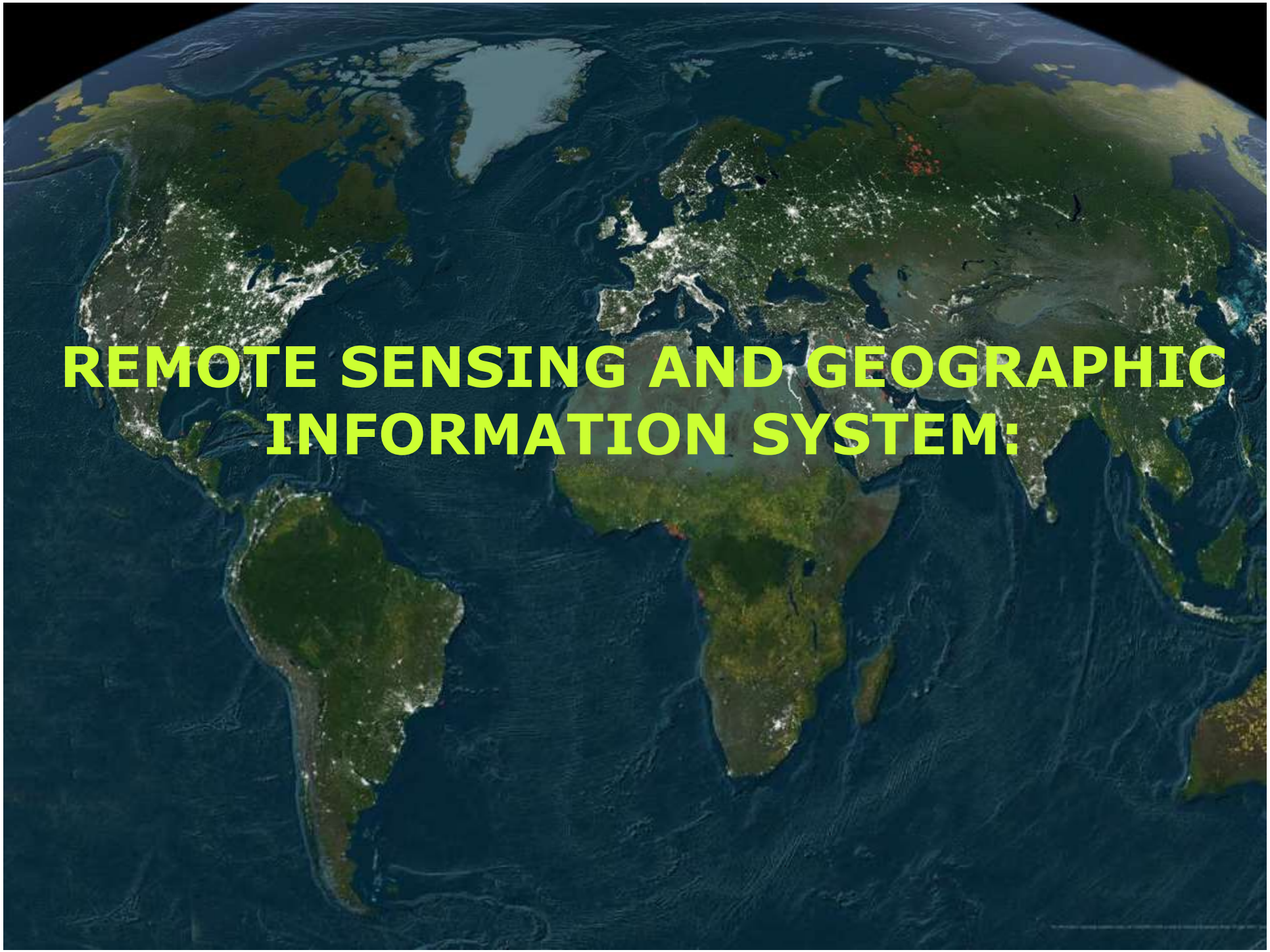
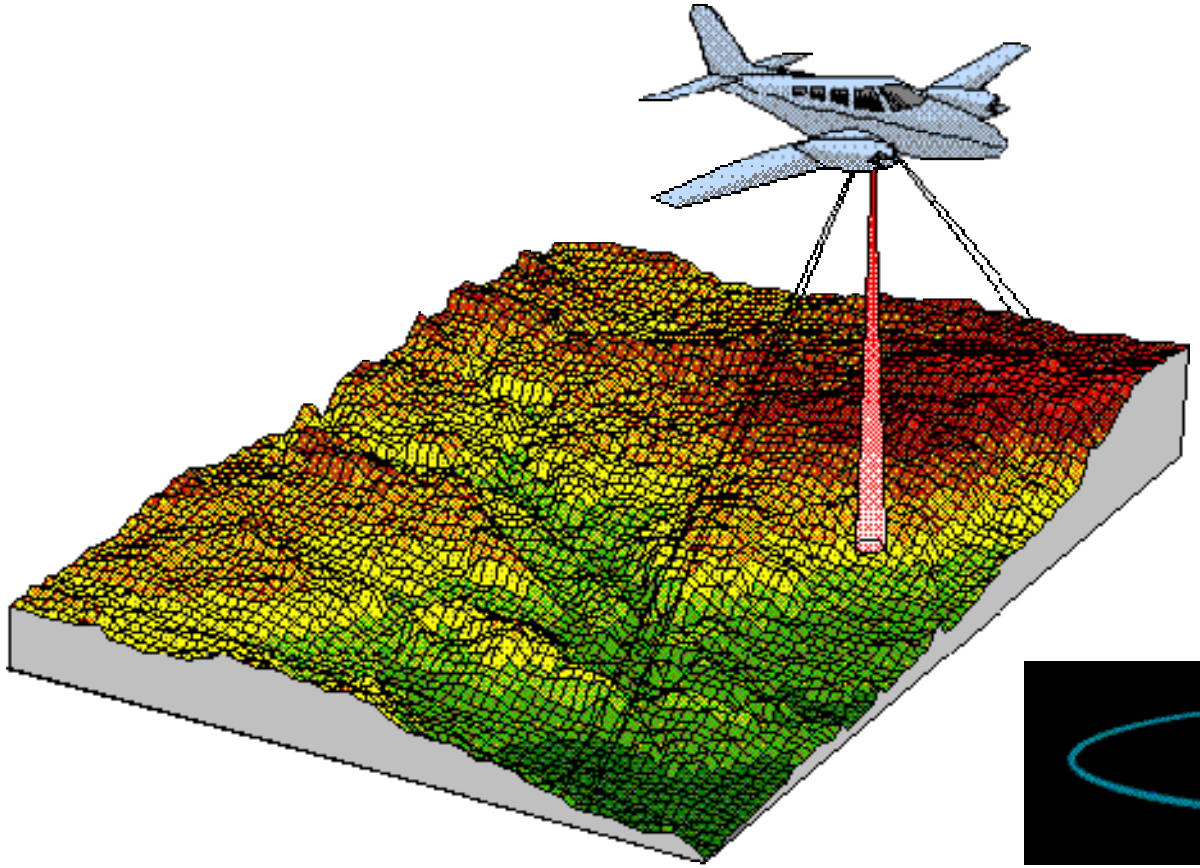
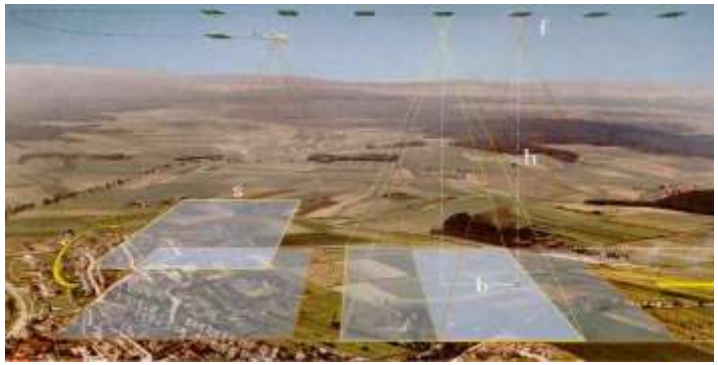
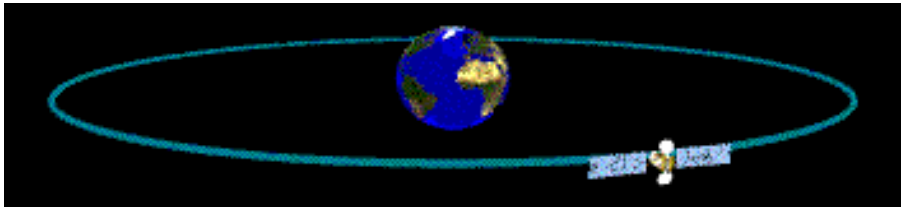

REMOTE SENSING AND GEOGRAPHIC
INFORMATION SYSTEM:

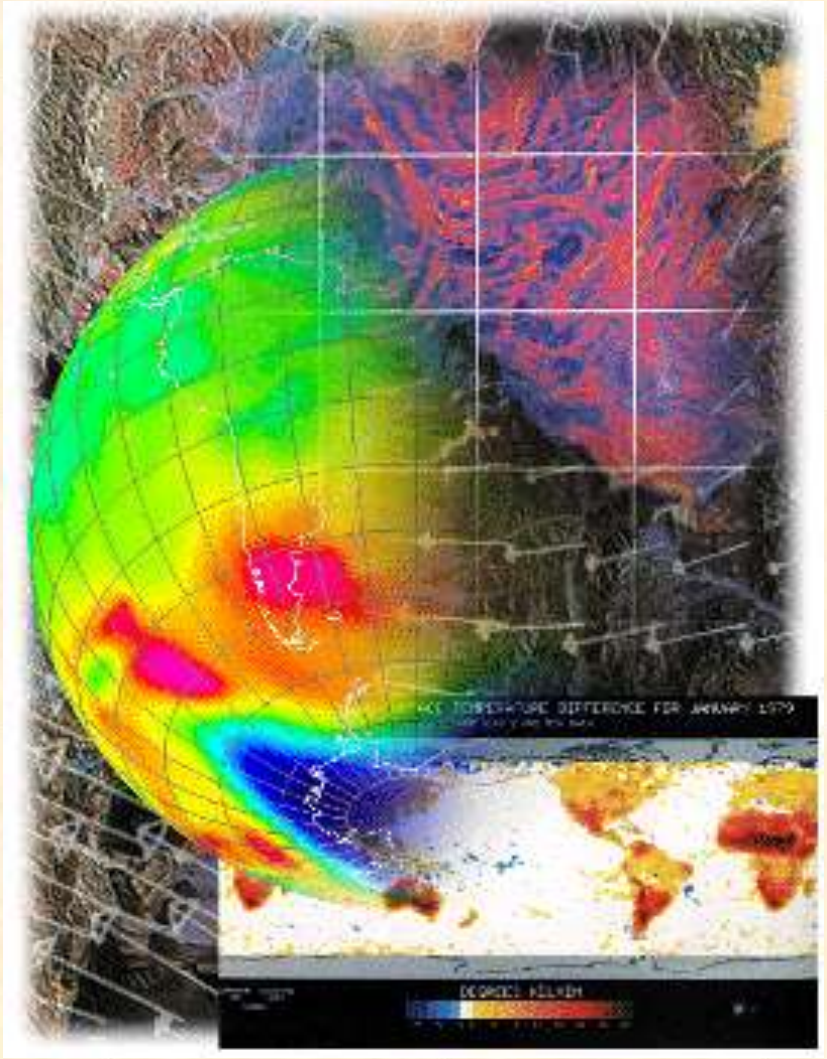
BASIC PRINCIPLES OF REMOTE SENSING







What is remote sensing?



- Using instruments to record an object or surface without touching it is called **REMOTE SENSING**. Most techniques make use of the electromagnetic spectrum. Instruments can include cameras, spectrometers and radar.

What is Satellite ?

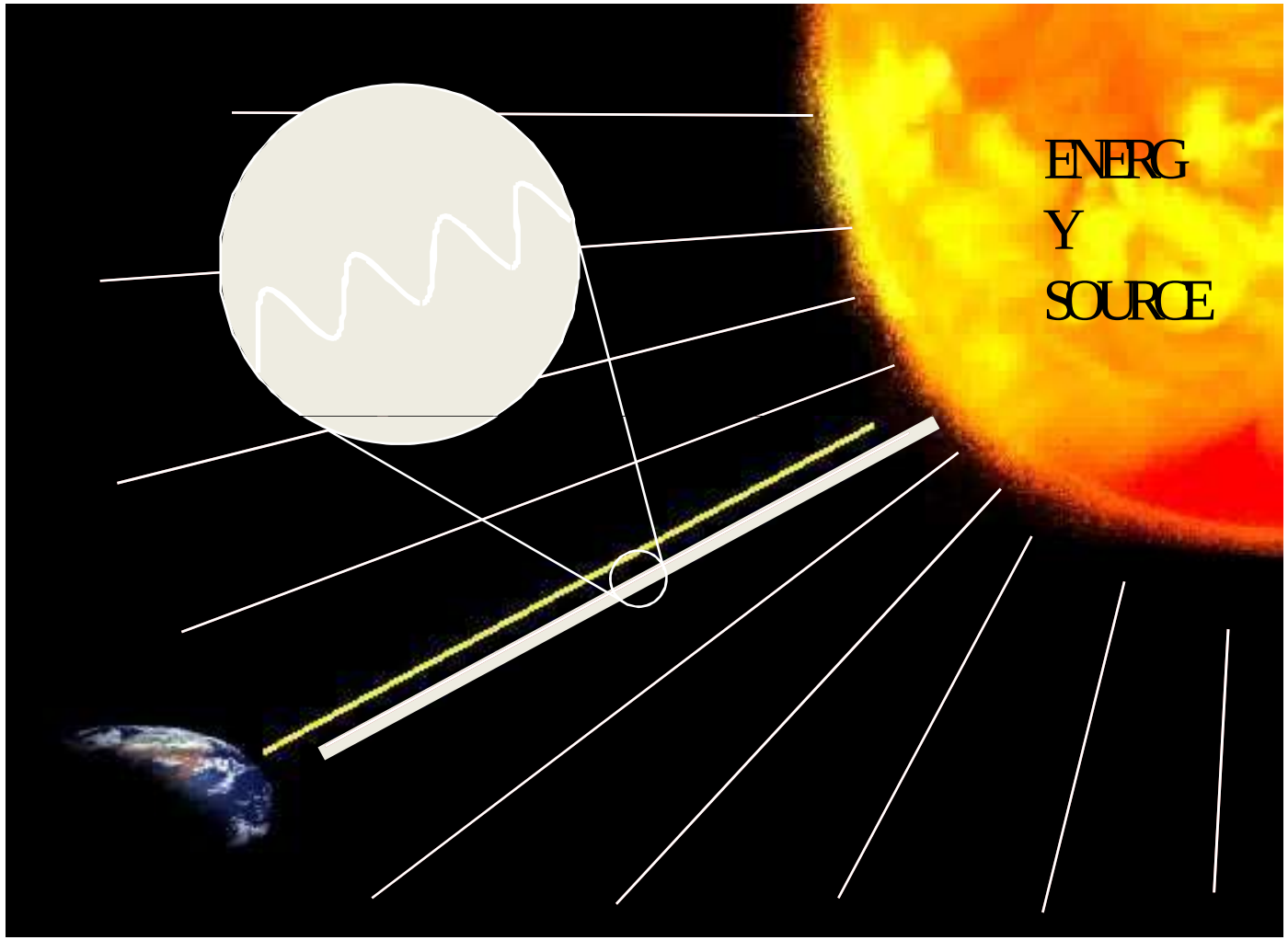
•The term **Satellite** simply refers to a body in orbit around another body.

•Satellites may serve many different purposes; they may be part of a television or telephone network, environmental monitoring, weather forecasting or they can carry instruments to investigate the earth's surface or earth's atmosphere.

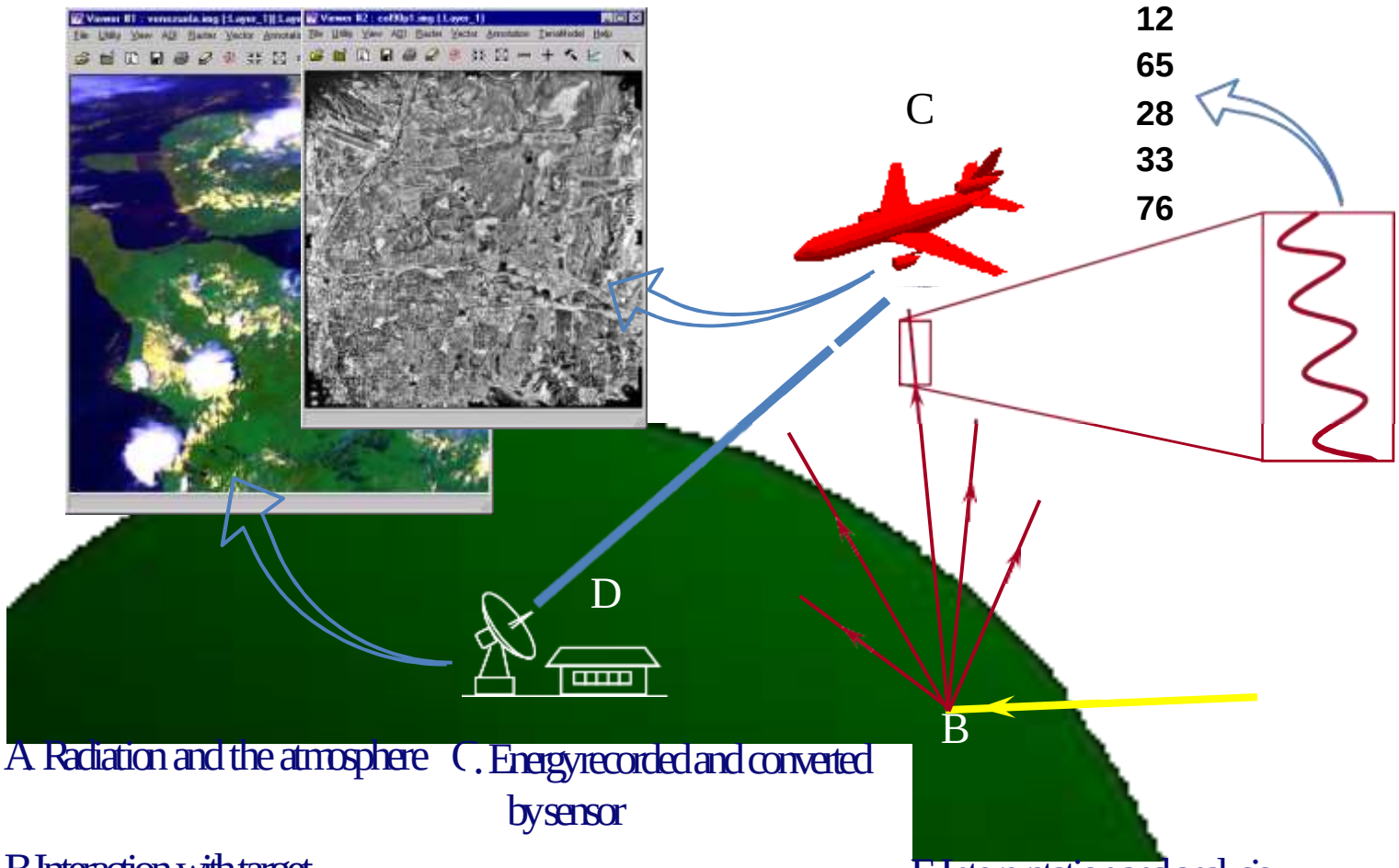
Stages in Remote Sensing

A source of electromagnetic energy
Transmission of Energy from the source to the surface of earth
Interaction with the intervening atmospheres
Interaction of EMR with the earth's surface
Transmission of Energy from the surface to the remote sensor
Sensor Data output
Data transmission , Processing and Analysis

The process of remote sensing

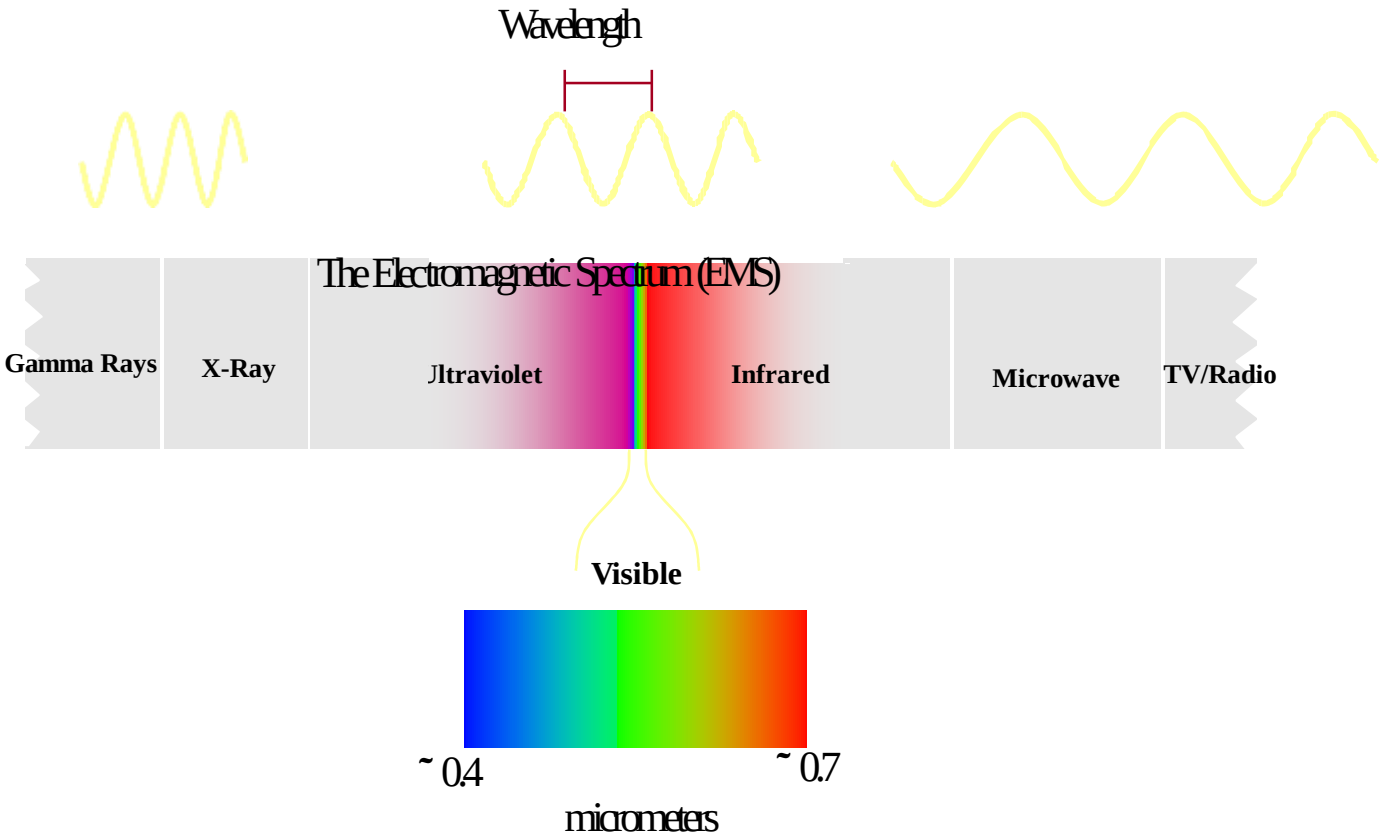


The process of remote sensing



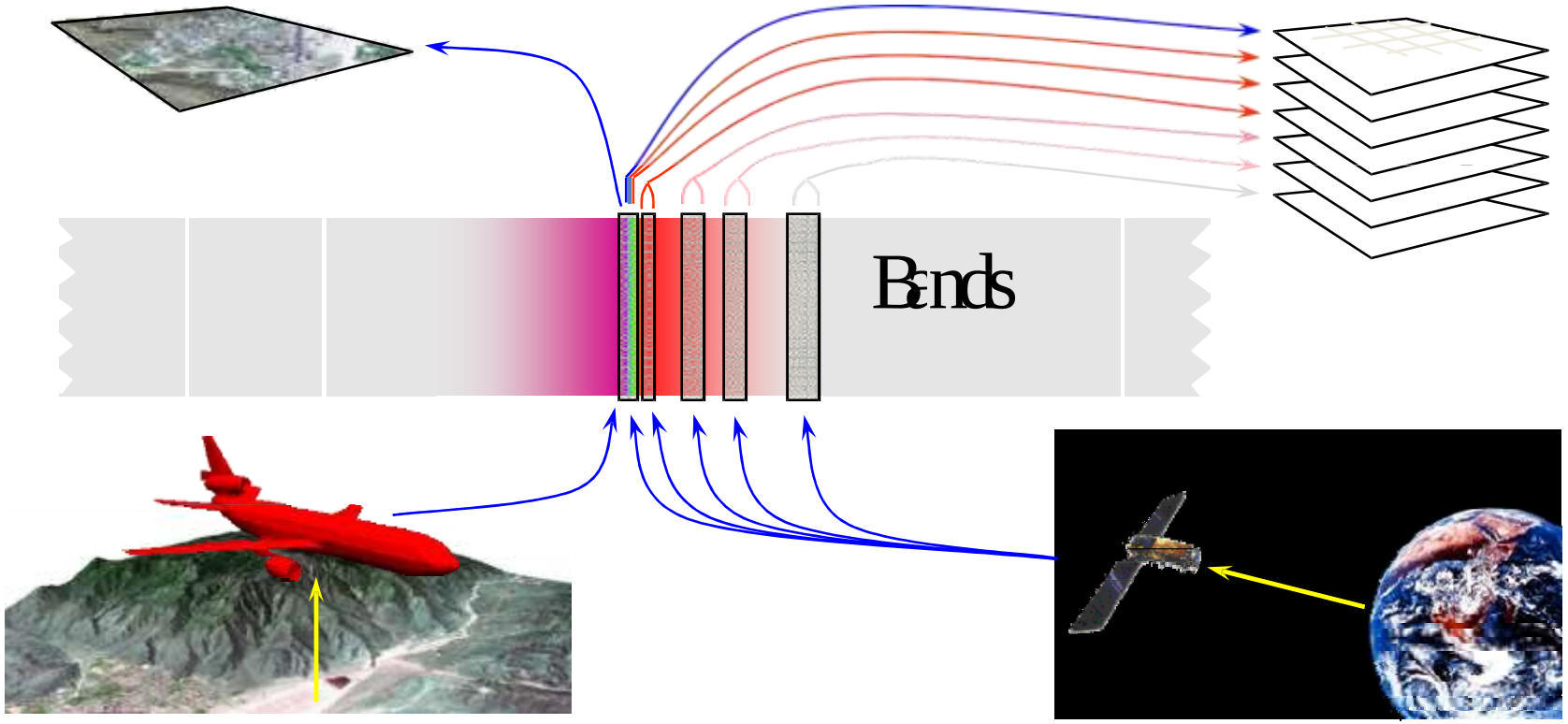
Measuring Light

- Light can be classified according to the length of the wave



Measuring Light: Bands

- Human eyes only ‘measure’ visible light
- Sensors can measure other portions of EMS



Electromagnetic Spectrum

Electromagnetic spectrum is a continuum consisting of the ordered arrangement of radiation according to the wavelength or frequency or energy. Or,

The total range of wavelengths extending from gamma rays to radio waves is referred as the electromagnetic spectrum.

Gamma rays (10^{-9}m) are the shortest wavelengths and most energetic, and radio waves (>1 m) are the least energetic.

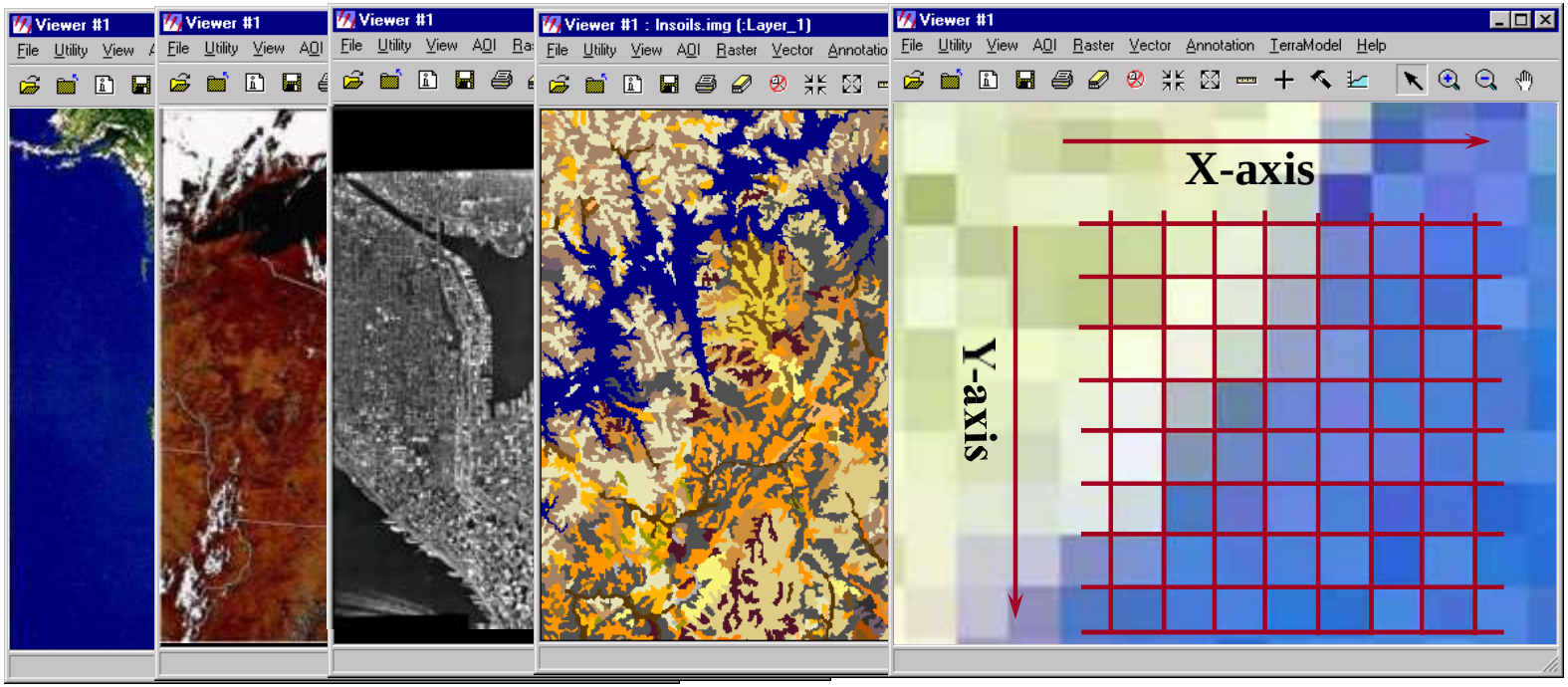
Electromagnetic spectral region and its characteristics (Sabines, 1987)

Gamma ray:	Incoming radiation is completely absorbed by the upper atmosphere and is not available for remote sensing.
X-ray:	Completely absorbed by the atmosphere. Not employed in remote sensing.
Ultraviolet:	Incoming wavelengths less than 0.3 µm are completely and 0.4 µm are partially absorbed by ozone in the upper atmosphere.
Visible:	Imaged with film and photodetectors. Includes reflected energy peak of earth at 0.5 µm.
Near IR:	Interaction with matter varies with wavelength. Atmospheric transmission windows are separated.
Mid IR:	Reflected solar radiation that contains information about thermal properties of materials. The band from 0.7-0.9 µm is detectable with film and is called the photographic IR band.

Thermal IR:	Principal atmospheric windows in the 8-14 µm thermal region. Images at these wavelengths are acquired by optical mechanical scanners and special vidicon systems but not by film.
Microwave:	0.1-30 cm longer wavelengths can penetrate clouds, fog, and rain. Images may be acquired in the active or passive mode
Radar:	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
Radio:	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelengths operate in this region.

What is an image?

- Data that are organized in a grid of columns and rows
- Usually represents a geographical area



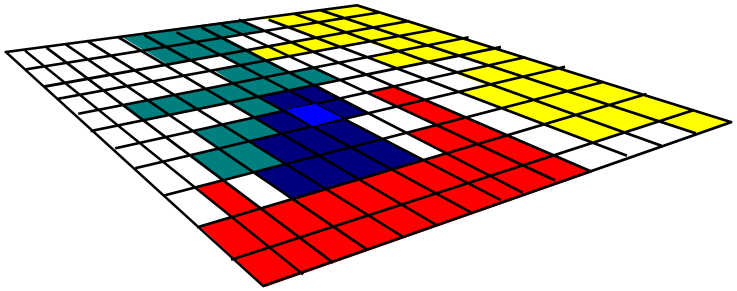
Two types of images

- REMOTELY SENSED images

Continuous data

- Measured Values (light)
- Quantitative

THEMATIC Images



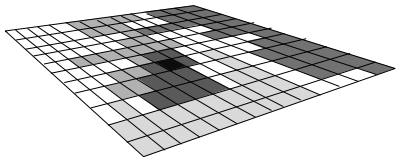
Discrete data

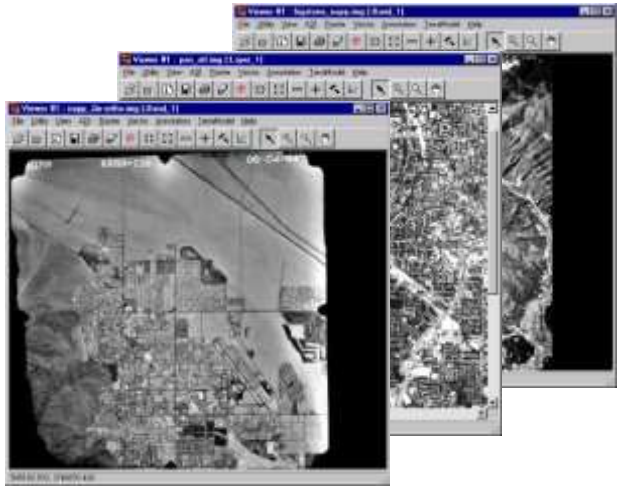
- Values only indicate class
- Qualitative

Continuous data

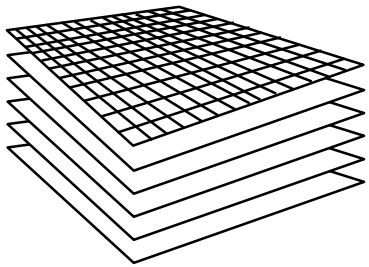
Two types:

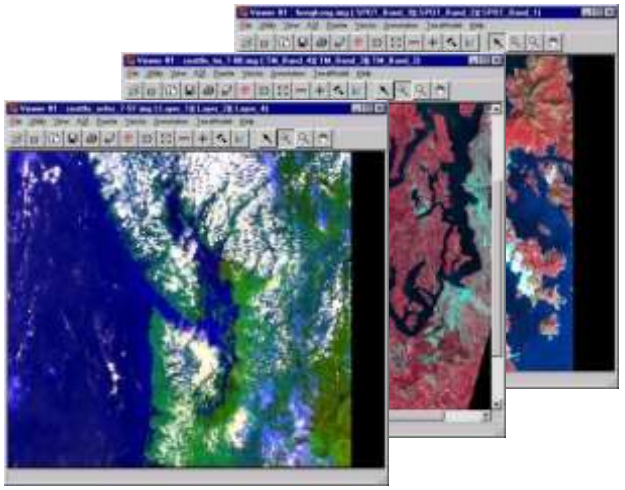
- Panchromatic (1 Band/layer)





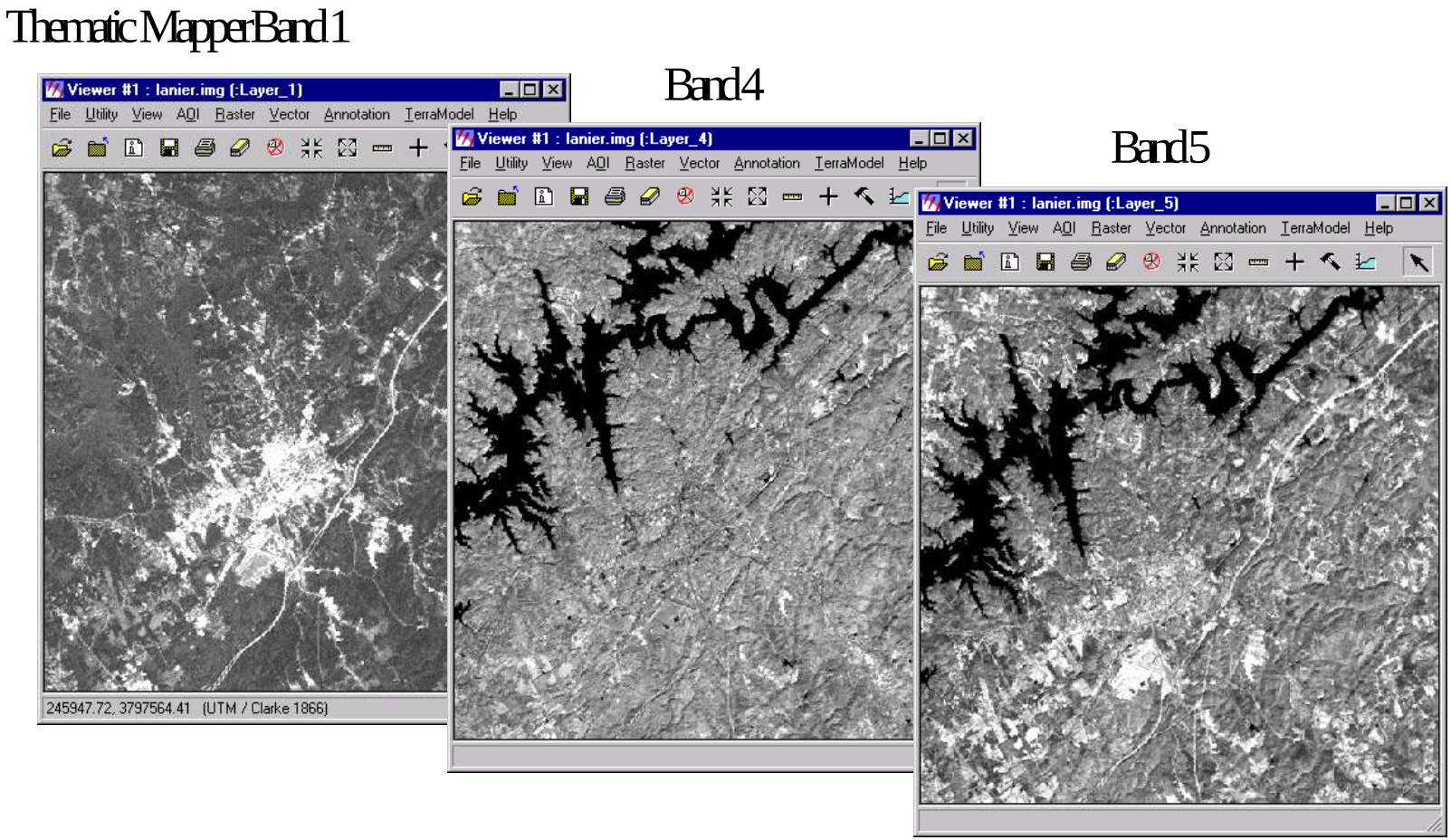
Multispectral (2 or more Bands)





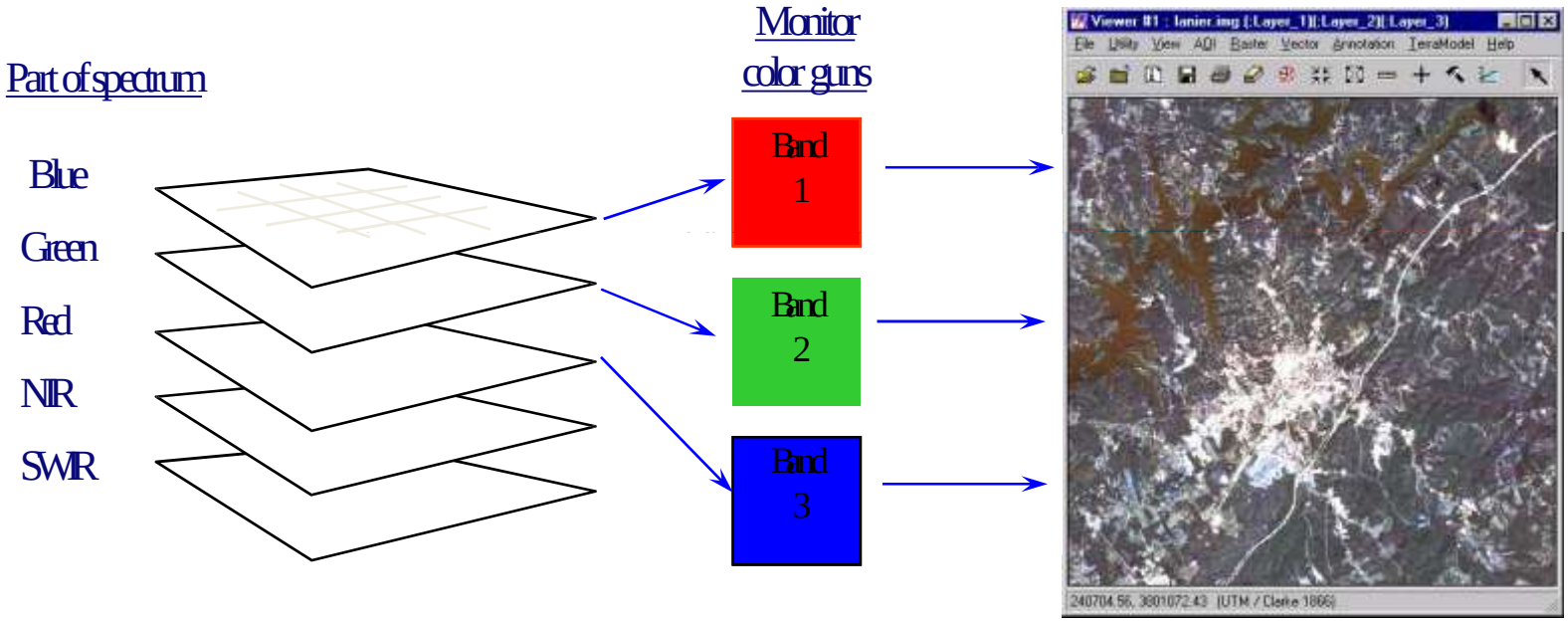
Viewing continuous images

- Each band or layer is viewable as a separate image



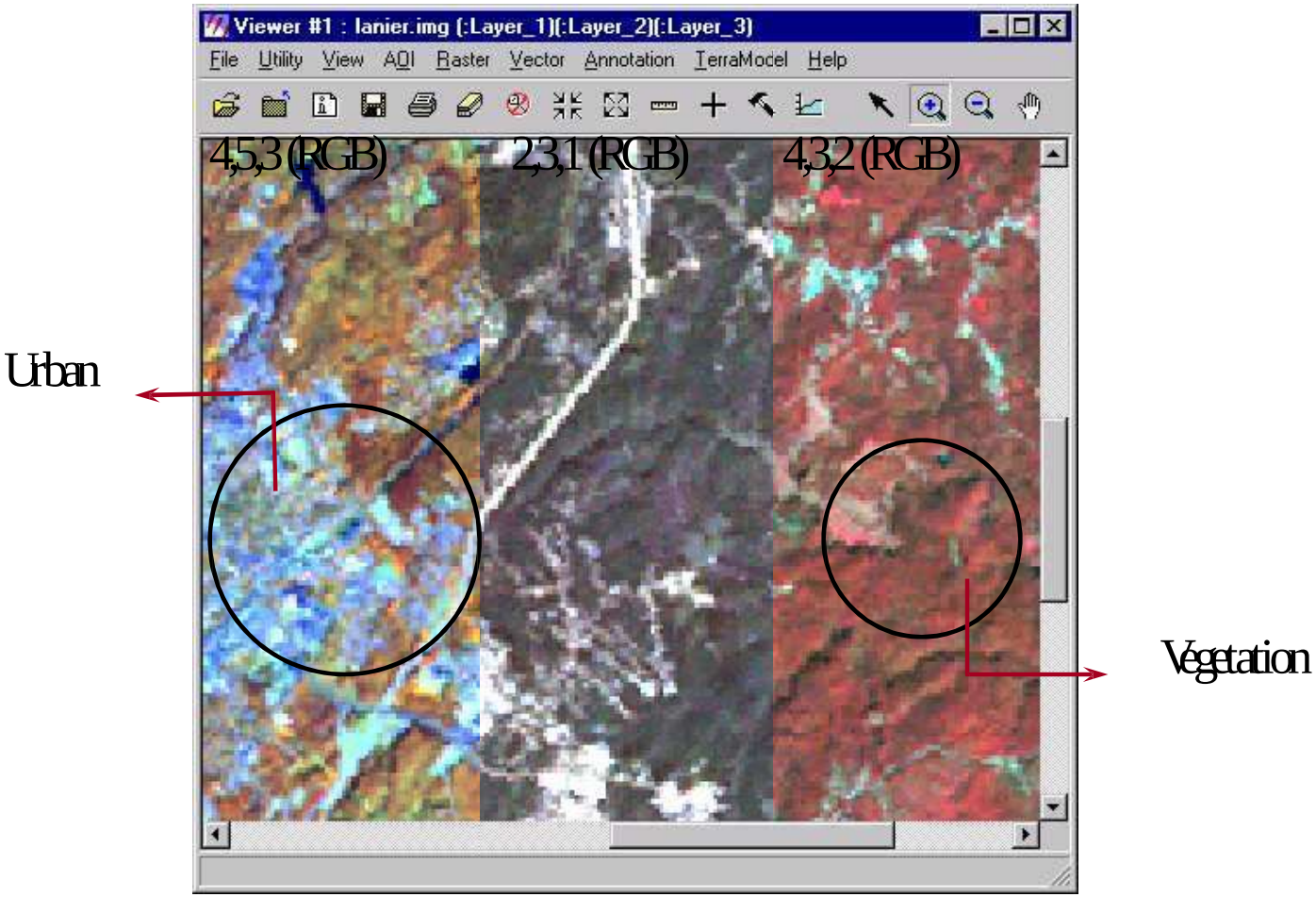
Viewing images

- **Three bands are viewable simultaneously**



Band Combinations

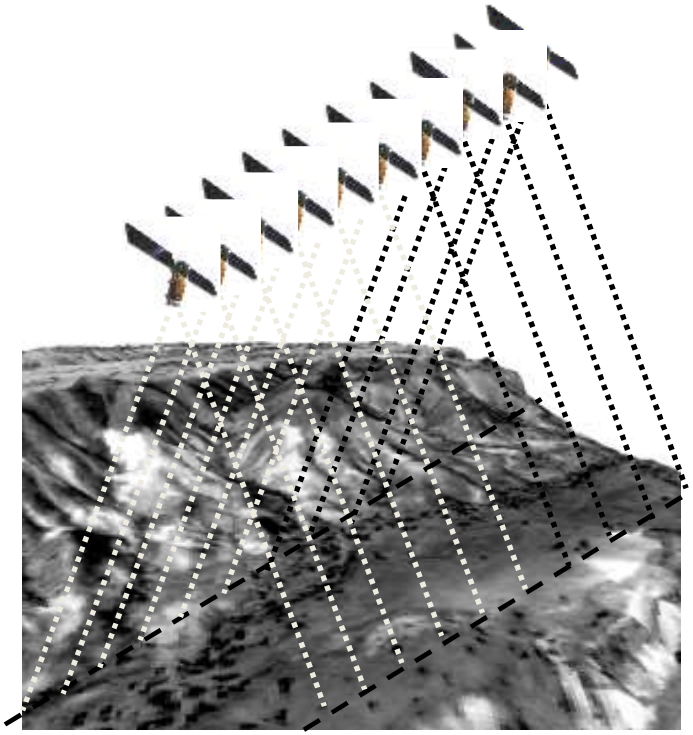
- Features can become more obvious



Effect of Different Bands

Swath

- Sensors collect 2D images of the surface in a swath below the sensor
- Example: Landsat has a 185 km swath



Pixels

- Resulting images are made of a grid of pixels

Each pixel stores a digital number (DN) measured by the sensor

Represents individual areas scanned by the sensor

The smaller the pixel, the easier it is to see detail

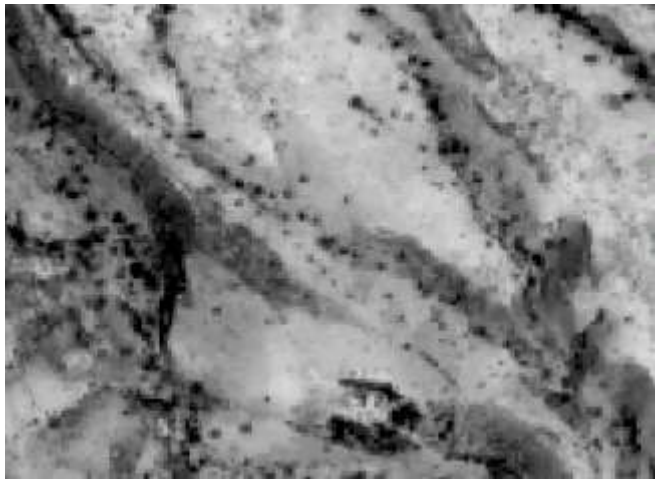
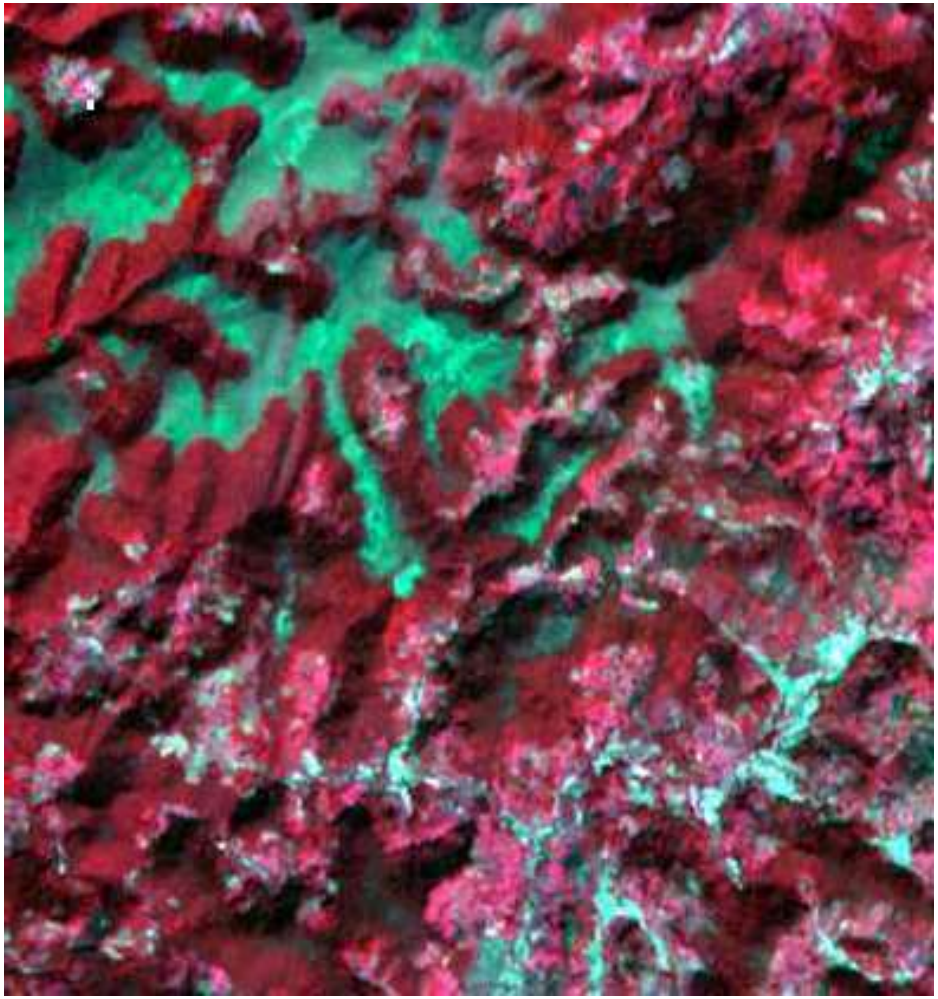
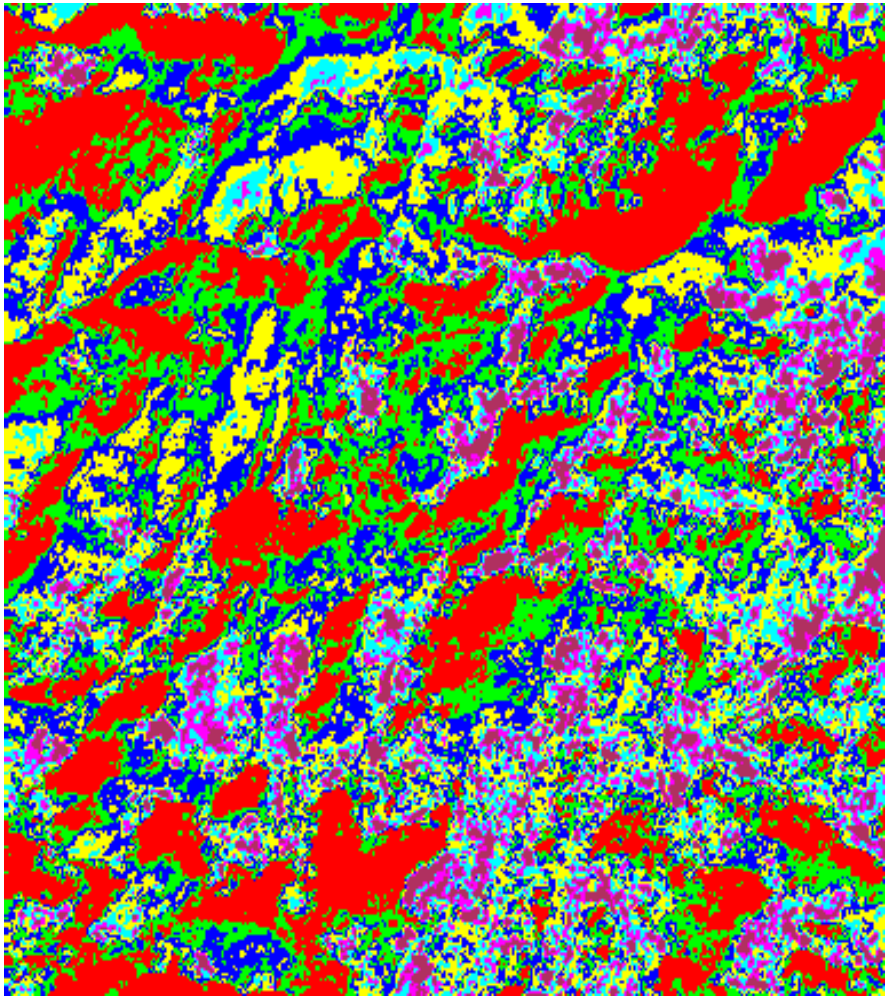


Image & Unsupervised Classification



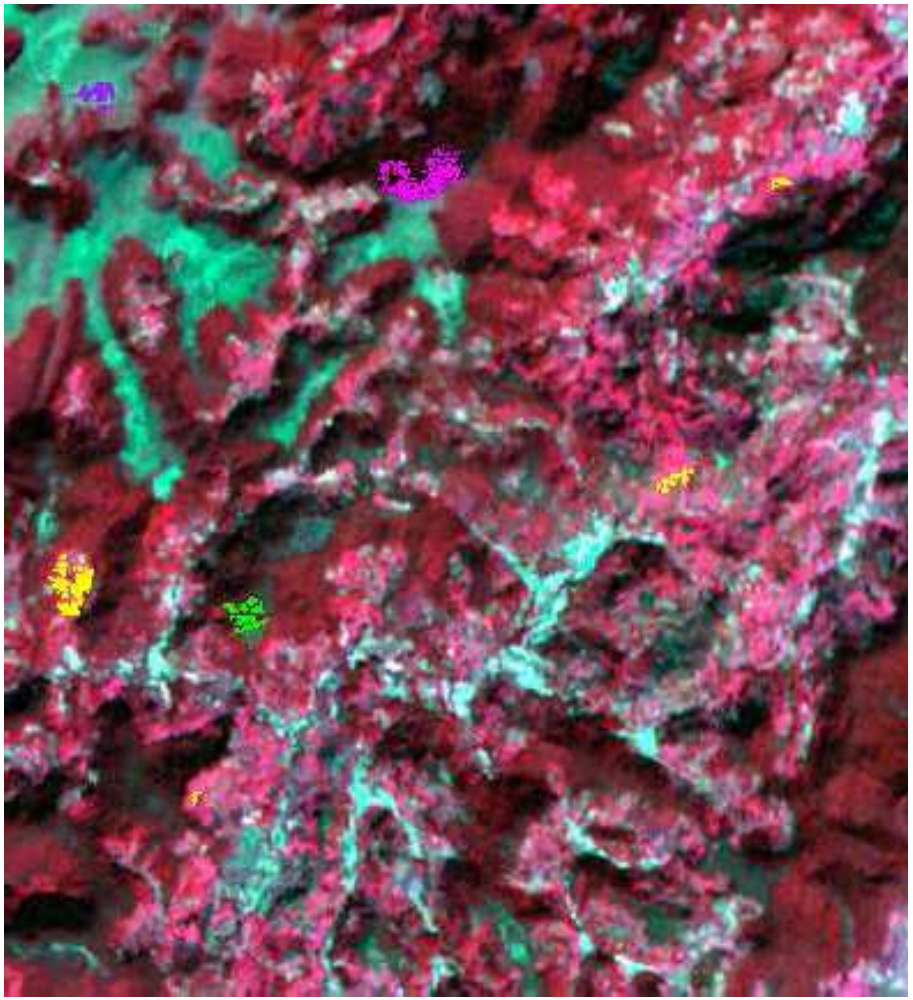


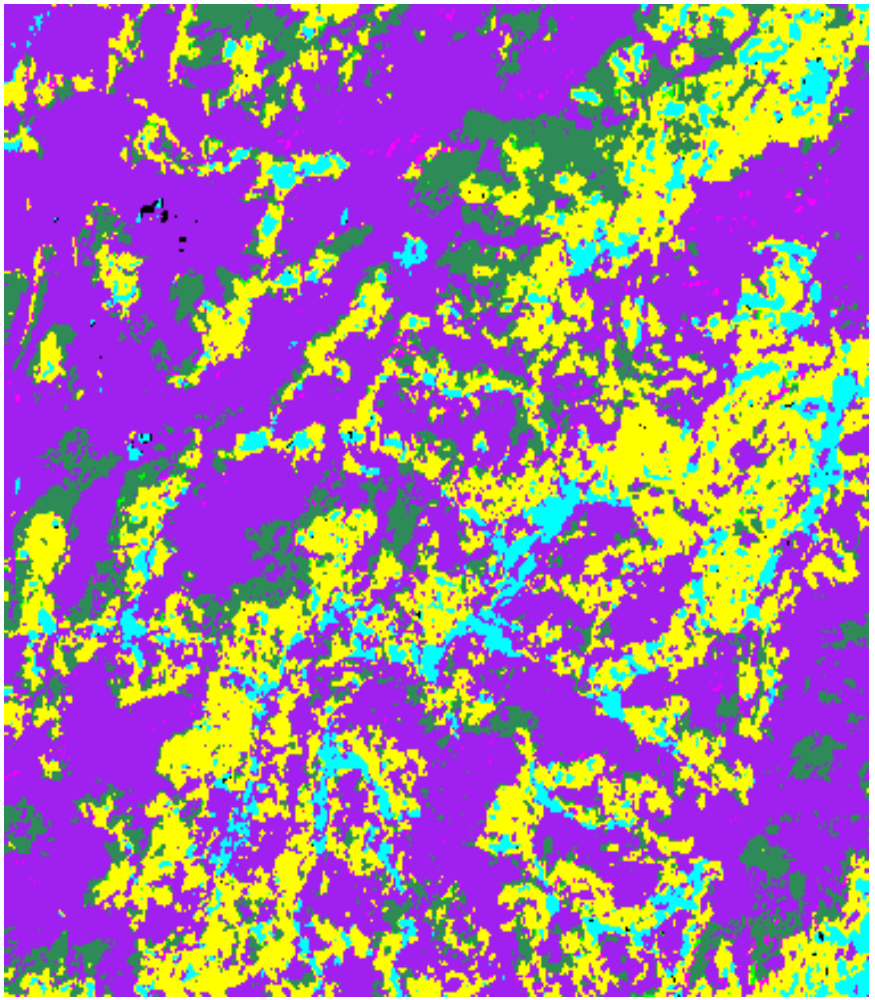
Types of Classification

I. Unsupervised classification

- Pixels in an image are assigned to classes without any *a* knowledge of their existence.
- Clustering methods used to determine spectral class of each pixel.
- Each spectral class is labeled *a posterior* by the analyst using ground information, maps etc.

Image & Supervised Classification





Types of Classification

II Supervised Classification

- Analyst identifies representative ‘training areas’ for different categories
- These training areas provide numerical spectral attributes of each land cover type.
- Different classifiers – minimum-distance-to-means, parallelepiped, maximum likelihood
- Outputs – thematic maps, tables of area, statistics for land cover classes, digital data files in GIS format, accuracy information etc.

Resolution: Ability of the system to render the information at the smallest discretely separable quantity in terms of distance (spatial), wavelength band of EMR (spectral), time (temporal) and/or radiation quantity (radiometric)

- **Spatial resolution: Defines the size of the Earth's surface that is stored in each pixel**

- **Spectral resolution: Defines the ability of the sensor to define wave length intervals**

- **Temporal resolution: Defines repetivity of the satellite**

- **Radiometric resolution: Defines the range of values that an individual pixel can have.**

Spatial resolution

Scanner's spatial resolution is the smallest ground segment sensed at any instant. It is also called ground resolution element.

LISS III	**Band**	**2 to 4**	**23.5 m**
	Band	**5**	**70.5 m**
WiFS			**188.3 m**
PAN			**5.8 m**
LISS IV			**2.5 m**

Spectral resolution

Sampling the spatially segmented image in different spectral intervals, thereby allowing the spectral irradiance of the image to be determined.

LISS III:

Band 2	0.52 - 0.59 μm
Band 3	0.62 - 0.68 μm
Band 4	0.77 - 0.86 μm
Band 5	1.55 - 1.70 μm
PAN	0.5 - 0.75 μm

Radiometric resolution

The smallest difference in radiant that can be detected is expressed as radiometric resolution

LISS III	7 bit / 128 levels
WiFS	7 bit / 128 levels
PAN	6 bit / 64 levels

Temporal resolution

Obtaining spatial and spectral data at certain time intervals. Temporal resolution is also called as the repetitivity of the satellite in case of satellites

IRS 1A/1B 22 days
IRS 1C/1D 24 days

1 meter panchromatic
(IKONOS)

10 meter panchromatic
(SPOT)

30 meter multispectral
(Landsat - TM or ETM)

80 meter multispectral
(Landsat - MSS)

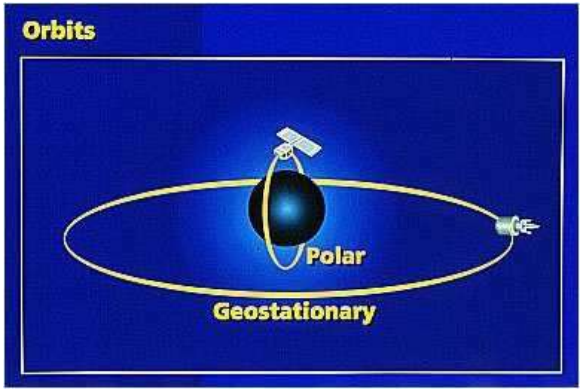
Orbital Characteristics of IRS Satellite

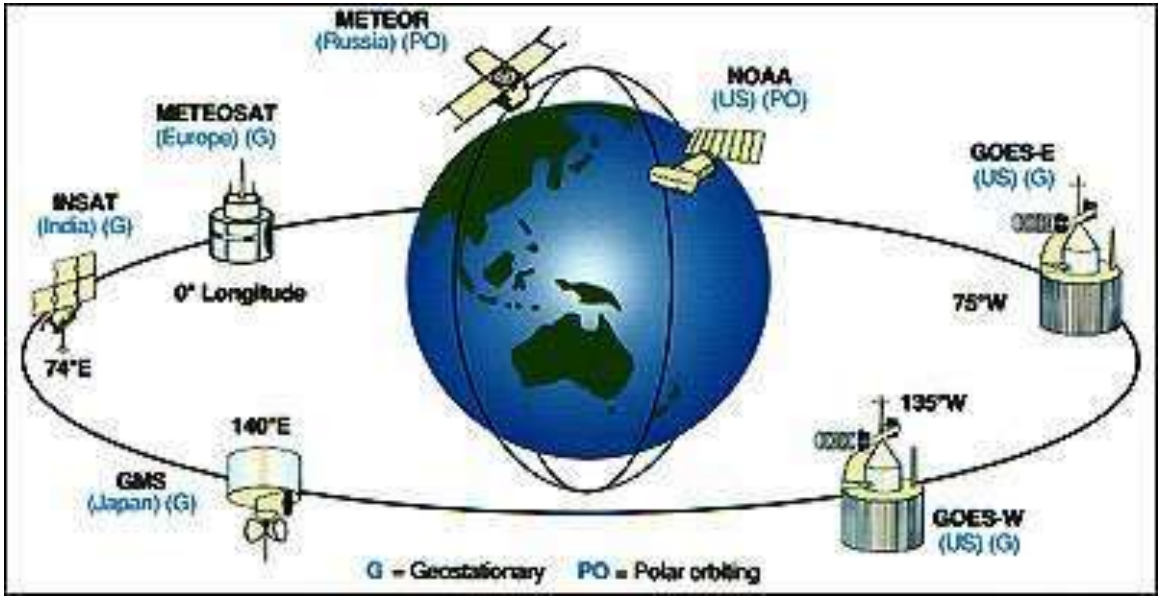
QuickBird-2

0.61

Satellite Orbits

- Satellites generally have either polar orbits (Sun synchronous) or geo stationary orbits.





Geostationary satellites: An equatorial west to east satellite orbiting the earth at an altitude of 35,000 km, the altitude at which it makes one revolution in 24 hours, synchronous with the earth rotation.

These platforms are covering the same place and give continuous near hemispheric coverage over the same area day and night. Its coverage is limited to 70°N to 70°S latitudes and one satellite can view one third of the globe. These are mainly used for communication and meteorological applications. GOES, METOSAT, INTELSAT, INSAT Satellites are the example of geostationary satellites.

Polar orbit or Sun synchronous: An earth satellite orbit in which the orbital plane is near polar and the altitude is such that the satellite passes over all places on earth having the same latitude twice in each orbit at the same local sun-time. Through these satellites the entire globe is covered on regular basis and gives repetitive coverage on periodic basis. All the remote sensing resources satellites may be grouped in this category. Few of these satellites are LANDSAT Series, SPOT Series, IRS Series, NOAA, SEASAT,

TIROS, HCMM, SKYLAB, SPACE SHUTTLE.

Earth Resources Satellites

- LANDSAT
- SPOT
- IRS(Indian Remote Sensing)
- HCMM (Heat Capacity Mapping Mission)
- METEOROLOGICAL
- NOAA
- GOES
- NIMBUS
- METEOSAT
- SEASAT
- IKONOS
- QUICKBIRD
- RADARSAT

Indian Remote Sensing Satellite

Past Satellites

Aryabhata,1975
Bhaskara I,1979
Bhaskara II,1981
Rohini Series,1980-83
SROSS Series,1985-92
IRS-1A,1988
IRS-P1,1993

Presently Working Satellites

IRS-1B,1991
IRS-P2,1994
IRS-1C,1995
IRS-P3,1996
IRS-1D,1997
IRS-p4,1999(Ocenasat)
IRS-P5,2005 (Cartosat)
IRS-P6,2003-04 (Resourcesat)
Cartsat-II, 2008

Future Satellites

INSAT-3E, INSAT-3D, INSAT-4 (A-G), GSAT (3-4) (Experimental), OCEANSAT-2, RISAT-1

Some Important Events of the History of Modern Remote Sensing

- **1950: Remote Sensing word was coined by Ms. Evelyn Pruitt of U.S. Office of Naval Research.**
- **1972: Launch of LANDSAT-I by NASA and beginning of modern Remote Sensing. First systematic, repetitive observation of the earth's land areas.**
- **1973: Launch of SKYLAB, first American space station.**
- **1970-1980: Rapid advances in digital image processing.**
- **1978: Launce of SEASAT-I Oceanography research satellite.**
- **1980: Launch of USSR METOR Satellite.**
- **1980-90: Launch of 2nd generation of LANDSAT Series with new sensor.**
- **1986: Launch of French Earth Observation Satellite (SPOT).**

Some Important Events of Indian Remote Sensing

- **1972: Establishment of Department of Space.**
- **1979: Launch of Earth Observation Satellite BHASKARA-I by ISRO.**
- **1981: Launch of BHASKARA-II**
- **1988: Launch of IRS 1A by Russian Rocket "Vostok".**
- **1994: Launch of IRS-P2 by individually developed PSLV-D2.**
- **1995: Launch of new generation IRS-1C Satellite.**
- **1996: Launch of IRS P3**
- **1997: Launch of IRS-1D Satellite.**
- **1999: Launch of IRS-P4 OCEANSAT**
- **2000: INSAT – 3B**
- **2002: INSAT-3C**
- **2003: INSAT-3A**
- **2003: IRS-P6 (RESOURCESAT).**
- **2004: EDUSAT**
- **2005: IRS-P5 (CARTOSAT-I).**
- **2008: CARTOSAT-II**

Definition of Remote Sensing

- Science of acquiring, processing and interpreting images that record the interaction between electromagnetic energy and matter.

- Science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.

- Instrumentation, techniques and methods to observe the Earth's surface at a distance and to interpret the images or numerical values obtained in order to acquire meaningful information of particular objects on the Earth.

BASICS AND PRINCIPLE OF GEOGRPHIC INFORMATION SYSTEM

What is Geographic Information System ?

A computer-based system of:

- **Capturing (data input is most time consuming)**
- **Storing (in various formats)**
- **Manipulating (editing, subtracting, etc.)**
- **Displaying (map, graphs, tables, etc.)**
- **Querying (finding subsets of data)**
- **Analyzing (seeing relationships between variables or parameters)**

of geographically referenced (or spatial) data.

GIS are decision support computer based system for collecting, storing, presenting and analyzing **spatial information.**

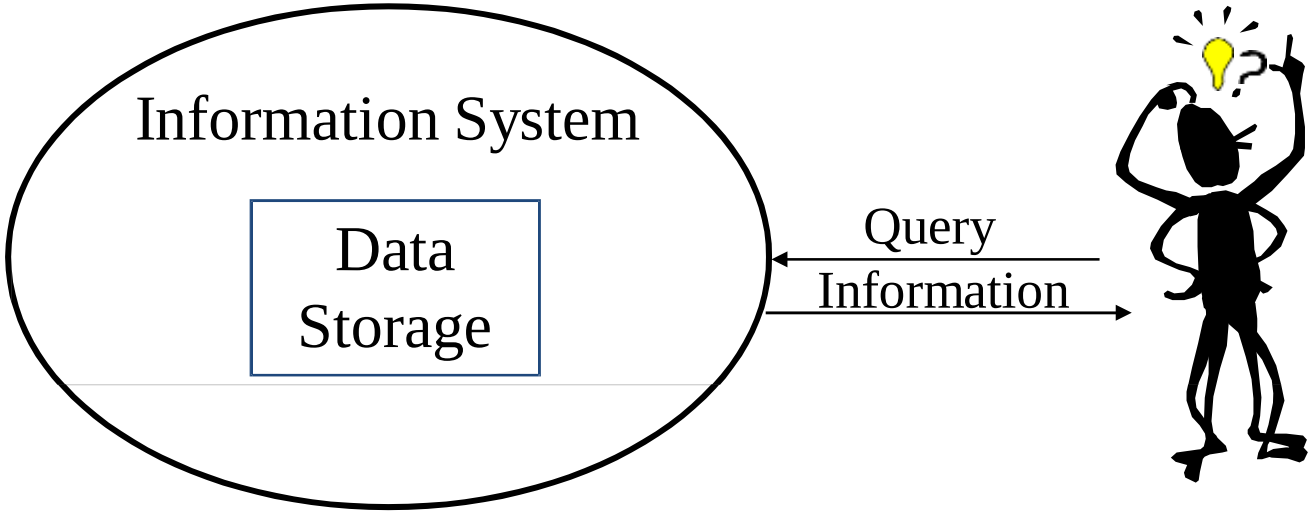
Data is representations that can be operated upon by a computer. **Spatial data** means the data that contains positional value.

Information is the data that has been interpreted by a human being.

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.

What is an Information System?



Information systems can be very simple, telephone directory can be an example.

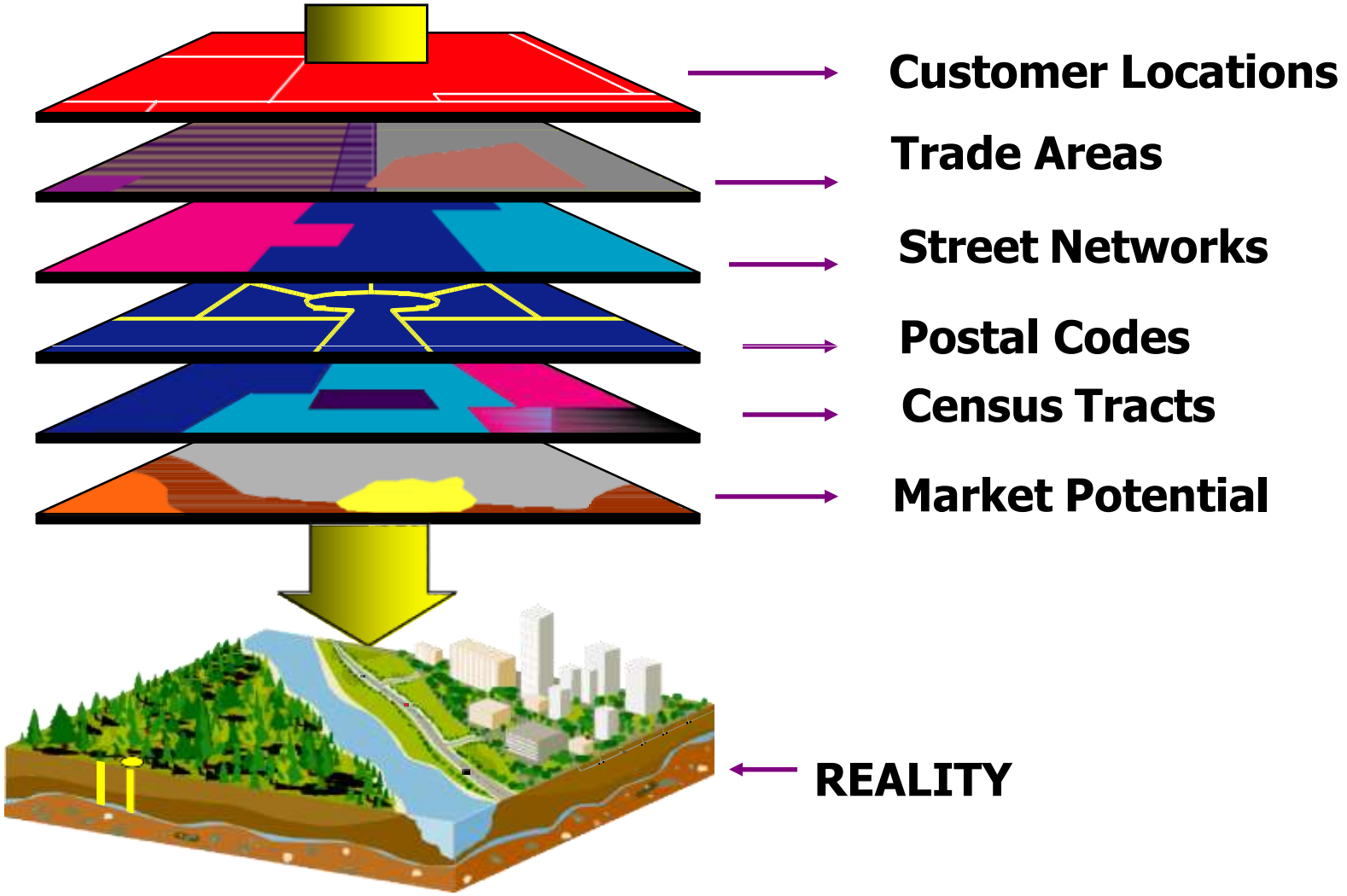
Geographical information and spatial data type

GIS Data Type

Geographic data consists of **spatial** and **non-spatial** data. The spatial data gives information about the geometrical orientation, shape and size of a feature, and its relative position with respect to the position of other features. Non-spatial data, also known as attribute data, are information about various attributes like length, area, population, acreage, etc.

Geographic Information System

GIS Integrates All the Parts… to See the Whole!



A **database** is a repository capable of storing large amounts of data. It comes with a number of useful functions:

- the database can be used by multiple users at the same time i.e., *concurrent use*,

- the database offers a number of techniques for storing data and allows to use the most efficient one – it supports *storage optimization*,

- the database allows to impose rules on the stored data, which will be automatically checked after each update to the data – i.e., it supports *data integrity*,

- the database offers an easy to use data manipulation language, which allows to perform all sorts of data extraction and data updates – it has a *query facility*,

- the database will try to execute each query in the data manipulation language in the most efficient way – i.e., it offers *query optimization*.

Data Representation

i.Nominal data values are values that provide a name or identifier so that we can discriminate between different values. An example is the geological units, land use/ land cover classification. This type of data value is sometimes called **categorical data**.

ii.Ordinal data values are data values that can be put in some natural sequence. Household income, for instance, could be classified as being either low, average or high.

iii.Interval data value and **ratio data value**. Interval data value does not know arithmetic zero value, and does not support multiplication or division. For instance, a temperature of 20°C is not twice 10°C, thus centigrade temperatures are interval data. **Ratio data** have a natural zero value or real origin, and multiplication and division of values are sensible operators, distance measured in meters are example.

Geographic Phenomena is defined as something of interest that

- can be numbered or described,
- can be georeferenced, and
- can be assigned a time (interval) at which it is/was present.

Geographic field is a geographic phenomenon for which, for every point in the study area, a value can be determined. Fields can be *discrete* or *continuous*.

Continuous field: temperature, barometric pressure or elevation.

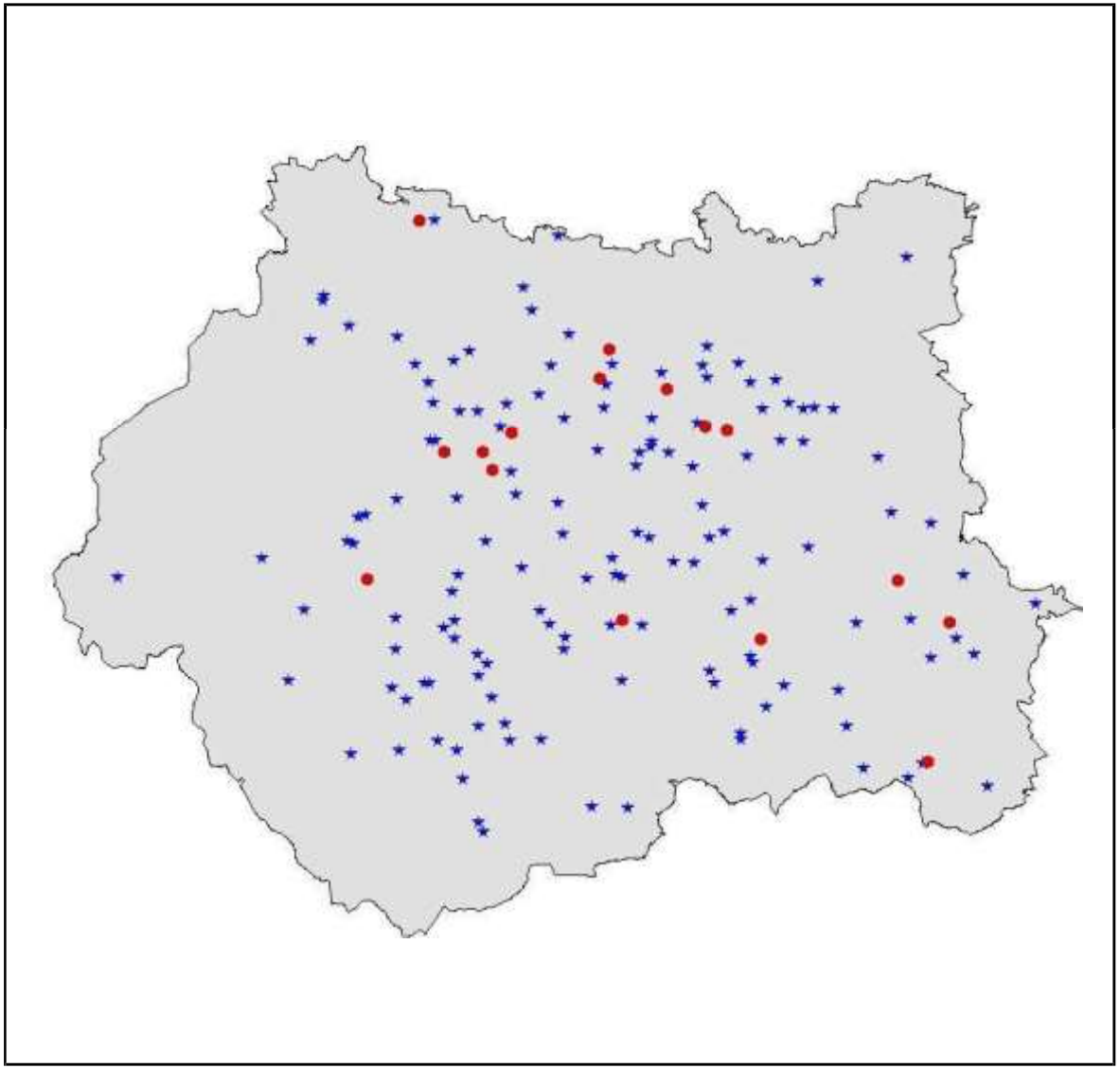
Discrete field cut the study space in mutually exclusive, bounded parts, with all locations in one part having the same field value. Geological classes, soil type, land use type, crop type or natural vegetation type.

Geographic Objects: When geographic phenomena is not present everywhere in the study area but somehow “sparsely’ populates it, we look in terms of geographic objects. Their position in space is determined by a combination of one or more of the following parameters:

- location (where is it?),
- shape (what form is it?),
- size (how big is it?), and
- orientation (in which direction is it facing?)

Boundary Location, shape and size are fully determined if we know an area's boundary, so the boundary is a good candidate for representing it. This is specially true for areas that have naturally **crisp** boundaries. A crisp boundary is one that can be determined with almost arbitrary precision. **Fuzzy** boundaries are not precise lines, but rather itself an area of transition.

Point: A spatial object with no area is a point, that can be associated with arrange of data, such as wells, rain gauge stations etc.



- Houses
- Hospitals
- Schools
- Police Station
- Post Office
- Telephone Booth
- Metro Station
- etc…..

Points
one x and y coordinate

Lines
straight line between two xy coordinates

Polygon: A closed area is represented by polygon.

- Administrative boundaries
- Lakes
- Buildings
- Urban extents
- Natural features
- etc ……..

Points
one x and y coordinate

Lines
straight line between two xy coordinates

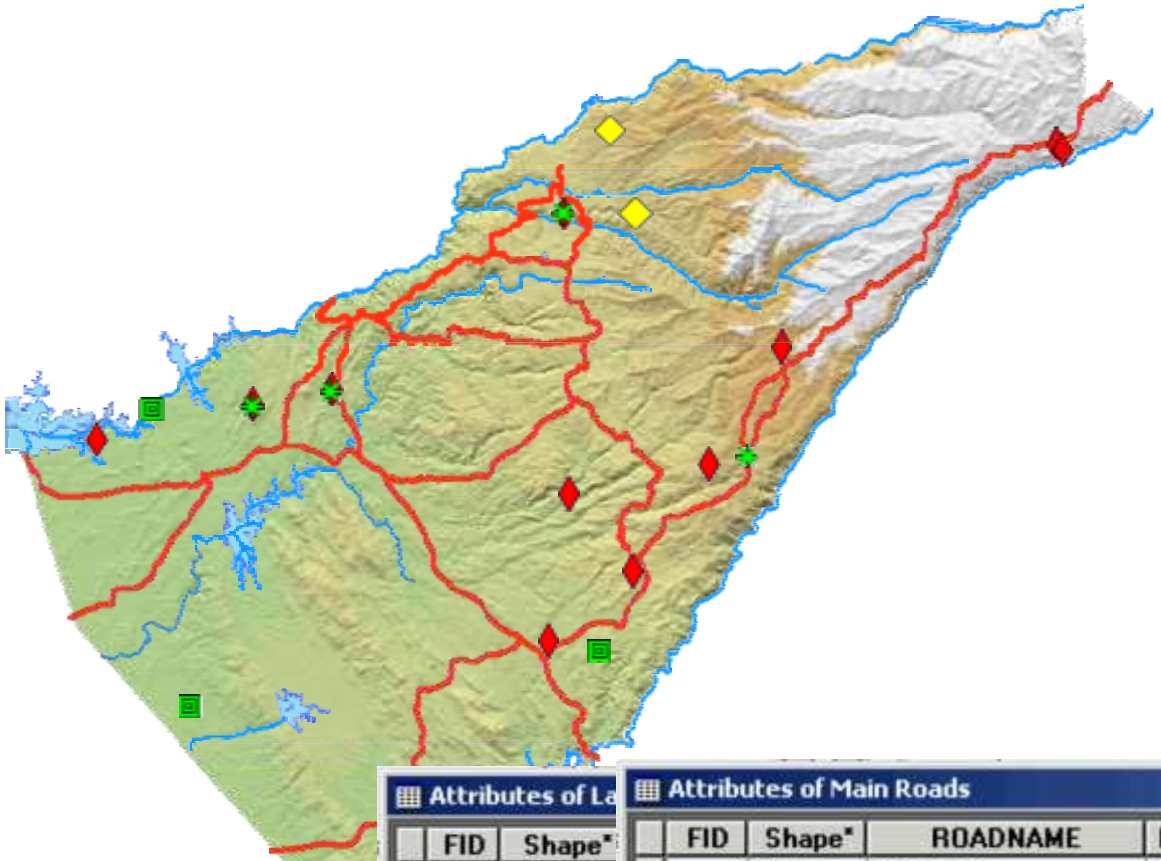
Polygons
lines between many xy coordinates, line closes

Raster
many xy coordinates in rows and columns

In the GIS world these types of geographic data are called Feature classes, and one point or line or polygon is a geographic feature.

Sometimes "shape file" or "layer" is used for describing a feature class

These data can be integrated to create a map with all non-spatial information (attributes)



- Solid Waste Sites
- Main Roads
- Main Rivers
- Main Lakes
- Image

Attributes of La

FID	Shape*
13	Polygon
17	Polygon
16	Polygon
14	Polygon
8	Polygon

Attributes of Main Roads

FID	Shape*	ROADNAME	DIRECTION	SHOULDE	NUM_LANES	SUR_TYPE
0	Polyline	RIDGE RD	two_way	non_graded	2	Paved
1	Polyline	LAUREL ST	two_way	non_graded	2	Paved
2	Polyline	HWY26	two_way		2	Paved
3	Polyline	JESUS MARIA	two_way	non_graded	2	Paved
4	Polyline	HWY 49	two_way		2	Paved
5	Polyline	HWY 49	two_way		2	Paved

Definitions:

- A system which uses a spatial database to provide answers to queries of a geographical nature (Goodchild, 1991)

- A computer assisted system for the capturing, storage, retrieval, analysis, and display of spatial data within a particular organization (Clark, 2001)

- A powerful set of tools for collecting, storing, retrieving at will, and displaying spatial data from the real world (Burrough et al., 2000)

- GIS is a computerized system that facilitates the phases of data entry, data analysis and data presentation, especially in cases when georeferenced data is dealt (ITC Educational Text Book)

- An organized collection of computer hardware, software, geographical data, and personal designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (ESRI).