SPECTRAL SIGNATURES AND IMAGE INTERPRETATION

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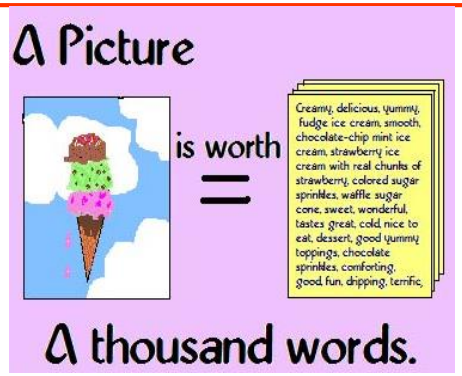
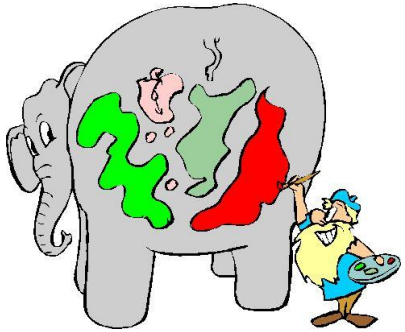
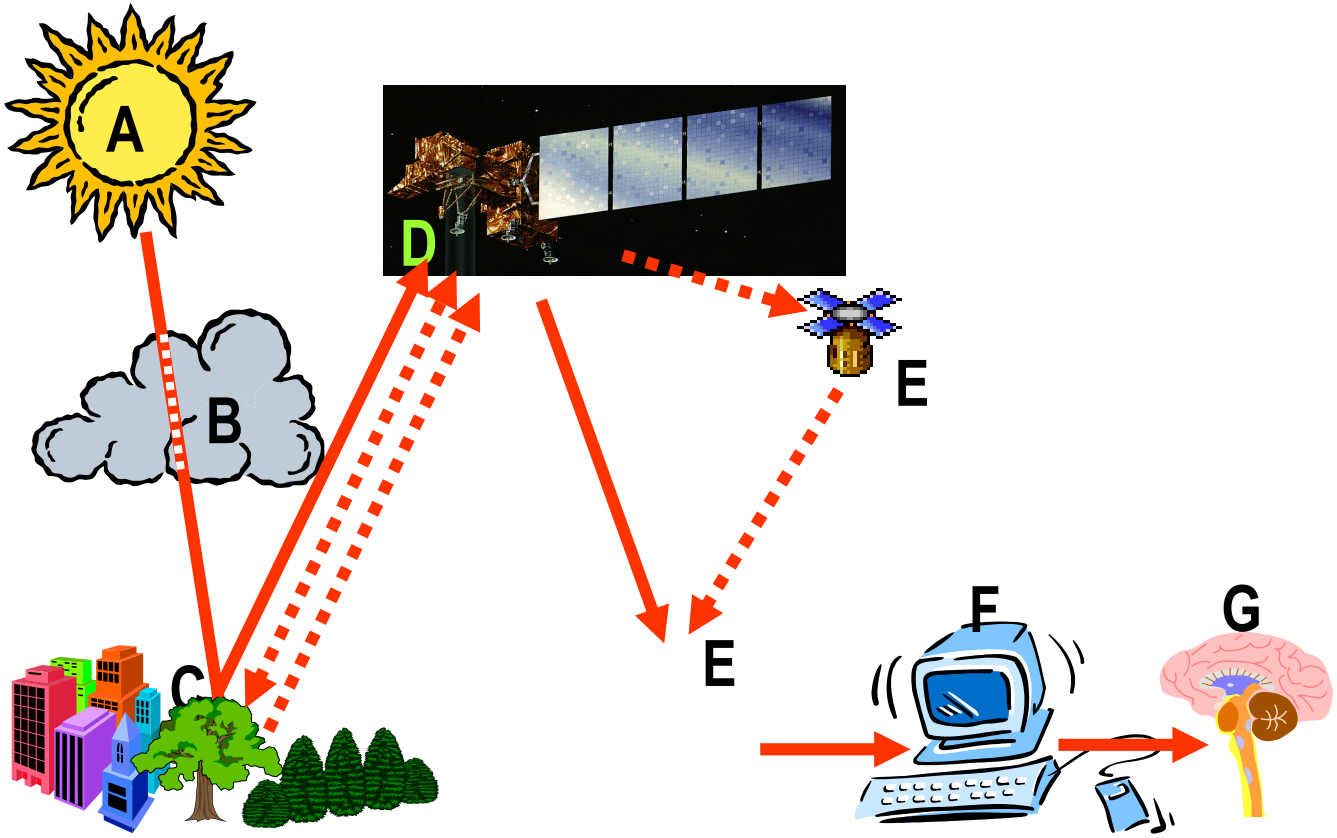

A Picture
is worth
Creamy, delicious, yummy, fudge ice cream, smooth, chocolate-chip mint ice cream, strawberry ice cream with real chunks of strawberry, colored sugar sprinkles, waffle sugar cone, sweet, wonderful, tastes great, cold, nice to eat, dessert, good yummy toppings, chocolate sprinkles, comforting, good fun, dripping, terrific,
A thousand words.




A
B
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E
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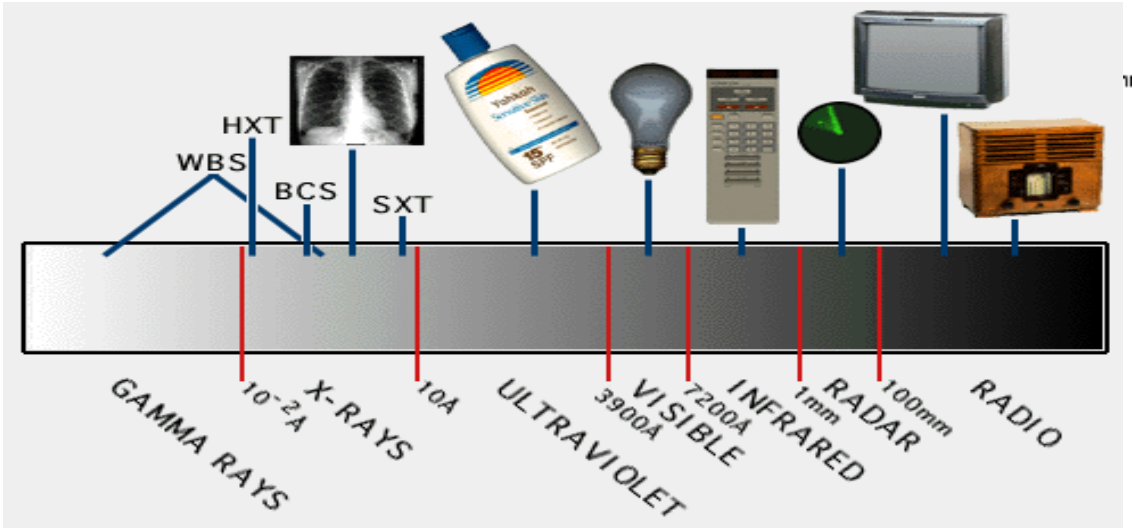
The Electromagnetic Spectrum

- The electromagnetic spectrum ranges from the shorter wavelengths (including gamma and x-rays) to the longer wavelengths (including microwaves and broadcast radio waves).

- There are several regions of the electromagnetic spectrum which are useful for remote sensing.



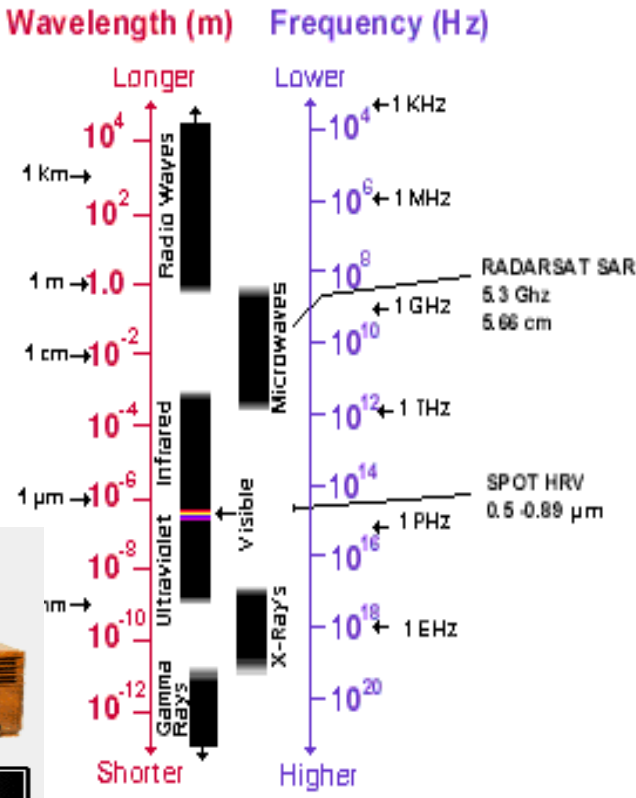


IMAGE INTERPRETATION

- Analysis of remote sensing imagery involves the identification of various targets in an image.
- Targets may be defined in terms of the way they reflect or emit radiation.
- Radiation is measured and recorded by a sensor, and ultimately depicted as an image product.
- Act of examining images to identify objects and judge their significance.
- Information extraction process from the images. Involves a considerable amount of subjective judgment.
- An interpreter is a specialist trained in study of photography or imagery, in addition to his own discipline.

- Image is a pictorial representation of an object or a scene.
- Image can be analog or digital.
- A digital image is made up of square or rectangular areas called pixels.
- Each pixel has an associated pixel value which depends on the amount reflected energy from the ground.

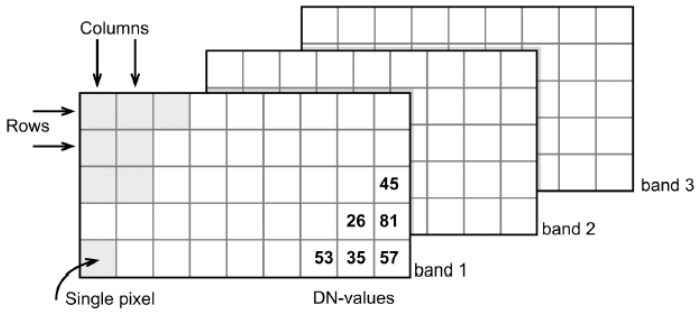
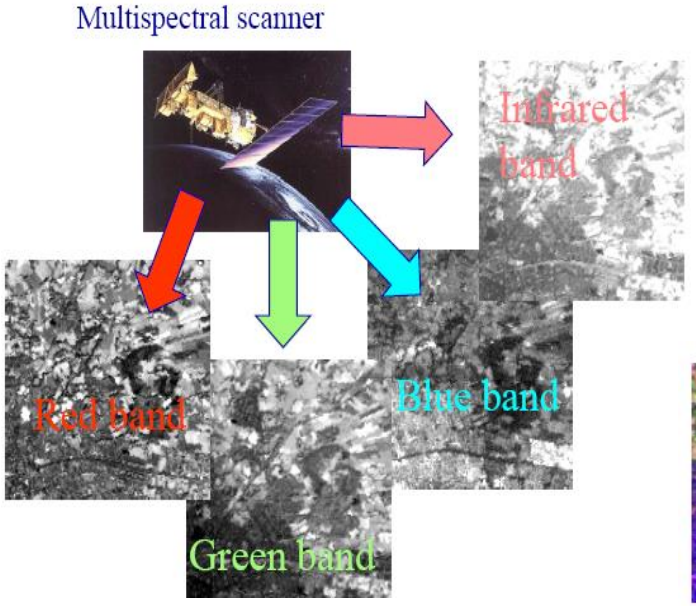
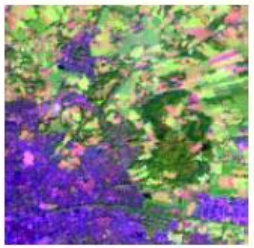


Image file
Image architecture made up of "picture elements" PIXELS





Band combination

What makes interpretation of imagery more difficult than the everyday visual interpretation of our surroundings?

- We lose our sense of depth when viewing a two-dimensional image, unless we can view it **stereoscopically** so as to simulate the third dimension of height.
- Viewing objects from directly above also provides a very different perspective than what we are familiar with.
- Combining an unfamiliar perspective with a very different scale and lack of recognizable detail can make even the most familiar object unrecognizable in an image.
- Finally, we are used to seeing only the visible wavelengths, and the imaging of wavelengths outside of this window is more difficult for us to comprehend.

Data Characteristics:

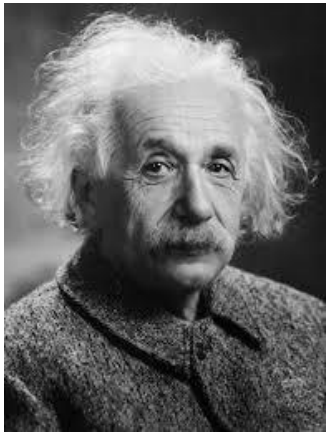
- Spectral resolution = part of the EM spectrum measured.
- Radiometric resolution = smallest differences in energy that can be measured.
- Spatial resolution = smallest unit area measured.
- Revisit time (temporal resolution) = time between two successive image acquisitions over the same area.

Advantages of Using Images over ground observation

- Synoptic view
- Permanent record
- Spectral resolution
- Spatial resolution
- Cost and time effective
- Stereoscopic view
- Easy interpretation of context

Spectral Signature

- **Identity** is whatever makes an entity recognizable.
- A signature is that which gives an object or piece of information its identity.



Albert Einstein

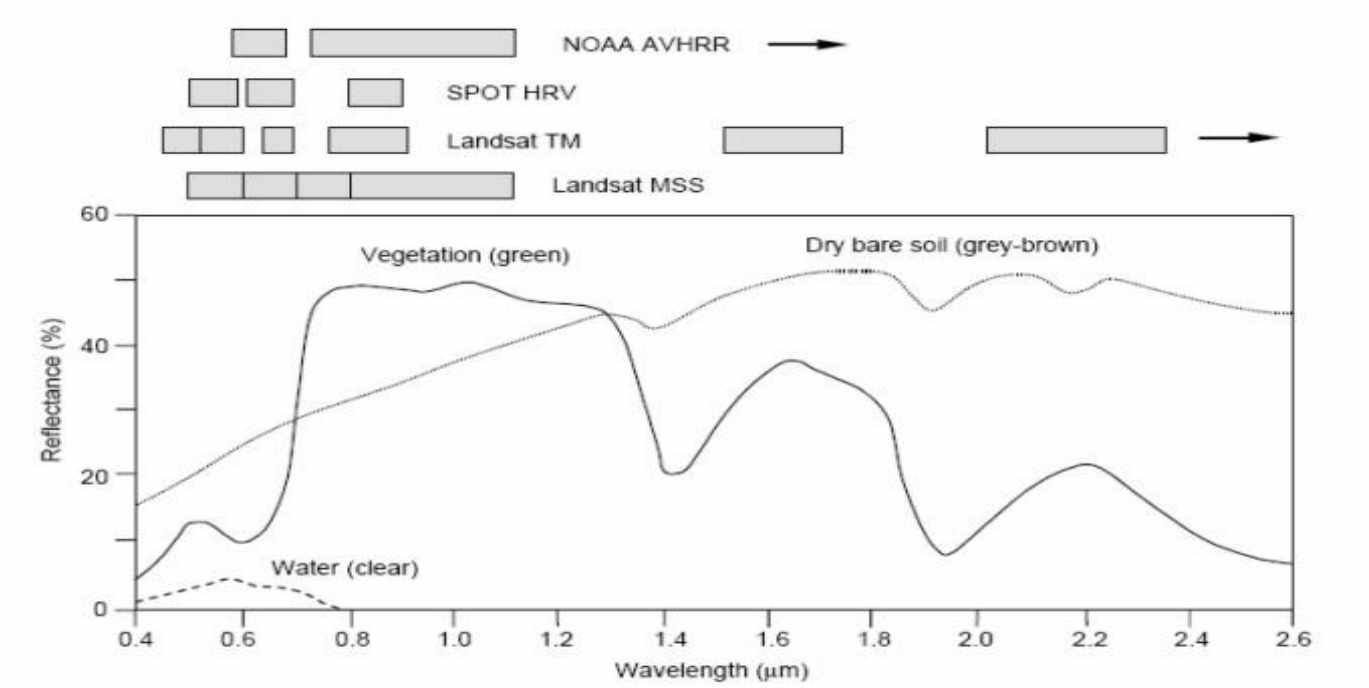
Elizabeth Taylor

Shahrukh Khan

- Characteristic feature which forms key to enable an object to be identified.
- Spectral, Spatial, temporal and polarization variations which facilitate discrimination of features on remotely sensed data.

What is a spectral reflectance curve ?

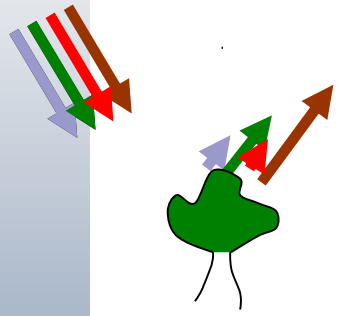
A spectral reflectance curve is a graph of the spectral reflectance of an object as a function of wavelength and is very useful for choosing the wavelength regions for remotely sensed data acquisition for a certain application.

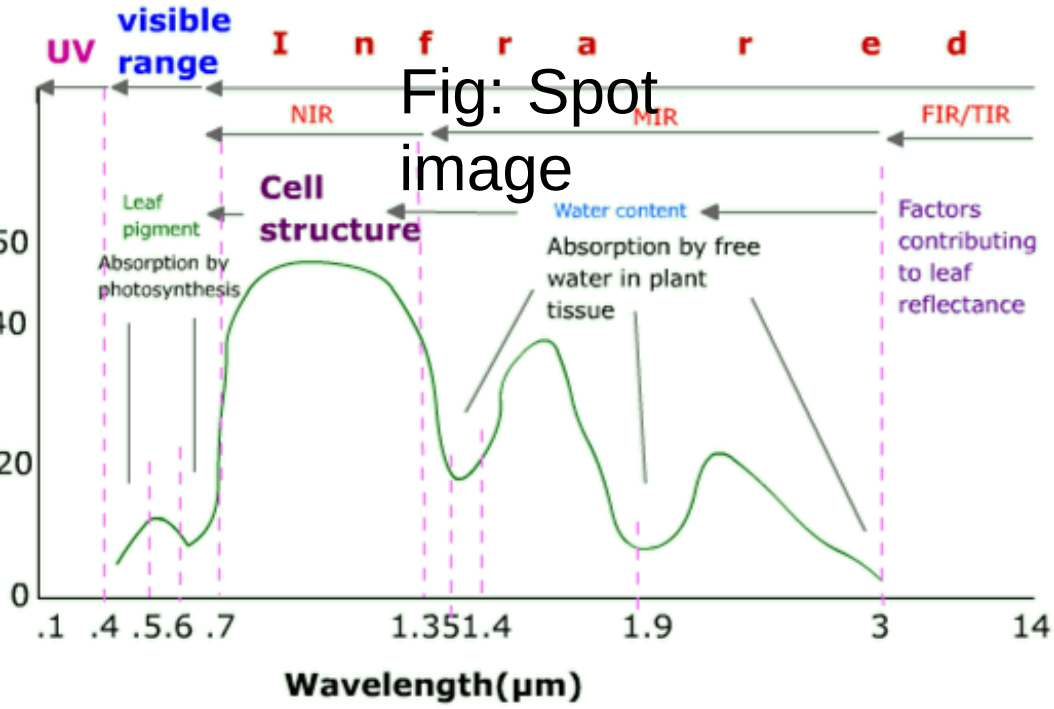


Significance of spectral signature in remote sensing

- Spectral responses measured by RS sensors over various features.
- Spectral reflectance & spectral emittance curves.
- Variability of spectral signature: useful for evaluation of condition, not for spectral identification of earth features.
- Temporal and spatial effects on spectral response patterns.
- Change detection depends on temporal effects.

Spectral Signature for Vegetation

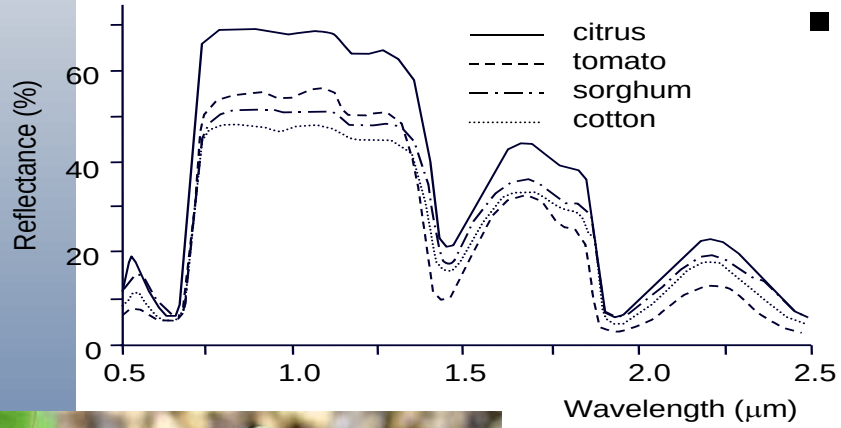




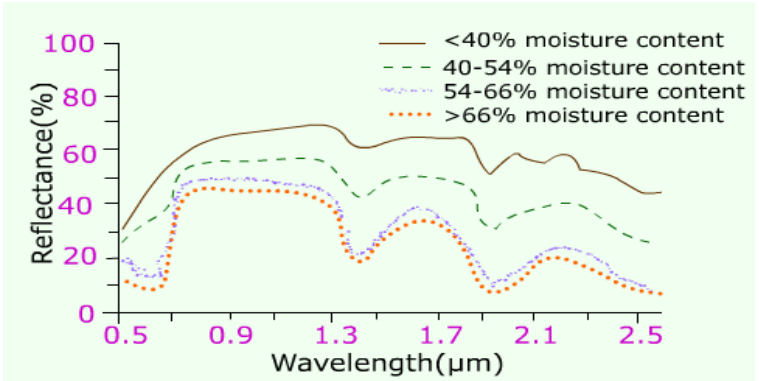
- A general characteristic of vegetation is its green colour caused by the pigment chlorophyll.
- Chlorophyll reflects green energy more than red and blue energy, which gives plants green colour.

Fig: Spot image

- The major difference in leaf reflectance between species, are dependent upon leaf thickness.
- It affects both pigment content and physiological structure.



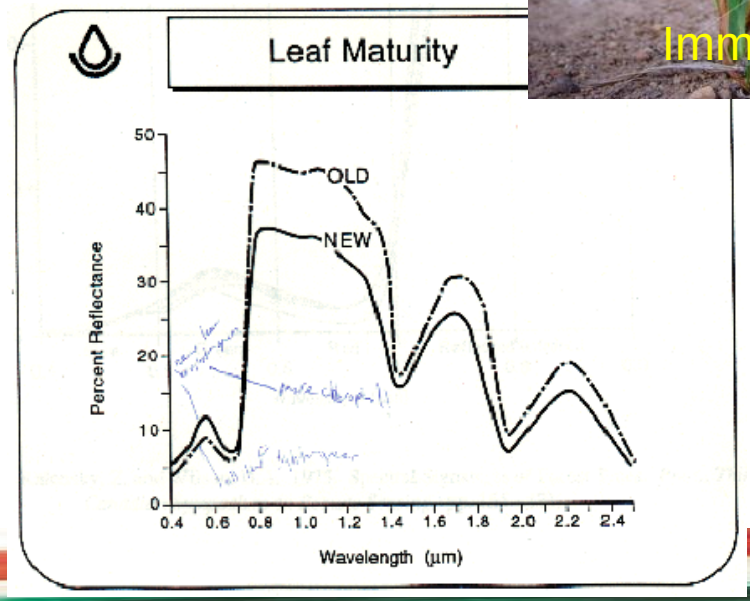
- Leaf reflectance is reduced as a result of absorption by three major water absorption bands that occur near wavelengths of 1.4 μm, 1.9 μm and 2.7 μm and two minor water absorption bands that occur near wavelengths of 0.96 μm, and 1.1 μm



Influence of the moisture content of maize leaves on the spectral reflectance

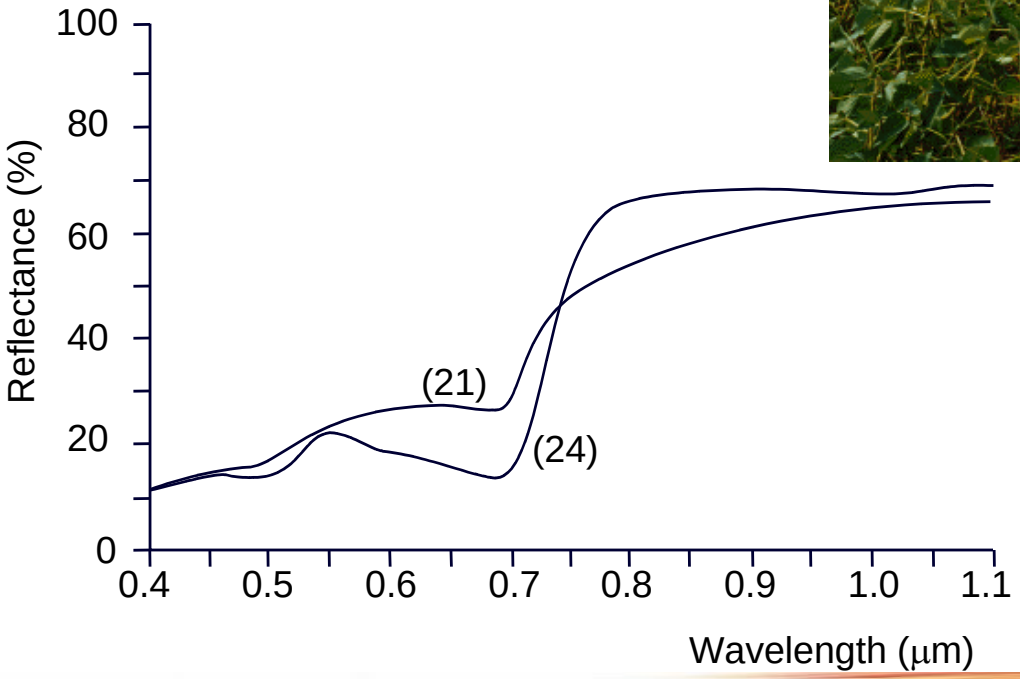
Needle-leaf trees canopies reflect significantly less near-infrared radiation compared to broad-leaf vegetation.

Immature leaves contain less chlorophyll and fewer air voids than older leaves, they reflect more visible light and less infrared radiation.



Reflectance is also affected by health of vegetation

Healthy plants



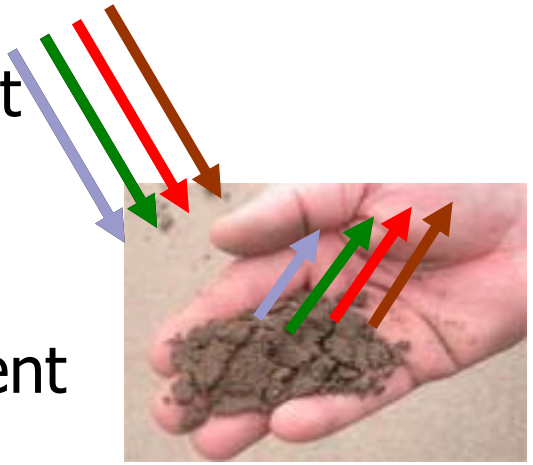
Infected plants

Q1. Image interpretation is

a. Information extraction process
b. Correcting errors in the image
c. Application of enhancement algorithms to the image

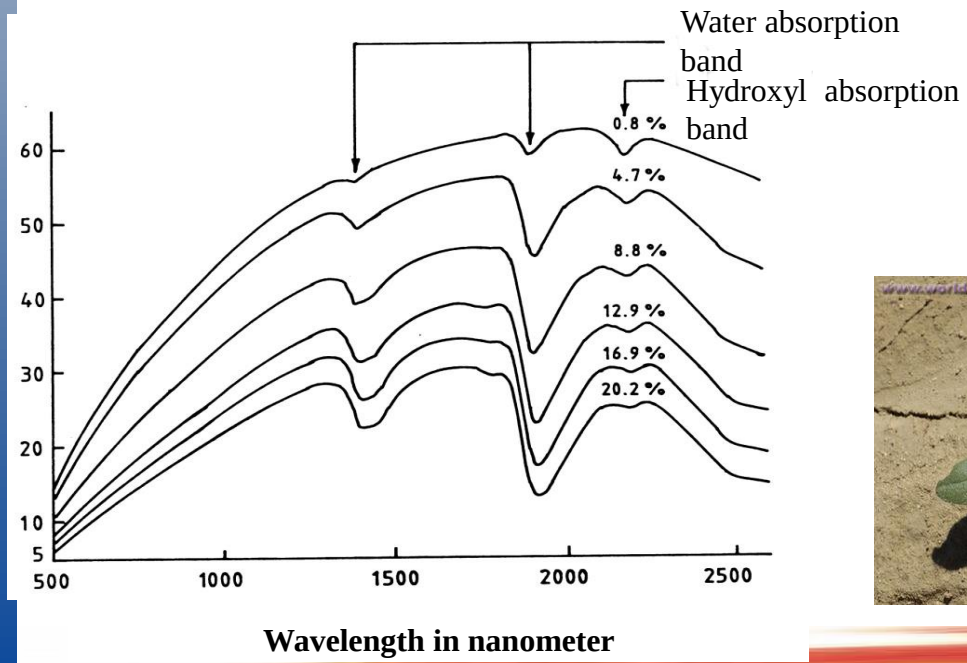
Spectral Signature for Soil

- Moisture content
- Organic content
- Structure
- Iron oxide content
- Texture



Soil Moisture:

- A wet soil generally appears darker
- Increasing soil moisture content lowers reflectance but did not change shape of the curve

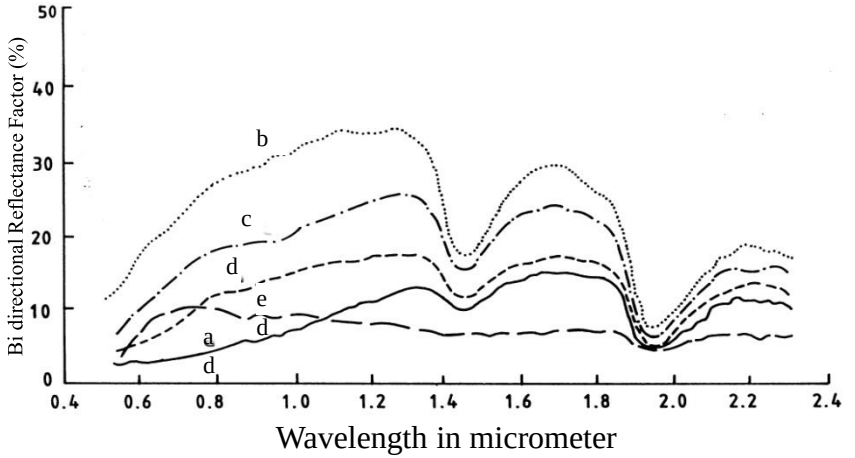


Organic content:

- A soil with 5% or more organic matter usually appears black in colour.
- Less decomposed organic materials have higher reflectance in the near IR region.
- Very high decomposed organic materials show very low reflectance throughout the reflective region of the solar spectrum

SOIL – IRON CONTENT

- The presence of iron especially as iron oxide affects the spectral reflectance
- Reflectance in the green region decreases with increased iron content, but increases in the red region
- Iron dominated soils have strong absorption in mir (> 1.3 μm)



Representative reflectance spectra of surface samples of 5 minerals soils; (a) High organic content, moderately fine texture; (b) Low organic, Low iron content; (c) Low organic, medium iron content; (d) High organic content, moderately coarse texture and (e) High iron content, fine texture.

Soil structure

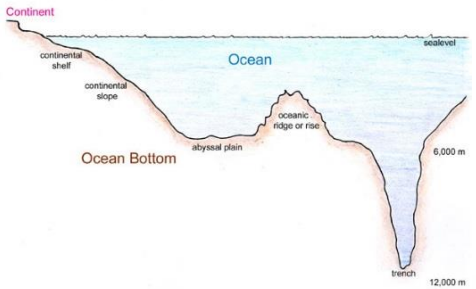
- A clay soil tends to have a strong structure, which leads to a rough surface on ploughing; clay soils also tend to have high moisture content and as a result have a fairly low diffuse reflectance.
- Sandy soils also tend to have a low moisture content and a result have fairly high and often specular reflectance properties.

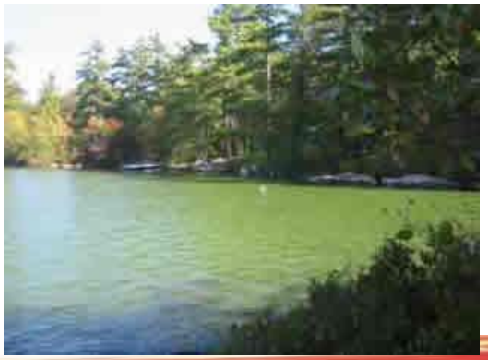
Clayey soil

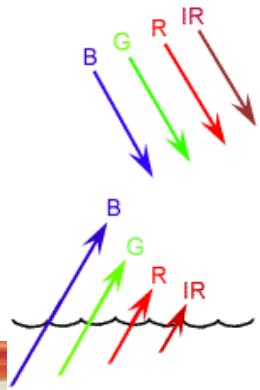
Sandy soil

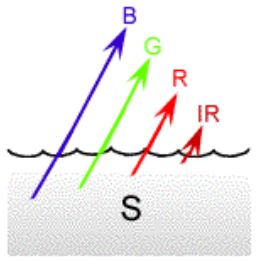
Spectral Signature for Water

- Reflection of Light - Wavelengths
- Water Depths – Shallow , Deep
- Suspended material
- Chlorophyll Content
- Surface Roughness



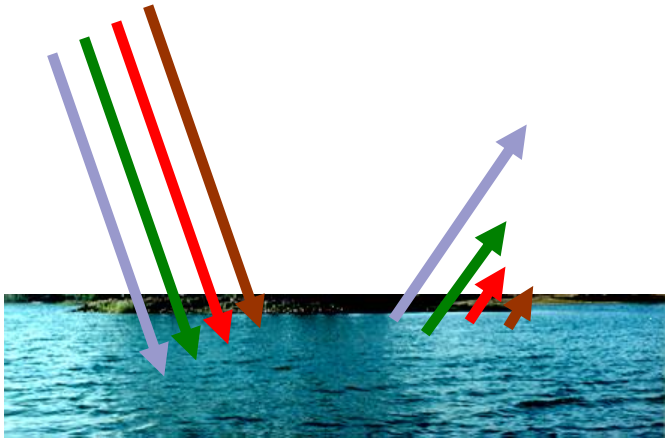


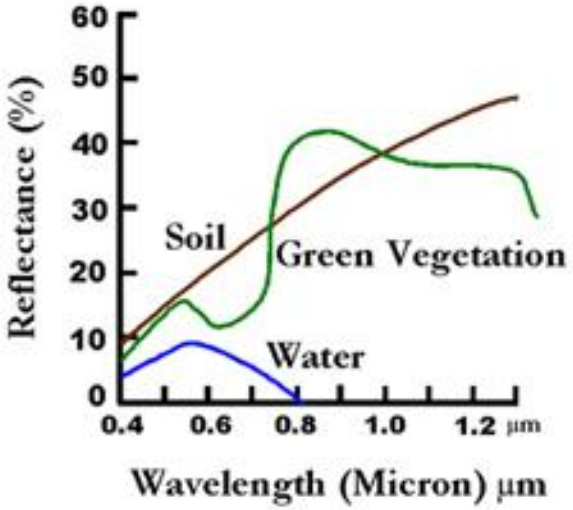




Spectral Reflectance of Water

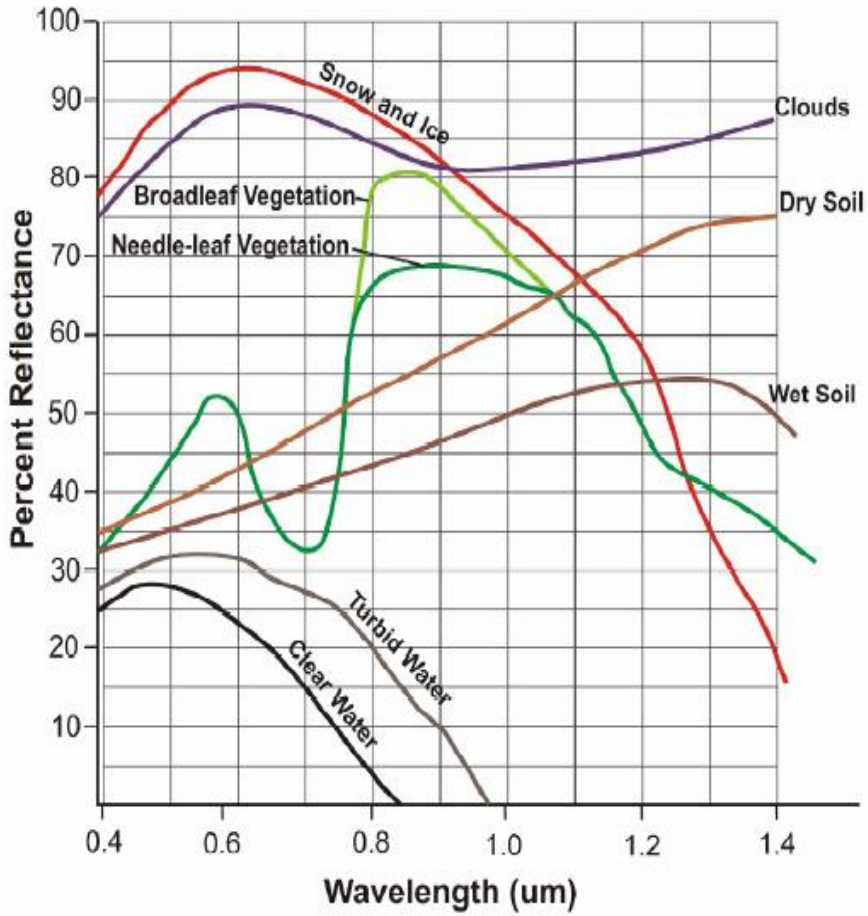
- The majority of radiant flux incident upon water is either not reflected but is either absorbed or transmitted.
- In visible wavelengths of EMR, little light is absorbed, a small amount, usually below 5% is reflected and the rest is transmitted.
- Water absorbs NIR and MIR strongly leaving little radiation to be either reflected or transmitted. This results in sharp contrast between any water and land boundaries.



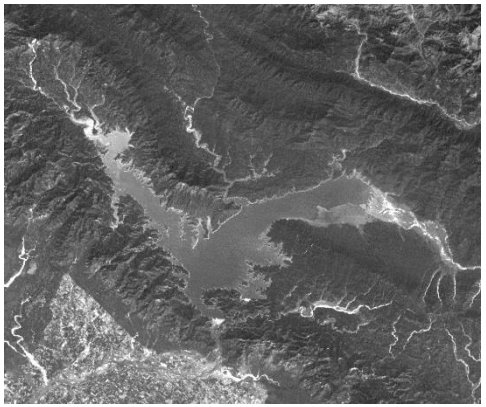


Factors governing spectral Reflectance of Snow

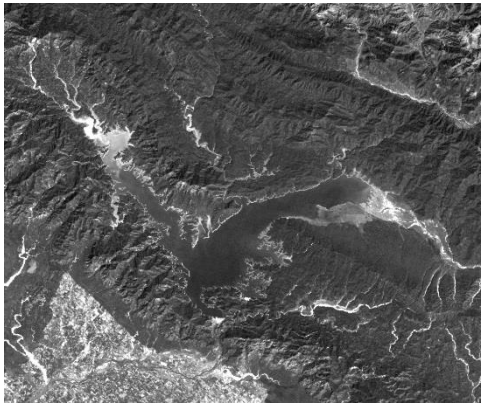
- GRAIN SIZE (HENCE AGE)
  - Reflectance falls at all wavelengths as grain size increases
- SNOW PACK THICKNESS
  - Reflectance of snow decreases as it ages
- LIQUID WATER CONTENT
  - Even slightly melting snow reduces reflectance
- CONTAMINANT PRESENT
  - Contaminations (soot, particles, etc.) Reduce snow reflection in the visible region.



- The lines in the figure represent average reflectance curves compiled by measuring large sample features.
- Observe how distinctive the curves are for each feature.
- The configuration of these curves is an indicator of the type and condition of the features to which they apply.
- Although the reflectance of individual features will vary considerably above and below the average, these curves demonstrate some fundamental points concerning spectral reflectance

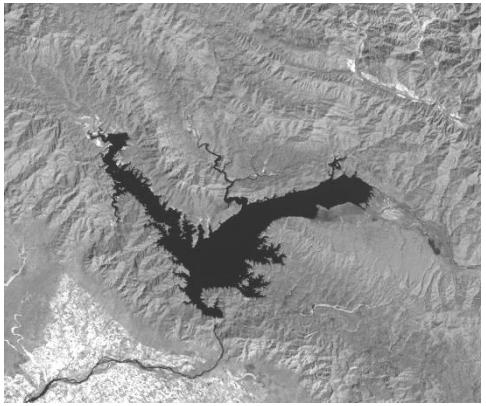


Band (.45 to .515μm)

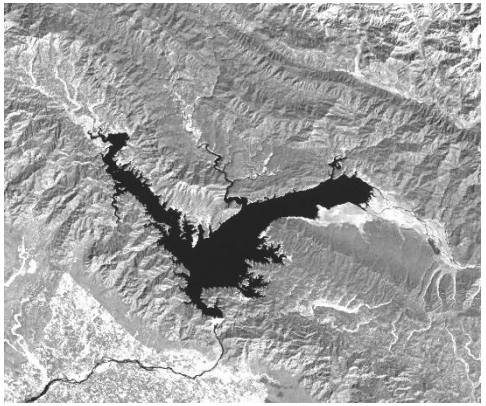


Band (.525 to .605 μm)

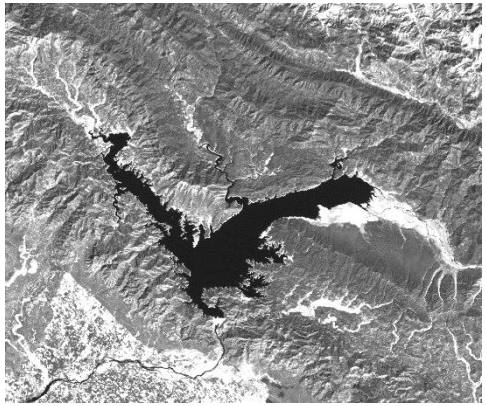
Band (.63 to .690 μm)



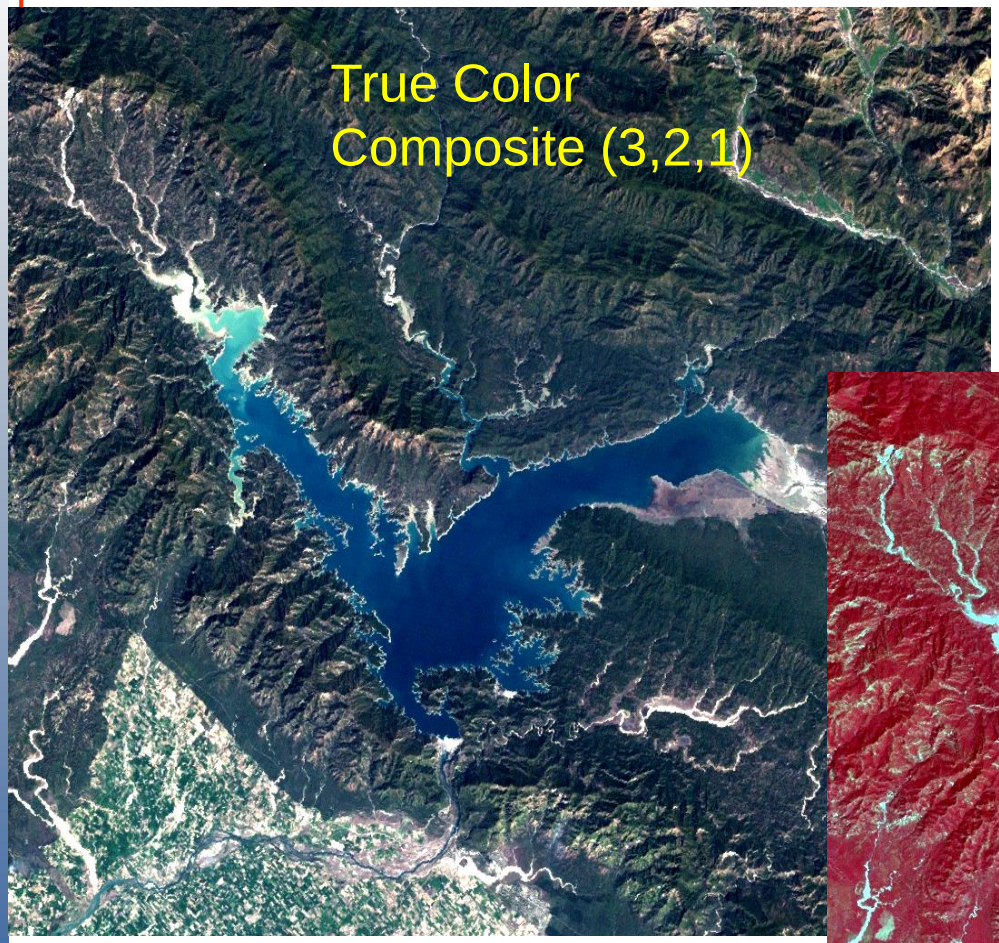
Band (.75 to .90 μm)

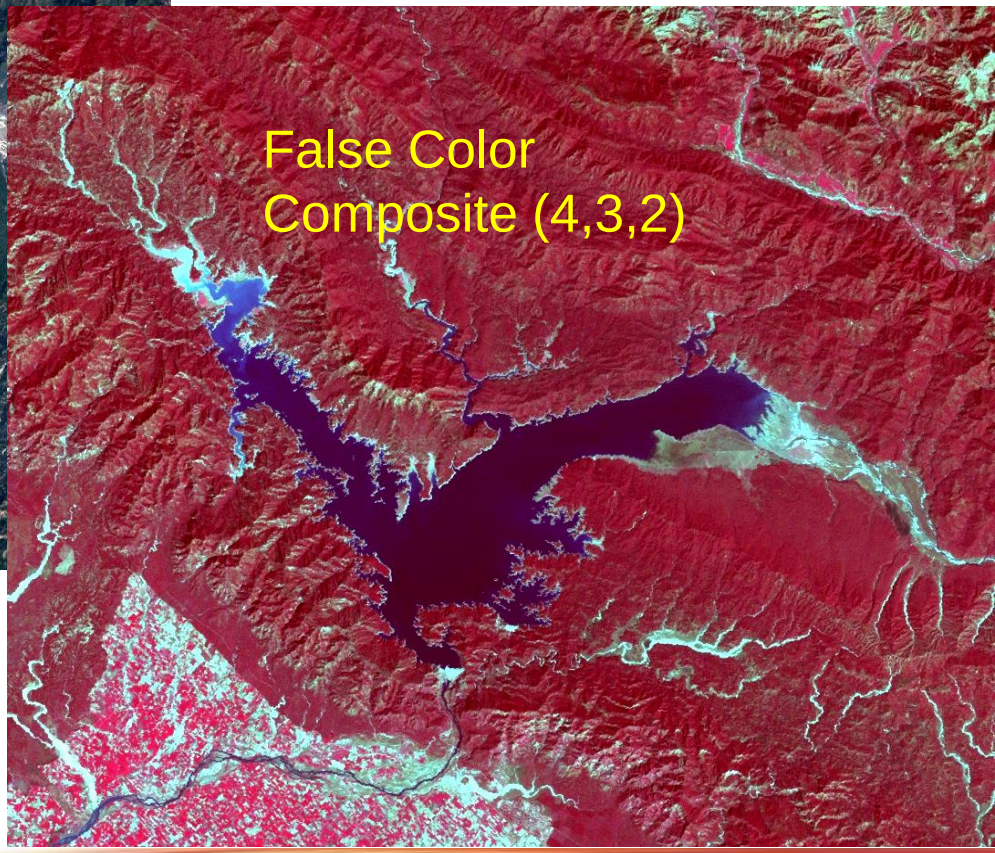


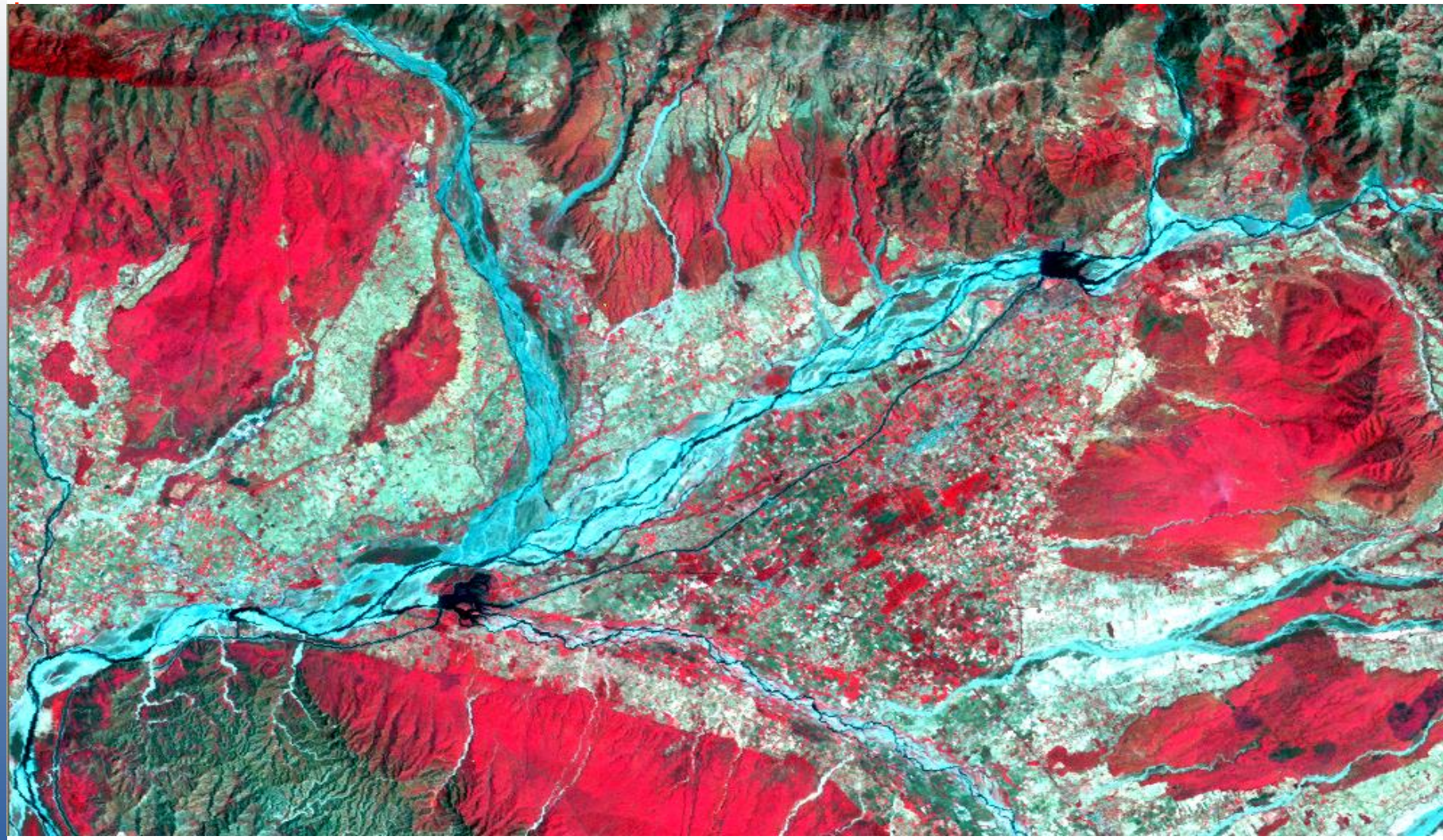
Band (1.55 to 1.75 μm)



Band (2.09 to 2.35μm)


True Color
Composite (3,2,1)


False Color
Composite (4,3,2)



Landsat ETM (IR R G)

Band	Wavelength (μm)	Principal applications
1	0.45 – 0.52 (blue)	Penetration of clear water: bathymetry; mapping of coastal waters; chlorophyll absorption; distinction between deciduous and coniferous vegetation.
2	0.52 – 0.60 (green)	Records the green reflectance peak of vegetation; assesses plant vigor; reflectance from turbid water.
3	0.63 – 0.69 (red)	This band operates in the chlorophyll absorption region and is best for detecting roads, bare soil.
4	0.76 – 0.90 (near-infrared)	This band is used to estimate biomass. Although it separates water bodies from vegetation and discriminates soil moisture, it is not as effective as B3 for road identification.
5	1.55 – 1.75 (mid-infrared)	Band 5 is considered to be the best single band overall. It discriminates roads, bare soil, and water. It also provides a good contrast between different types of vegetation and has excellent atmospheric and haze penetration. Discriminates snow from clouds,
6	2.08 – 2.35 (mid-infrared)	This band is useful for discriminating mineral and rock types and for interpreting vegetation cover and moisture.

Methods of Image Interpretation

- **Visual**

1. Visual interpretation on a hardcopy image/photograph
2. Visual interpretation on a digital image

- **Digital image processing**

Types of interpretation

- Qualitative
- Quantitative

- Image is a pictorial representation of pattern of landscape.
- Pattern indicates type of objects and their physical, biological, and cultural relationships
- Similar objects under similar conditions reflect similarly.
- A systematic examination of photos and supporting material.
- Interpretation is made of physical nature of the object.
- Information extracted is proportional to knowledge, skill and experience of analyst; the methods and equipment used.

Factors governing interpretability

- Training, Experience
- Nature of object or phenomenon
- Quality of photographs
- Equipment and method of interpretation
- Interpretation keys, guides, manuals and other aids
- Prior knowledge of the area.

Methodology depends on……

- Kind of information to be interpreted
- Accuracy of the results to be obtained
- The reference level of the person executing the interpretation
- Kind and type of imagery or photographs available
- Instruments available
- Scale and other requirements of the final map
- External knowledge available and any other surveys in the area.

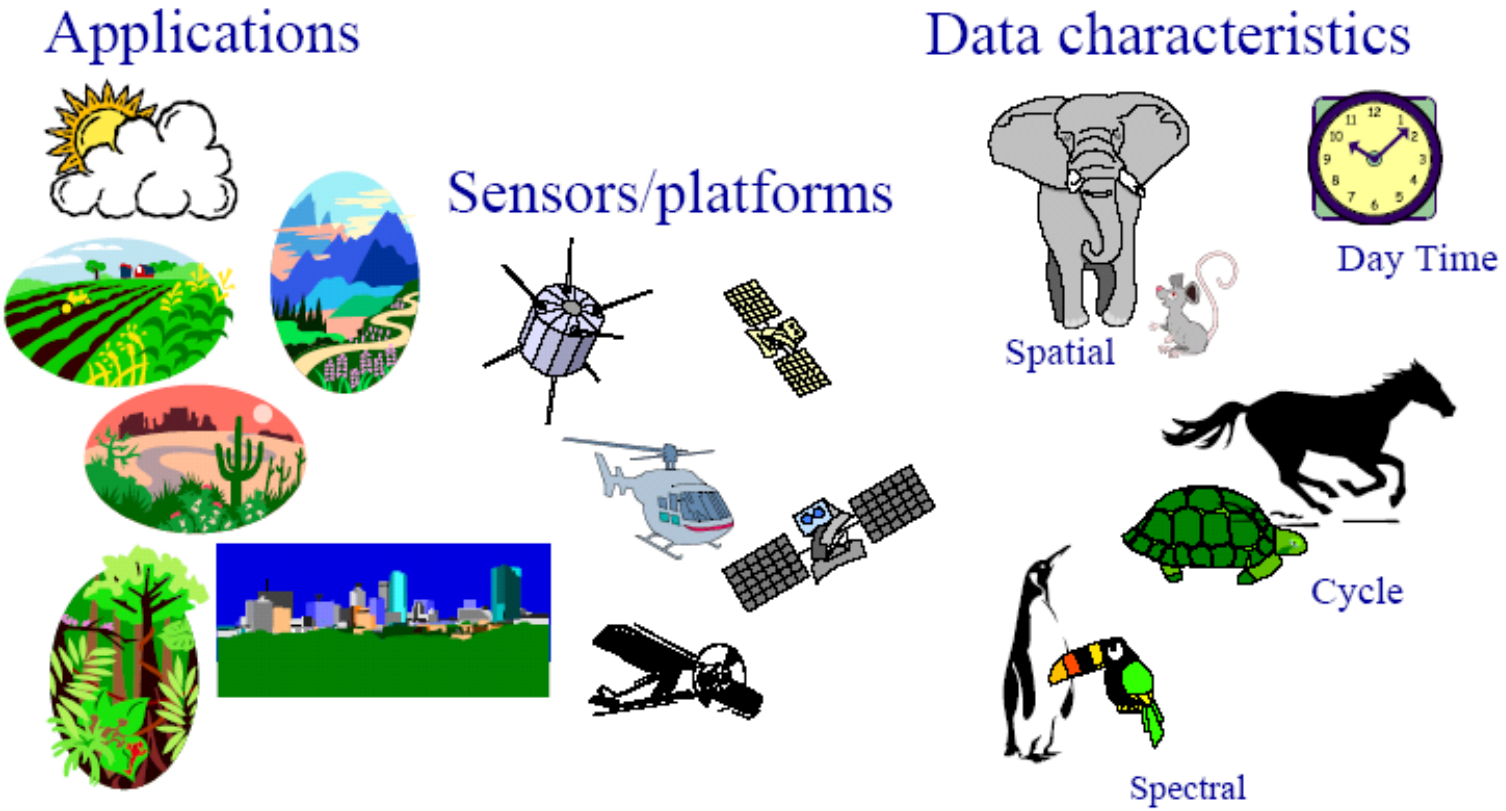
ACTIVITIES OF IMAGE INTERPRETATION

- Detection
- Recognition
- Analysis

Deduction
Classification
Idealization

Convergence of evidence

Data Selection Criteria



Q2. A spectral reflectance curve is a

a. Graph of the number of pixels for each tonal value.
b. Pie chart representing area of landuse classes
c. Graph of the spectral reflectance of an object as a function of wavelength

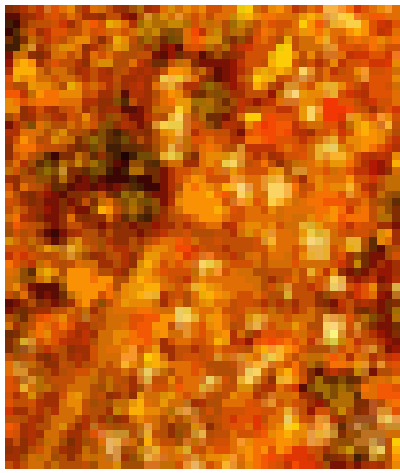
ELEMENTS OF IMAGE INTERPRETATION

- Recognizing targets is the key to interpretation and information extraction.
- Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of –

tone, shape, size, pattern, texture, shadow, and association.

Tone

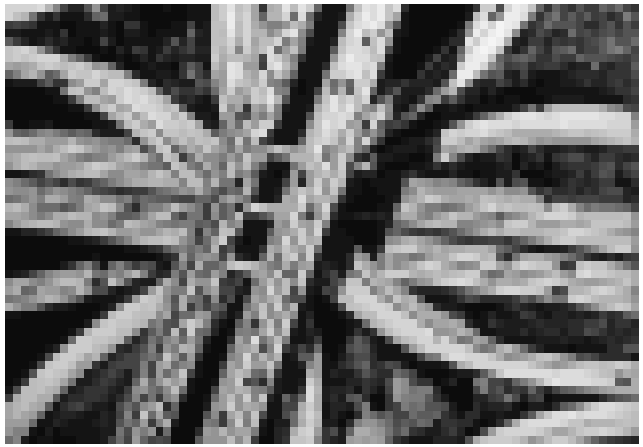
- Tone refers to the relative brightness or colour of objects in an image.
- Generally, tone is the fundamental element for distinguishing between different targets or features.
- Variations in tone also allows the elements of shape, texture, and pattern of objects to be distinguished.



Shape

- **Shape** refers to the general form, structure, or outline of individual objects.
- Shape can be a very distinctive clue for interpretation.

- Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts.



- Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes

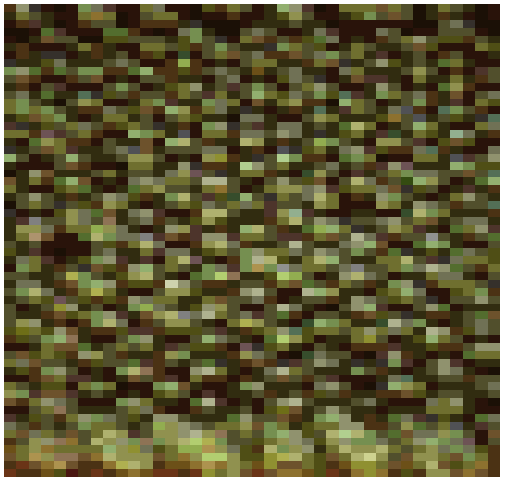
Size

- **Size** of objects in an image is a function of scale.
- It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target.
- A quick approximation of target size can direct interpretation to an appropriate result more quickly.

For example, if an interpreter had to distinguish zones of land use, and had identified an area with a number of buildings in it, large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

Pattern

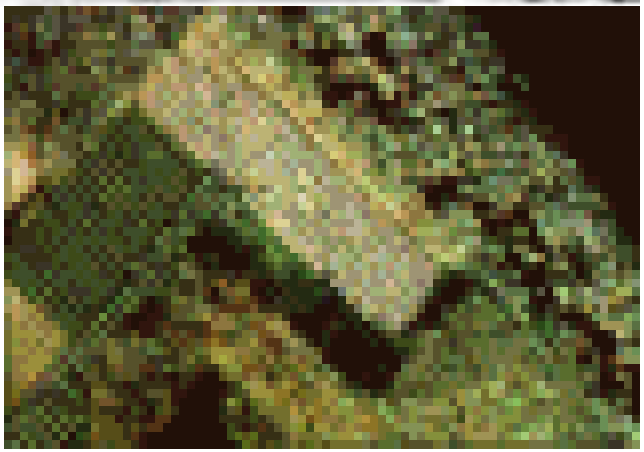
- **Pattern** refers to the spatial arrangement of visibly discernible objects.
- Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern.



Orchards with evenly spaced trees, and urban streets with regularly spaced houses are good examples of pattern.

Texture

- **Texture** refers to the arrangement and frequency of tonal variation in particular areas of an image.
- Texture is one of the most important elements for distinguishing features in radar imagery.

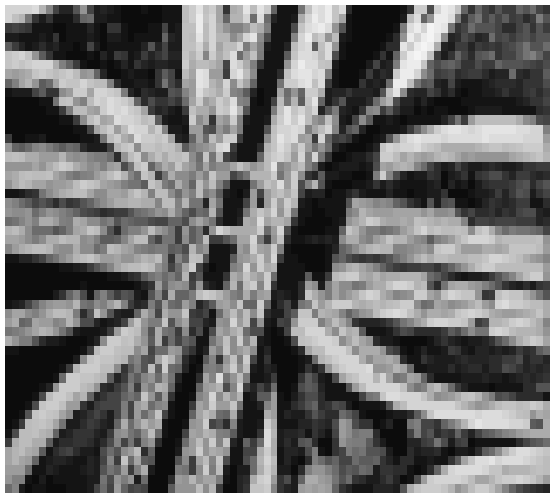


Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation.

Shadow

- **Shadow** may provide an idea of the profile and relative height of a target or targets which could make identification easier.

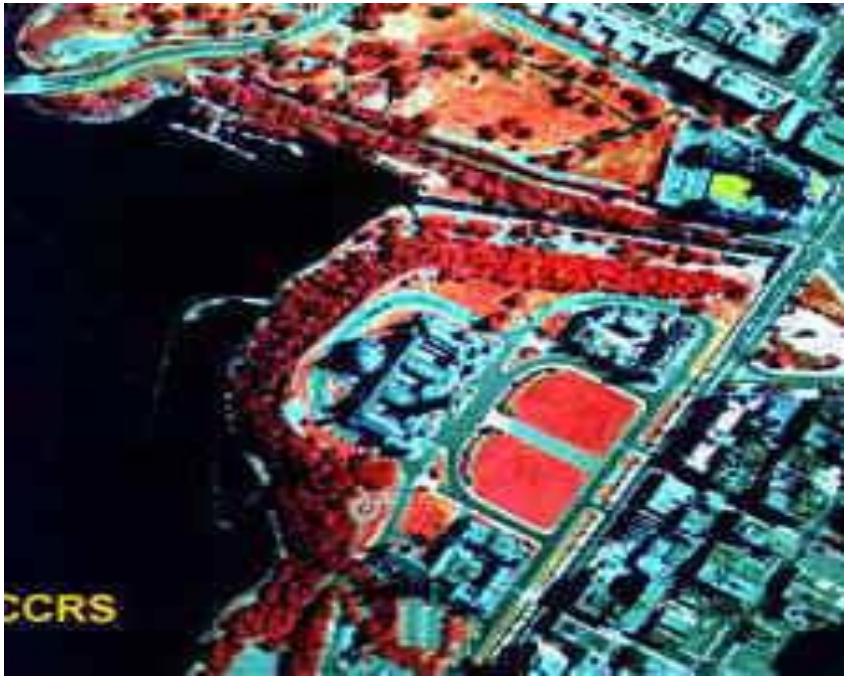
- However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings.



Association

- **Association** takes into account the relationship between other recognizable objects or features in proximity to the target of interest.
- The identification of features that one would expect to associate with other features may provide information to facilitate identification.

Commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields.



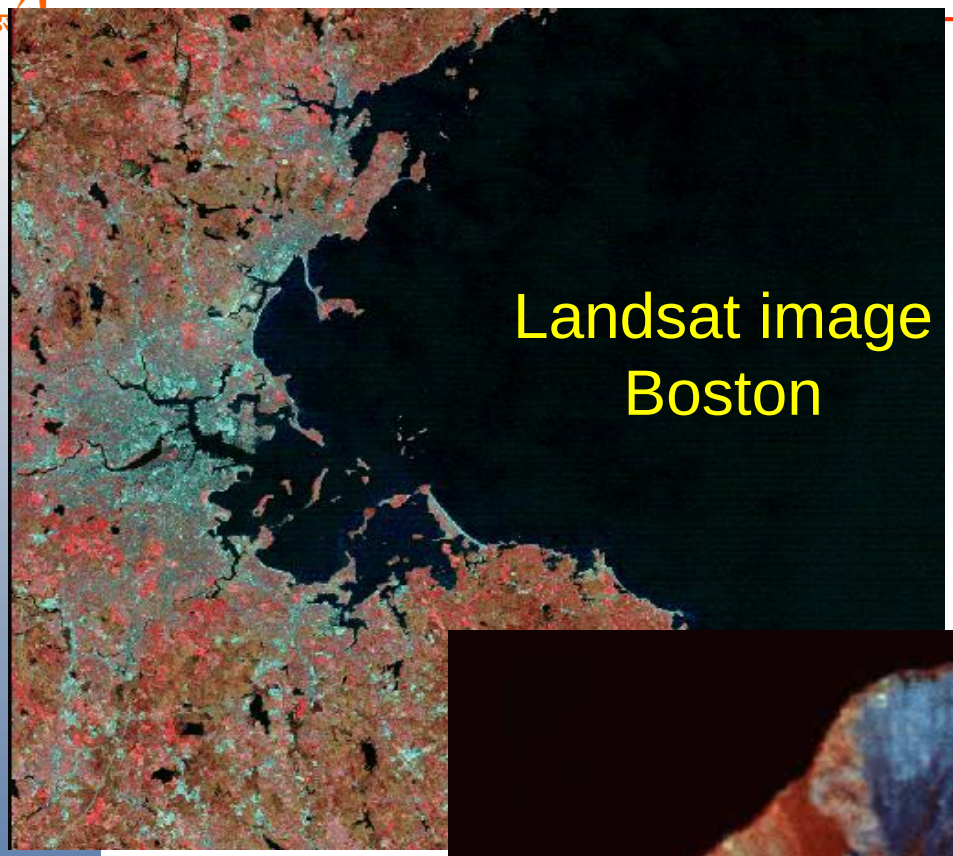
Colour and ***false colour*** (or colour infrared) Images:
For a normal colour photograph, the layers are sensitive to blue, green, and red light - the same as our eyes. Accordingly, these photos appear to us the same way that our eyes see the environment. The colors resemble those which would appear to us as "normal" (i.e. trees appear green, etc.).

Q3. Texture refers to

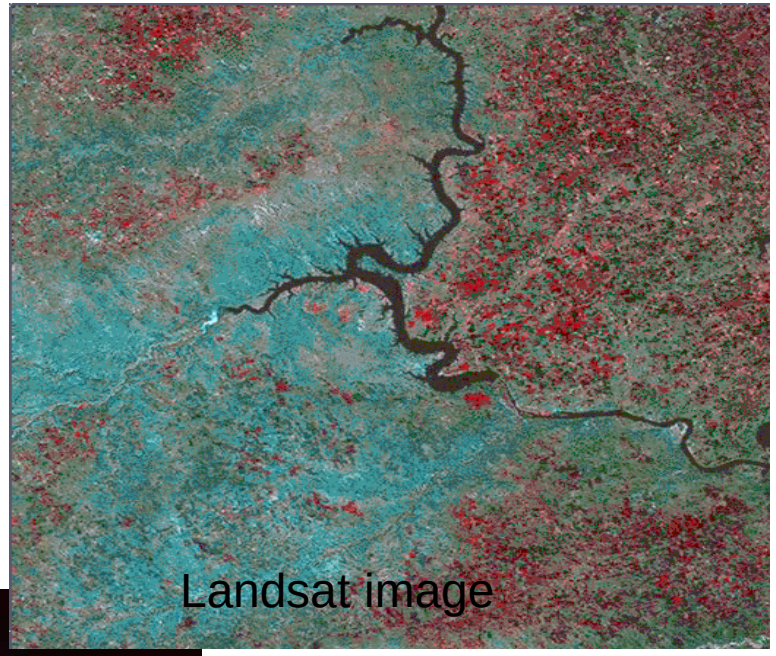
a. Spatial arrangement of visibly discernible objects.

b. The arrangement and frequency of tonal variation in particular areas of an image.

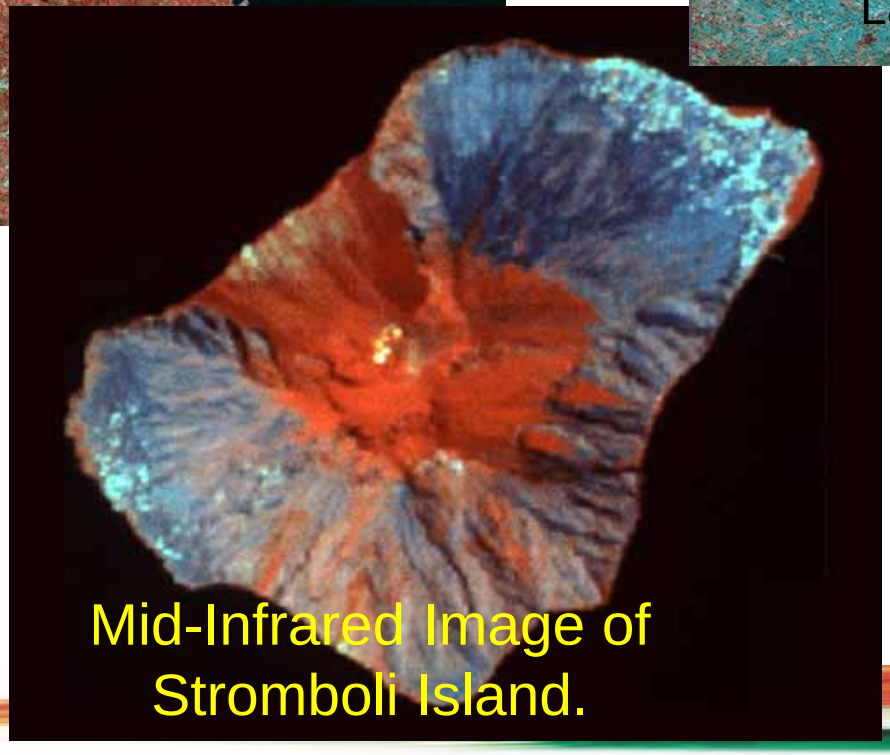
a. General form, structure, or outline of individual objects



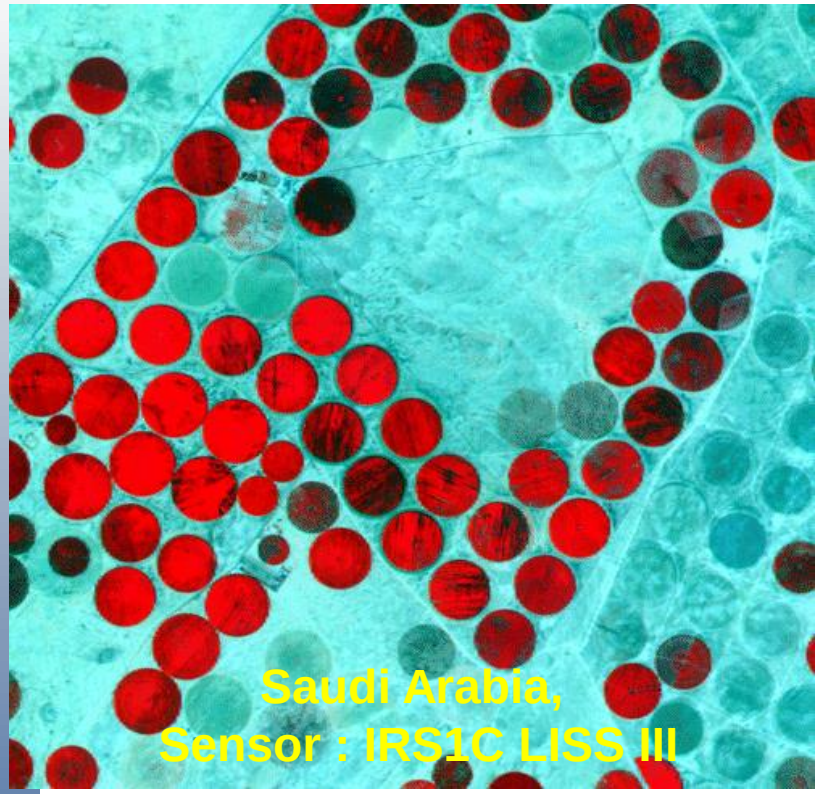
Landsat image
Boston



Landsat image

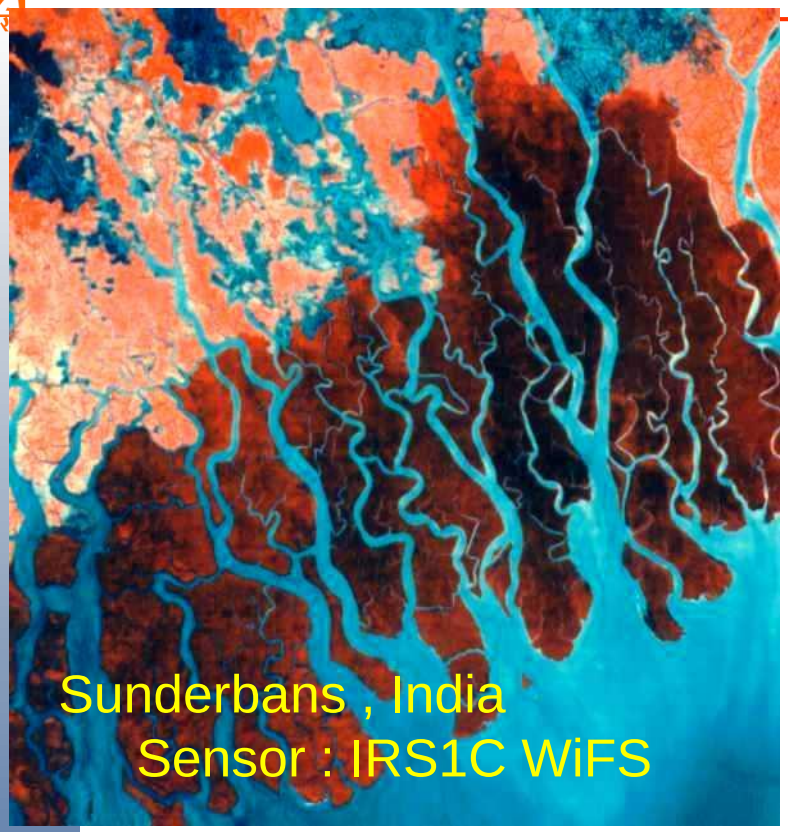


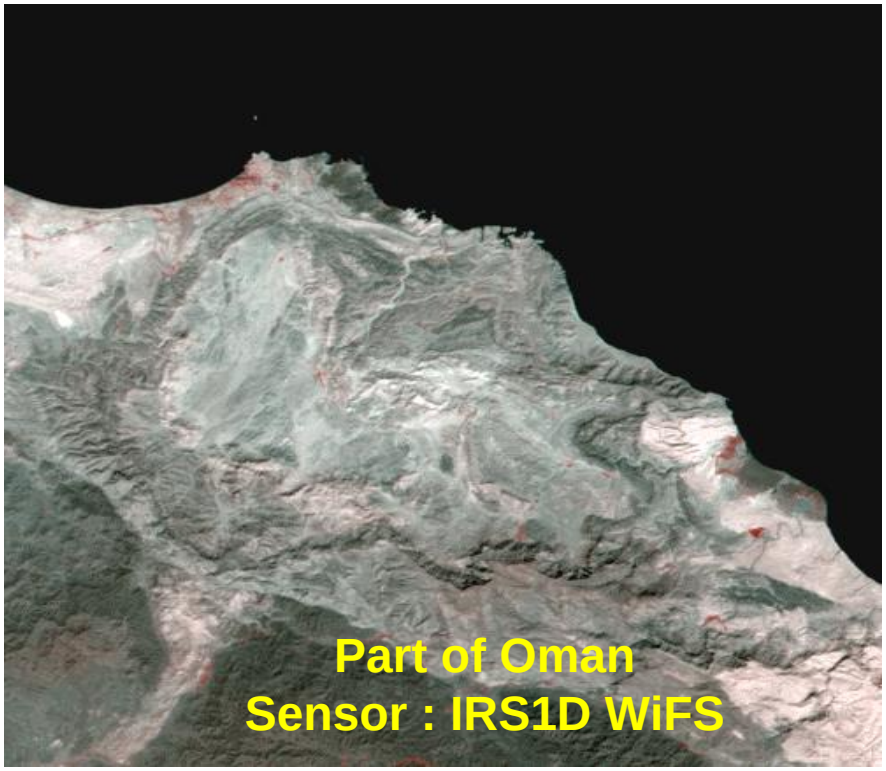
Mid-Infrared Image of
Stromboli Island.



- **The circular features indicate sprinkler irrigation systems.**
- **Red color indicates crop & dark color fallow land.**

- **Multispectral image - Marmagoa & Tiswadi areas of Goa state.**
- **Sedimentation in the River Zuari & River Mandovi & the red patches represent densely vegetated areas.**
- **The Dabolim airport near the town of Vascodagama (the lower middle part of the image.)**

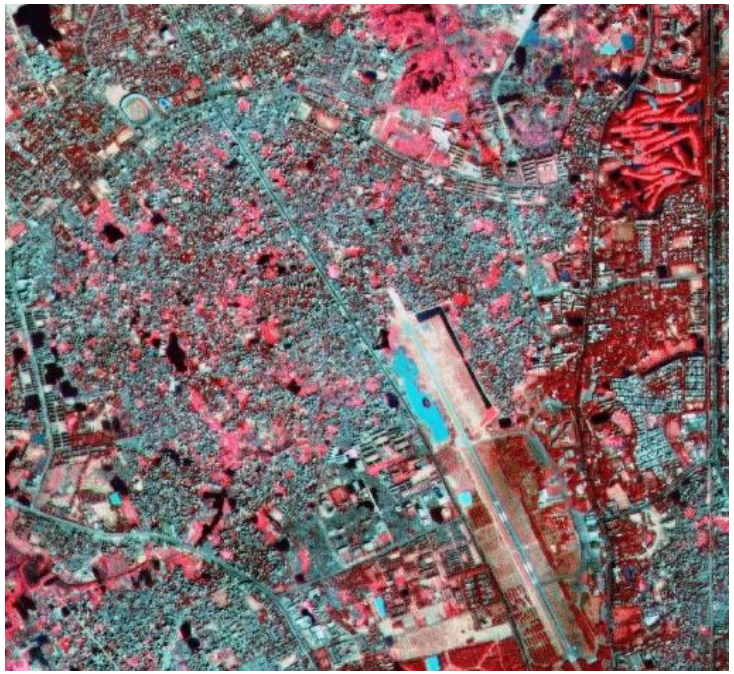




- East Coast of India & Sunderbans.
- Waters in the shallow areas near coast - light blue color.
- Mangroves are seen in bright red color in the wet land areas.
- The river Hoogly dispersing sediments into the sea.

The gulf of Oman is seen here.

The mountains & rocky terrain of the area are seen through WiFS sensor .



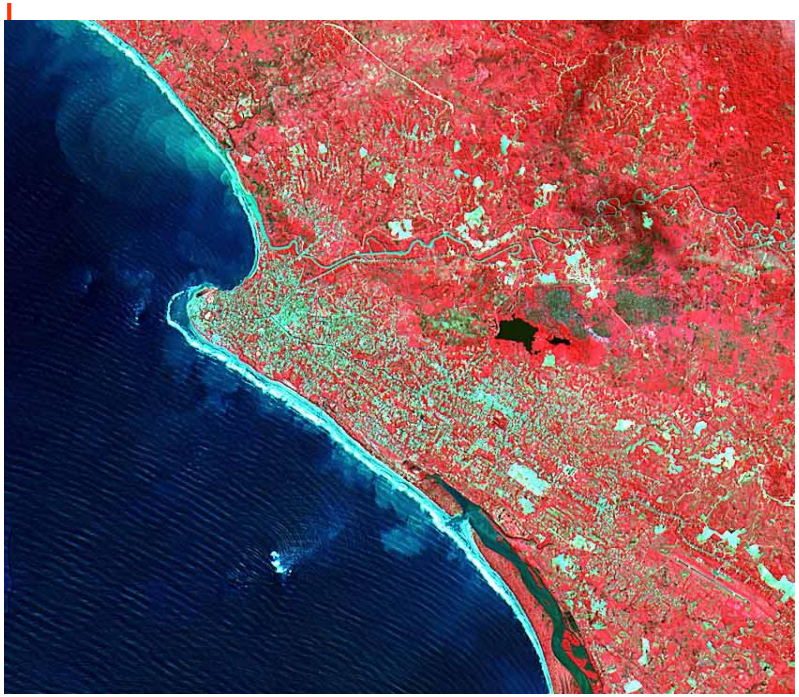
Dhaka , Bangladesh
Sensor : IRS1C LISS III+PAN

Rome , Italy
Sensor : IRS1C LISS III+PAN

- Image shows part of Dhaka city.
- Features like stadium & city airport are clearly seen.

Image shows part of Rome.

The runways of the 'h' shaped airport can also be seen.



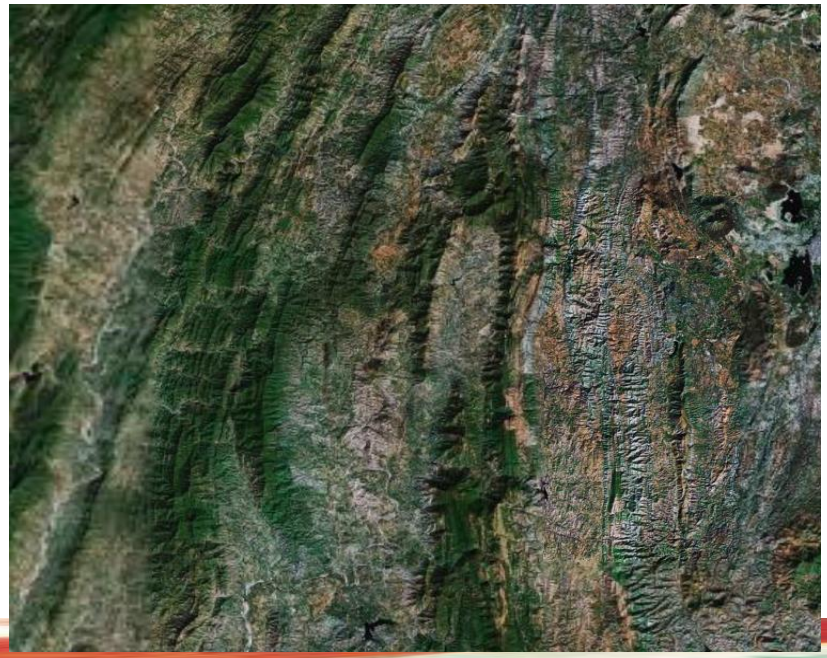
Spot multi-Spectral image

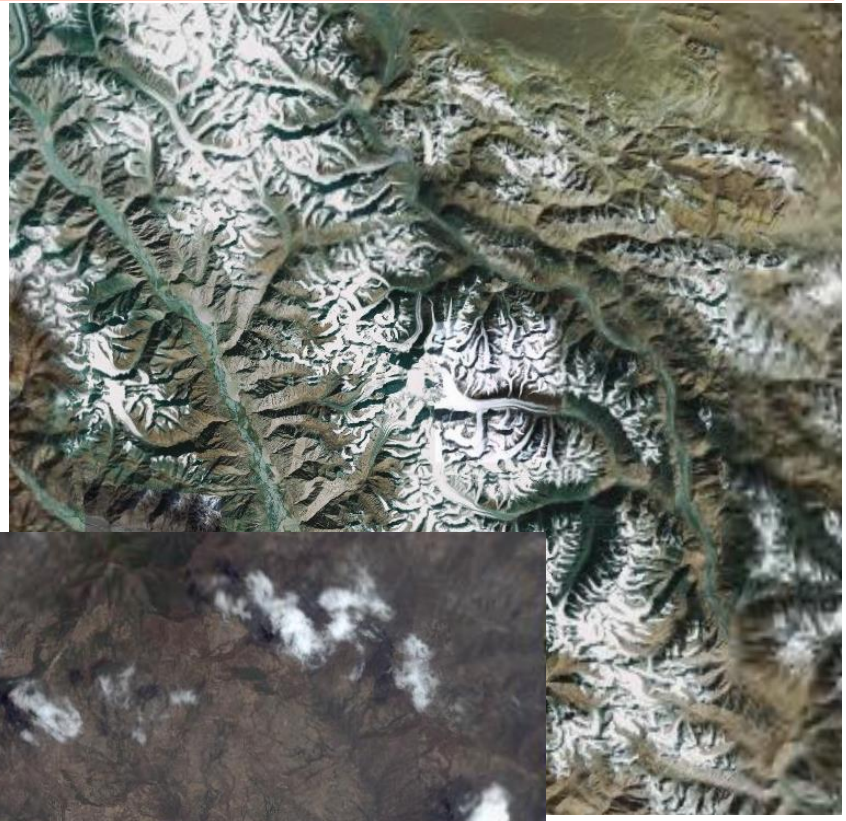
Industrial Area
Pan-sharpened multi-spectra
Resolution, 70 cm

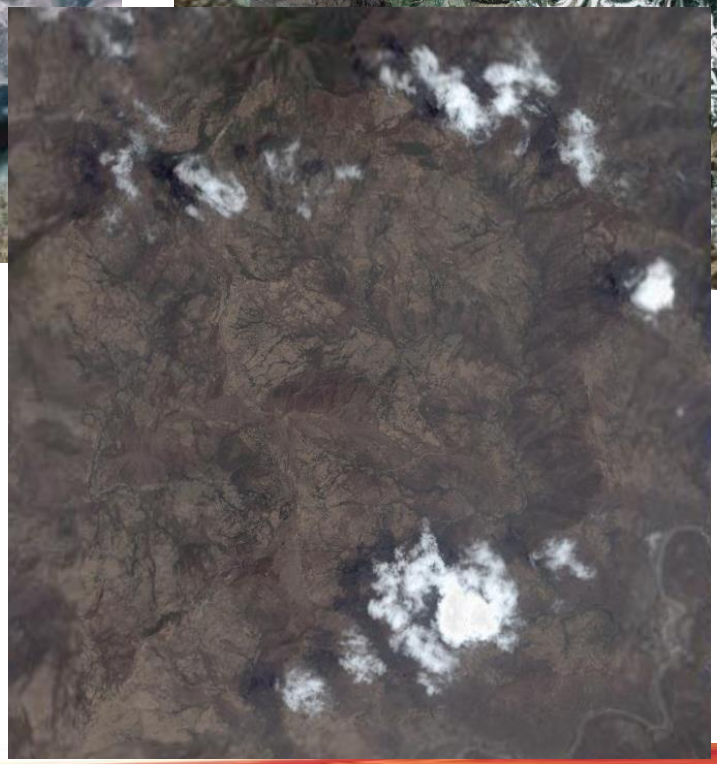
Roads, rivers, water bodies, topography and urban areas can all be distinguished.

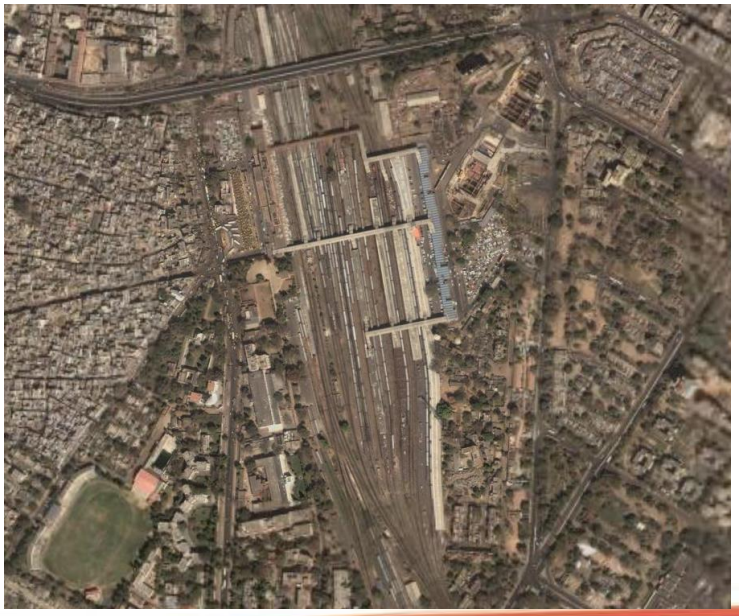
This one-meter resolution satellite image of the Pentagon was collected on Sept. 7, 2001 by Space Imaging's IKONOS satellite, only four days before the terrorist attack.

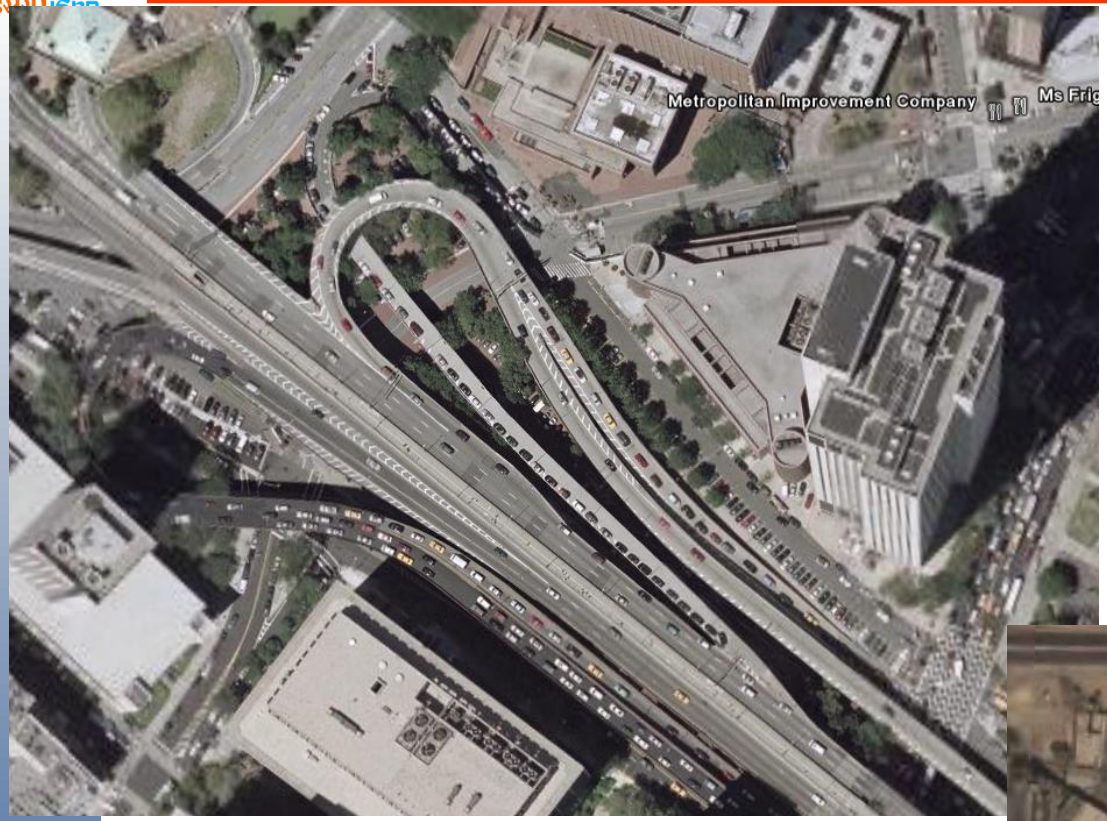
This satellite image of the Pentagon was collected at 11:46 a.m. EDT on Sept. 12, 2001 by Space Imaging's IKONOS satellite. The image shows extensive damage to the western side and interior rings of the multi-ringed building. Also visible are the emergency and rescue vehicles parked around the helipad.










Metropolitan Improvement Company

1. In the image identify the features (1-5)
2. Discuss the elements of interpretation used for identification of each feature.

Manual vs Digital

- Manual interpretation and analysis dates back to the early beginnings of remote sensing for air photo interpretation.
- Manual interpretation requires little, if any, specialized equipment.
- Manual interpretation is often limited to analyzing only a single channel of data or a single image at a time..
- Manual interpretation is a subjective process, meaning that the results will vary with different interpreters.

- Digital processing and analysis is more recent with the advent of digital recording of remote sensing data and the development of computers.
- Digital analysis requires specialized, and often expensive, equipment.
- The computer environment is more amenable to handling complex images of several or many channels or from several dates.
- Digital analysis is based on the manipulation of digital numbers in a computer and is thus more objective, generally resulting in more consistent results.

However, determining the validity and accuracy of the results from digital processing can be difficult.

- It is important to reiterate that visual and digital analyses of remote sensing imagery are not mutually exclusive.
- In most cases, a mix of both methods is usually employed when analyzing imagery.
- The ultimate decision of the utility and relevance of the information extracted at the end of the analysis process, still must be made by humans.

The material for the presentation has been compiled from various sources- books, tutorials, lecture notes, several resources on the www. and Contributions from Ms.Shefali Agrawal, Ms.Minakshi Kumar & Ms.Poonam S. Tiwari

Thank You

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