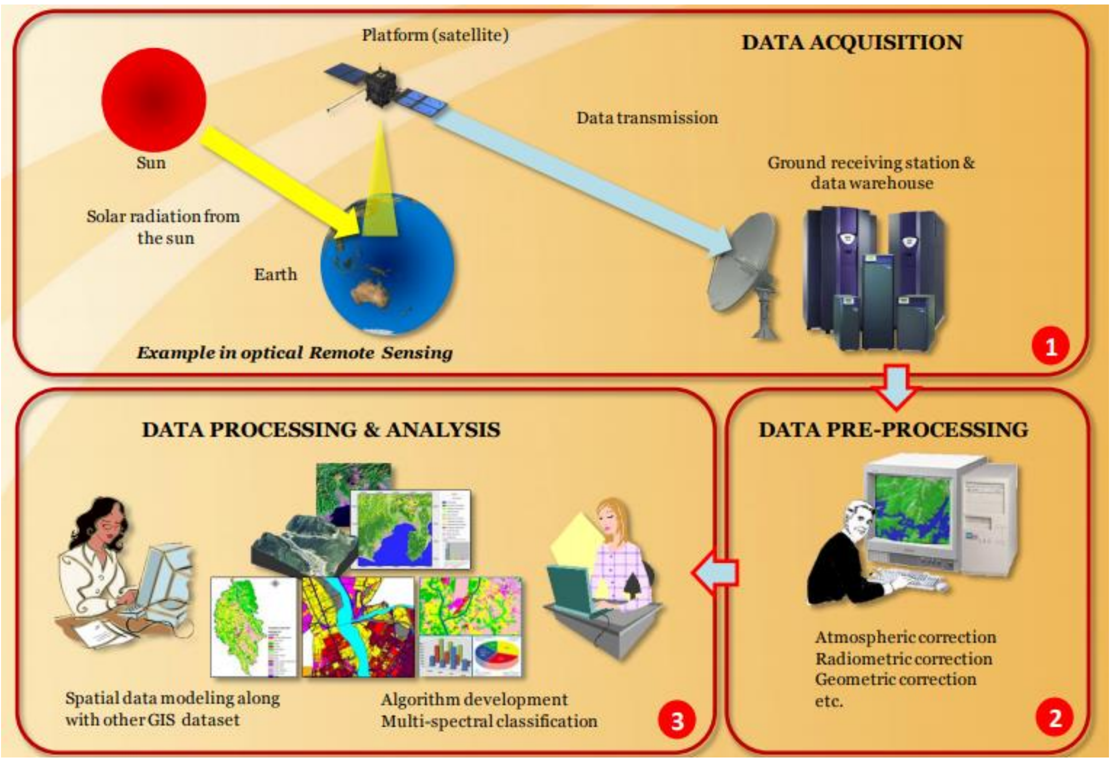
Course name: Remote Sensing Techniques (lecture-one)
Fourth class- Remote Sensing and GIS Department

1. REMOTE SENSING

The science of acquiring information about the earth using instruments which are remote to the earth's surface, usually from aircraft or satellites. Instruments may use visible light, infrared or radar to obtain data. Remote sensing offers the ability to observe and collect data for large areas relatively quickly, and is an important source of data for GIS.

2. Remote Sensing and GIS Work Flow



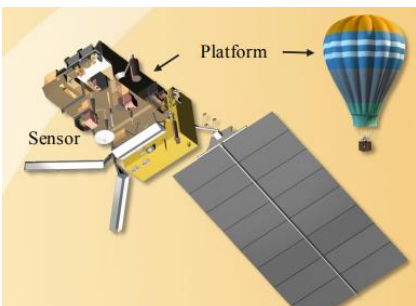
3. Components in Remote Sensing

- **Platform:** The vehicle which carries a sensor. i.e. satellite, aircraft, balloon, etc...

- **Sensors:** Device that receives electromagnetic radiation and converts it into a signal that can be recorded and displayed as either numerical data or an image.

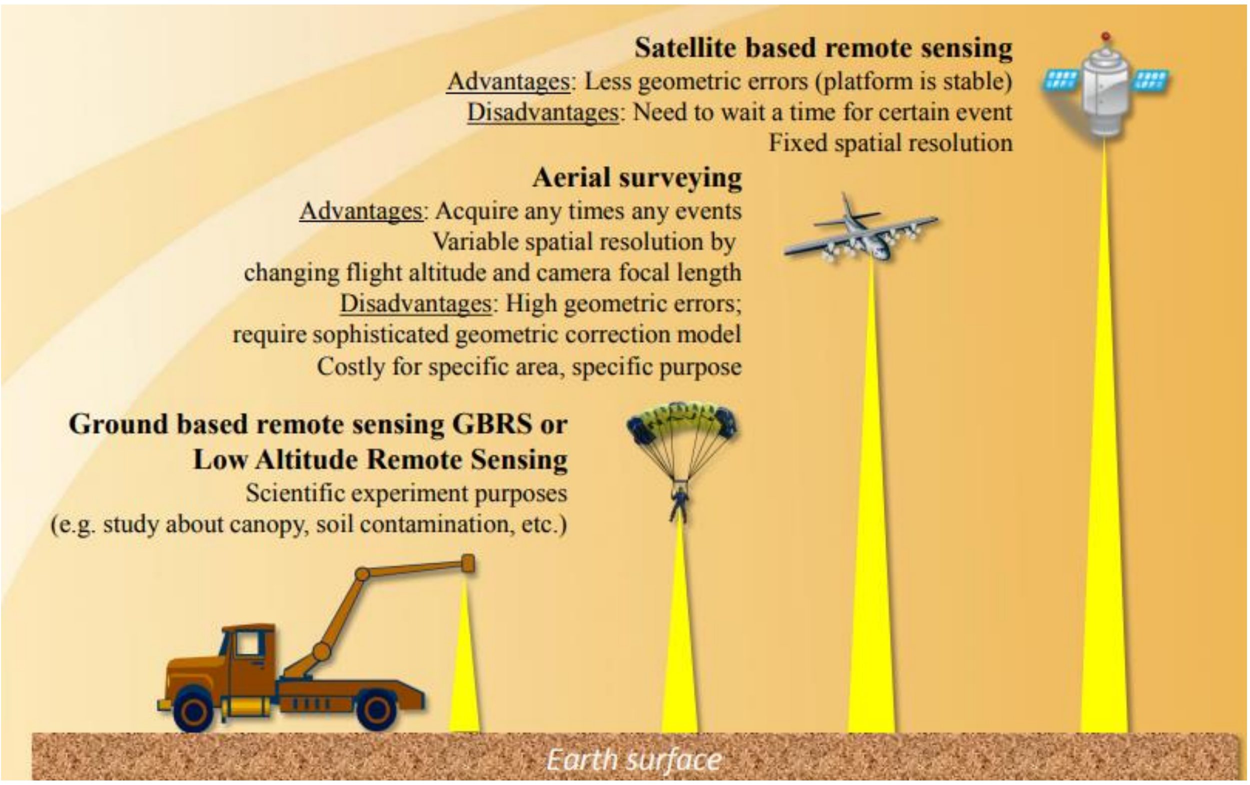
One platform can carry more than one sensor.

For example:



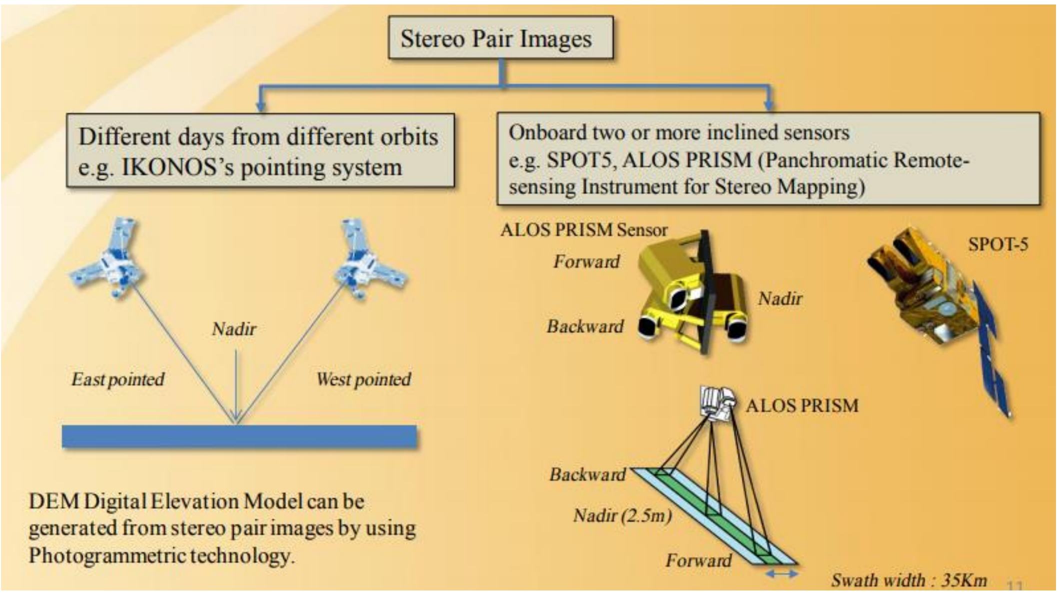
Platform Name	Sensor Name
Landsat TM	Thematic Mapper (Passive: Optical sensor)
Landsat ETM	Enhanced Thematic Mapper (Passive: Optical sensor)
ALOS	PRISM (Passive: Optical sensor) AVNIR-2 (Passive: Optical sensor) PALSAR (Active: Microwave sensor)

4. Multistage Remote Sensing Data Collection

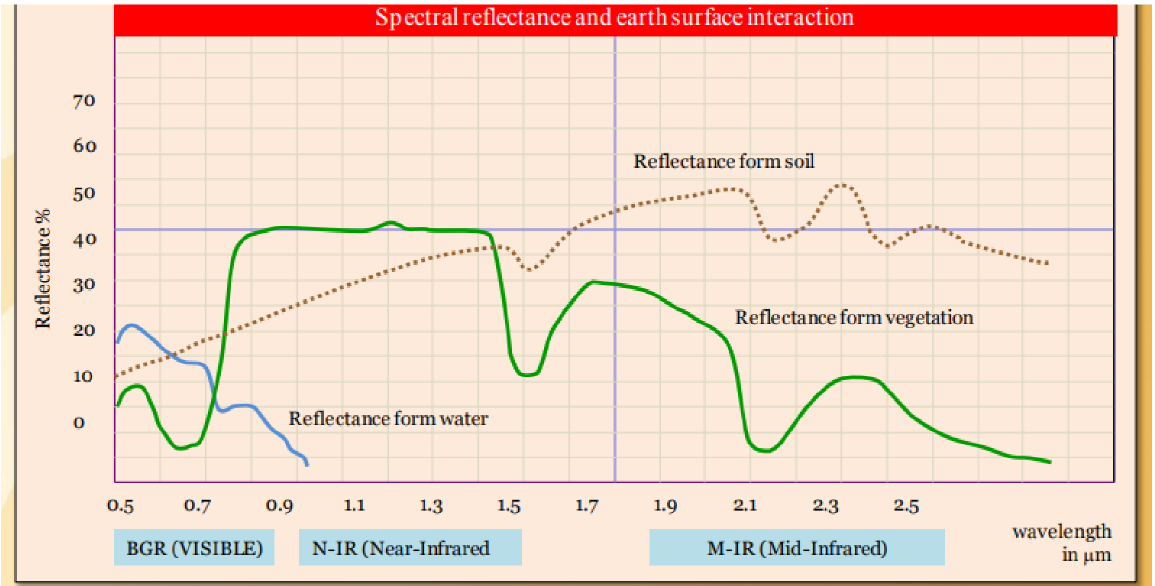


5. Stereo Pair Remote Sensing Data Collection

Some satellites capable to acquire stereo pair images that can be achieved when two images of the same area are acquired on different days from different orbits, one taken East of the other (i.e., East or West of the nadir). For this to occur, there must be significant differences in the inclination angles.



6. Spectral Reflectance and Earth Surface Interaction

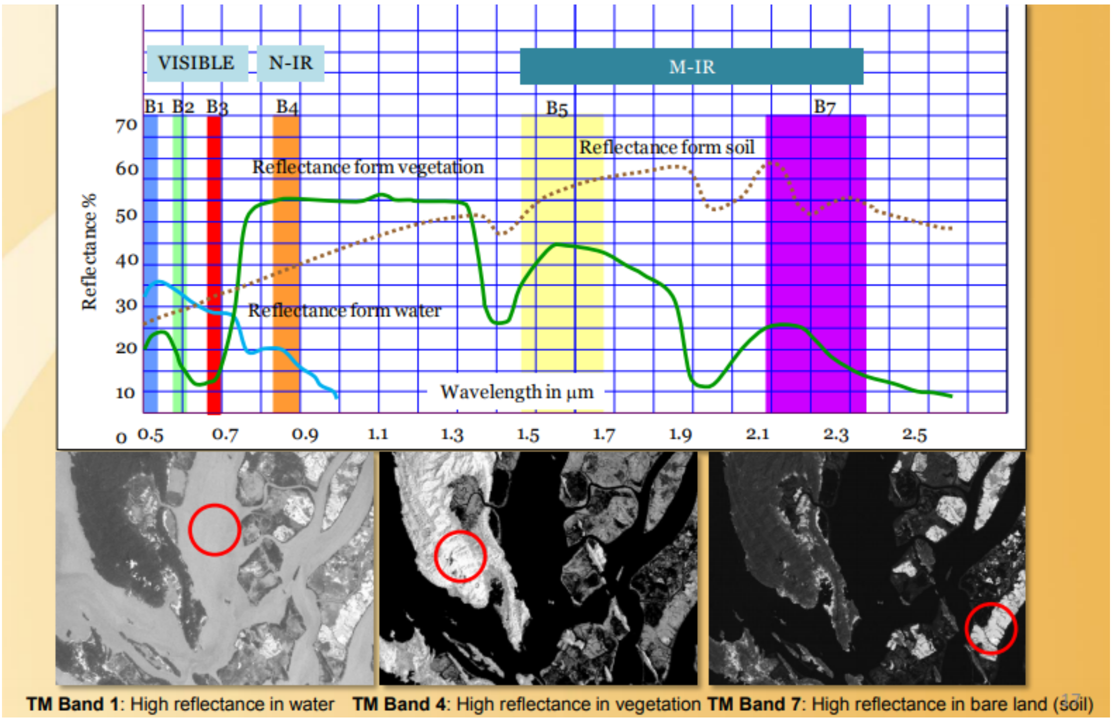


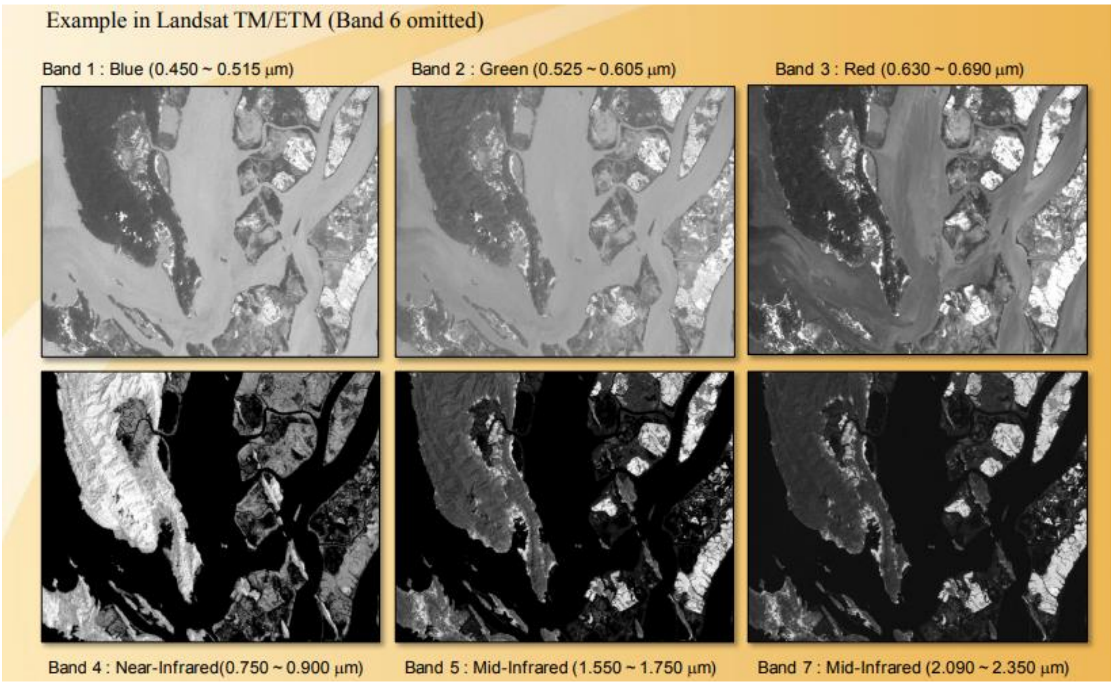
Surface category	Low reflectance	High reflectance
Water	N-IR (Near -Infrared)	Blue (Visible)
Vegetation	M-IR (Mid-Infrared)	N-IR (Near-Infrared)
Soil	Blue (Visible)	M-IR (Mid-Infrared)

7. Multi-spectral Remote Sensing Data (Image)

• Composed with more than one spectral band and each band represents specific wavelength

• Example in Landsat TM (Total 7 bands, Band 6 Thermal band omitted in here)





8. Properties and Principal Applications

Example in Landsat TM/ETM

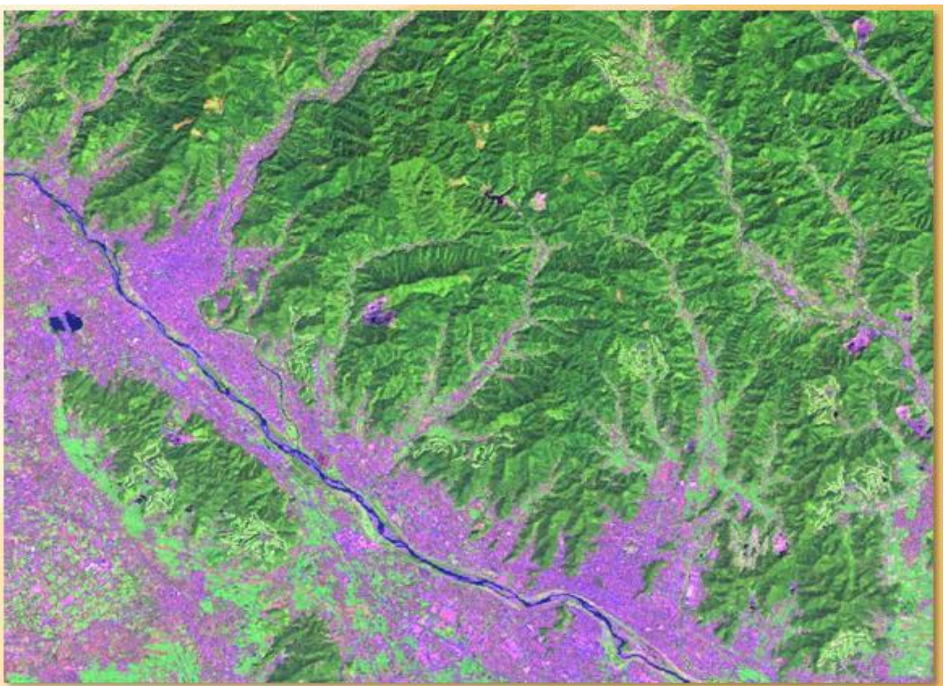
Band	Wavelength (µm)	Principal applications
B-1	0.45 - 0.52 (Blue)	This band is useful for mapping coastal water areas, differentiating between soil and vegetation, forest type mapping, and detecting cultural features.
B-2	0.52 - 0.60 (Green)	This band corresponds to the green reflectance of healthy vegetation. Also useful for cultural feature identification.
B-3	0.63 - 0.69 (Red)	This band is useful for discriminating between many plant species. It is also useful for determining soil boundary and geological boundary delineations as well as cultural features.
B-4	0.76 - 0.90 (Near-Infrared)	This band is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification and emphasizes soil/crop and land/water contrasts.
B-5	1.55 - 1.75 (Mid-Infrared)	This band is sensitive to the amount of water in plants, which is useful in crop drought studies and in plant health analyses. This is also one of the few bands that can be used to discriminate between clouds, snow, and ice.
B-6	10.4 - 12.5 (Thermal Infrared)	This band is useful for vegetation and crop stress detection, heat intensity, insecticide applications, and for locating thermal pollution. It can also be used to locate geothermal activity.
B-7	2.08 - 2.35 (Mid-Infrared)	This band is important for the discrimination of geologic rock type and soil boundaries, as well as soil and vegetation moisture content.

9. Visual Interpretation (Band combination)

First step interpretation and to distinguish various land covers into different colors

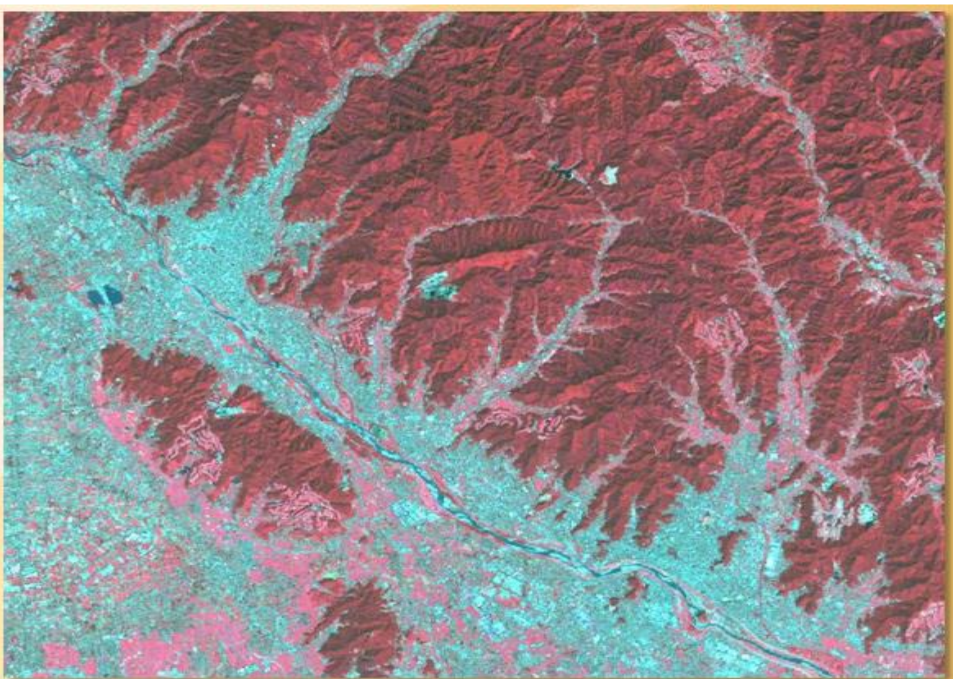
Example1: RGB 321 in Landsat TM/ETM gives natural color. Assign band 3 to red channel, band 2 to green channel and band 1 to blue channel in computer display. To see landscape in realistic view.

Example2: RGB 543 in Landsat TM/ETM gives false color. Assign band 5 to red channel, band 4 to green channel and band 3 to blue channel in computer display. To discriminate between soil, vegetation and water.



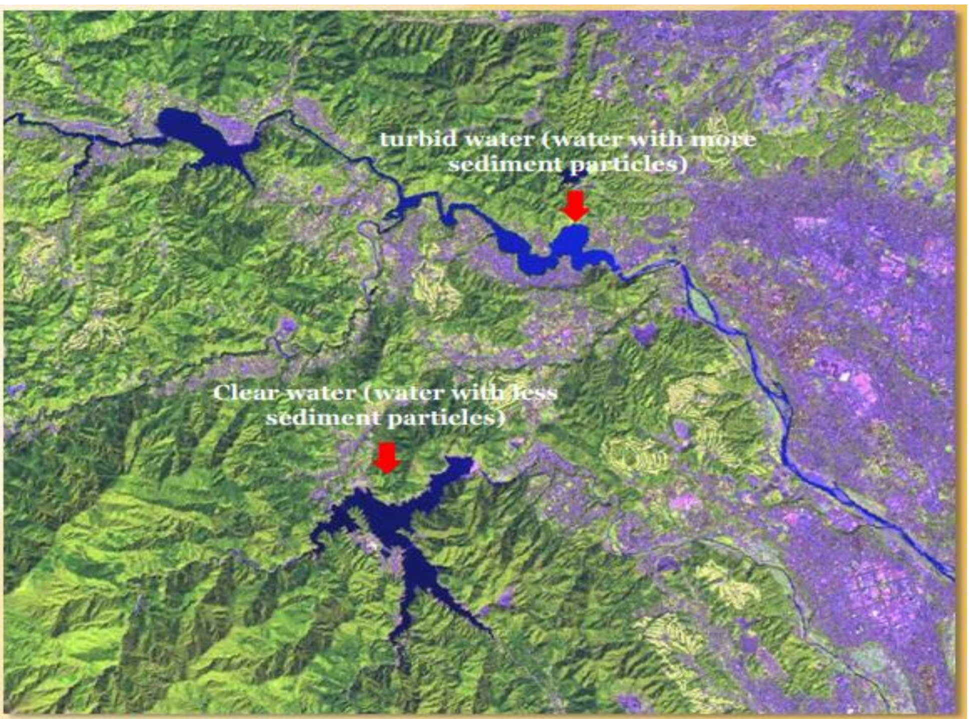
Landsat TM5 Tokyo (Ashikaga, Isezaki)

Example3: RGB 432 in Landsat TM/ETM gives false color. Assign band 4 to red channel, band 3 to green channel and band 2 to blue channel in computer display. To determine vegetation stress and vigor.



Landsat TM5 Tokyo (Ashikaga, Isezaki)

Example4: RGB 541 in Landsat TM/ETM gives false color. Assign band 5 to red channel, band 4 to green channel and band 1 to blue channel in computer display. To assess water quality. Turbid water gives bright blue and clear water gives dark blue.



Landsat TM5 Tokyo (Hachioji)

10. Apply Algorithms

We can manipulate between bands (playing with DN Digital Numbers) and extract meaningful information.

(a) NDVI (Normalized Difference Vegetation Index) Perhaps, well known and useful algorithm is NDVI (Normalized Difference Vegetation Index). Vegetation is low reflectance in Red band and high reflectance in Infrared band. By normalizing this two bands, we can measure vegetation stress and vigor.

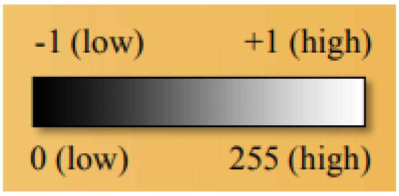
General formula	NDVI = (Infrared – Red) / (Infrared + Red) The value is between +1 (vigor) ~ -1 (stress)
NOAA AVHRR	NDVI = (B2 – B1) / (B2 + B1)
Landsat TM/ETM	NDVI = (B4 – B3) / (B4 + B3)
IKONOS/QuickBird	NDVI = (B4 – B3) / (B4 + B3)

(b) NBR (Normalized Burn Ratio)

Landsat TM/ETM   NBR = (B4 – B7) / (B4 + B7)

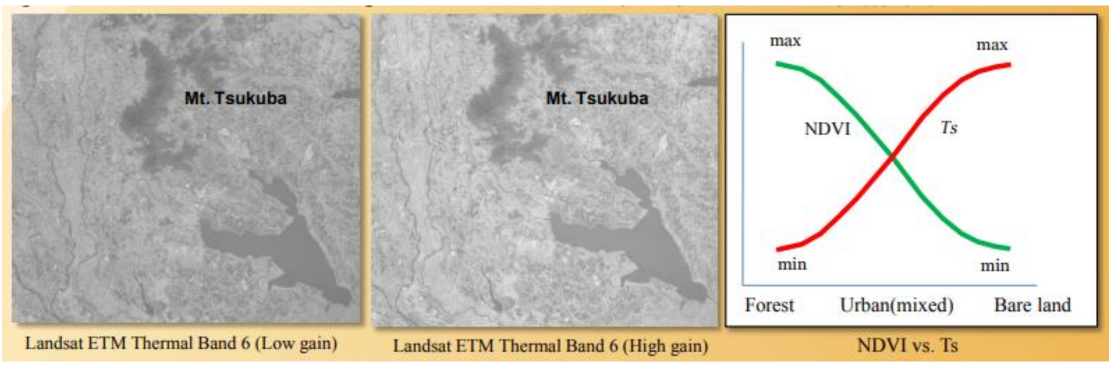
These two bands provide the best contrast between photosynthetically healthy and burned vegetation

Example: Vegetation index (NDVI) stretched to 8- bit.



Landsat TM5 Tokyo (Hanno)

(c) Surface Temperature Some satellites carry thermal sensors. For example, Landsat TM/ETM, NOAA AVHRR ASTER, MODIS, etc. Thermal band records thermal emissive from the land surface objects. This band is good to study between surface temperature (Ts) and other land covers. For example, some researchers use surface temperature an NDVI to classify the land use land cover. Thermal band spatial resolution is normally coarser than other bands because temperature does not change very well within the small area. Example: Landsat ETM thermal band spatial resolution is 60m compares to other bands (30m).



Landsat ETM Thermal Band 6 (Low gain) | Landsat ETM Thermal Band 6 (High gain) | NDVI vs. Ts

11. Conversion

Step1. Conversion of the Digital Number (DN) to Spectral Radiance (L)

$L = L_{MIN} + (L_{MAX} - L_{MIN}) * DN / 255$

Where L = Spectral radiance L_{MIN} = 1.238 (Spectral radiance of DN value 1) L_{MAX} = 15.600 (Spectral radiance of DN value 255) DN = Digital Number

Step2. Conversion of Spectral Radiance to Temperature in Kelvin

$$T_B = \frac{K_2}{\ln\left(\frac{K_1}{L} + 1\right)}$$

Where K_1= Calibration Constant 1 (607.76) K_2 = Calibration Constant 2 (1260.56) T_B = Surface Temperature

Step3. Conversion of Kelvin to Celsius

$T_B = T_B - 273$

Tsukuba City surface temperature map generated from Landsat TM5 satellite acquired by 1987-05-21, 11:00AM Local Time (JST).