GIST 8118
Mod 02 - Satellites and Sensors

How the data is collected

How the data is displayed

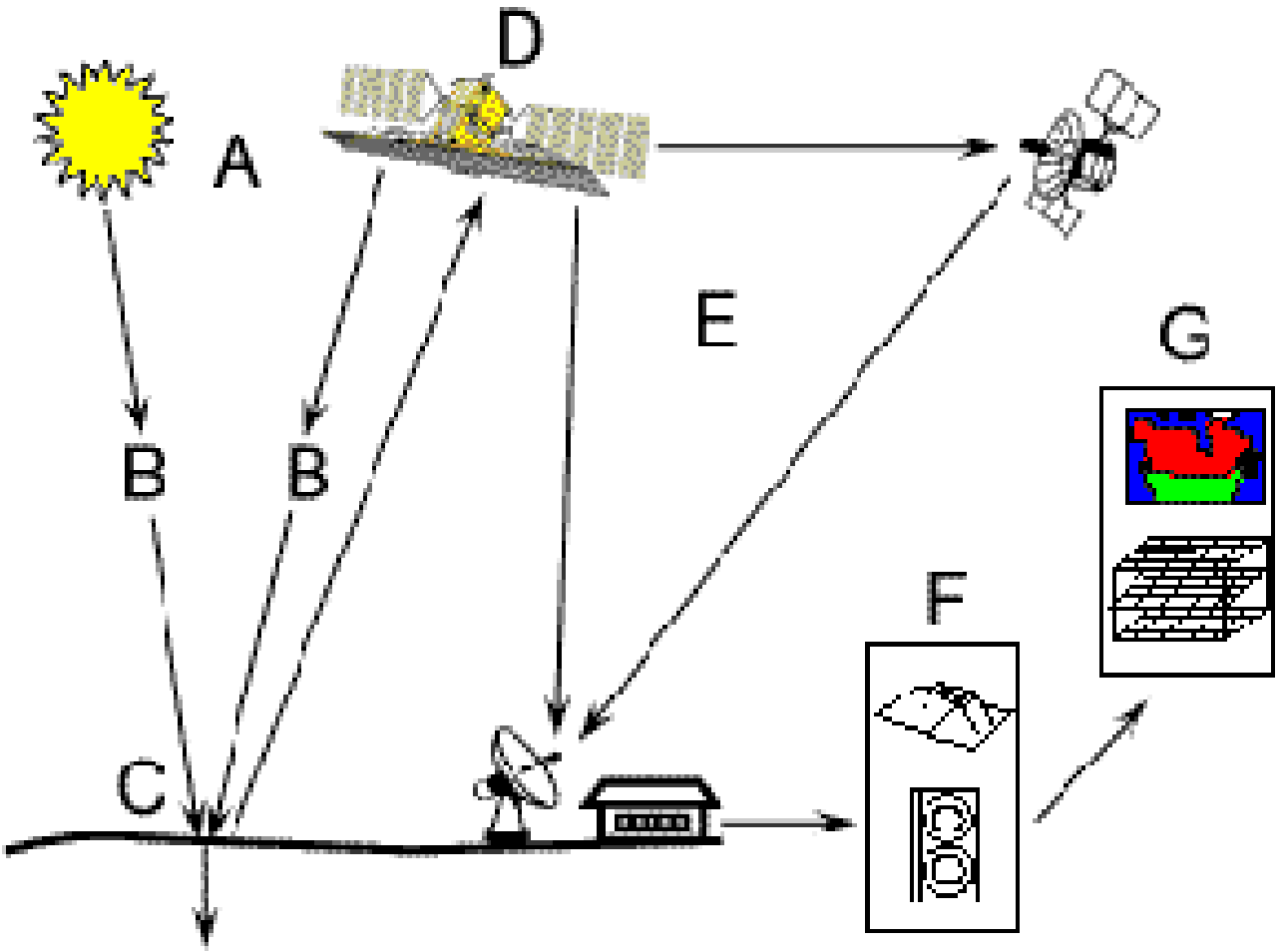
Mod 02 - Satellites and Sensors

- Lecture
  - Remote Sensing System
  - Data Acquisition
  - EM Radiation
  - Spectral Signatures
  - Platforms
  - Image creation
  - Satellite Properties
  - Examples
- Lab Module 02
  - Viewing images
  - Comparing different sensors
  - Creating signatures

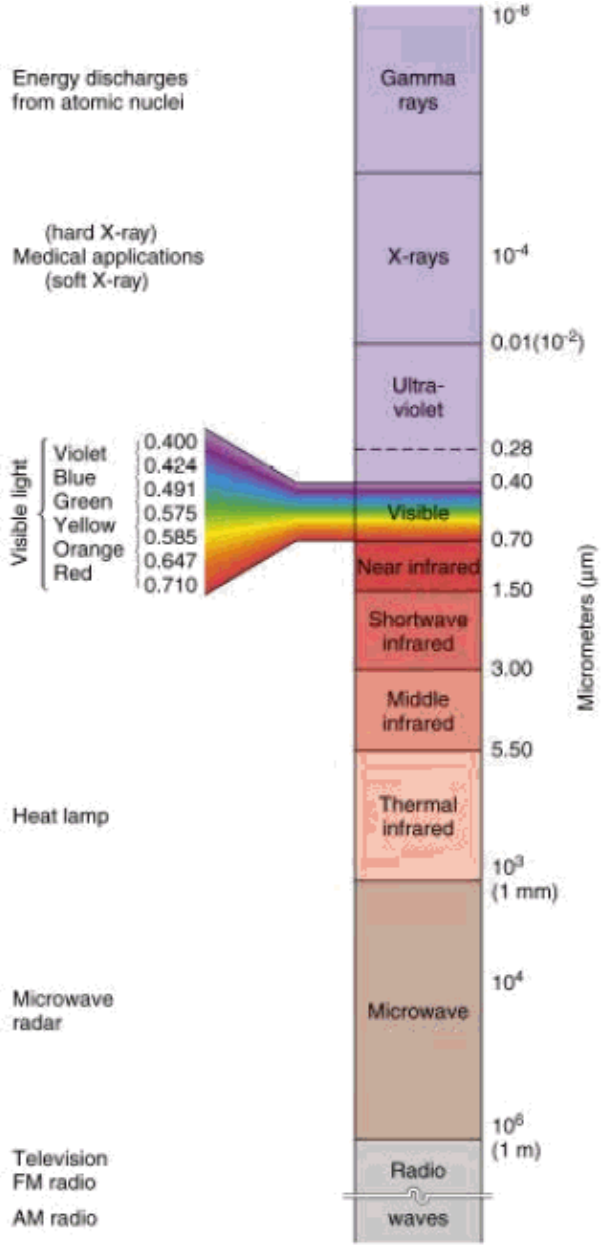
A Remote Sensing System

- A - Energy source
- B – Atmosphere
- C - Object
- D - Platform
- D - Sensor
- E - Data recording / transmission
- E - Ground receiving station
- F - Data processing
- G - Expert interpretation / data users

A Remote Sensing System

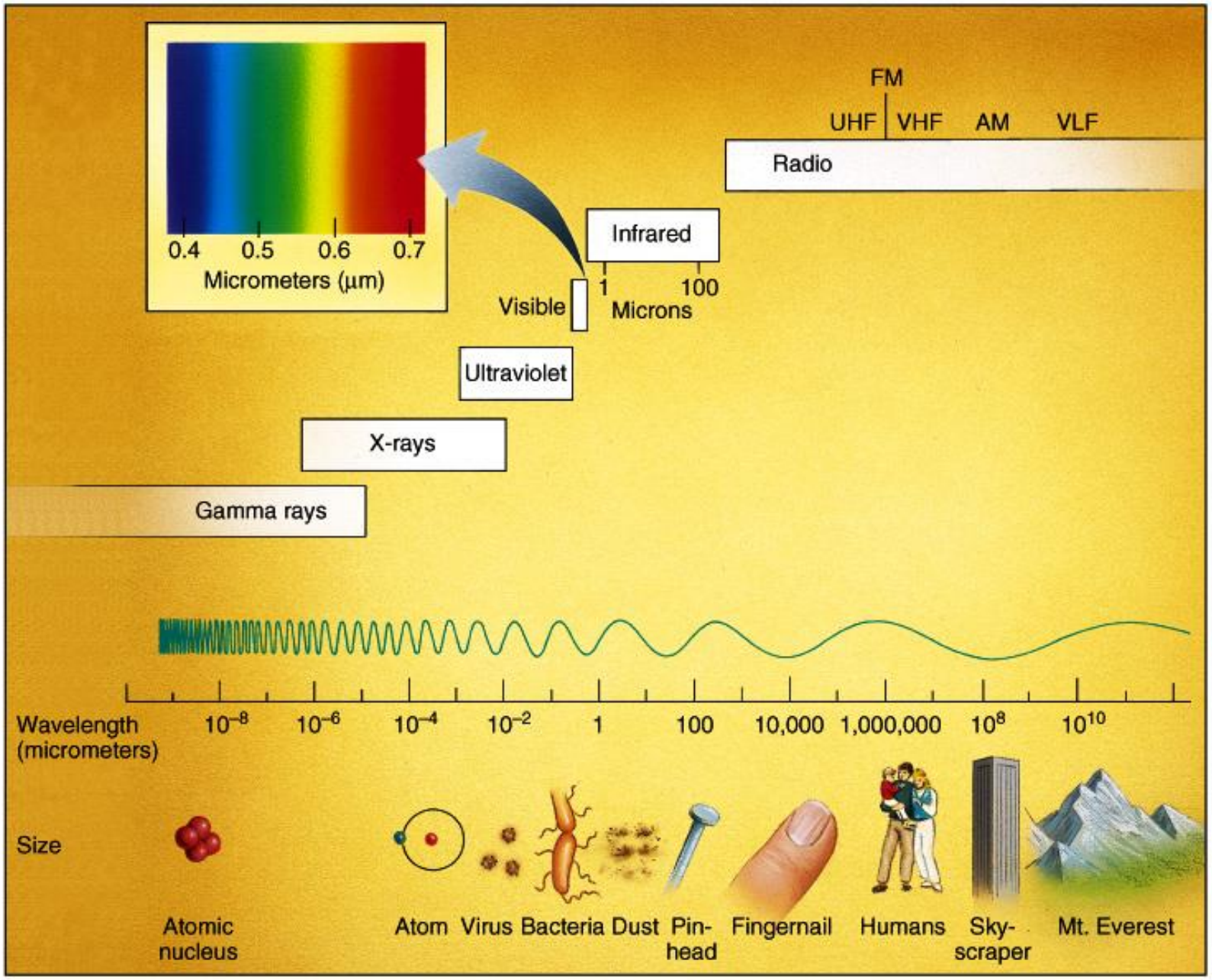


The Electromagnetic Spectrum



Data Acquisition

- RS instrument measures energy received in 3 useful areas of the spectrum:-
  - 1) Visible / near / mid infrared
    - passive
      - solar energy reflected by the surface
      - determine surface (spectral) reflectance
    - active
      - LIDAR - active laser pulse
      - time delay (height)
  - 2) Thermal infrared
    - energy measured - temperature of surface and emissivity
  - 3) Microwave
    - active
      - microwave pulse transmitted measure amount scattered back
    - passive
      - emitted energy at shorter end of microwave spectrum

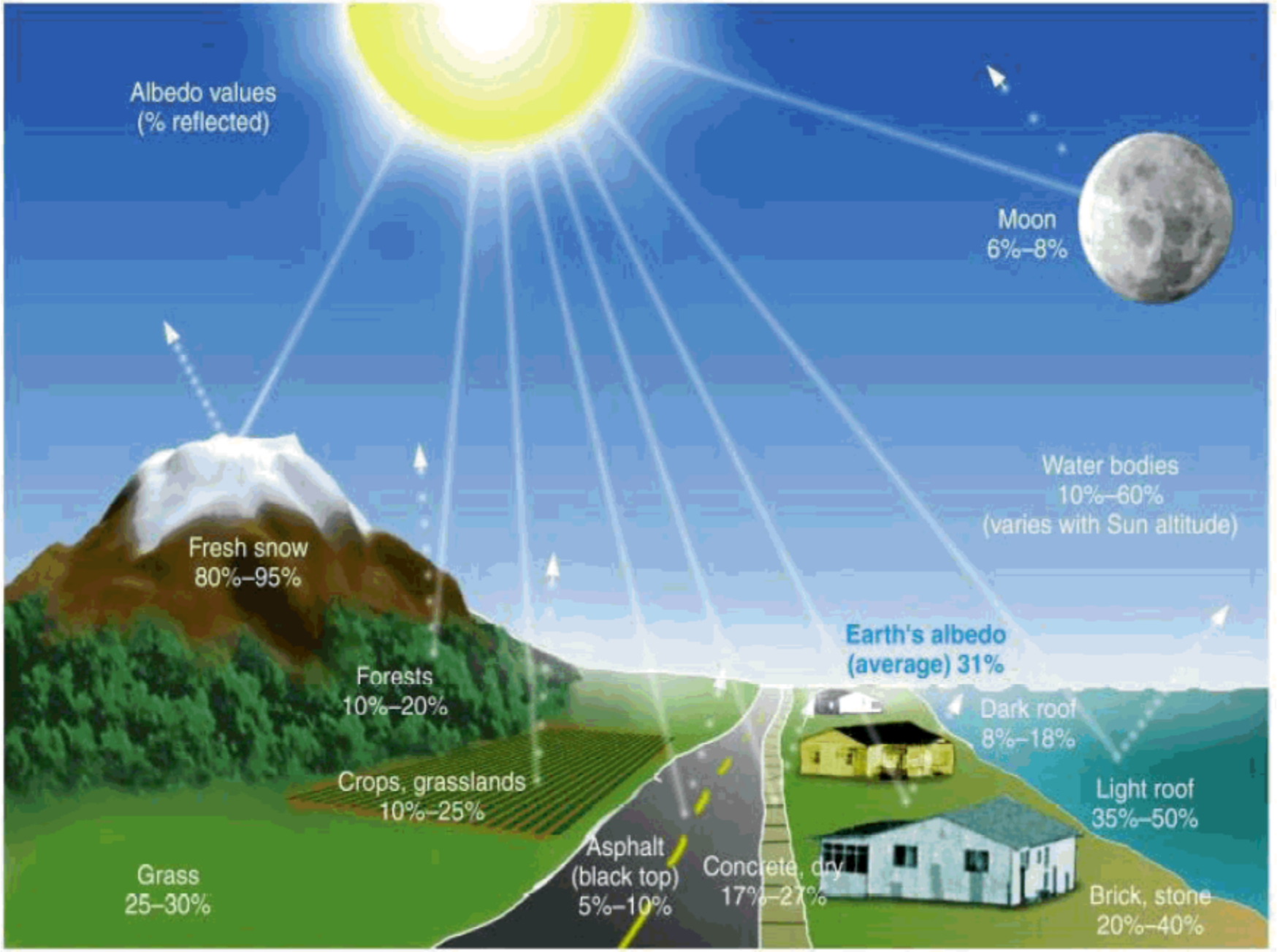

FM
UHF
VHF
AM
VLF
Radio
Infrared
1
100
Microns
Visible
0.4
0.5
0.6
0.7
Micrometers (μm)
Ultraviolet
X-rays
Gamma rays
Wavelength
(micrometers)
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
100
10,000
1,000,000
10^{8}
10^{10}
Size
Atomic nucleus
Atom
Virus
Bacteria
Dust
Pin-head
Fingernail
Humans
Sky-scraper
Mt. Everest

Measurement of EM Radiation

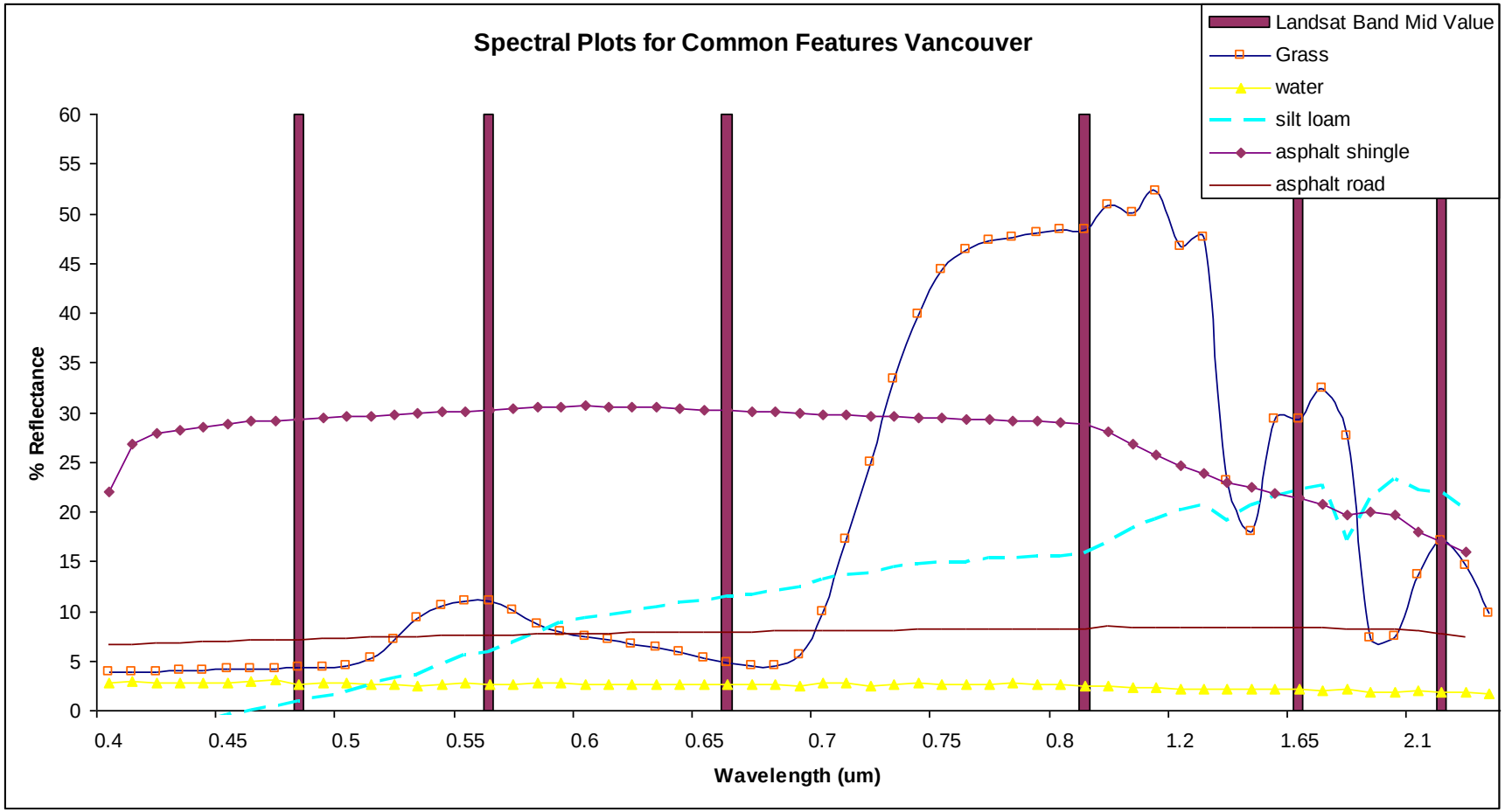
- Intrinsic properties
  - emission, scattering, absorption
- Energy Source
  - Sun / Earth / artificial
- Source properties
  - vary in intensity
  - vary across wavelengths
  - vary with physical / chemical properties
  - can vary with viewing angle

Spectral Signatures

- For any given material, the amount of solar radiation that reflects, absorbs, or transmits varies with wavelength. This important property of matter makes it possible to identify different substances or classes and separate them by their spectral signatures (spectral curves)
- Remote Sensing Tutorial [http://rst.gsfc.nasa.gov/Intro/Part2_5.html]


Albedo values
(% reflected)
Moon
6%–8%
Water bodies
10%–60%
(varies with Sun altitude)
Fresh snow
80%–95%
Earth's albedo
(average) 31%
Forests
10%–20%
Dark roof
8%–18%
Crops, grasslands
10%–25%
Light roof
35%–50%
Asphalt
(black top)
5%–10%
Concrete, dry
17%–27%
Grass
25–30%
Brick, stone
20%–40%

Spectral Signature Example



Platforms - Airplane

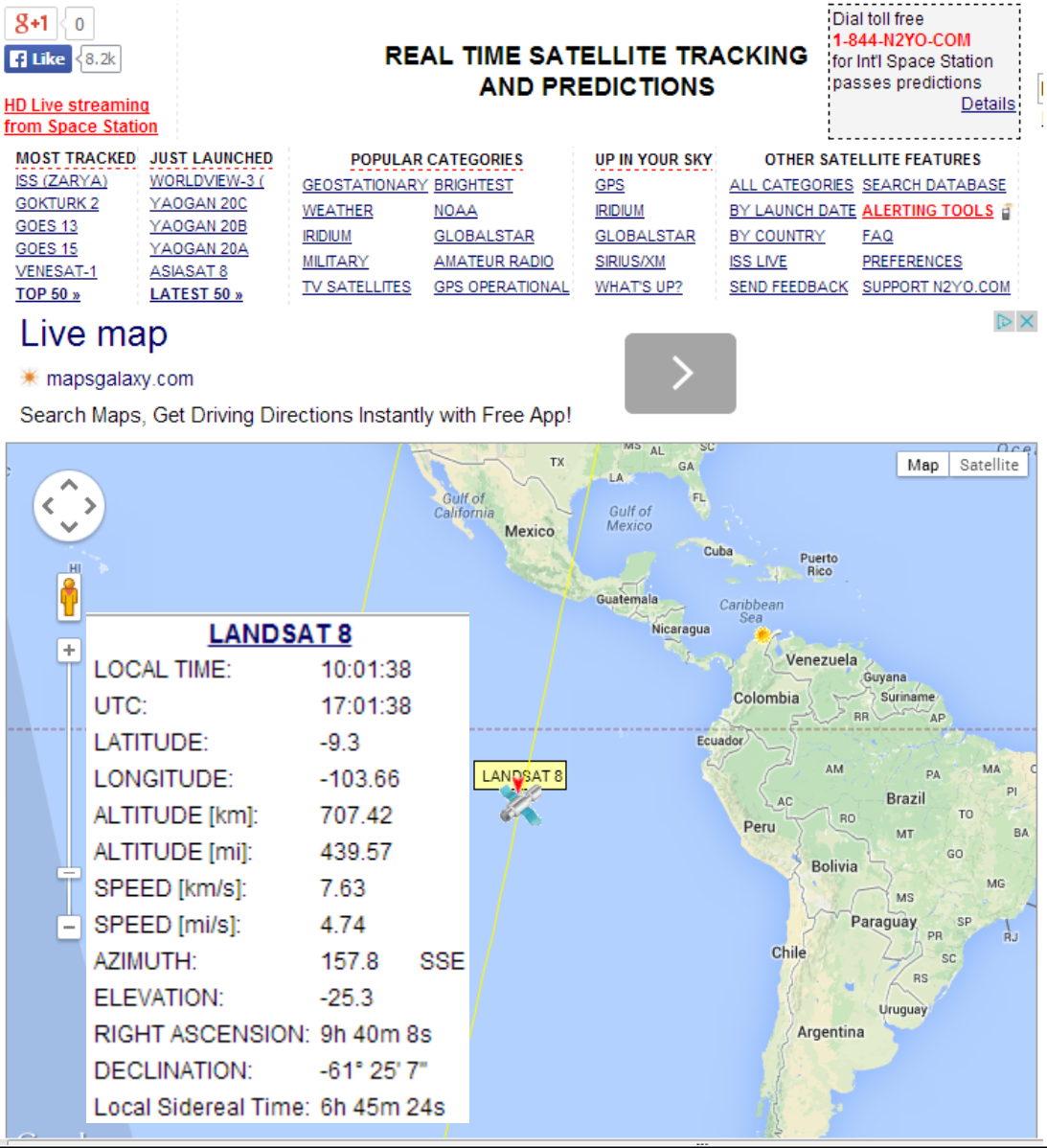
- Aircraft are often used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time.
- Aerial platforms are primarily stable wing aircraft, although helicopters are occasionally used.

Platforms - Satellite

- In space, remote sensing is sometimes conducted from the space shuttle or, more commonly, from satellites.
- Because of their orbits, satellites permit repetitive coverage of the Earth's surface on a continuing basis.
- Cost is often a significant factor in choosing among the various platform options.

Current Satellites – Earth Observation

- Track it live
  - www.n2yo.com
  - Landsat 8
  - Aug 20 10:01am 2014
  - Off coast of South America



List of satellites

- http://en.wikipedia.org/wiki/List_of_Earth_observation_satellites

List of earth observation Satellites

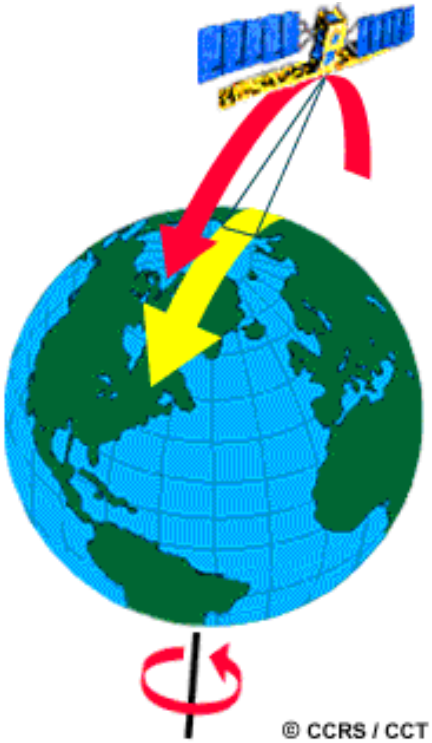
- Landsat 8
- Radarsat 2
- Spot 5
- Envisat
- List of current and past
- http://en.wikipedia.org/wiki/List_of_Earth_observation_satellites#Earth_Observing_System

Satellites

- Organization, satellite name, sensor , payload(data properties)
    - Landsat 8, OLI
    - Managed by NASA,
    - Data is distributed by USGS,
- http://en.wikipedia.org/wiki/List_of_Earth_observation_satellites

Track

- Polar Orbit
  - Path of satellite



- Swath
  - Ground area width of scene

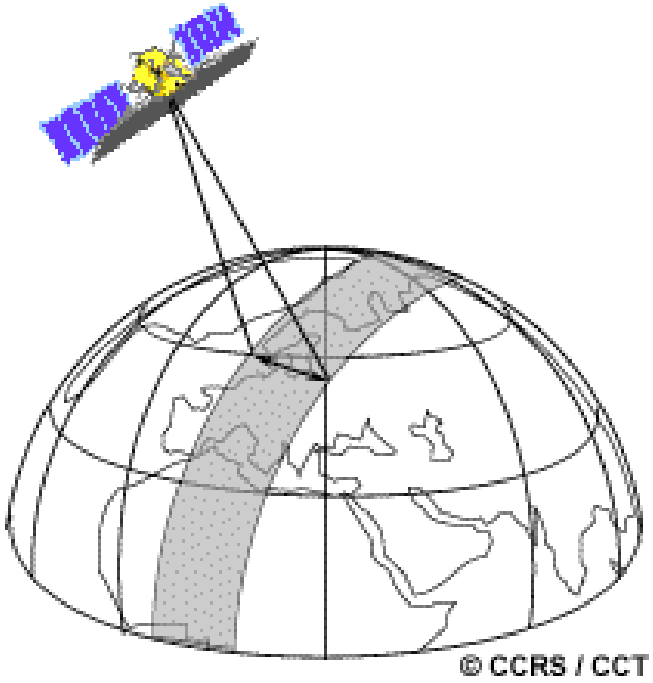
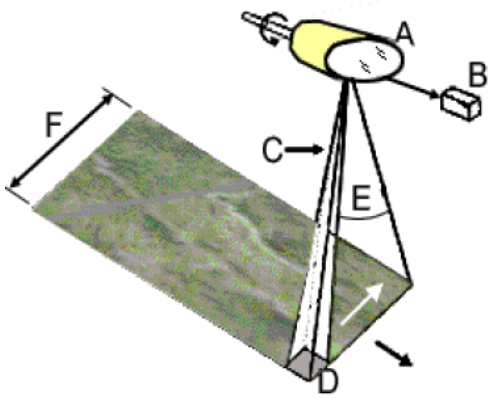
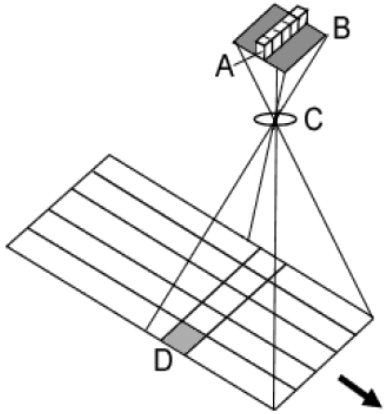


Image Creation

- Whiskbroom scanner
  - point sensor using rotating mirror
  - build up image as mirror scans
  - Landsat 7 MSS, TM
- Pushbroom scanner
  - array of sensing elements (line) simultaneously
  - build up line by line
  - Landsat 8, SPOT
- http://earthobservatory.nasa.gov/Features/EO1/eo1_2.php





Radar

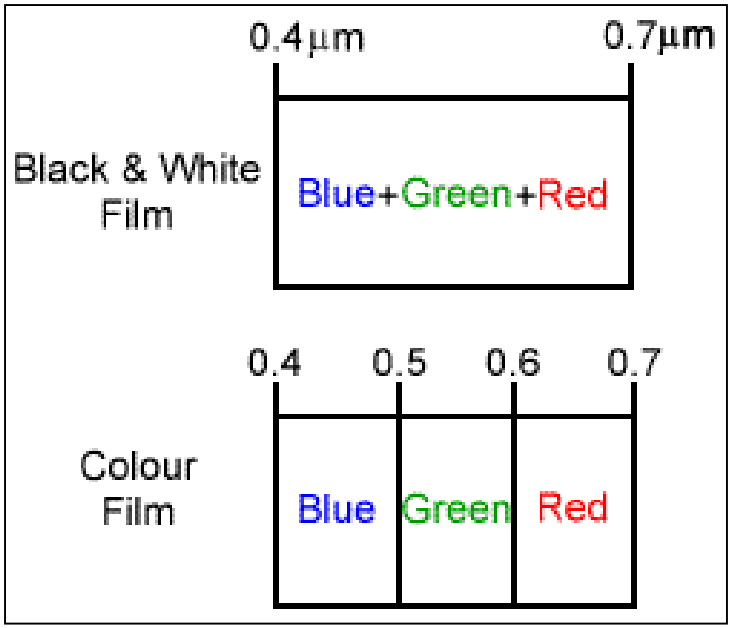
- real aperture radar
  - microwave
  - energy emitted across-track
  - return time measured
  - amount of energy (scattering)
- synthetic aperture radar
  - microwave
  - higher resolution - extended antenna
  - simulated by forward motion of platform
  - ERS-1, -2 SAR (AMI), Radarsat SAR, JERS SAR

Satellite Data Properties

- Spectral
  - Wave length range / sensor
    - OLI BAND1
  - Number of ‘bands’ collected
- Spatial
  - Ground cover of pixel
    - 28.5 X28.5 stated as 30m
- Radiometric
  - Number of bits stored
    - 8 bit [values of 0-255]
    - 12 bit [values of 0-4096]
- Temporal
  - Time to revisit
    - 16 days

Spectral resolution

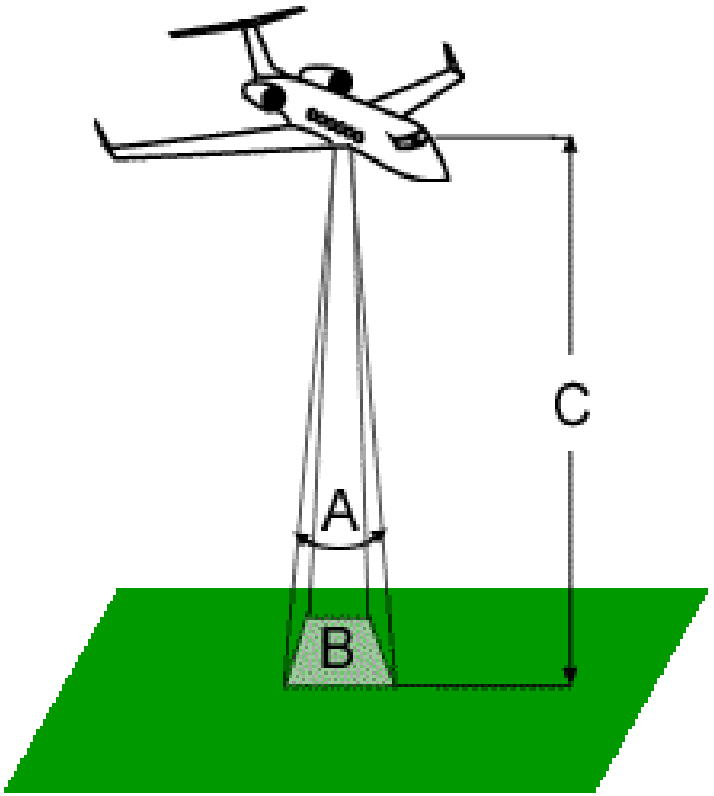
- Spectral resolution describes the ability of a sensor to define fine wavelength intervals.
- The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.



Black and white film has a coarser spectral resolution than color film.

Spatial resolution

- Spatial resolution depends among other things on the *IFOV* of the imaging system.
- In this figure A is the IFOV, B is the resolution cell (pixel in an image) and C is the distance between the sensor and the ground.



Spatial resolution

- The smallest discernable area on the ground is called the resolution cell and determines a sensor's maximum spatial resolution.
- For a homogeneous feature to be detected, its size generally has to be equal to or larger than the resolution cell.

Coarse spatial resolution

Fine spatial resolution

Spatial resolution

- The smallest ground area that can be discerned in an image.
- In Landsat TM images (non-thermal bands only) the spatial resolution is 28.5m x28.5m.
- In SPOT Panchromatic images it is 10m x 10m.

Radiometric resolution

- The smallest "slice" of a band or portion of the EM spectrum in which the reflectance of a feature may be assigned a digital number.
- In other words, the finest distinction that can be made between objects viewed in the same part of the EM spectrum.
- The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy.
- The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Radiometric resolution

- Scanning systems with a 2^6 (64 "slices") radiometric resolution are not able to make as many distinction as a scanning system with a 2^8 (256 "slices") radiometric resolution.

2-bit

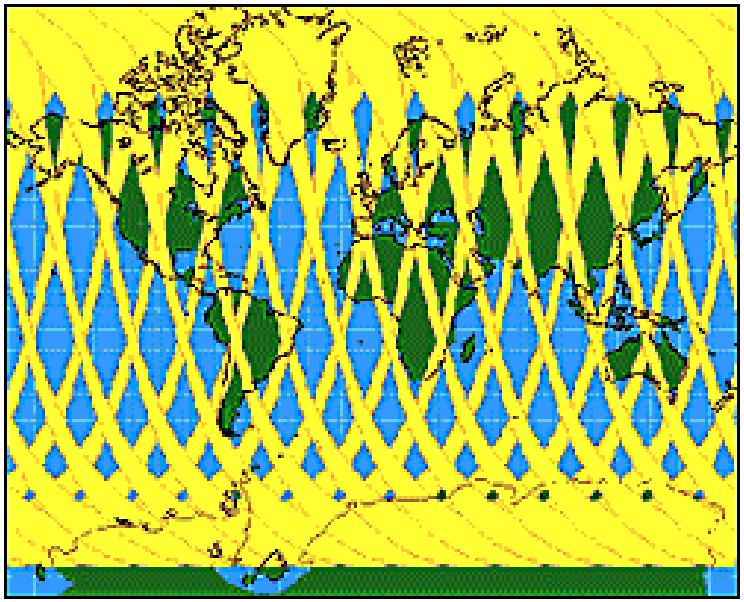
8-bit

Temporal resolution

- The shortest period of time in which a satellite will revisit (pass over) a spot on the earth's surface.
- Landsat 8 for example has a temporal resolution of 16 days, while NOAA GOES (AVHRR) has a temporal resolution of 12 hours.

Temporal resolution

- The temporal resolution of a remote sensing system to image the exact same area at the same viewing angle a second time is thus called the temporal resolution.
- However, because of some degree of overlap in the imaging swaths of adjacent orbits for most satellites and the increase in this overlap with increasing latitude, some areas of the Earth tend to be re-imaged more frequently.



examples

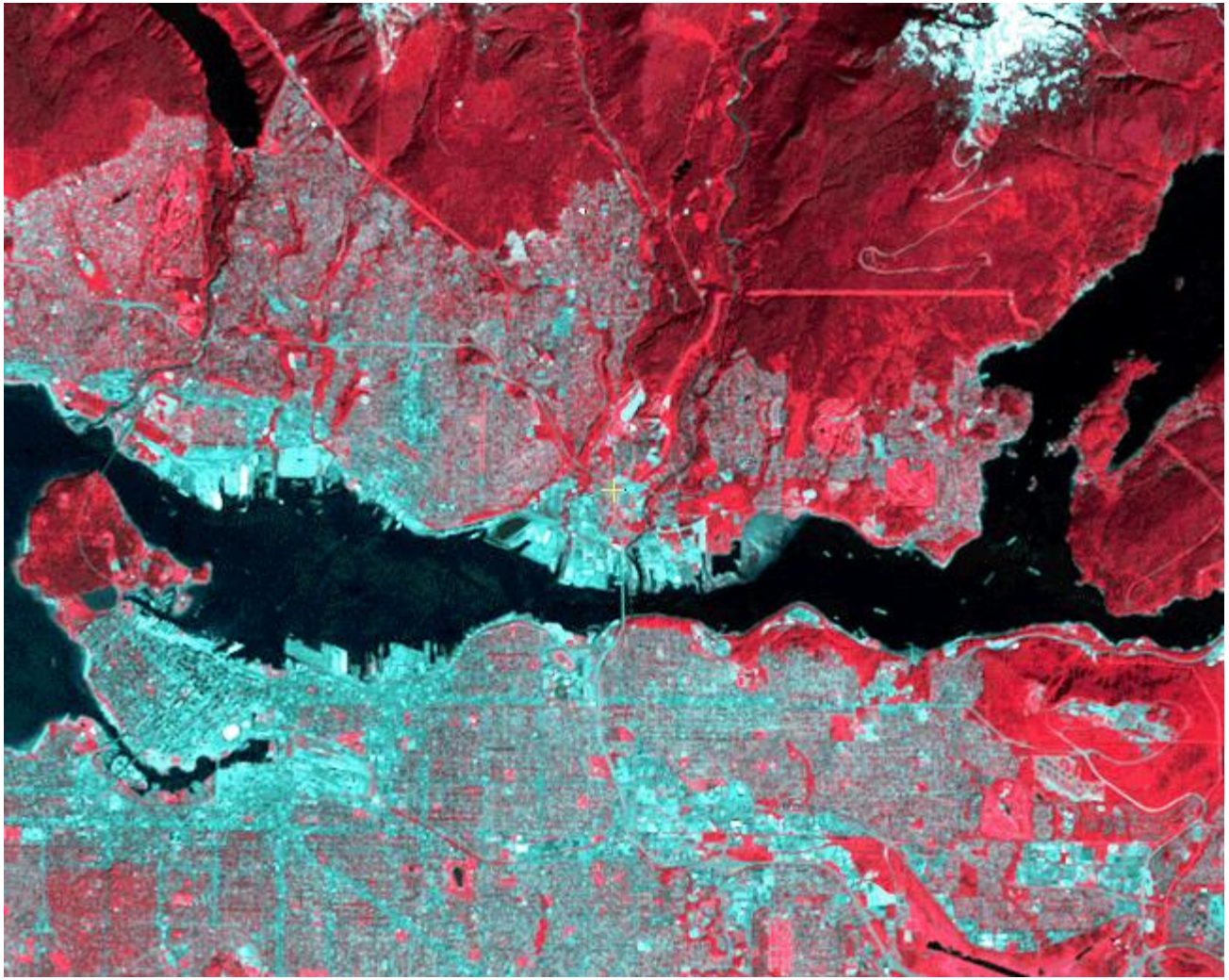
- Visible / NIR / MIR - day only, no cloud cover
  - vegetation presence
  - geological mapping (structure, mineral / petroleumexploration)
  - urban and land use
  - phytoplankton blooms
  - meteorology (clouds, atmospheric scattering)
  - DEM generation (stereo imagery)
- Thermal infrared - day / night, rate of heating / cooling
  - heat loss (urban)
  - thermal plumes (pollution)
  - mapping temperature
  - geology
  - forest fires
  - meteorology (cloud temp, height)
- Active microwave - little affected by atmospheric conditions, day / night
  - surface roughness (erosion)
  - water content (hydrology) - top few cms
  - vegetation - structure (leaf, branch, trunk properties)
  - DEM production (SAR interferometry)

Image Display

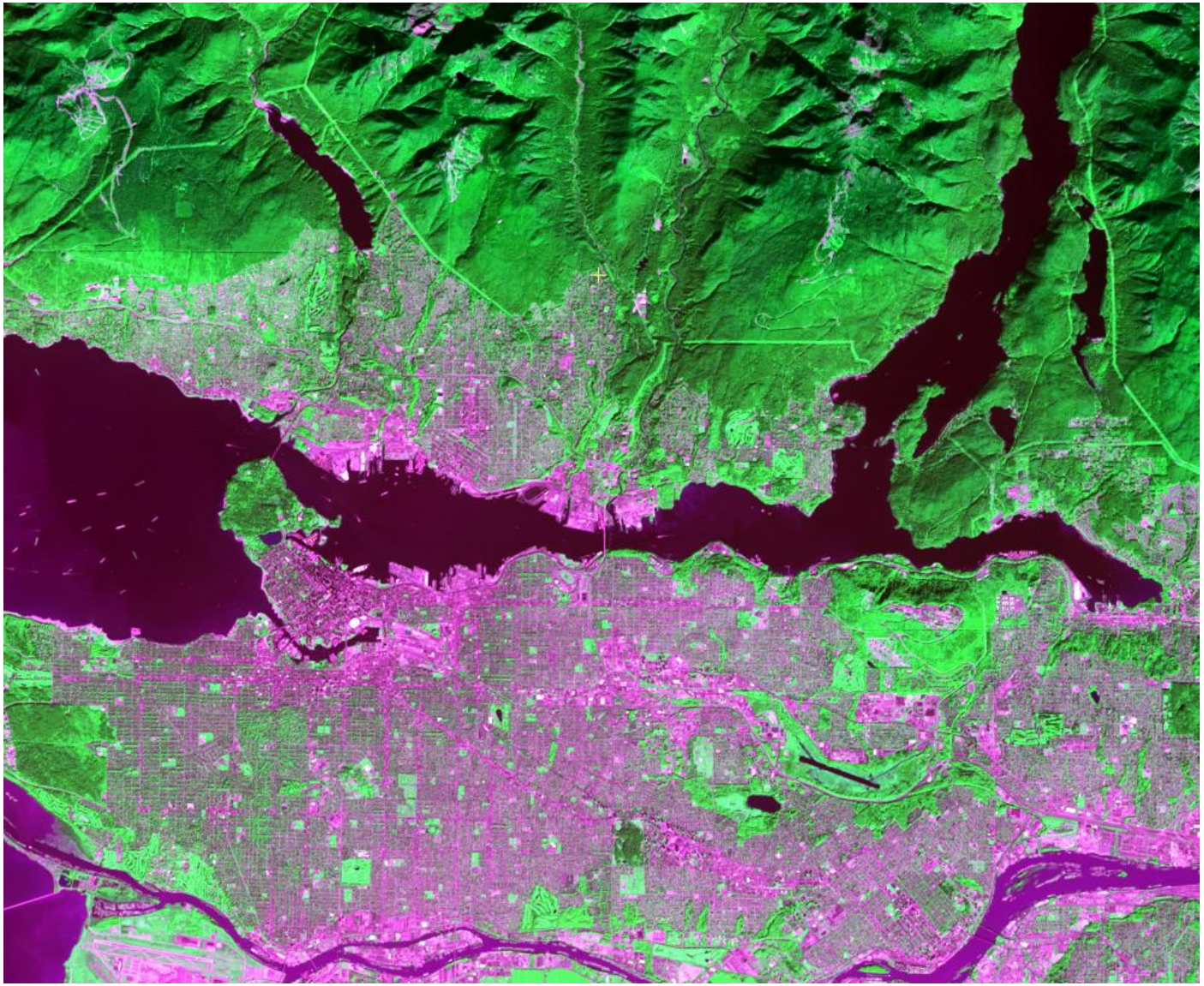
- BW
- RGB
- Additive color

Natural Color 432

Color infrared 543



False Colour - 253



- End of Lecture now on to practical exercises.