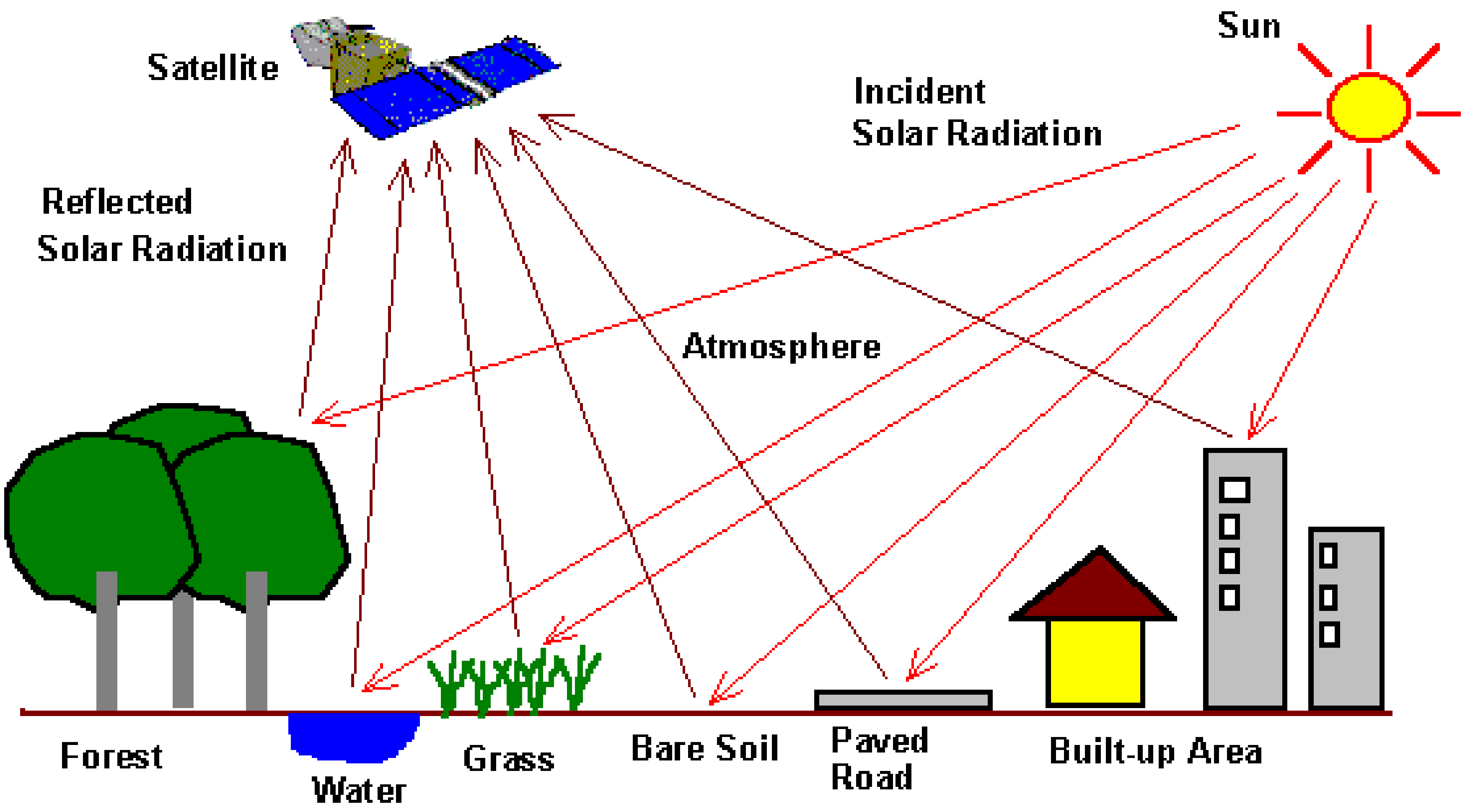
Introduction to Remote Sensing and GIS and their applications

REMOTE SENSING



Remote Sensing and Image Processing

Aerial Photography and Photogrammetry

Structure

- **Definitions of Remote Sensing**
- Origins of remote sensing
- Types of aerial photograph
- Photogrammetry
- Parallax
- Human vision
- Conclusions

Definitions of Remote Sensing

Can be very general, e.g.
"The acquisition of physical data of an object **without touch or contact**" (Lintz and Simonett, 1976)
"The observation of a target by a device **some distance away**" (Barrett and Curtis, 1982)

Definitions of Remote Sensing

Or more specific, e.g.
"The use of **electromagnetic radiation sensors** to record images of **the environment**, which can be interpreted to yield **useful information**" (Curran, 1985)

Remote sensing is the art and science of making measurements of the earth using sensors on airplanes or satellites.

These sensors collect data in the form of images and provide specialized capabilities for **manipulating, analyzing, and visualizing those images**.

Remote sensed imagery is integrated within a GIS.

Definitions of Remote Sensing

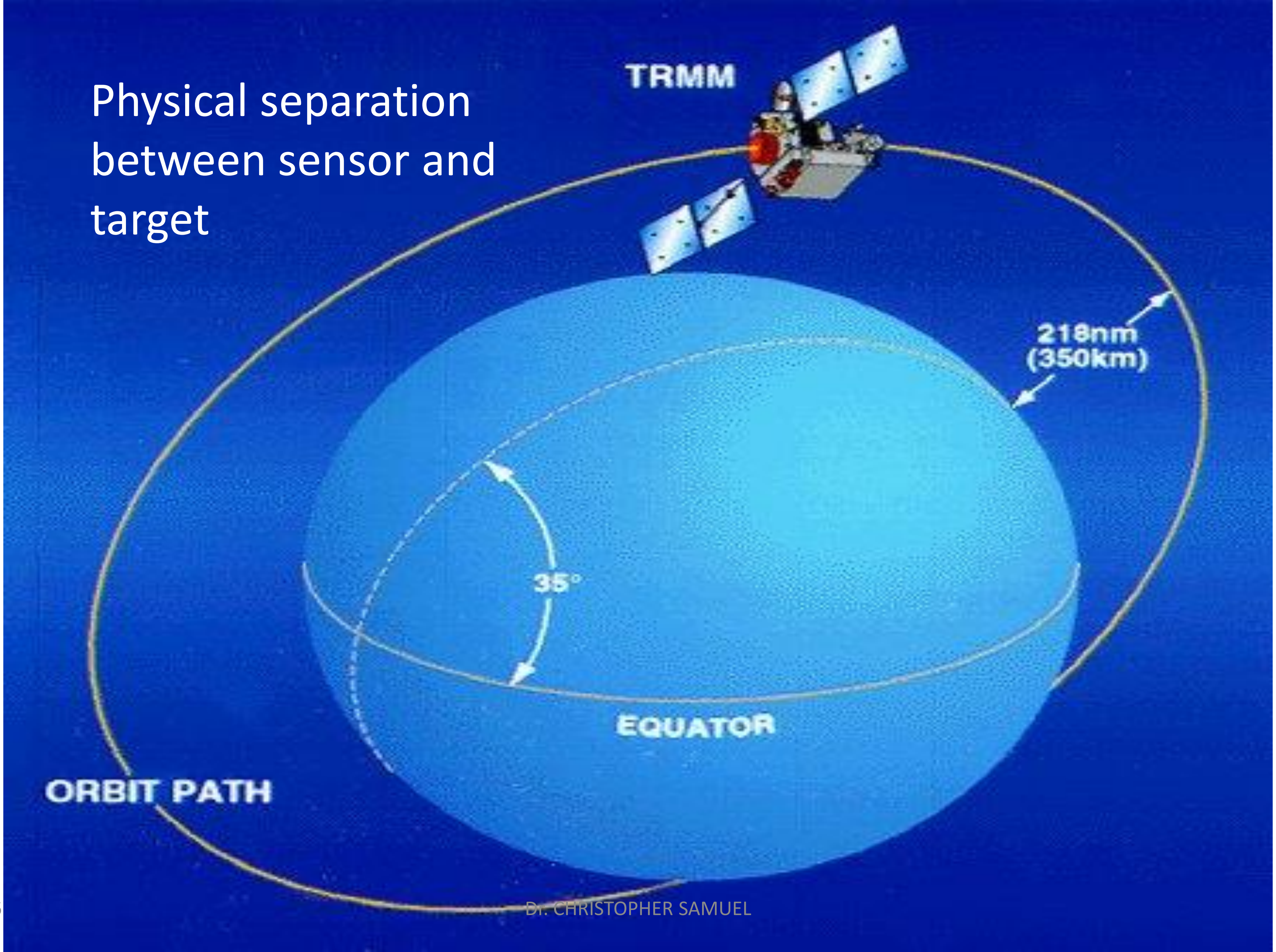
Or more specific, e.g.
"The use of sensors, normally operating at wavelengths from the **visible to the microwave**, to collect information about the Earth's **atmosphere, oceans, land and ice surfaces**" (Harris, 1987)

Definitions of Remote Sensing

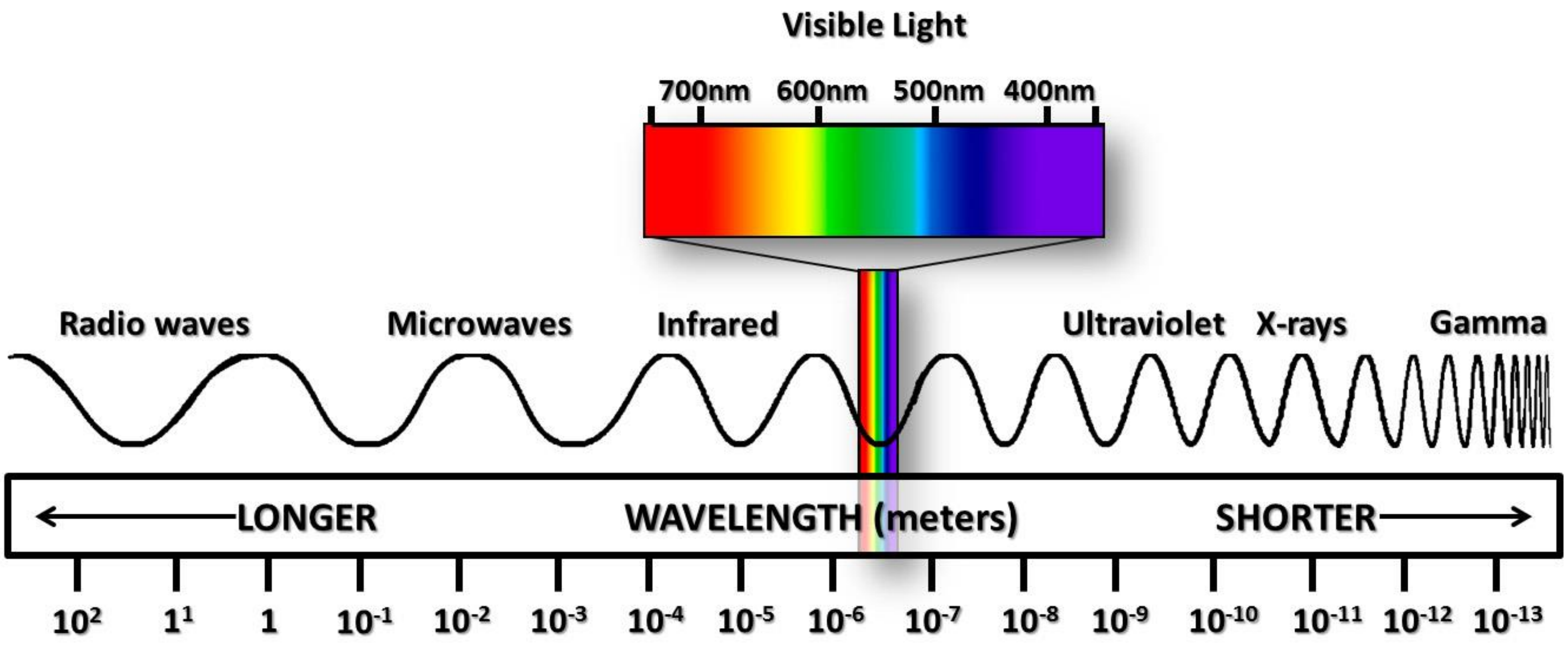
Main characteristics

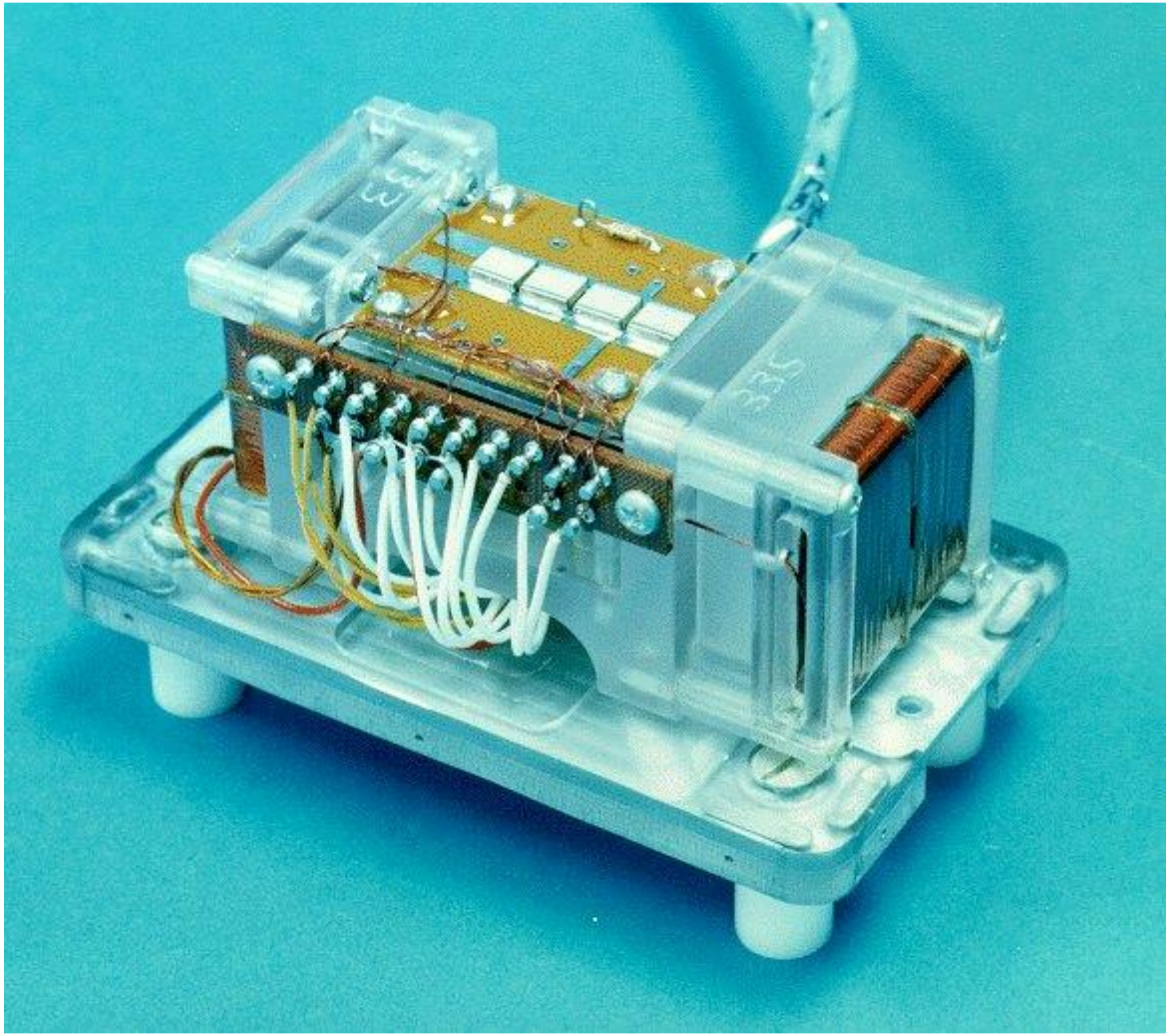
- Physical separation between sensor and target
- Medium = electromagnetic radiation (sonar is an exception)
- Device to sample and measure radiation (sensor)
- Target is the terrestrial environment (atmosphere, oceans, land surface)

Physical separation between sensor and target

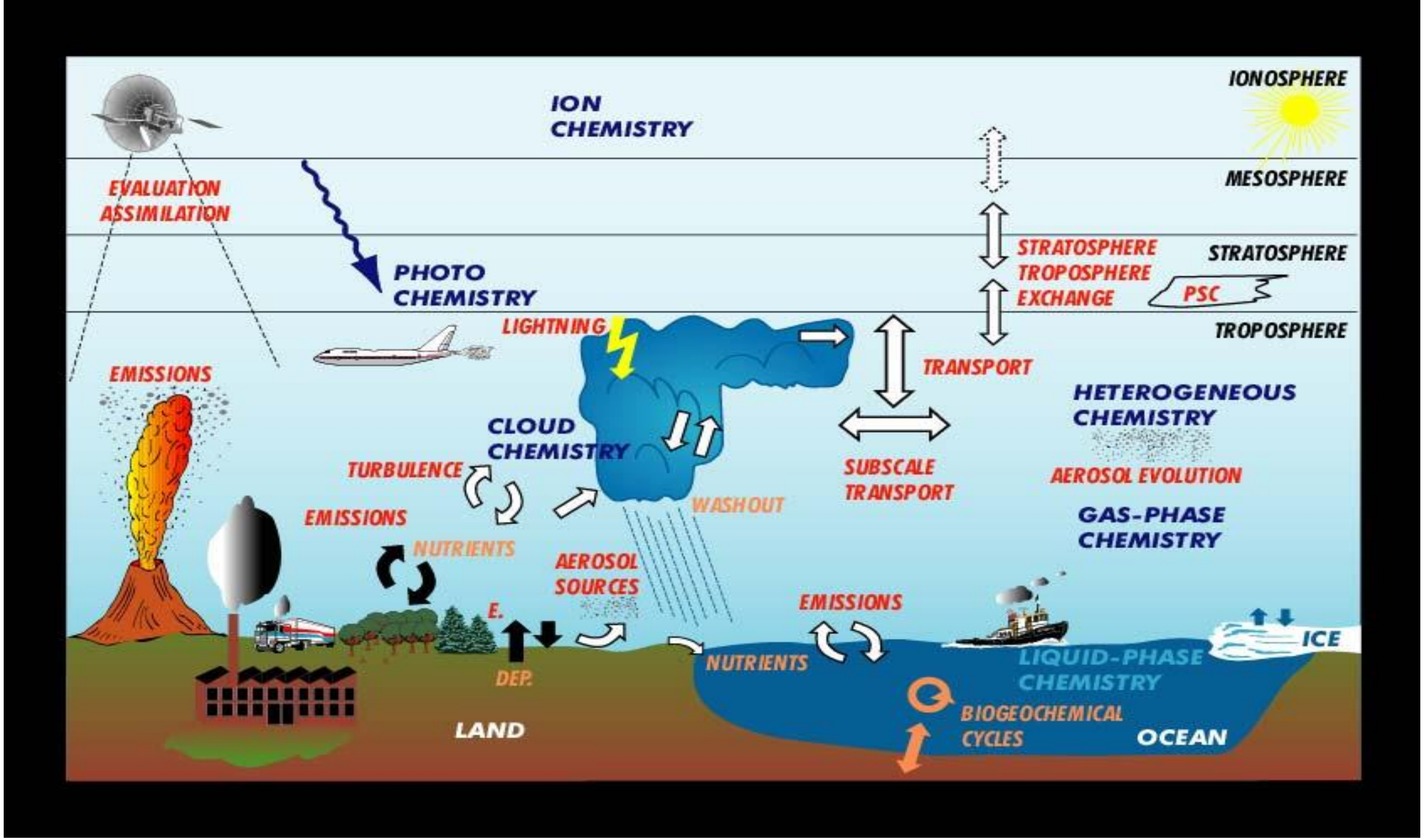


ELECTROMAGNETIC RADIATION





Device to sample and measure radiation (sensor)



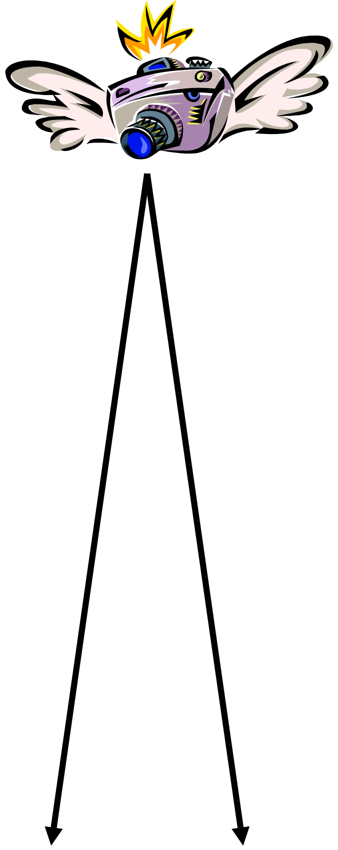
Target is the terrestrial environment (atmosphere, oceans, land surface)

Origins of Remote Sensing

Remote sensing began with aerial photography

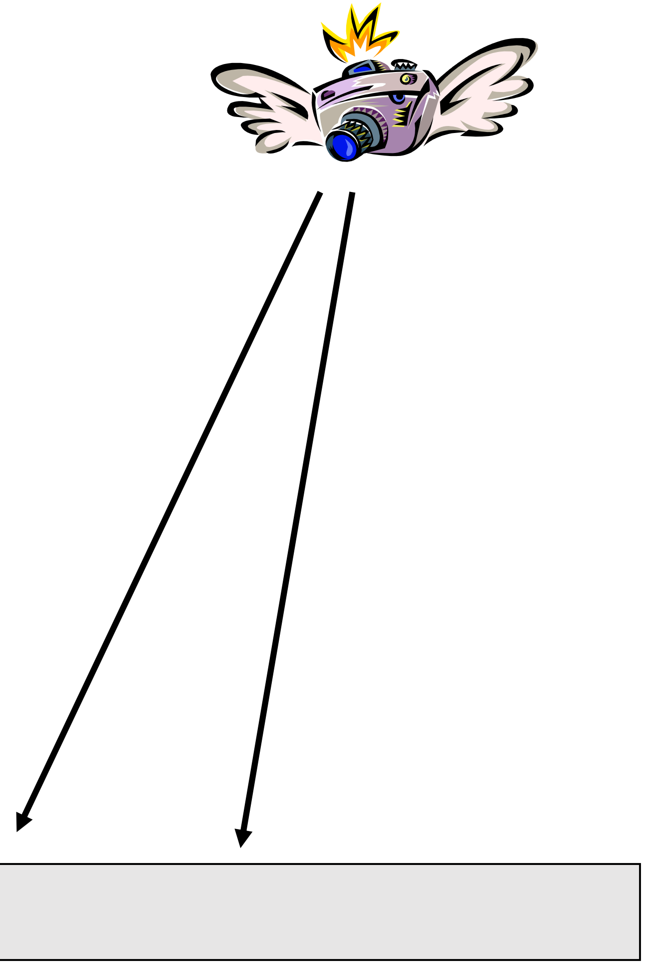
Types of aerial photograph

- Vertical
- Low oblique
- High oblique



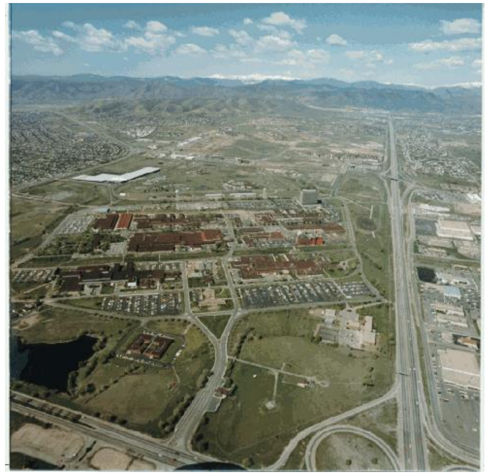
Types of aerial photograph

- Vertical
- Low oblique (no horizon)
- High oblique



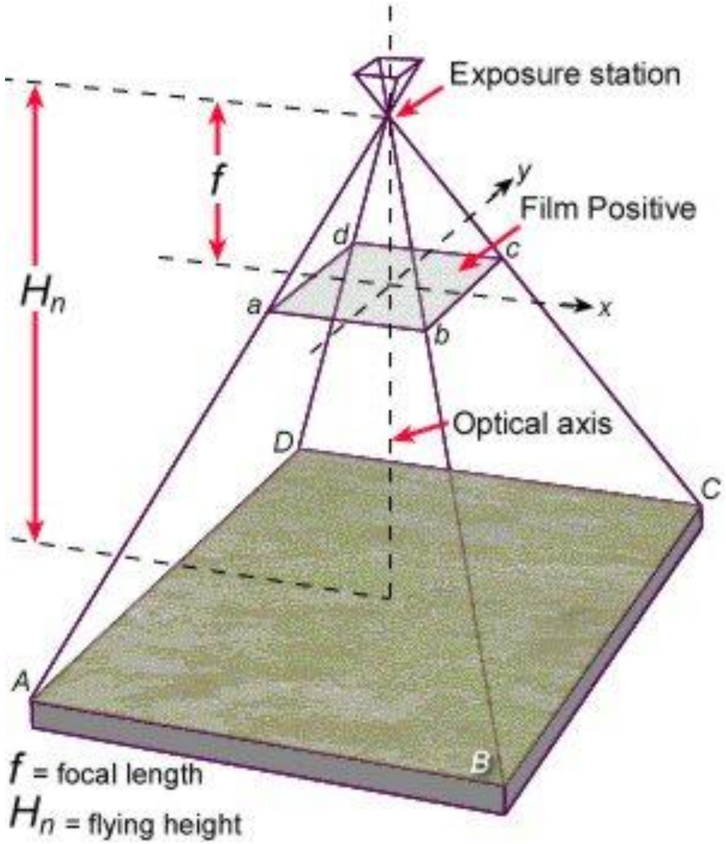
Types of aerial photograph

- Vertical
- Low oblique
- High oblique



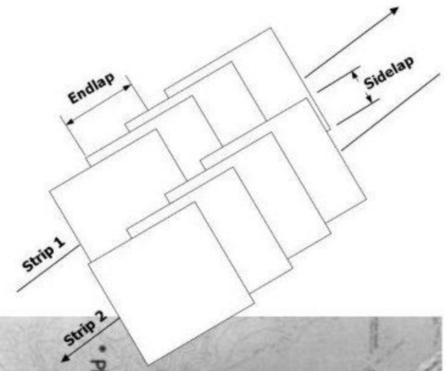
Types of aerial photograph

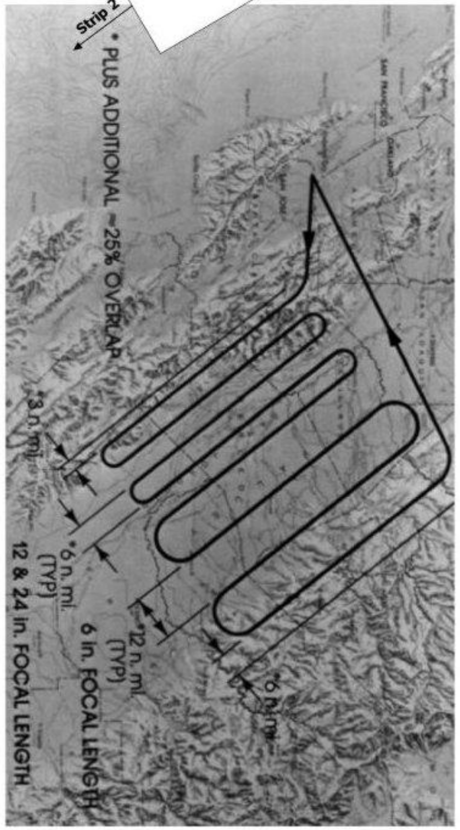
Vertical is most important as it has minimum distortion and can be used for taking measurements



Types of aerial photograph

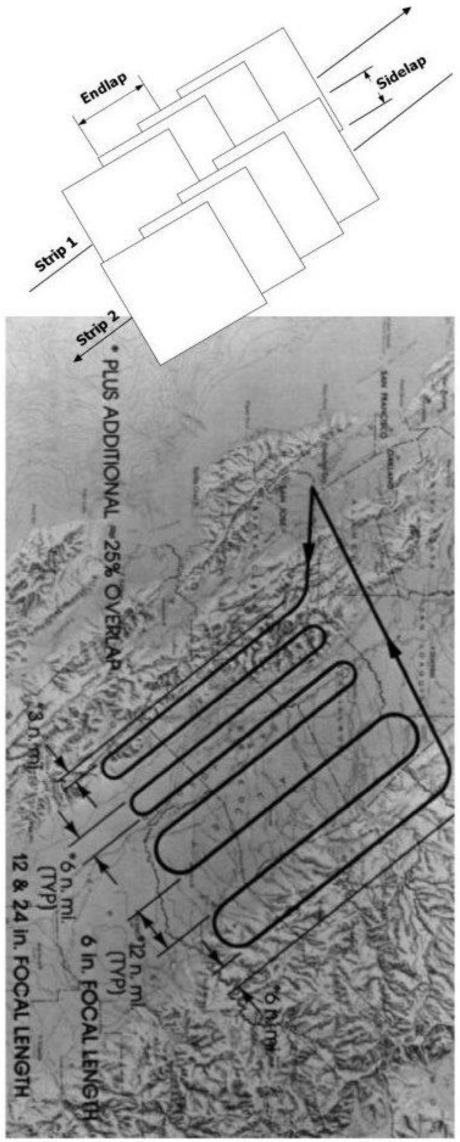
An aerial photograph mission will be flown in strips, shutter timing set for 60% endlap (needed for parallax) and strips spaced for 30% sidelap (to avoid missing bits)





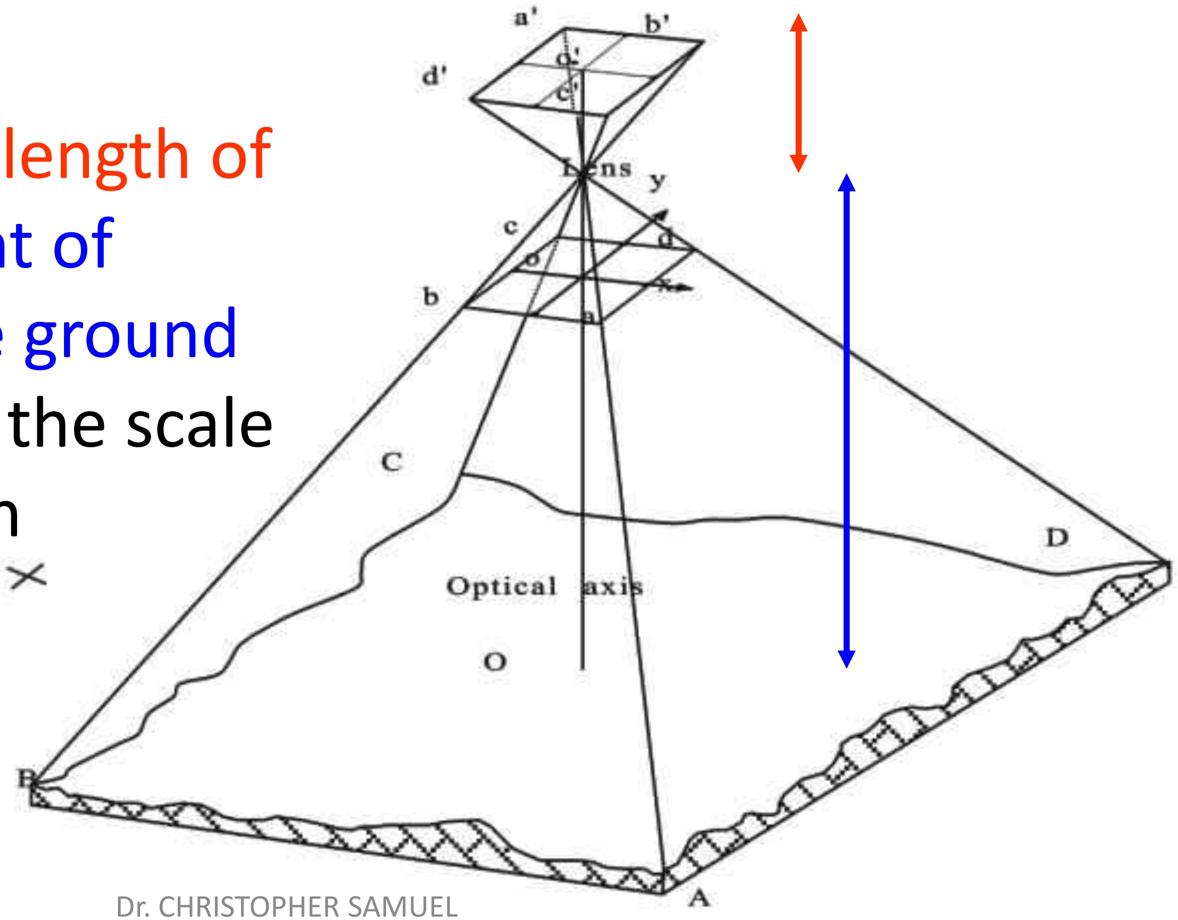
Types of aerial photograph

- Endlap (or forelap) is the important bit
- It ensures every point on the ground appears in at least two photographs
- Distance between principal point of adjacent photographs is known as the "air base"

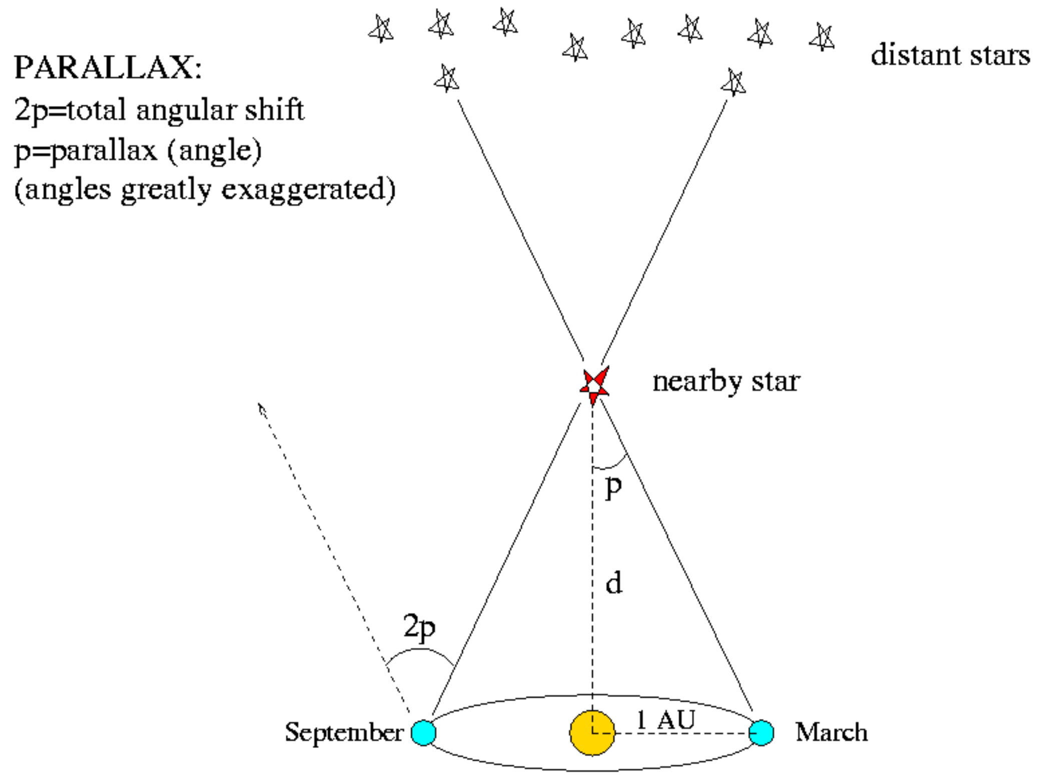


Photogrammetry

If you know focal length of camera and height of aircraft above the ground you can calculate the scale of the photograph

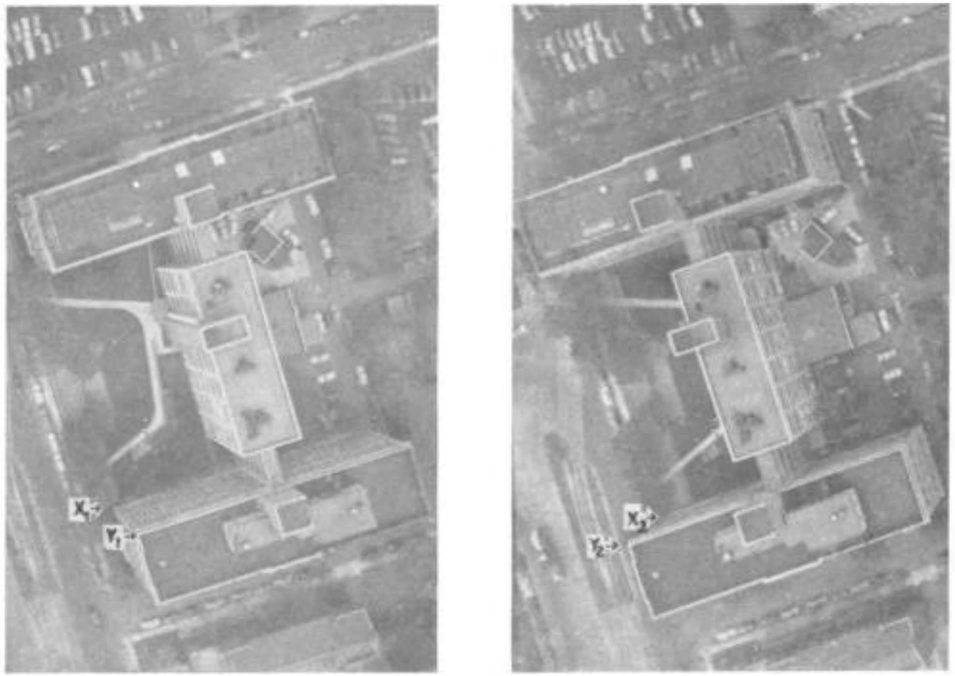


Parallax



Parallax is used to find distance to stars, using two viewing points on either side of Earth's orbit

Parallax



The same principle can be used to find height of objects in stereopairs of vertical aerial photographs

Parallax

$$\text{Height of object} = \frac{H \cdot dP}{P + dP}$$

H = height of aircraft above ground
P = absolute parallax at base of object being measured*
dP = differential parallax

* For convenience the photo base length of a stereo pair is commonly substituted for absolute stereoscopic parallax (**P**)

Conclusions

- Remote sensing involves collecting information about the Earth from a distance using electromagnetic sensors
- It evolved from aerial photography
- Vertical stereopairs of aerial photographs are used to take 3-D measurements by measuring parallax
- Human vision is binocular, enabling us to resolve parallax for depth perception
- Human vision includes perception of colour

The Importance of Remote Sensing - Continued

Allows for the collection of much more data in a shorter amount of time

- Leads to increased land coverage AND
- Increases ground resolution of a GIS

Digital Imagery greatly enhances a GIS

- DIRECTLY: Imagery can serve as a visual aid
- INDIRECTLY: Can serves as a source to derive information such as…
  - Land use/land cover
  - Atmospheric emissions
  - Vegetation
  - Water bodies
  - Cloud cover
  - Change detection (including sea ice, coastlines, sea levels, etc.)

RS Methods in GIS

- **SARELLITE SENSORS**
- Passive Sensors:
  - Landsat TM (thematic mapping)
  - AVHRR (Advanced Very High Resolution Radiometer)
  - Spot High Resolution
  - MODIS Moderate Resolution Imaging Spectroradiometer (NASA)
  - IKONOS IKONOS satellite is a high resolution satellite operated by DigitalGlobe
  - Quickbird QuickBird collects image data to 0.65 m pixel resolution degree of detail. This satellite is an excellent source of environmental data useful for analyses of changes in land usage, agricultural and forest climates.
- Passive Systems: Aerial Photography (from Airplanes, Drones, Balloons)
- Active Sensors: Radar
  - DEMs (Digital Elevation Models)

Coarser Resolution Satellite Sensors Used

LANDSAT Thematic Mapper

Good for regional coverage

30m MS resolution

15 m panchromatic resolution

Most Common Use:

Land Cover/Land Use Mapping

MODIS

36 spectral bands

Most Common Uses:

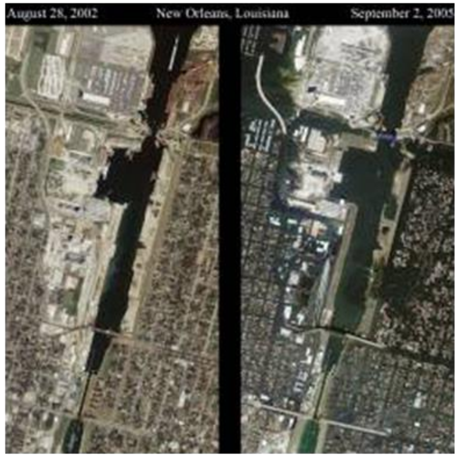
Cloud/Aerosol Properties

Ocean Color

Atmospheric Water Vapor

Sea/Atmospheric Temperatures

Higher Resolution Satellite Sensors Used



IKONOS

4 m visible/infrared resolution

1 m panchromatic resolution

Quickbird

2.5 m multispectral resolution

61 cm (~2 ft.) panchromatic resolution

MOST COMMON USES FOR HIGH RESOLUTION:

Accurate Base Maps

Infrastructure Mapping

Disaster Assessment (Smaller Scale)

Digitizing Data

- **MANUAL**
  - Map is fixed to digitizer table
  - Control Points are digitized
  - Feature Boundaries are digitized in stream or point mode
  - The layer is proofed and edited
  - The layer is transformed/registered to a known system

- **AUTOMATED SCANNERS**
  - Digitizing done automatically by a scanner
  - There is a range of scanner qualities
  - Most utilize the reflection/transmission of light to record data
  - "Thresholding" allows for the determination of both line and point features from a hardcopy map
  - Editing still required

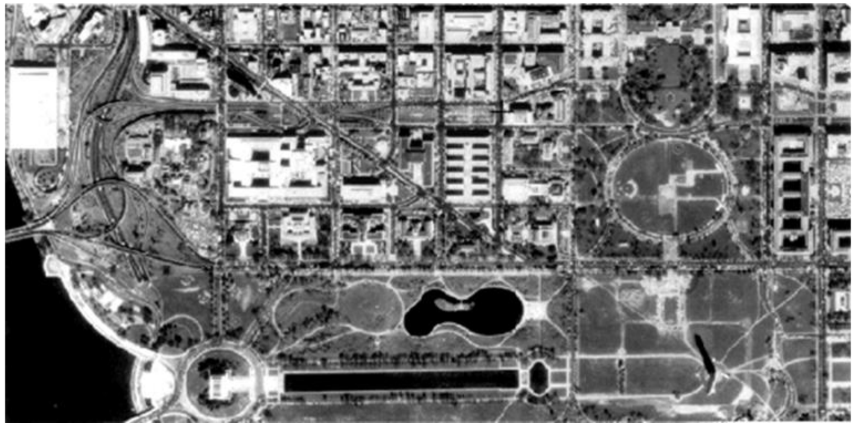
- **DIRECT DATA ENTRY**
  - Coordinate Geometry is used, with GPS playing a vital role
  - This involves directly entering in coordinates measured in the field
  - These coordinates can then be tagged with attribute data
  - This data this then downloaded to a computer and incorporated into a GIS

Air Photos: DOs

- An **orthophotograph** is an aerial photograph that has been corrected to remove distortions caused by:
  - Camera optics
  - Tilt
  - Elevation differences

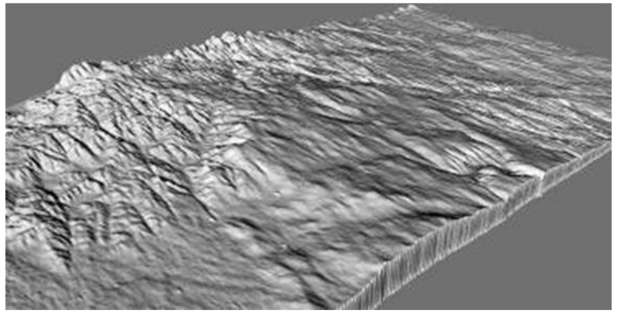
- **Digital Conversion (“Registration”)**
  - Must be converted to digital format before integration into a GIS
  - Photograph is split into many pixels
  - Distortion at each point must be calculated
  - A photograph is considered registered when each pixel has its exact position (geographically) placed with the above distortions having been taken into account

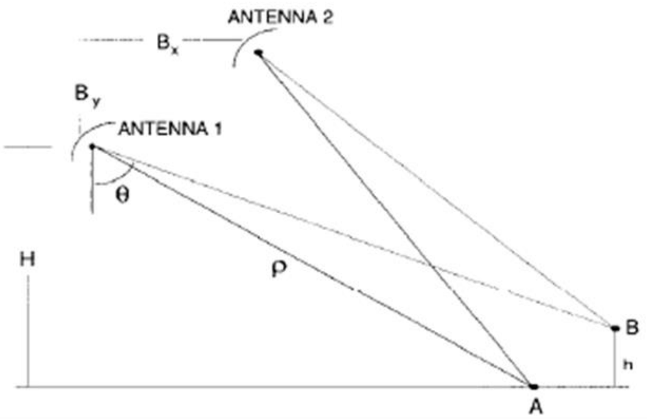
- These registered air photos can then be used to extract data or as a base map for a GIS (or both)



Radar Data: DEMs

- Active sensors provide the most thorough, accurate and intricate model of topography
- Radar can reach places nearly impossible to survey manually
- **Interferometric Synthetic Aperture Radar**
  - Two passes of a radar satellite are used
  - Any phase difference of returned echoes yields information about the angle from which the echo was returned
  - Allows for topographic information to be derived



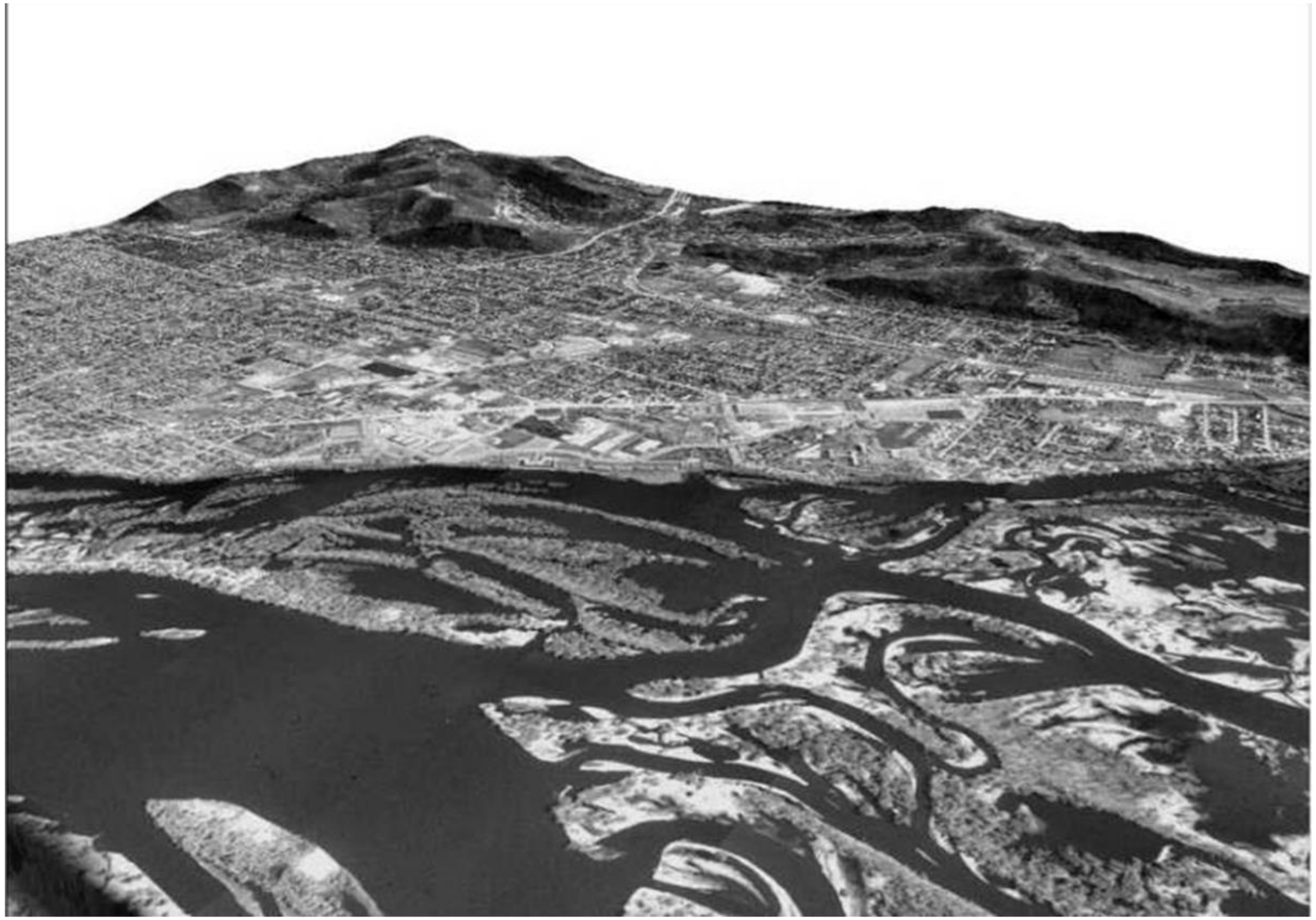


h is pixel height and phi is phase difference:

$$\phi = \frac{2\pi}{\lambda}[B_x \sin\theta - B_y \cos\theta]$$

$$h = H - \rho(\cos\theta)$$

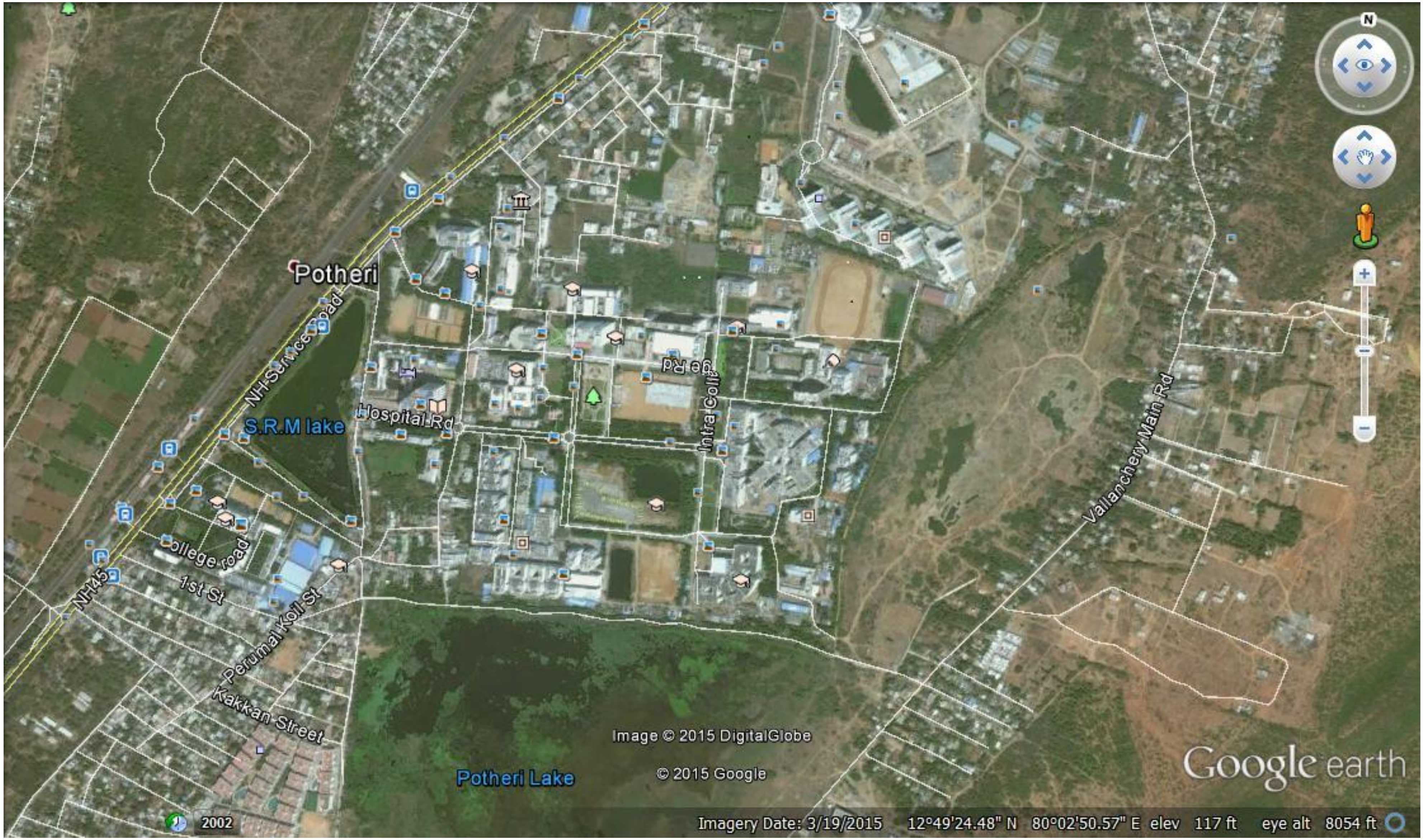
Source: http://www.sco.wisc.edu/maps/digitalelevation.php#GIS



This image was created by overlaying a 1m resolution DO on a DEM of the same area (both utilize the same projection)

Applications

- Change Detection
- Disaster Assessment
  - Hurricane Katrina & Rita
  - 2004 Tsunami
- Atmospheric Modeling
  - aerosols
  - air pollution
  - climate change
- Ocean
  - topography
  - currents


Potheri
NH Service Road
S.R.M lake
Hospital Rd
Intra College Rd
Vallanchery Main Rd
College road
1st St
NH45
Perumal Koil St
Kakkan Street
Potheri Lake
Image © 2015 DigitalGlobe
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Google earth
2002
Imagery Date: 3/19/2015 12°49'24.48" N 80°02'50.57" E elev 117 ft eye alt 8054 ft

THE END