# Digital Sources

## Objectives

This unit will discuss sources of digital data such as digital cartographic databases of systematic data collector and data provider, automated surveying, Global Positioning System and Remote Sensing. This unit will not discuss the technical and processing detail of each source of digital data. At the end of the unit, the student will be able to locate the digital data sources for a particular project.

## Digital Data Sources

## 1. Existing Digital Dataset

Existing Digital dataset can be acquired from systematic data collectors such as government agencies, national and regional mapping agencies, statistical offices, municipalities and local government agencies, tax assessment departments, electricity department, telecommunication departments, water supply and sanitation department, engineering firms and transportation departments, fire fighting department, metropolitan authority, meteorological department, agriculture and forestry department, specialized agencies such as census offices, and private remote sensing corporations. The digital terrain data, natural resources, socio-economic, human settlements, infrastructure, land ownership, cadastral surveys, soil, geology, rainfall, temperature, water flow, water quality and utilities can be acquired at free or at a cost from these agencies and department. The metadata (will be discussed in lesson four unit one) of the data is normally maintained and available to the user by these agencies and department.

Ad hoc data collectors such as academic institutes, international and national non-government organizations, research institutes and private survey firms, etc. collect data for a specific project purpose at a particular coordinate system. The scale and time span of the study, observation methods, classification and interpretation are unique to the specific survey purpose.

The data provider who may be also systematic data collector such as Swiss Federal Office of Topography (http://www.swisstopo.ch/en/INDEX.htm) offer or sell geographical data in a variety of details, formats, scales and structure. The data provider maintains the metadata of the data and available to the user.

The Roelof Odden's bookmark (http://oddens.geog.uu.nl/index.html) listed more than 20,000 cartographic links of data collector, ad hoc data collector and data provider to browse, search and acquire the existing digital data.

The compatibility of characteristics of existing digital data such as currency of the data, scale, projection and coordinate system, the data collection techniques and strategy, positional accuracy data quality, attribute accuracy data quality, classification and interpretation methods used, resolution and minimum mapping unit of data must be paid attention to combine these data from different digital sources to one project.

The existing digital data can be distributed using media such as CDROMS, Zip disks, Floppy disks, Tapes and through Internet FTP Sites.

It is very important to be able to share and convert the digital data from a hardware system or a software program to another in order to be cost effective and time efficient.

Various standard formats such as Topographically Integrated Geographic Encoding and Referencing System (TIGER) files of U.S.Census Bureau (USCB), USGS Digital Elevation

Models (DEMs) format, USGS Digital Orthophoto Quadrangles (DOQs) format were developed nationally.

Occasionally, software vendors develop formats that become de facto standards for the transfer of information. Some of the most widely used formats are the DXF, or drawing exchange format, developed by AutoDesk, MIF developed by MapInfo, Coverage, GRID, E00 and Shape file format developed by ESRI, and GIS, LAN and IMG format developed by ERDAS.

The modern GIS software provides utility for data conversion utilities to convert various nationally and internationally defined standard formats from one system to another. Moreover, many GPS systems allowed exporting GPS data directly to one of these formats.

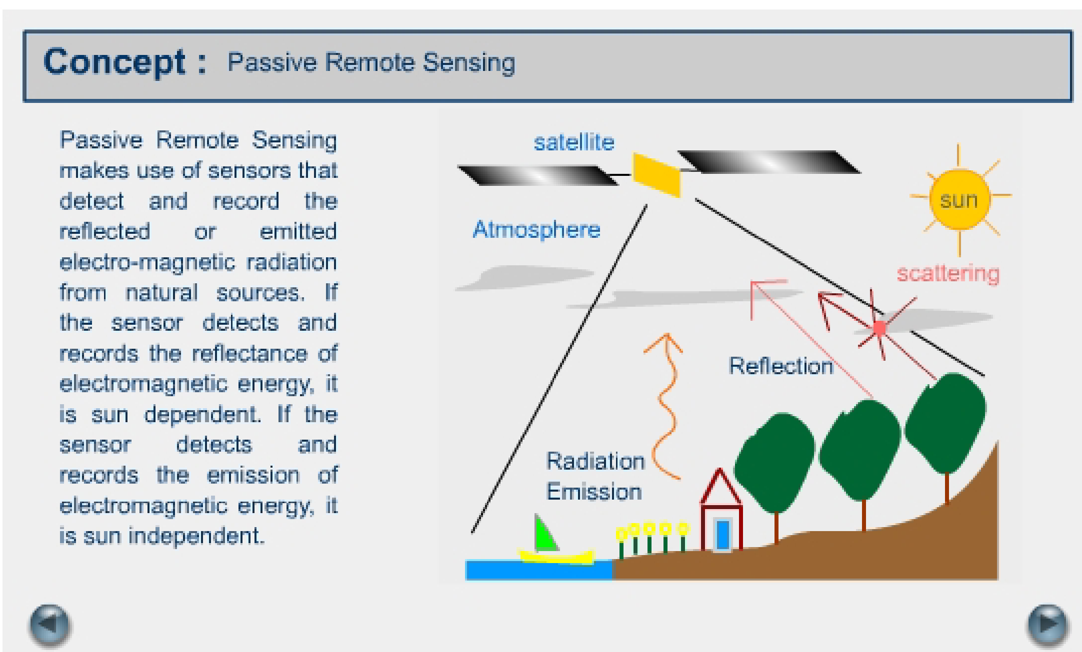
The Spatial Data Transfer Standard (http://mcmcweb.er.usgs.gov/sdts/) offers the free various data translations and export import tools.

Moreover, GeoCommunity's GIS Data Depot offers the free translator tools to translate formats.

Moreover, Internet Map Server which runs on top of browsers and offer basic GIS functions to view, integrate, measure and spatial query, is used to access data stored at a particular provider's web server. ESRI's ArcObject and ArcIMS Internet Map Server, Intergraph's Geomedia Webmap and AutoDesk's Mapguide are examples of Internet Map Servers.

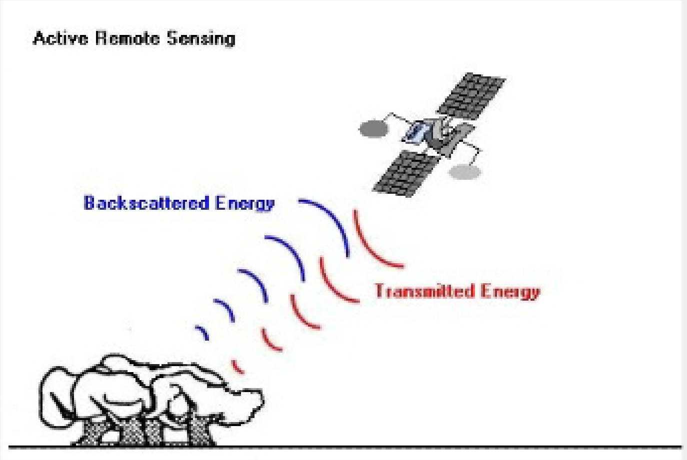
## 2. Remote Sensing

"Remote Sensing is the science and art of acquiring information (spectral, spatial, temporal) about material objects, areas, or phenomena through the analysis of data acquired by a device from measurements made at a distance, without coming into physical contact with the objects, area, or phenomena under investigation." (Lilisand & Kiefer)

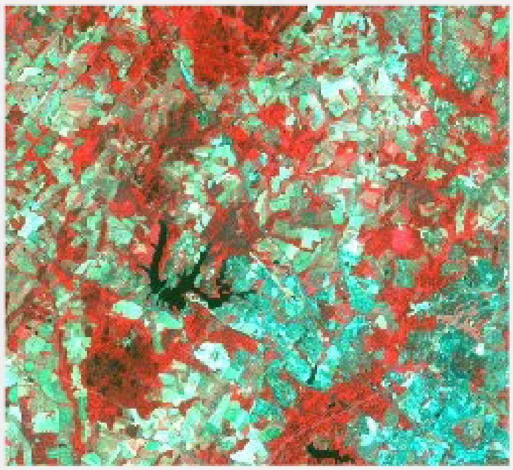


## Concept : Active Remote Sensing

Active Remote Sensing makes use of sensors that detect and record reflected or backscattered electromagnetic radiation from objects that are irradiated from artificially generated energy sources, such as radar. Active remote sensing is sun independent.

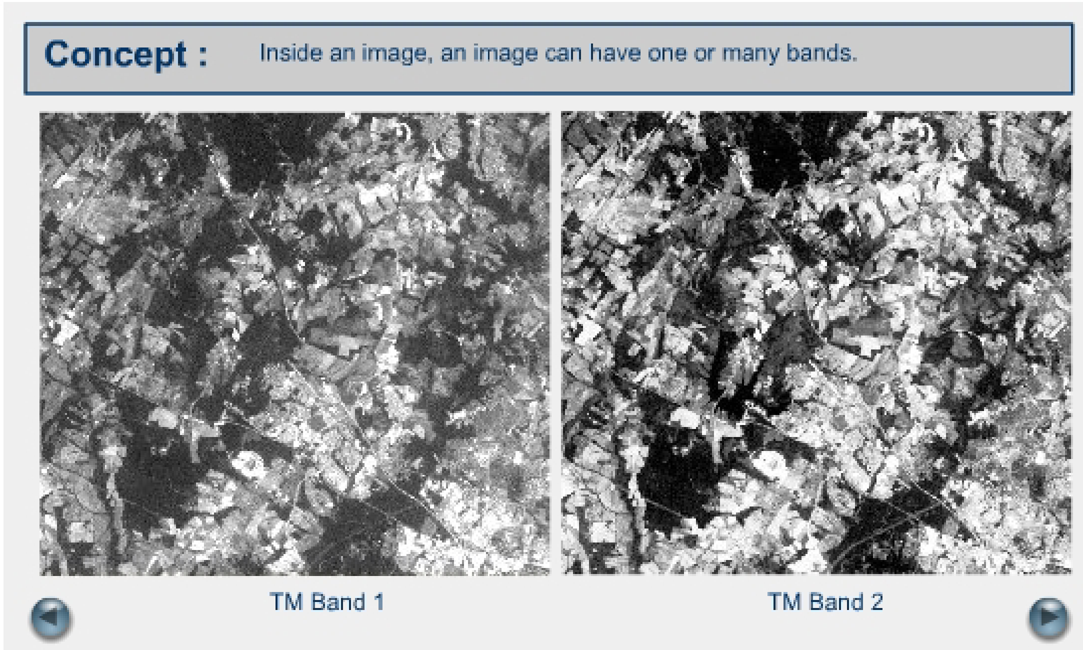


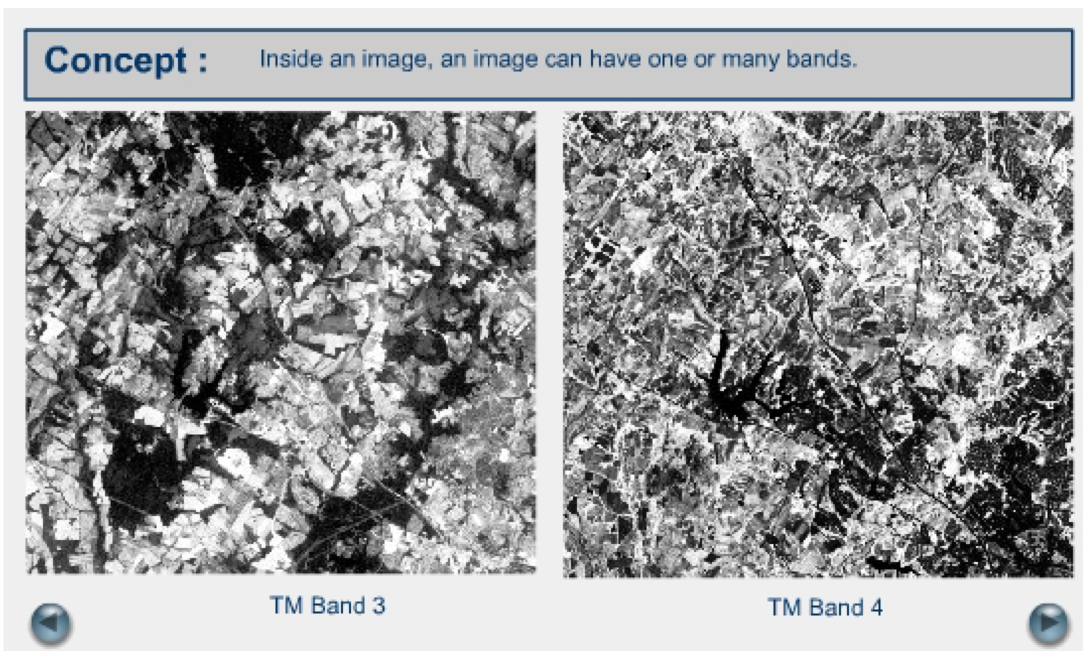

## Concept : Example of Landsat TM images



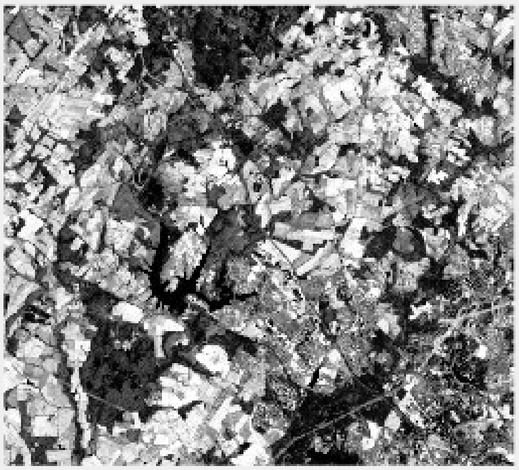
False color composite

Natural color composite

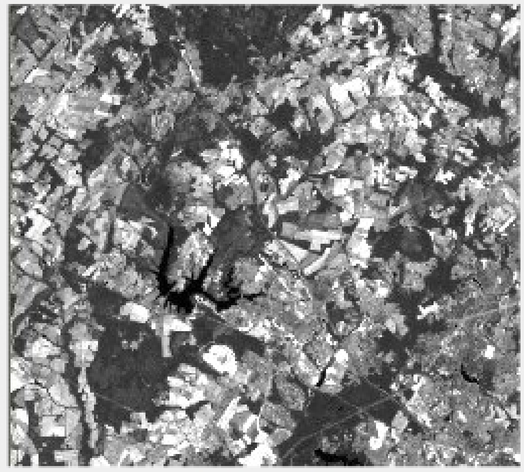

Concept :
Inside an image, an image can have one or many bands.
TM Band 1
TM Band 2


Concept :
Inside an image, an image can have one or many bands.
TM Band 3
TM Band 4

**Concept :** Inside an image, an image can have one or many bands.



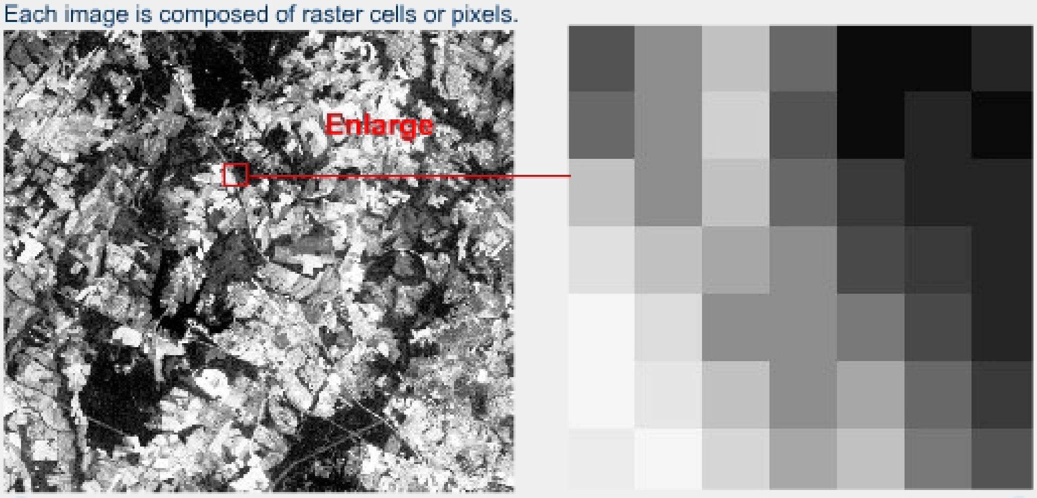
TM Band 5



TM Band 6

**Concept :** Inside an image, an image can have one or many bands.

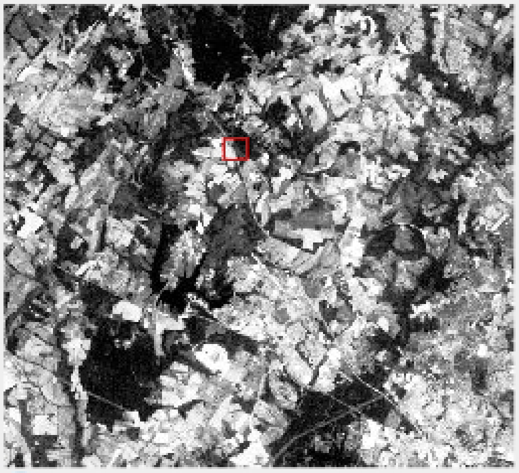
Each image is composed of raster cells or pixels.




Example with band 2

**Concept :** Inside an image, an image can have one or many bands.

**Each cell has a value. These values are call digital numbers.**



| | | | | | | |
|---|---|---|---|---|---|---|
| 48 | 52 | 54 | 49 | 43 | 43 | 44 |
| 49 | 52 | 55 | 48 | 43 | 44 | 43 |
| 54 | 52 | 54 | 49 | 45 | 44 | 44 |
| 59 | 54 | 53 | 42 | 47 | 45 | 44 |
| 62 | 58 | 52 | 52 | 51 | 47 | 44 |
| 62 | 60 | 54 | 52 | 53 | 49 | 45 |
| 61 | 62 | 57 | 53 | 54 | 51 | 48 |

Example with band 2

**Concept :** Inside an image, an image can have one or many bands.

**The digital numbers are displayed as grayscale image.**

**Therefore, you see as grayscale picture.**

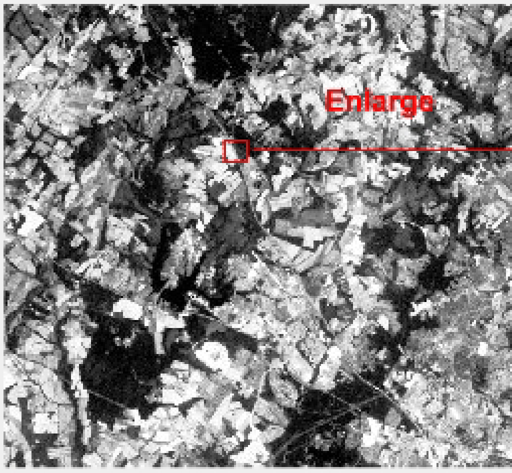
**Actually, you are seeing numbers.**

**Each cell has a value from 0 to 255 in 8 bit satellite images and aerial photographs.**

| | | | | | | |
|---|---|---|---|---|---|---|
| 48 | 52 | 54 | 49 | 43 | 43 | 44 |
| 49 | 52 | 55 | 48 | 43 | 44 | 43 |
| 54 | 52 | 54 | 49 | 45 | 44 | 44 |
| 59 | 54 | 53 | 42 | 47 | 45 | 44 |
| 62 | 58 | 52 | 52 | 51 | 47 | 44 |
| 62 | 60 | 54 | 52 | 53 | 49 | 45 |
| 61 | 62 | 57 | 53 | 54 | 51 | 48 |

Example with band 2

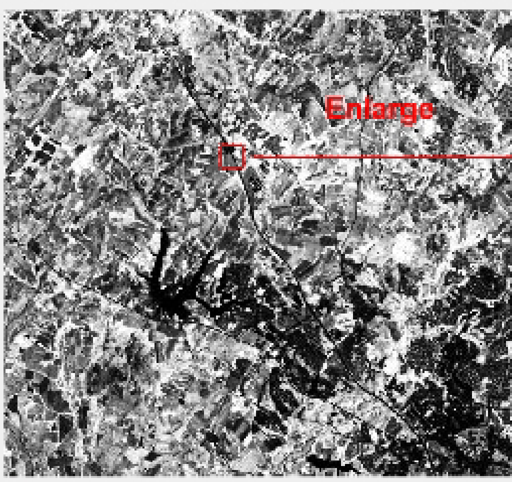
**Concept :** Inside an image




| | | | | | | |
|---|---|---|---|---|---|---|
| 55 | 64 | 66 | 56 | 46 | 43 | 40 |
| 53 | 62 | 65 | 53 | 43 | 43 | 43 |
| 67 | 61 | 62 | 54 | 46 | 42 | 40 |
| 83 | 67 | 63 | 61 | 49 | 44 | 40 |
| 89 | 76 | 61 | 65 | 58 | 48 | 45 |
| 89 | 82 | 68 | 64 | 65 | 54 | 45 |
| 89 | 86 | 75 | 65 | 66 | 58 | 50 |

Example with band 3

**Concept :** Inside an image




| | | | | | | |
|---|---|---|---|---|---|---|
| 92 | 75 | 75 | 90 | 108 | 122 | 127 |
| 105 | 80 | 71 | 91 | 118 | 132 | 127 |
| 111 | 91 | 71 | 85 | 116 | 131 | 129 |
| 113 | 102 | 79 | 77 | 113 | 123 | 124 |
| 113 | 108 | 91 | 76 | 97 | 111 | 116 |
| 113 | 111 | 98 | 79 | 82 | 102 | 111 |
| 110 | 109 | 104 | 87 | 77 | 100 | 113 |

Example with band 4

## Concept : Pictoral representation and digital numbers

A band represents a segment of the electromagnetic spectrum that has been collected by a sensor.

The value of each pixel represents the reflection radiation or emission radiation or backscattering level in the specific portion (Band-1, Band-2 etc.) of electromagnetic energy spectrum, detected and recorded by the sensor

## Concept : Displaying multiband rasters

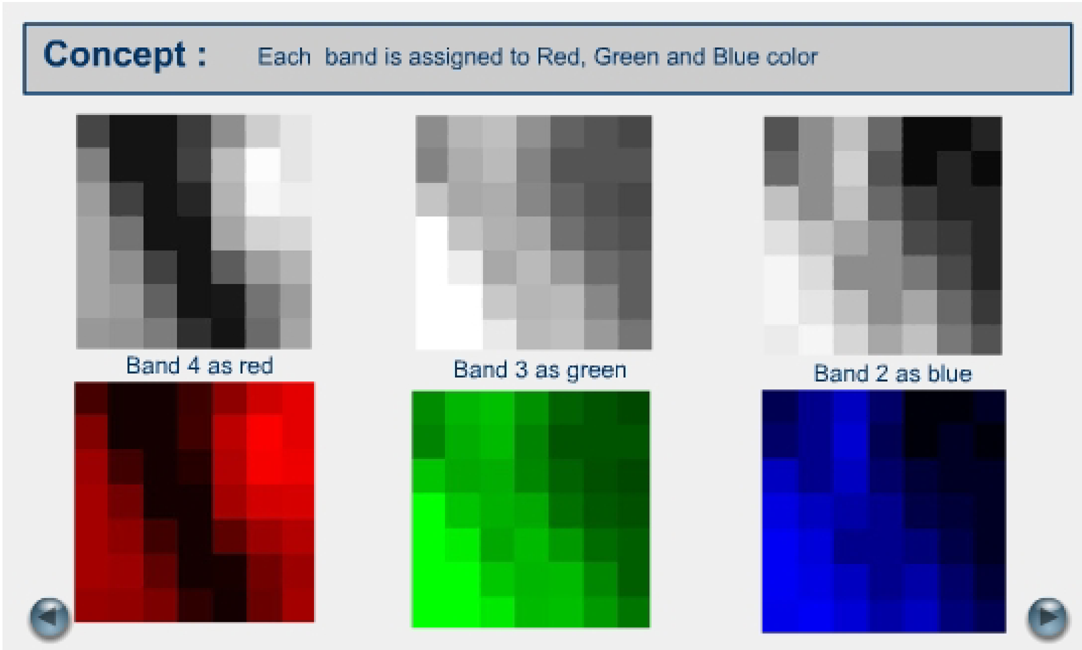
The image data may have more than one band such as Landsat TM images that you have seen.

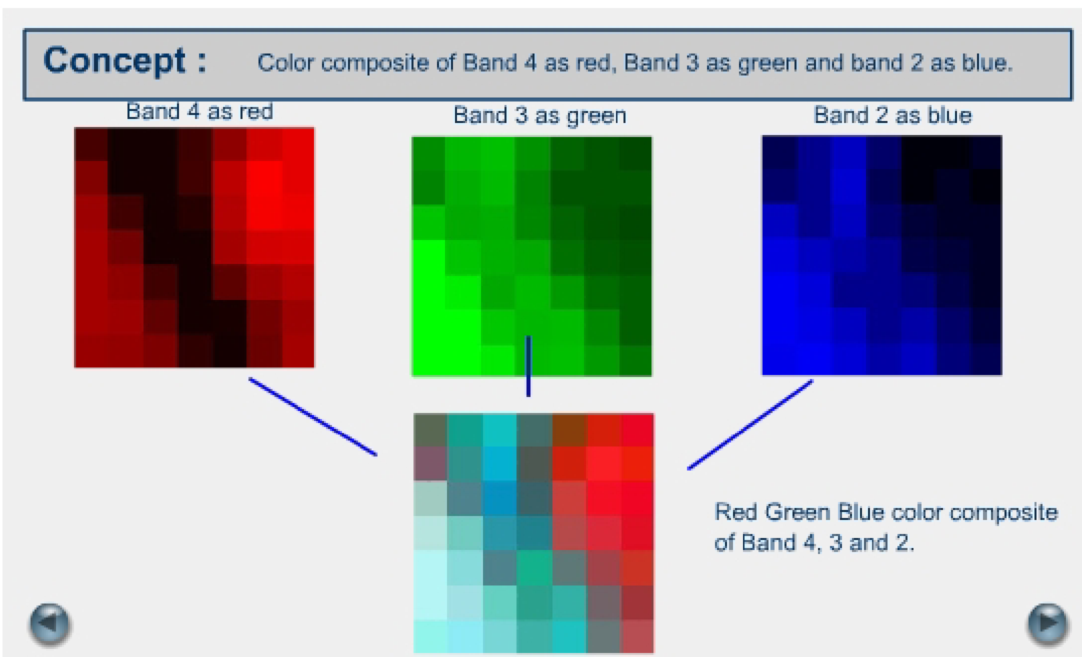
Multibands raster images are often displayed as red-green-blue composite. This band configuration is common because these bands can be displayed on computer display, which employ a red-green-blue color rendition model.

One band is assigned as blue color.
One band is assigned as green color.
One band is assigned as red color.

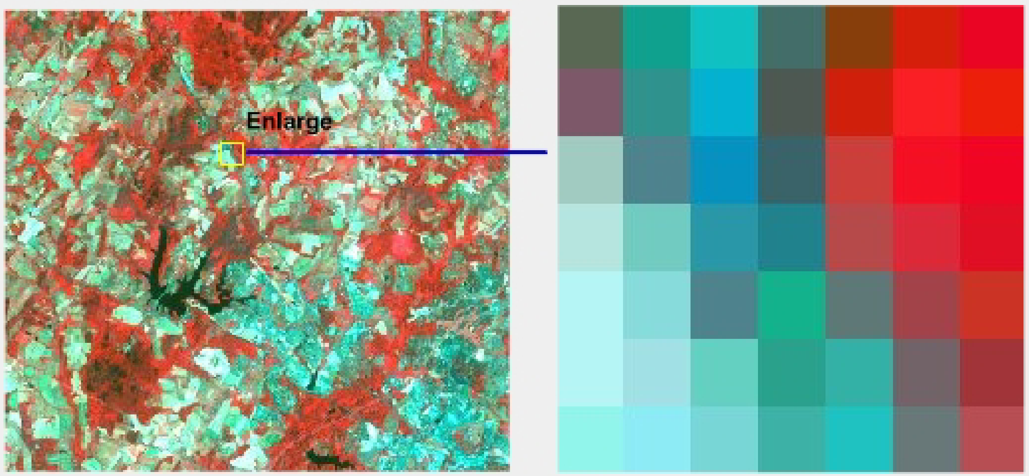
Then three bands is display as composite.

See the example on the next page.


Concept :
Each band is assigned to Red, Green and Blue color
Band 4 as red
Band 3 as green
Band 2 as blue


Concept :
Color composite of Band 4 as red, Band 3 as green and band 2 as blue.
Band 4 as red
Band 3 as green
Band 2 as blue
Red Green Blue color composite
of Band 4, 3 and 2.

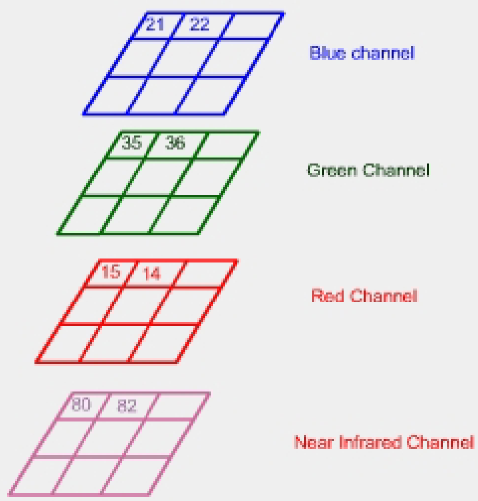
**Concept :** Color composite of Band 4 as red, Band 3 as green and band 2 as blue.




Red Green Blue color composite
of Band 4, 3 and 2.

**Concept :** Digital numbers represent the certain aspect of the earth's surface

The Remote Sensing Satellite Sensor registers a single value for each of a limited numbers of wavebands of electromagnetic radiation at a particular range of wavelengths, that have been chosen to detect and record the information about certain aspect of the earth's surface such as vegetation, soil, rock, agriculture, water and snow.



## Concept : Resolution: Spectral resolution

Four distinct types of resolution must be considered.

**Spectral resolution** is the specific wavelength intervals in the electromagnetic spectrum (EMS) that a sensor can record. Wide intervals in the electromagnetic spectrum are referred to as coarse spectral resolution, and narrow intervals are referred to as fine spectral resolution. Therefore, SPOT panchromatic sensor is considered to have coarse spectral resolution because it records Eletromagnetic RadiationEMR between 0.51 and 0.73 Micron meter. Band 3 of Landsat TM sensor has fine resolution because it records EMR between 0.63 and 0.69 Micron meter (Jensen 1996).

The spectral band or channels of remote sensing satellite are designed to detect and record the certain physical aspect of earth surface cover at a particular level of generalization at a particular wavelength of EMR at a particular time.

## Concept : Spectral resolution continue..

The physical aspect of earth surface cover is indirectly measured through reflection characteristice (reflected energy) , emission characteristics (emission energy or heat) or back scattering characteristics (microwave backscatter energy). These characteristics are determined by the chemical composition, physical characteristics and spatial orientation of earth surface cover. These characteristics can be detected through the detected DN values of each wavelength band.

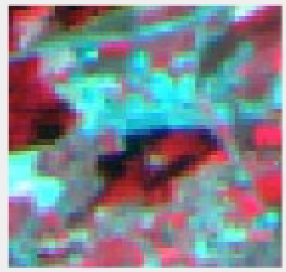
The discrimination capability is higher with a higher number of wavebands, which have been carefully chosen to optimise the capability for the recognition of different earth surface features. Therefore hyper-spectral sensors record continuous spectra for each pixel and therefore generate a huge amount of data.

## Concept : Resolution : spatial resolution

The spatial resolution is the area on the ground represented by each pixel. The finer the resolution, the lower the number. For example, a spatial resolution of 30 meters is coarser than a spatial resolution of 10 meters.

The spatial resolution or the area covered by a single pixel varies from a square kilometre to a few square centimetres for aircraft based, high-resolution sensors. The spatial resolution corresponds to the dimension of smallest detail that can be distinguished on the ground.

SPOT Panchromatic 10 m spatial resolution



Landsat TM 30 M spatial resolution

See the example on the right side

## Concept : Resolution: radiometric resolution

The radiometric resolution indicates the number of possible data file values in each band. It refers to the dynamic range, or a number of possible data file values in each band.

The data can be recorded in 8-bit ($2^8$ or 0 to 255) digital level, 10-bit ($2^{10}$ or 0 to 1024) digital level, 16-bit ($2^{16}$ or 0 to 65536) digital level or 32-bit ($2^{32}$or 0 to 4294967296) digital level. Higher digital level or spectral quality permits the detection of small variation in the physical nature of observed surfaces, such variation resulting in readily discernable changes in image fragment of interest.

## Concept : Resolution: Temporal resolution

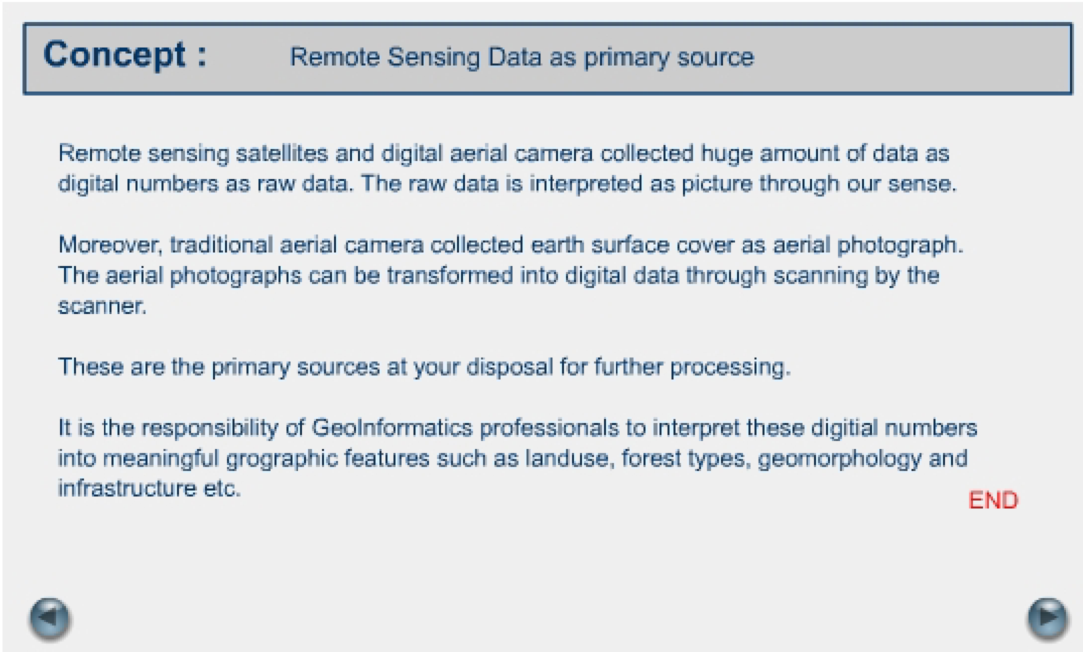
**Temporal resolution** indicates how often a sensor obtains imagery of a particular area. Landsat TM can revist to the same area of the earth at every 16 days and SPOT can revisit to the same area every 3 days.

Temporal resolution is an important factor to consider in change detection studies.

## Concept : Brief introduction to processing of remotely sensed data

The remotely sensed data are affected by the atmospheric conditions, surface topography, focal length of the optical system and sensor viewing geometry. Therefore, atmospheric correction and geometric correction are necessary to minimize the radiometric and geometric distortions before classification, interpretation and integration into the geographical database.

The type, characteristics and phenomenon of earth surface's features are identified, measured, interpreted and mapped through the manual interpretation procedures or computer assisted digital transformation procedures. The visual appearance of the images can be improved by increasing contrast, stretching the range of grey levels or colours used and by edge enhancing, detecting, to make it easier to identified earth surface's features.




## 3. Use of Remote Sensing Data in GIS

Geometric correction of satellite data with reference to the projection system of GIS database is pre-requisite to use.

**1. Use of Classified data**

Land cover map, vegetation maps or forest type maps etc. can be derived from remote sensing data through image processing techniques or manual interpretation. These maps can be converted to the compatible formats of GIS system and can be combined with other geographical data for spatial analyses and monitoring environmental changes.

**2. Use of Image data**

Remote sensing image can be classified or analyzed with other existing geographic information in order to obtain a higher accuracy of classification. For example, Digital Elevation Model (DEM) will be useful to discriminate mangrove and other kind of forests in the image. Moreover, combining elevation map and image data can separate different earth surface's features such as pine and hill evergreen forests.

**3. Satellite Orthophoto Maps (SOMs)**

By using the digital elevation model, and ground control points (GCPs), the aerial photos and satellite digital data (in digital format) can be orthorectified. These image maps are called orthophoto or Satellite orthophoto maps (SOMs). The X, Y, Z distortions of original image data is corrected.

These image maps are used to overlay the political boundaries, roads and railways. Such an image map can be successfully used for visual interpretation.

Digital elevation model (DEM) is used with remote sensing data for shading corrections in mountainous areas.

**4. Moving the RS data to GIS**

Remote Sensing data is almost always processed and stored in raster data structures. When working simultaneously with an image processing system and a **raster GIS**, it is usually easy to move data between the two. Once the remote sensing data has been converted to a desired thematic content type, transferring this data to a raster GIS is relatively easy. Most operational image processing and raster GIS systems provide mechanisms to read and write 8-bit-per pixel raster arrays.

More work is involved when transferring raster data derived from image processing system to a **vector GIS**. **Continuous data** such as vegetation abundance, involves extracting the contours of abundance (often call isolines), the vectors are passed to the GIS, along with labels to indicate values associated with the contour lines.

When working with **discrete data** such as Land use derived from image processing techniques, the pixels that form the boundaries of the areas are detected in order to isolate the implicit homogeneous polygons in the derived image. Then the boundary pixels are used to develop the vectors surrounding the areas and attributes value and class name are assigned to the bounded areas. The analyst will often smooth the stair steps boundary between classes of spatial objects to make the vector plots appear more realistic. One should remember that the underlying data might have been irreversibly changed. It is important to understand that the conversion processes are limited by the underlying data, in terms of precision and accuracy.

## Exercises

1. To combine the data from different digital data sources for a project, what are the compatibility characteristics to the existing digital data to be considered?

2. How are the existing digital data distributed?

3. What kind of information can be collected with GPS? What kind of information GPS provide?

4. What is the difference between Active Remote Sensing and Passive Remote Sensing?

5. What is the minimum pre-requisite to use remotely sensed data in GIS database?