geo-coordinates
2) To know altitude
3) To survey
4) For acreage estimation
5) Navigation
6) Transportation

Geospatial Technology based Information

i. Information on spatial distribution of natural resources
ii. Information of field variability like Nitrogen, Phosphorous, Potash, OM, pH etc
iii. Soil moisture information
iv. Information on crop biophysical parameters such as LAI, biomass, height etc
v. Nutrient and water status of crops
vi. Pests and disease identification and extent
vii. Acreage of different crops
viii. Suitability of various crops/plants
ix. Information on best route/optimum route for transportation of agricultural produces
x. Information on suitable sites for establishing industries.