UNIT II

Elements of Image interpretation

Compiled by Dr. Aparna S. Bhaskar

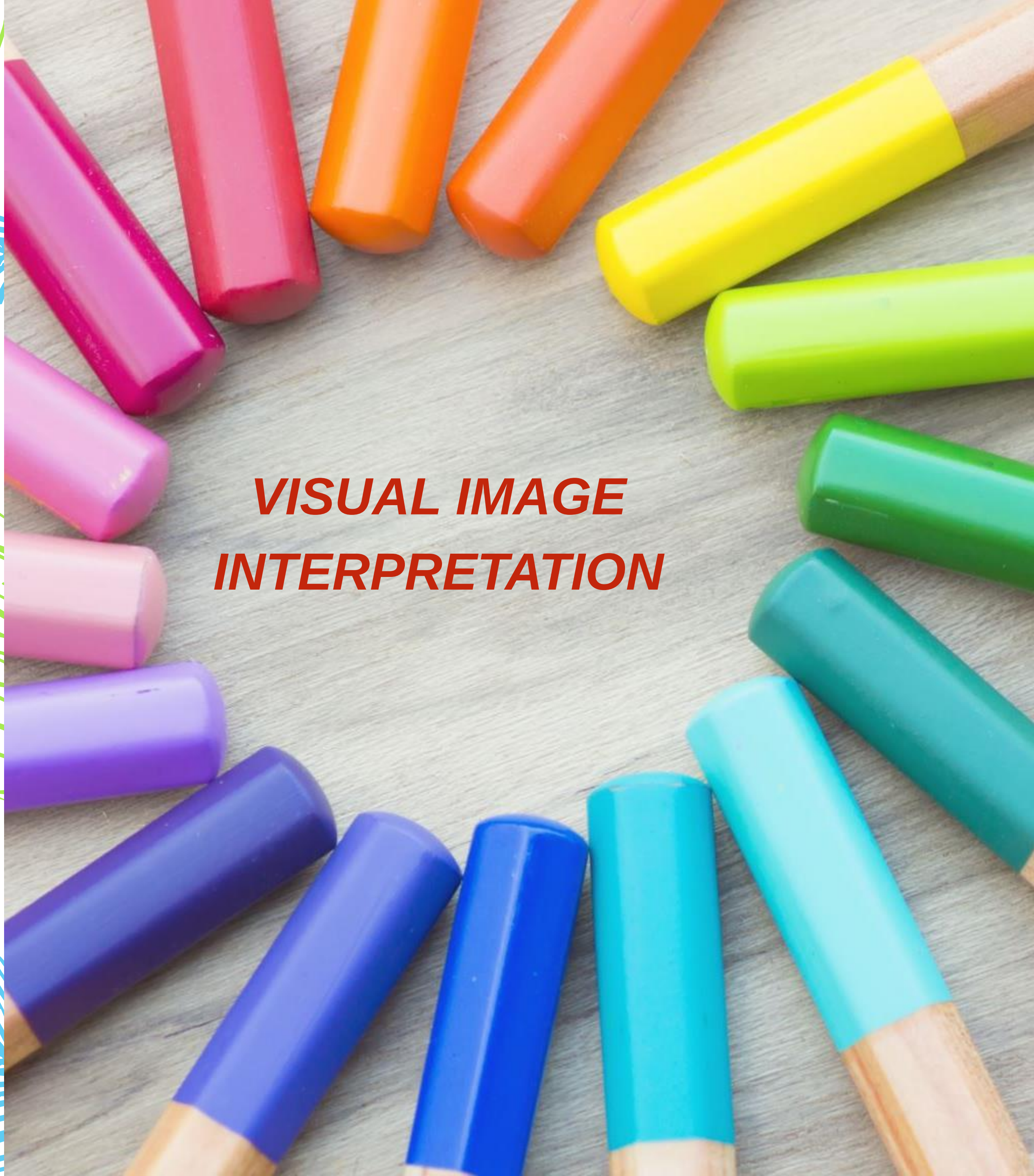


IMAGE INTERPRETATION

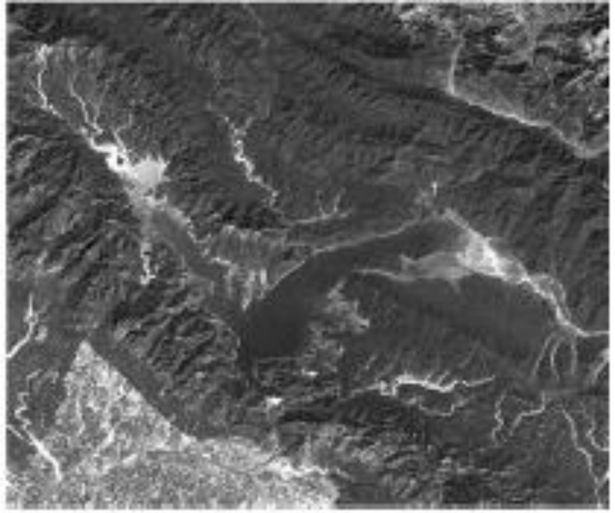
Image interpretation is defined as the act of examining images to identify objects and judge their significance.

- 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.
- This radiation is measured and recorded by a sensor, and ultimately is depicted as an image product such as an air photo or a satellite image.
- Information extraction process from the images.
- An interpreter is a specialist trained in study of photography or imagery, in addition to his own discipline.
- Involves a considerable amount of subjective judgment.

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 see only the visible wavelengths, and the imaging of wavelengths outside of this window is more difficult for us to comprehend.

Band (.45 to .515µm)



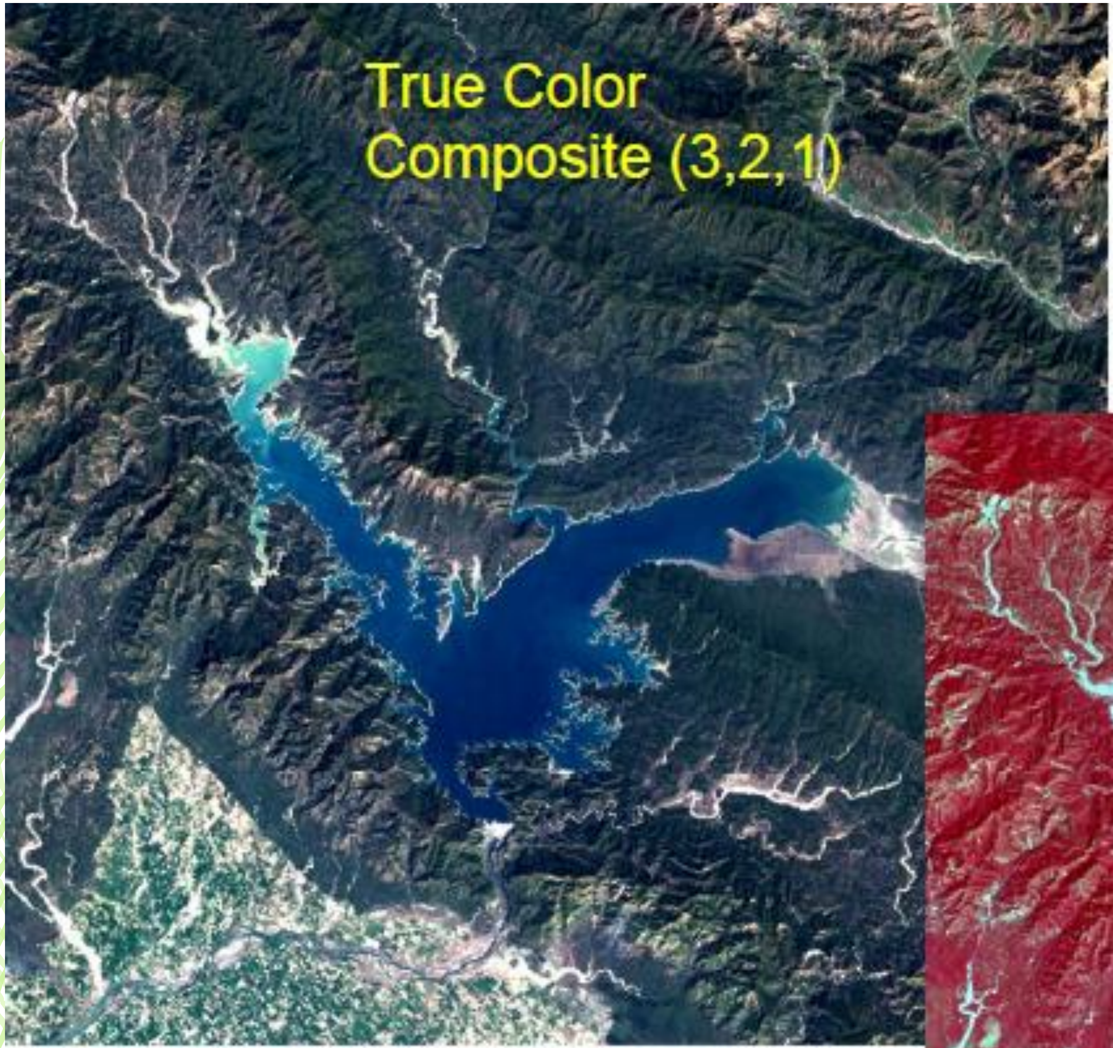
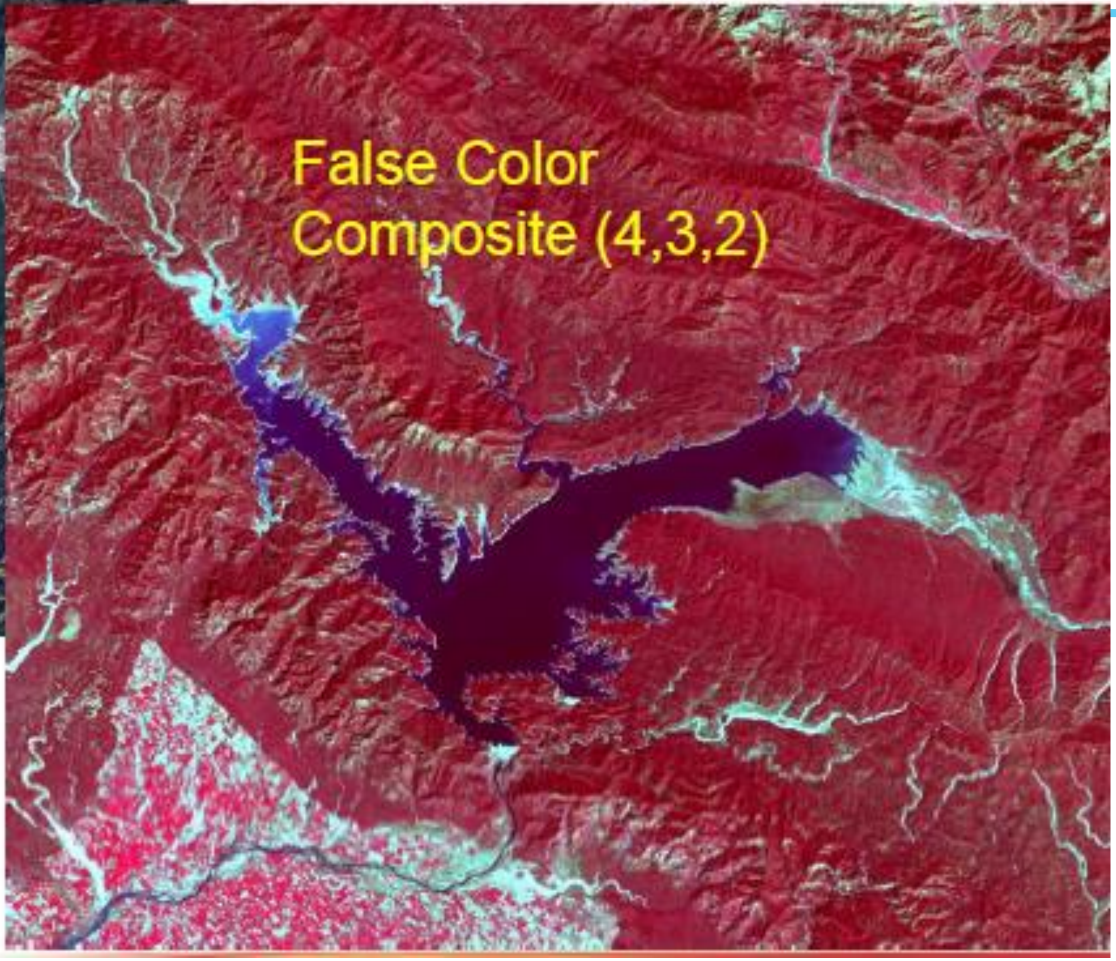
Band (.525 to .605 µm)

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)

Methods of Image Interpretation

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

- Digital image processing

Types of interpretation

- Qualitative
- Quantitative

Image analysis requires explicit recognition of eight ***elements of image interpretation*** that form the framework and understanding of an image

- Tone
- Shape
- Size
- Texture
- Pattern
- Shadow
- Site
- Association

Tone

– Refers to the average brightness of an area or, in the case of color imagery, to the dominant color of the region

- Depends on the nature of the surface in the angles of observation and illumination.
- Smooth surfaces behave like ***specular reflectors***, they tend to reflect radiation in a single direction
  - *These features may appear bright or dark*
- Rough surfaces behave this ***diffuse reflectors***.
  - *Scatter radiation in all directions.*
  - *A peer is medium gray tones*

- 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

- The outline of a feature
  - Important to note that shape depends on perspective

- **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

- The first to the dimensions of a feature
- ***Relative size*** determined by comparing the object with familiar nearby features
- ***Absolute size*** refers to the use of the aerial image to derive measurements

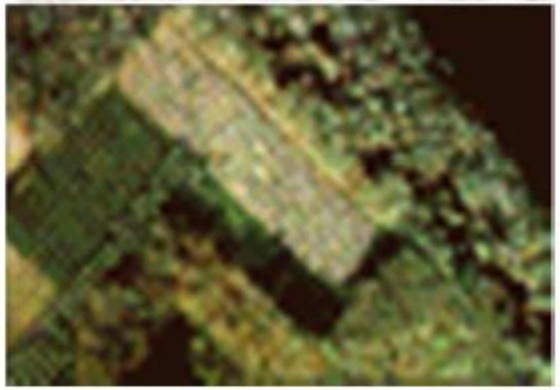
- **Size** of objects in an image is a function of scale.
- It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target.
- A quick approximation of target size can direct interpretation to an appropriate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

Texture

– Refers to the variation in tone over a surface or the apparent roughness of the surface as seen in the photo
– Created by micro shadows in small irregularities in the surface.

- **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.

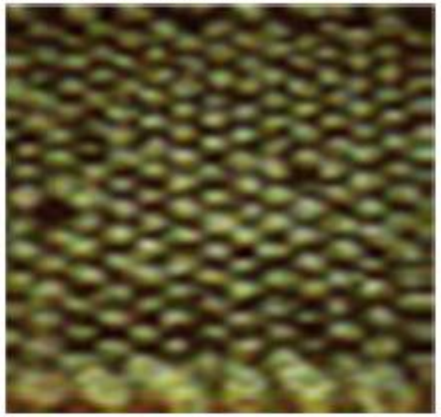



Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation.

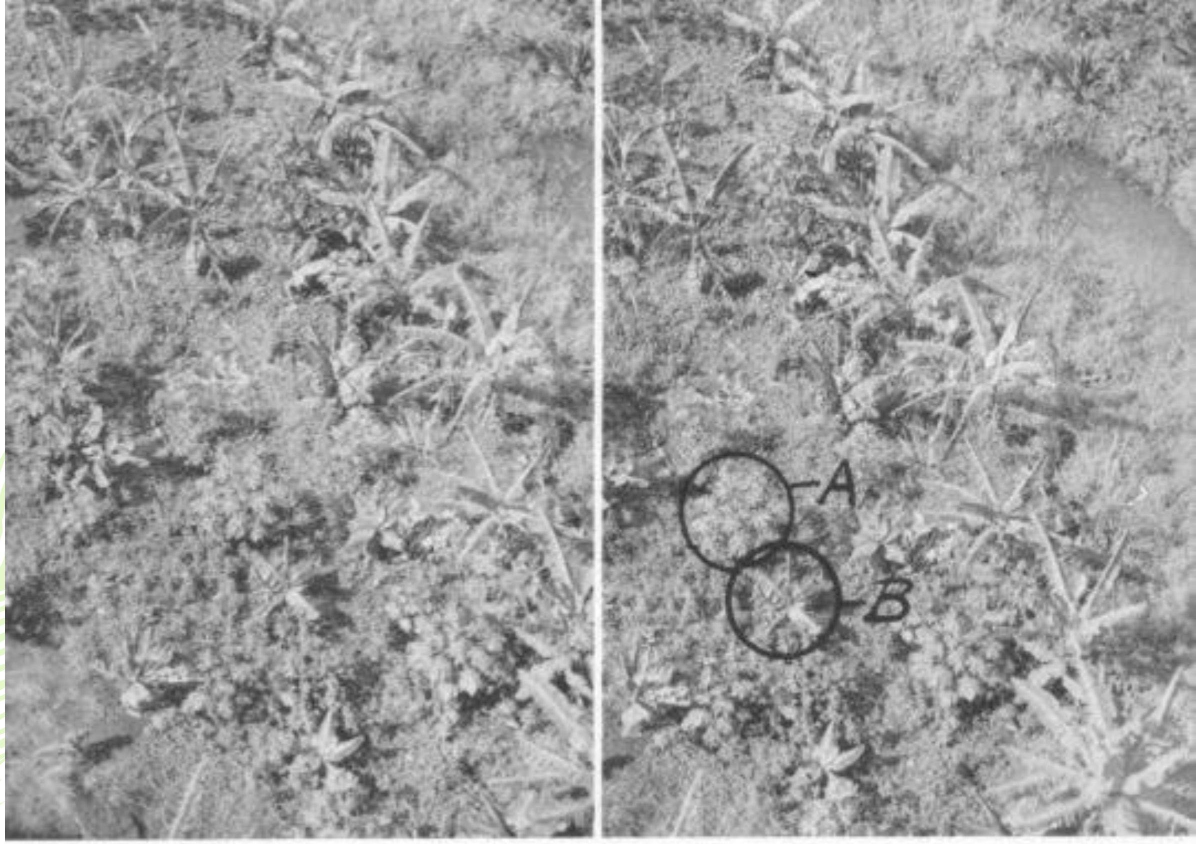
Pattern

- Refers to distinctive arrangement of features
  - Orchards have trees plant can rows

- **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.


A
B

Shadow

- Refers to large distinctive shadows that revealed the outline of a future as projected onto a flat surface.
  - Depends on the nature of the object, angle of illumination, perspective, and slope of the ground surface

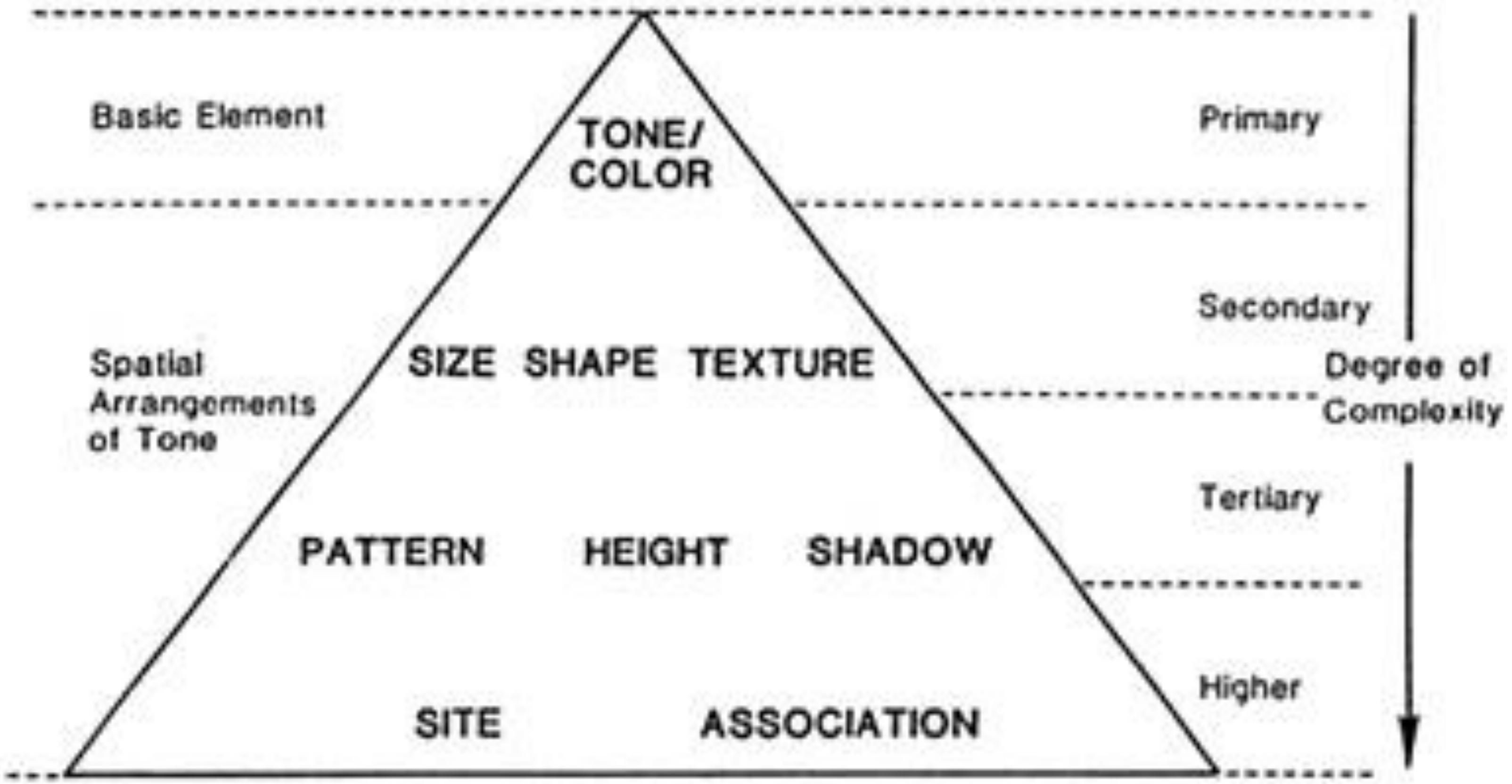
Site

– Refers to a features position with respect to topography and drainage.
  – Some things occupy a distinctive topographic position because of their function
    – *Sewage treatment facilities at the lowest feasible topographic position.*
    – *Power plants located adjacent to water for cooling*

Association

- Association refers to the distinctive spatial interrelationships between features
  - Schools often associated with athletic fields.
  - Large parking lots often associated with malls
- Commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields.

PRIMARY ORDERING OF IMAGE ELEMENTS
FUNDAMENTAL TO THE ANALYSIS PROCESS



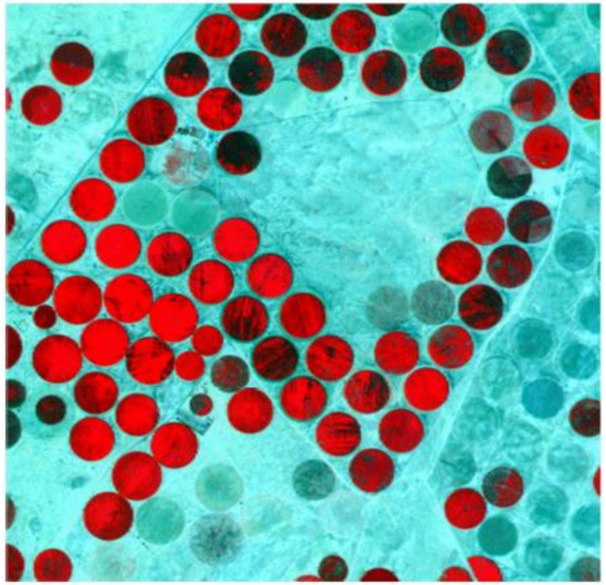
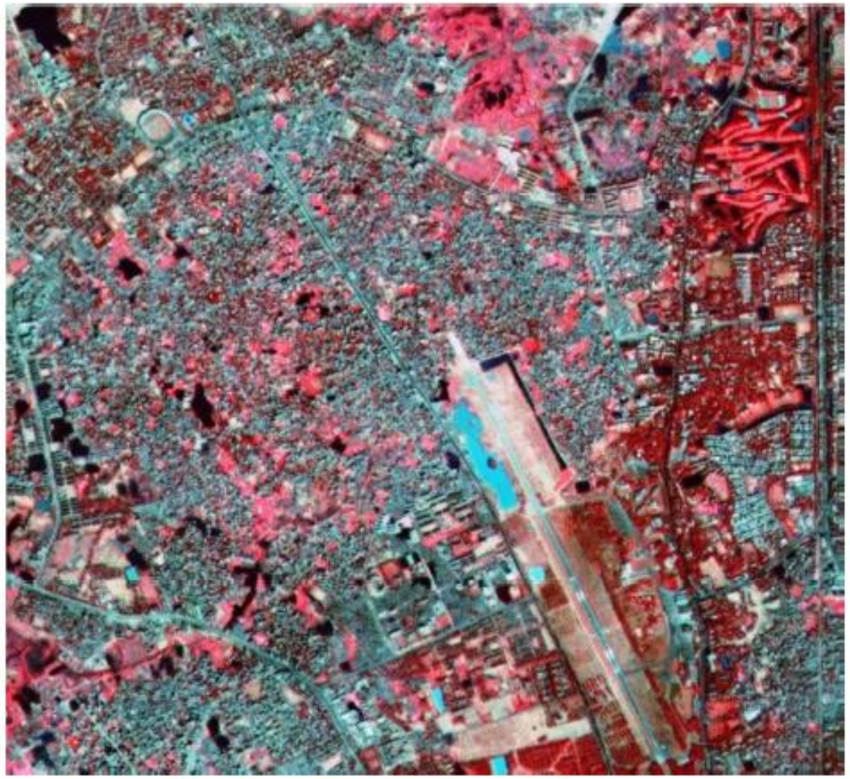
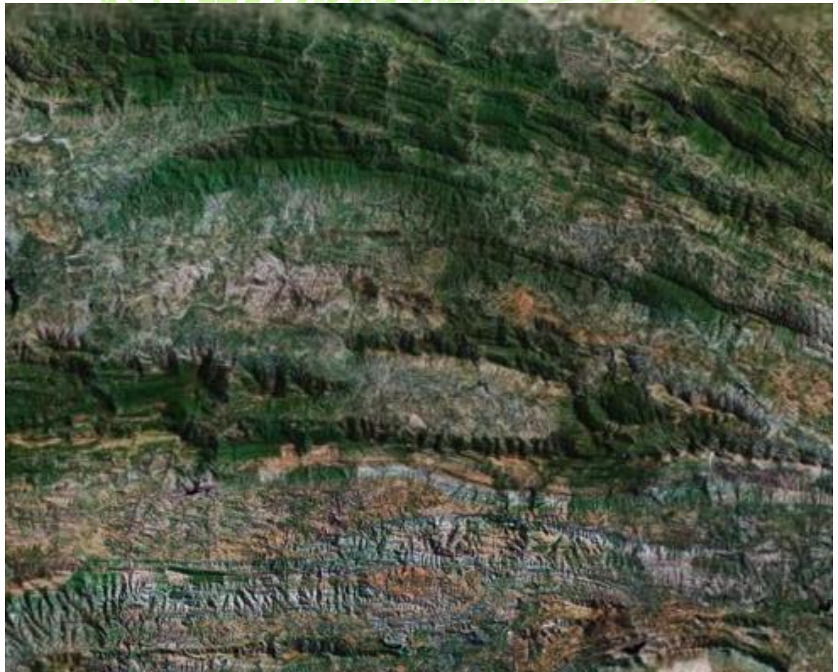


Fig : Saudi Arabia, Sensor : IRS1C

Rome , Italy
Sensor : IRS1C LISS III+PAN



Dhaka , Bangladesh
Sensor : IRS1C LISS III+PAN



Raster data format

DIGITAL IMAGE FORMATS

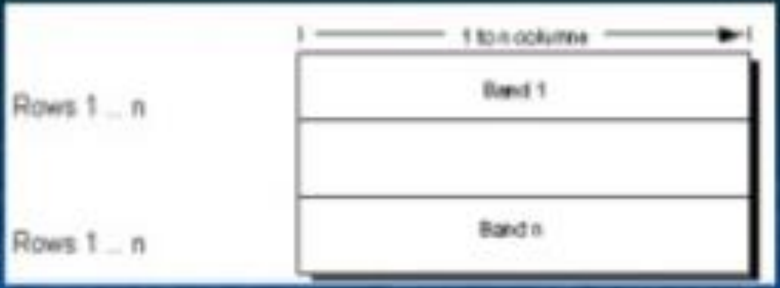
Digital Image Processing

Digital image processing can be defined as the computer manipulation of digital values contained in an image for the purposes of image correction, image enhancement and feature extraction.

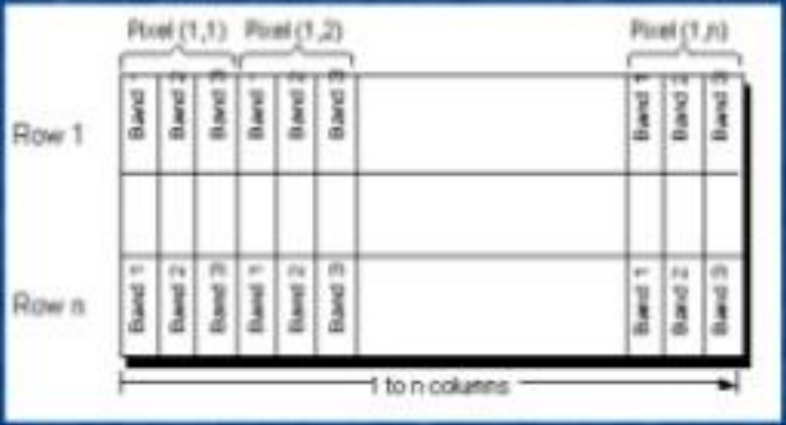
DATA FORMATS

In order to properly process remotely sensed data, the analyst must know how the data is organized and stored on digital tapes and how the data are processed by computers and software. The commonly used data formats used for storing digital remotely sensed data

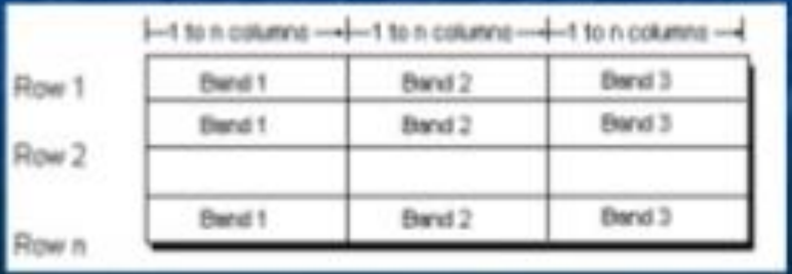
1 Band Interleaved by Pixel (BIP) Format
2 Band Interleaved by Line (BIL) Format
3 Band Sequential (BSQ) Format



- Band sequential (BSQ) format stores information for the image one band at a time. In other words, data for all pixels for band 1 is stored first, then data for all pixels for band 2, and so on.



- Band interleaved by pixel (BIP) data is similar to BIL data, except that the data for each pixel is written band by band. For example, with the same three-band image, the data for bands 1, 2 and 3 are written for the first pixel in column 1; the data for bands 1, 2 and 3 are written for the first pixel in column 2; and so on.



- Band interleaved by line (BIL) data stores pixel information band by band for each line, or row, of the image. For example, given a three-band image, all three bands of data are written for row 1, all three bands of data are written for row 2, and so on, until the total number of rows in the image is reached.

Radiometric correction

Atmospheric correction

Geometric correction

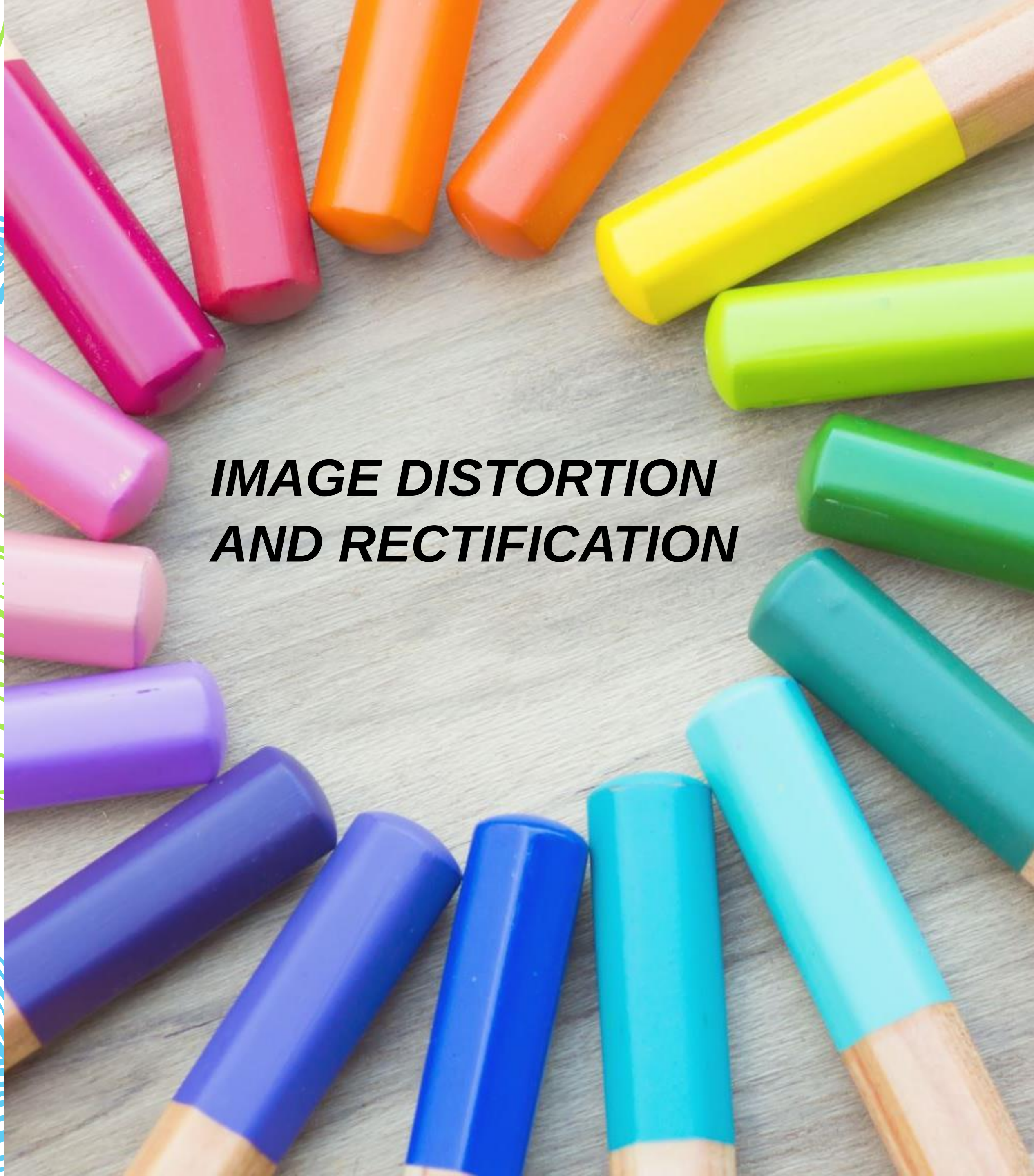


IMAGE DISTORTION AND RECTIFICATION

Image rectification and restoration

Aims to correct distorted and degraded image data to create a more faithful representation of the original scene.

This step is often termed **preprocessing** because it normally precedes the actual image analysis that extracts information from an image for a specific application

Typical preprocessing operations include

(1) **Radiometric preprocessing** to adjust digital values for the effect of atmosphere for example a hazy atmosphere

(2) **Geometric preprocessing** to bring an image into registration with a map or another image.

Radiometric errors- Causes

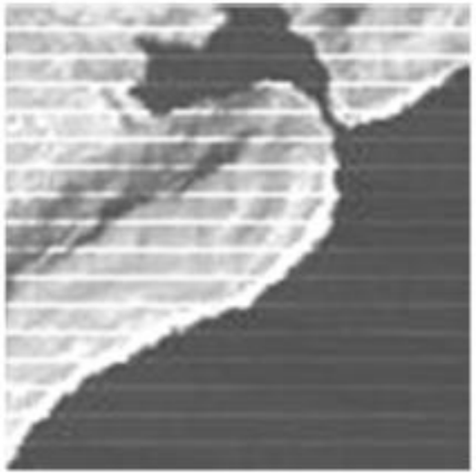
- Radiometric errors are caused by detector imbalance and atmospheric deficiencies.

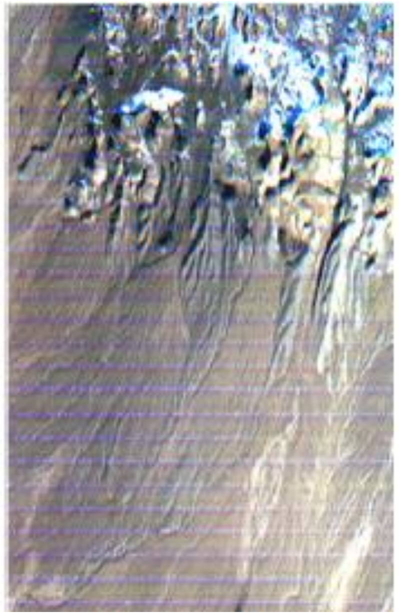
- Radiometric corrections are also called as cosmetic corrections and are done to improve the visual appearance of the image.

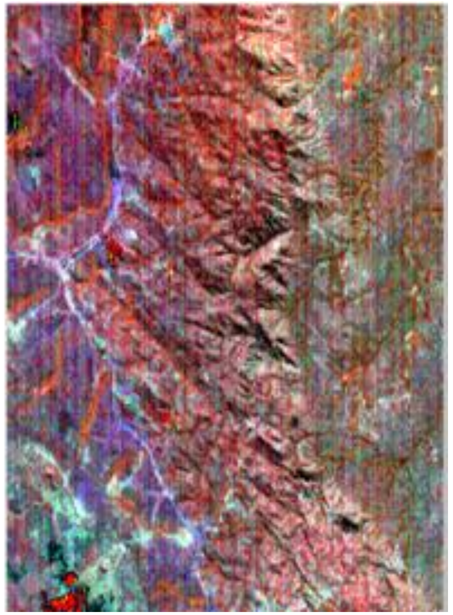
- Common radiometric errors
  - Periodic line or column drop-outs,
  - line or column striping.
  - random bad pixels (shot noise),
  - partial line or column drop-outs

Line Striping (Banding)

- The response of some of the detectors may shift towards the lower or higher end causing the presence of a systematic horizontal/vertical banding pattern.
- Banding is a cosmetic defect and it interferes with the visual appreciation of the patterns and features in the image.
- Variation in gain and offset of each sensor (linear sensor characteristic) as the sensor deteriorates in time





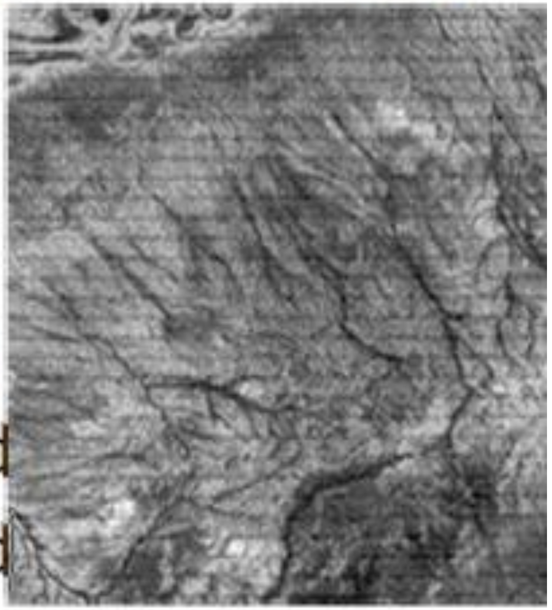


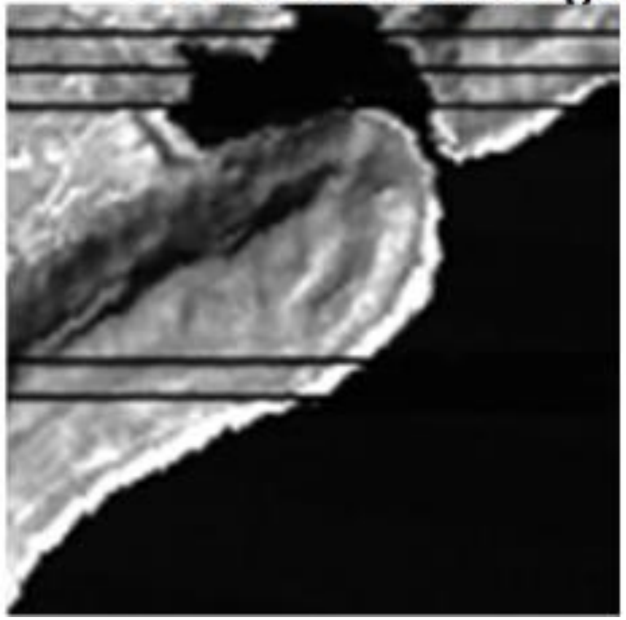
Line dropout / Striping (Banding)

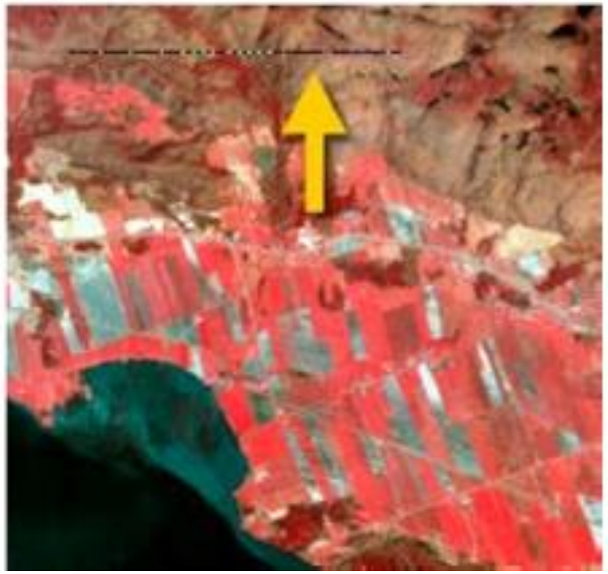
- Systematic

E.g.

Landsat MSS	6 sensors (per band)
Landsat TM	16 sensors (per band)
SPOT XS	3000 sensors (per band
SPOT PAN	6000 sensors (per band







Another line-oriented noise problem is line drop, where a number of adjacent pixels along a line (or an entire line) may contain erroneous DNs. This problem is solved by replacing the defective DNs with the average of the values for the pixels occurring in the lines just above and below

Bit errors are a good example of **random noise** within an image. Such noise causes images to have a "salt and pepper" or "snowy" appearance. This kind of noise can be removed by using moving neighborhood windows, where all pixels are compared to their neighbors.

Atmosphere induced errors

HAZE

- Scattered light reaching the sensor from the atmosphere
- Additive effect, reducing CONTRAST

SKYLIGHT

- Scattered light reaching the sensor after being reflected from the Earth's surface
- Multiplicative effect

SUNANGLE

- Time/Seasonal effect changing the atmospheric path
- Multiplicative effect

Atmospheric Haze Effect

DN values of objects in a single band

Object1:	DN = 20	DN = 20 + 20
Object2:	DN = 40	DN = 40 + 20
Contrast:	40/20 = 2X	60/40 = 1.5 X

Haze Correction- Dark Object Subtraction

Histogram Minimum Method

Assumption: infrared bands are not affected by Haze

- Identify black bodies: clear water and shadow zones with zero reflectance in the infrared bands
- Identify DN values at shorter wavelength bands of the same pixel positions. These DN are entirely due to haze
- Subtract the minimum of the DN values related to black bodies of a particular band from all the pixel values of that band

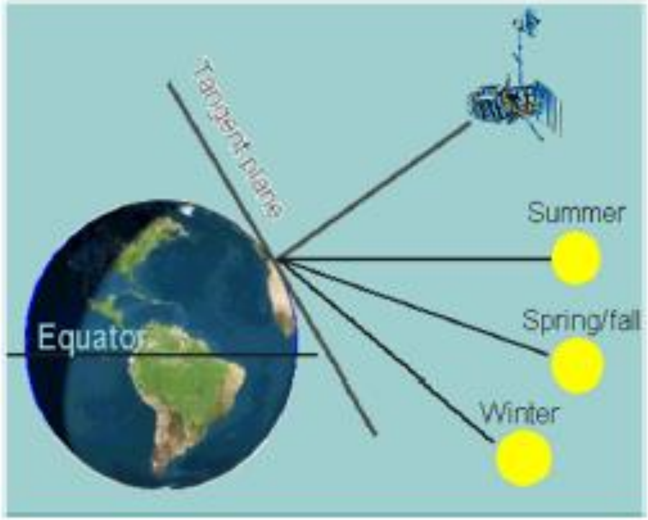
Sun Angle Correction

- The position of sun relative to earth changes depending on time of day and day of year.
- Solar elevation angle: Time- and location dependent
- In the northern hemisphere the solar elevation angle is smaller in winter than in summer
- The solar zenith angle is equal to 90 degree minus the solar elevation angle
- Irradiance varies with the seasonal changes in solar elevation angle and the changing distance between the earth and sun
- Correction necessary for mosaicking and change detection

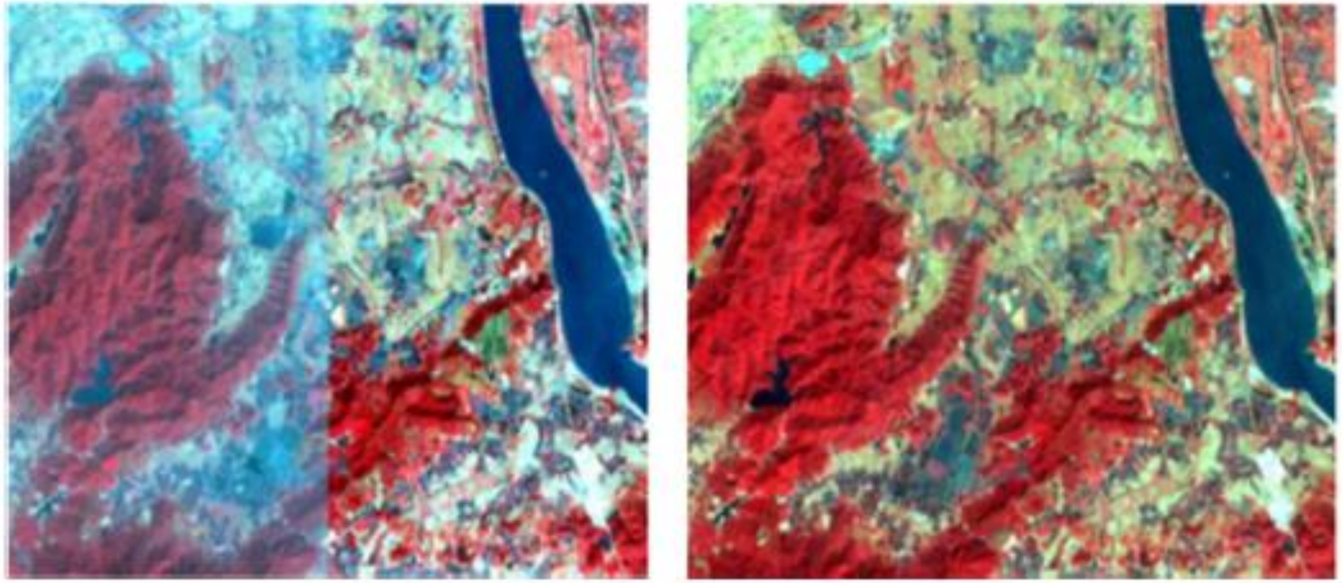
Sun Angle Correction

image data acquired under different solar illumination angles are normalized by calculating pixel brightness values assuming the sun was at the zenith on each date of sensing.

The correction is usually applied by dividing each pixel value in a scene by the sine of the solar elevation angle for the particular time and location of imaging.



$$DN' = \frac{DN}{SIN(\alpha)}$$



Atmospheric Correction

Atmospheric correction is the process of removing the effects of the atmosphere to produce surface reflectance values. Atmospheric correction can significantly improve the interpretability and use of an image. Ideally, this process requires knowledge of the atmospheric conditions and aerosol properties at the time the image was acquired.

Atmospheric Correction Models

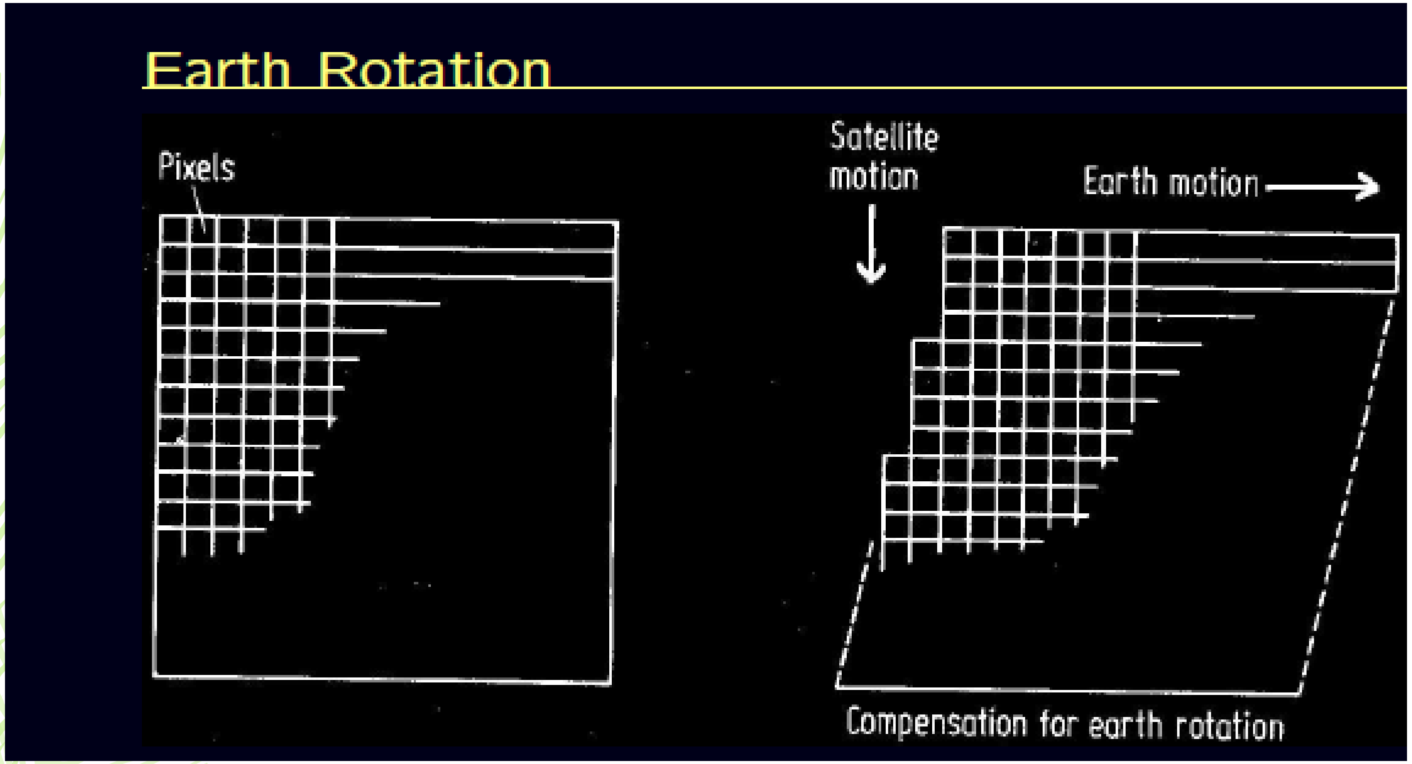
Atmospheric models can be used to account for the effects of scattering and absorption in the atmosphere. Many software packages include special atmospheric correction modules that use atmospheric radiation transfer models to produce an estimate of the true surface reflectance.

Dark Object Subtraction Method

This method is used when there is no available data on atmospheric conditions and aerosol properties at the time the image was acquired. The basic assumption of this method is that within the image some pixels are in complete shadow and their radiances received at the satellite are due entirely to atmospheric scattering (path radiance).

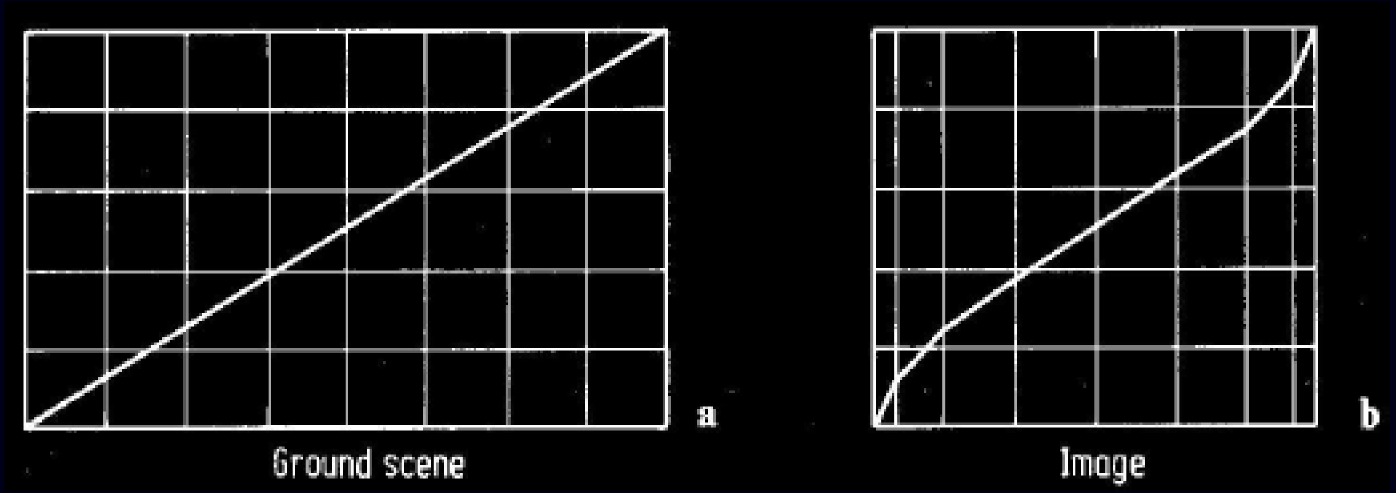
Types of geometric distortion

- Earth rotation
- Panoramic distortion
  - Further affected by Earth curvature
- Scan time skew
- Platform variations of
  - Height
  - Velocity
  - Attitude
    * Pitch
    * Roll
    * Yaw
- Aspect Ratio Distortion



Eastward rotation of the Earth, during a satellite orbit causes the sweep of scanning systems to cover an area slightly to the west of each previous scan. The resultant imagery is thus skewed across the image. This is known as **skew distortion** and is common in imagery obtained from satellite multispectral scanners.

Panoramic distortion: S-band effect



Small for SPOT, LANDSAT: $\theta = 7.5^\circ$: edge pixels 2% bigger

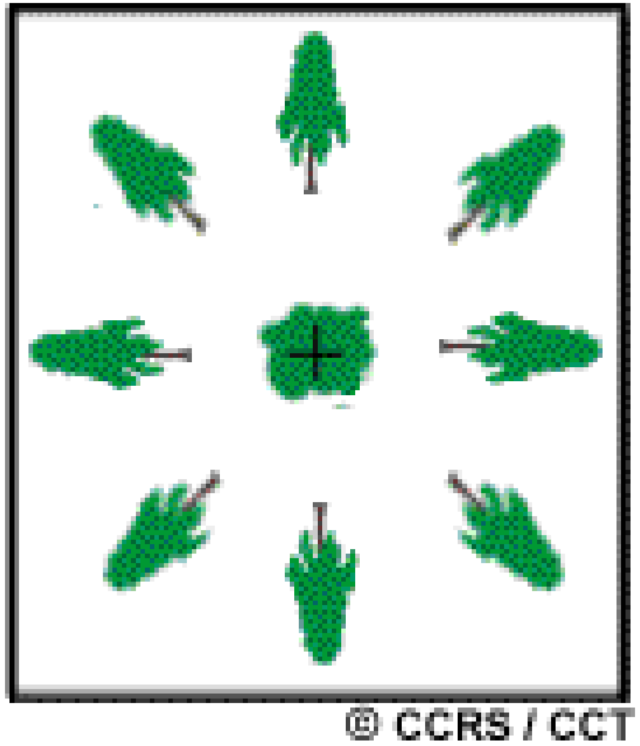
Large for AVHRR

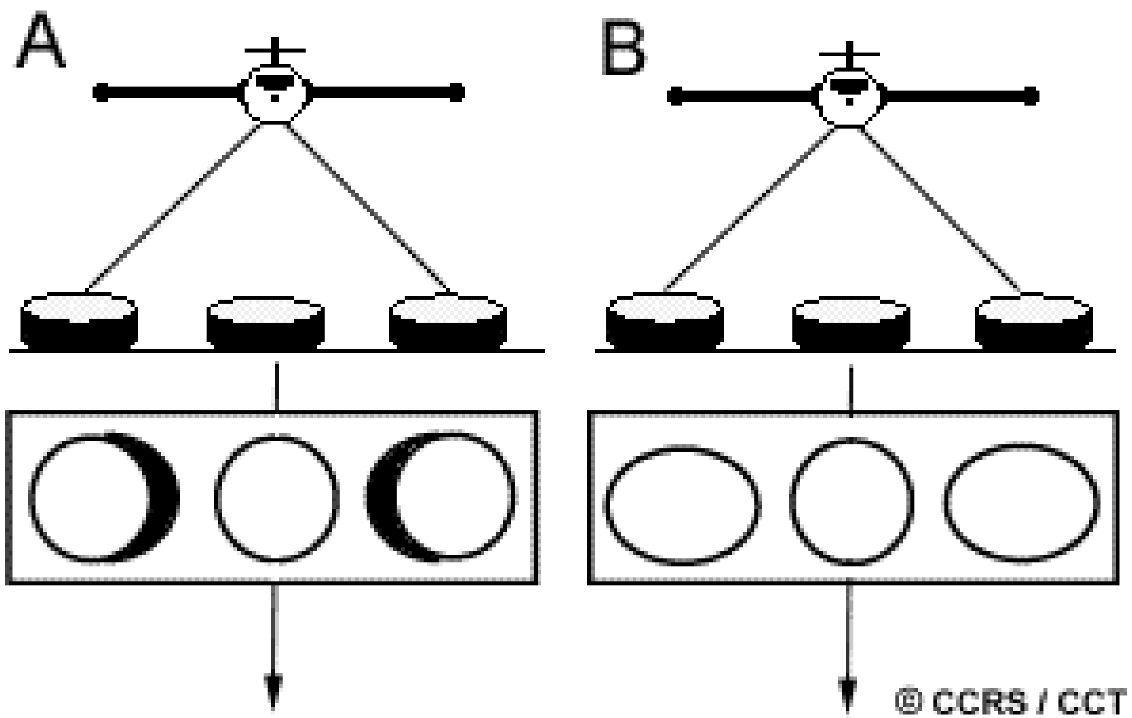
Very large for aircraft instruments $\theta = 40^\circ$: edge pixels 70% bigger

The **geometry of along-track scanner** imagery is similar to that of an aerial photograph for each scan line as each detector essentially takes a "snapshot" of each ground resolution cell. **Geometric variations between lines are caused by random variations in platform altitude and attitude along the direction of flight**.

Images from across-track scanning systems exhibit two main types of geometric distortion. As the sensor scans across the swath, the top and side of objects are imaged and **appear to lean away from the nadir point** in each scan line. Again, the displacement increases, moving towards the edges of the swath.

Another distortion (B) **occurs due to the rotation of the scanning optics**. As the sensor scans across each line, the distance from the sensor to the ground increases further away from the centre of the swath. Although the scanning mirror rotates at a constant speed, the IFOV of the sensor moves faster (relative to the ground) and scans a larger area as it moves closer to the edges. This effect results in the compression of image features at points away from the nadir and is called **tangential scale distortion**.

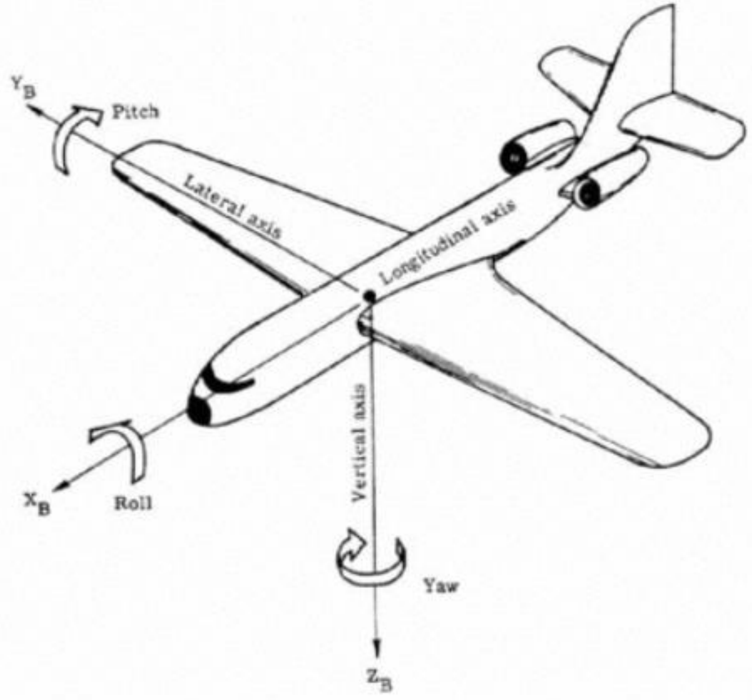


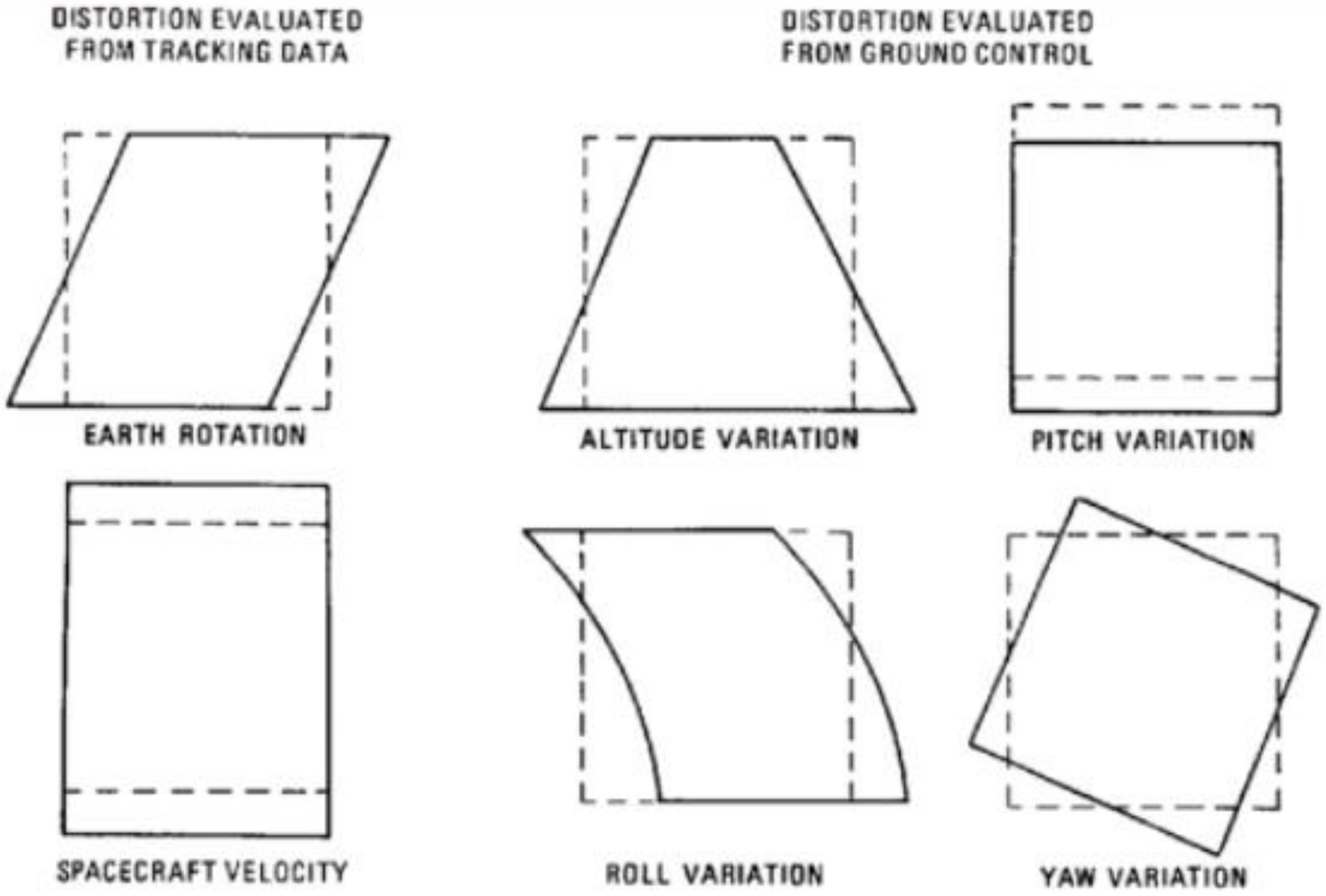


relief displacement

Geometric Distortions

Attitude Distortions





Geometric Errors and Corrections

- The transformation of remotely sensed images so that it has a scale and projections of a map is called geometric correction.
- It is concerned with placing the reflected, emitted, or back-scattered measurements or derivative products in their proper planimetric (map) location so they can be associated with other spatial information in a geographic information system (GIS)
- include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface

Rectification

- is a process of geometrically correcting an image so that it can be represented on a planar surface , conform to other images or conform to a map.
- i.e it is the process by which geometry of an image is made planimetric.
- It is necessary when accurate area , distance and direction measurements are required to be made from the imagery.
- It is achieved by transforming the data from one grid system into another grid system using a geometric transformation
- Grid transformation is achieved by establishing mathematical relationship between the addresses of pixels in an image with corresponding coordinates of those pixels on another image or map or ground.

Point operation

- *Contrast enhancement*

Local operation

- *Filtering techniques*

Image transformation

- *Image merging*

Image Enhancement

- Modification of an image to alter its impact on viewer
  - ***Enhancements are used to make it easier for visual interpretation and understanding of imagery.***
- Process of making an image more interpretable for a particular application
- Useful since many satellite images give inadequate information for image interpretation.
  - ***In raw imagery, the useful data often populates only a small portion of the available range of digital values***
- Attempted after image is corrected for distortions.
- May be performed temporarily or permanently.

Enhancement Types

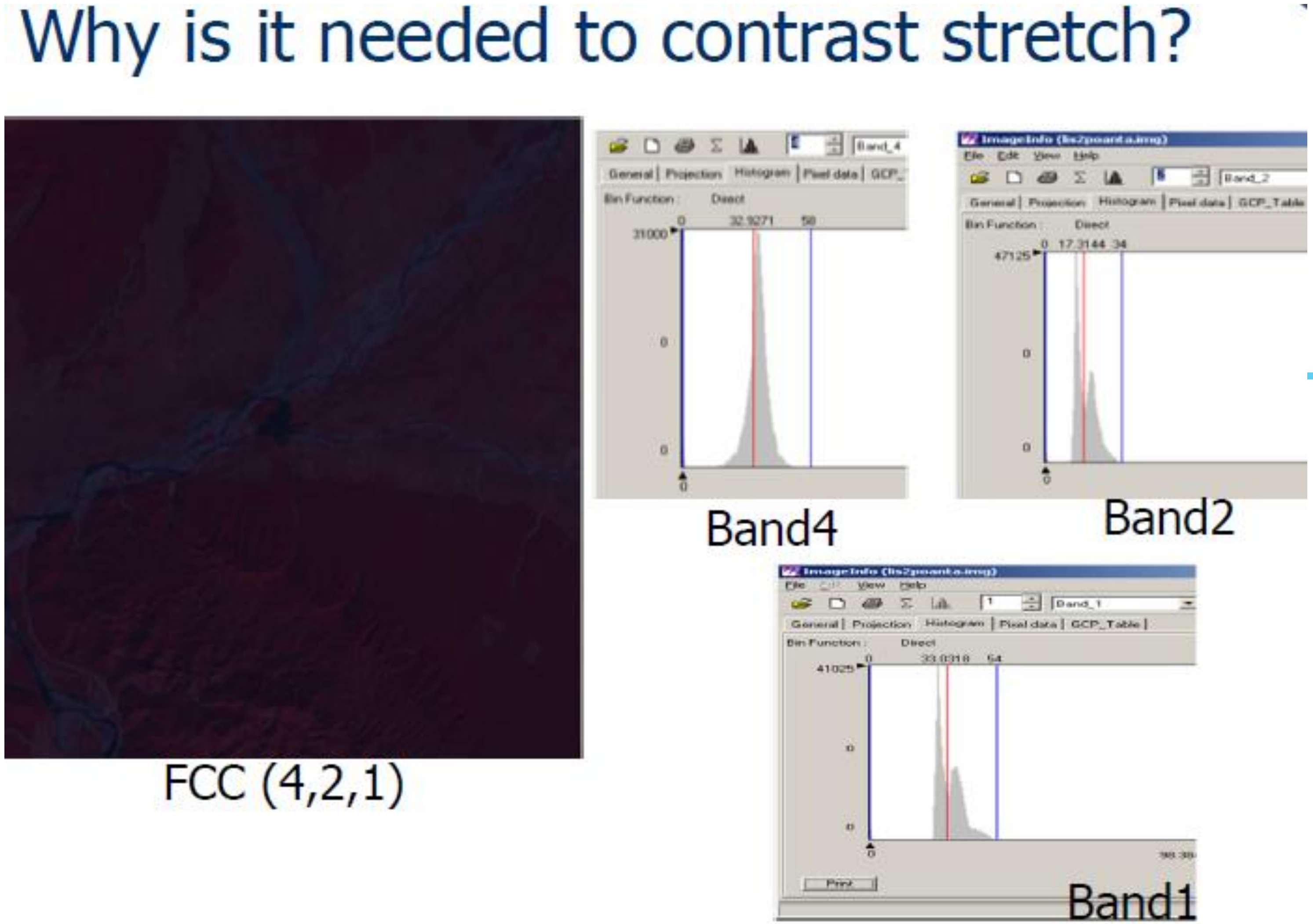
- **Point Operations (**Contrast enhancement, histogram equalization etc)
  - Modification of brightness values of each pixel in an image data set independently. (Radiometric enhancement**)**
  - Brings out contrast in the image
- **Local operations** (Filtering techniques)
  - Modification of pixel values based on the values of surrounding pixels. (spatial enhancement)
- **Image Transformations (Ratioing, PCA, Image merging etc)**
  - Enhancing images by transforming the values of each pixel on a multiband basis (spectral enhancement)

CONTRAST

- • Amount of difference between average gray level of an object and that of surroundings
- • Difference in illumination or grey level values in an image or
- • Intuitively, how vivid or washed-out an image appears
- • Ratio of Maximum Intensity to Minimum Intensity
- • Larger the ratio more easy it is to interpret the image

$$\mathrm{CON} = BV\,\mathrm{Max} \,/\, BV\mathrm{Min}$$

- Reasons for Low Contrast
  - • Scene itself has low contrast ratio
  - • Sensitivity of Detectors
  - • Atmospheric Scattering



The key to understanding contrast enhancements is to understand the concept of an **image histogram**.

A histogram is a graphical representation of the brightness values that comprise an image. The brightness values (i.e. 0-255) are displayed along the x-axis of the graph. The frequency of occurrence of each of these values in the image is shown on the y-axis.

Contrast Enhancement

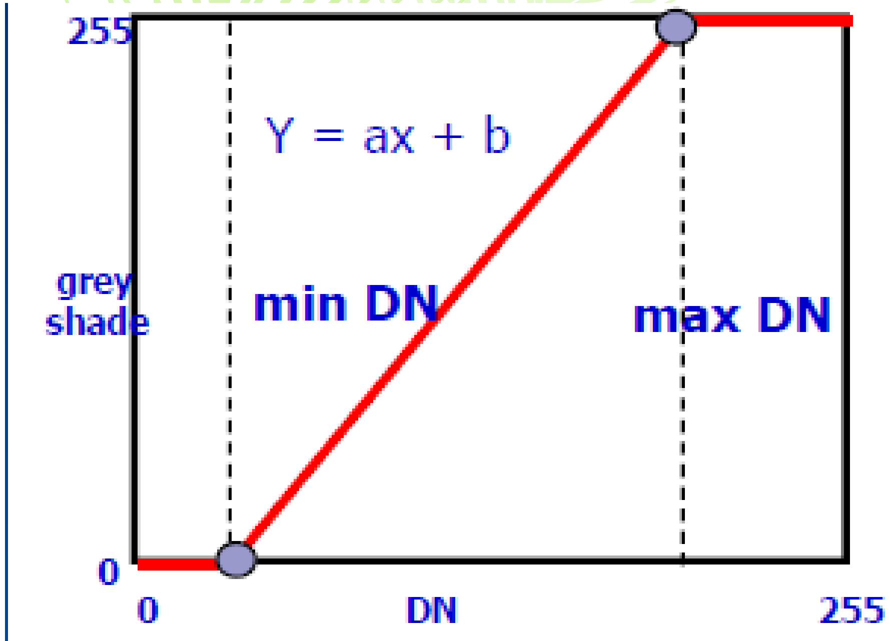
- **Expands the original input values to make use of the total range of the sensitivity of the display device.**
- The density values in a scene are literally pulled farther apart, that is, expanded over a greater range.
- The effect is to increase the visual contrast between two areas of different uniform densities.
- This enables the analyst to discriminate easily between areas initially having a small difference in density.

Types

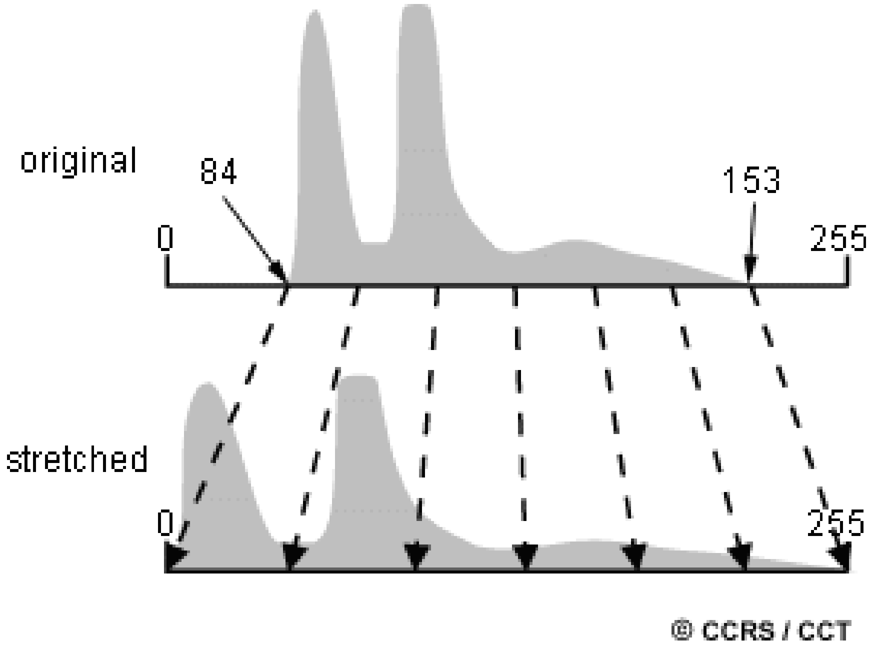
- Linear - Input and Output Data Values follow a linear relationship
- Non Linear- Input and output are related via a transformation function Y = ƒ(x)

Linear Contrast Stretch

- A DN in the low range of the original histogram is assigned to extreme black, and a value at the high end is assigned to extreme white.
- The remaining pixel values are distributed linearly between these two extremes



Transfer Function Linear stretch



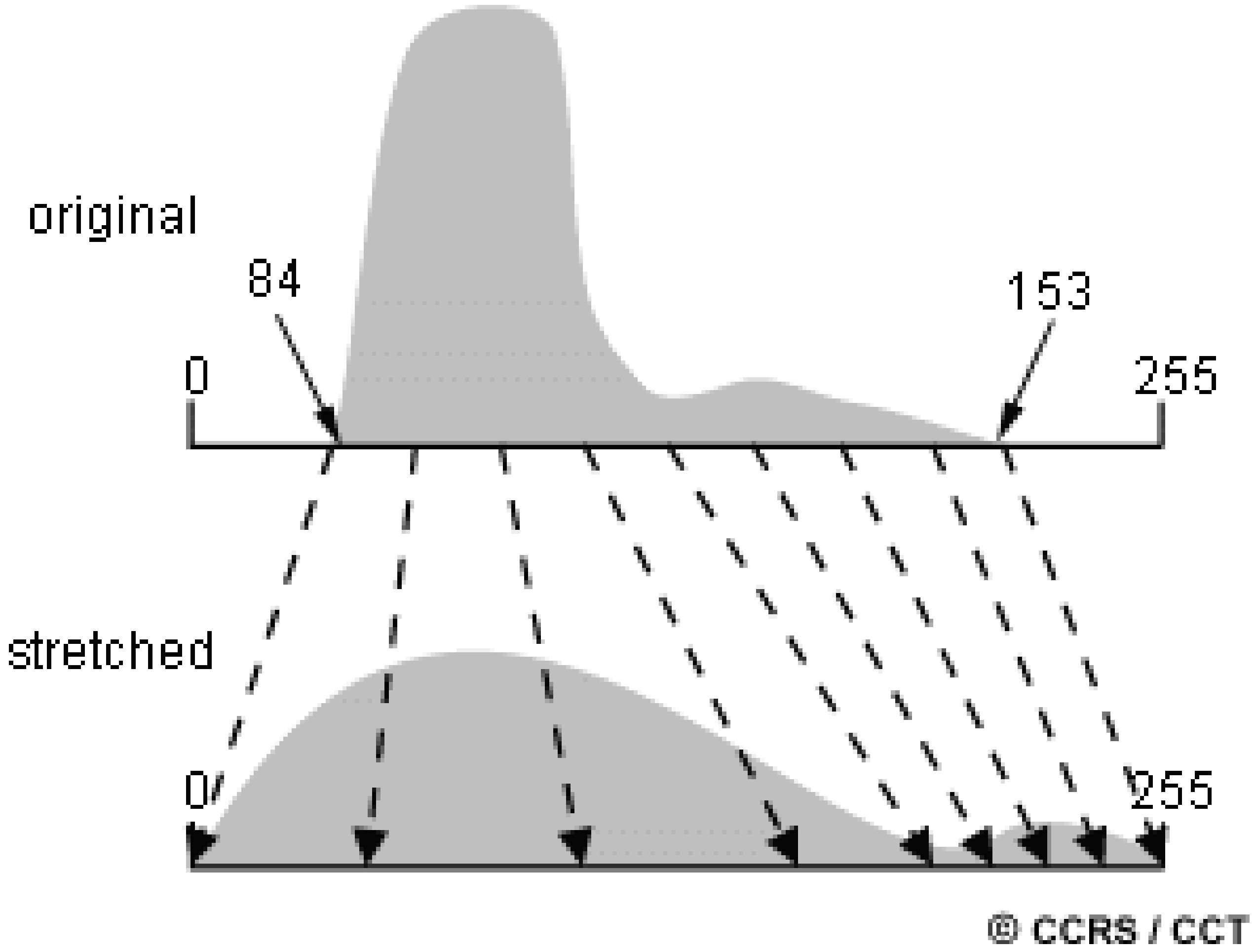
$$Y = (X - X_{min}) / X_{max} - X_{min}) * 255$$

Histogram Equalisation

- In this technique, histogram of the original image is redistributed to produce a uniform population density.
- This is obtained by grouping certain adjacent gray values.
- Thus the number of gray levels in the enhance image is less than the number of gray levels in the original image.
- Contrast is increased at the most populated range of brightness values of the histogram (or "peaks").
- It automatically reduces the contrast in very light or dark parts of the image associated with the tails of a normally distributed histogram.

It assigns more display values (range) to the frequently occurring portions of the histogram.
In this way, the detail in these areas will be better enhanced relative to those areas of the original histogram where values occur less frequently.

In other cases, it may be desirable to enhance the contrast in only a specific portion of the histogram.

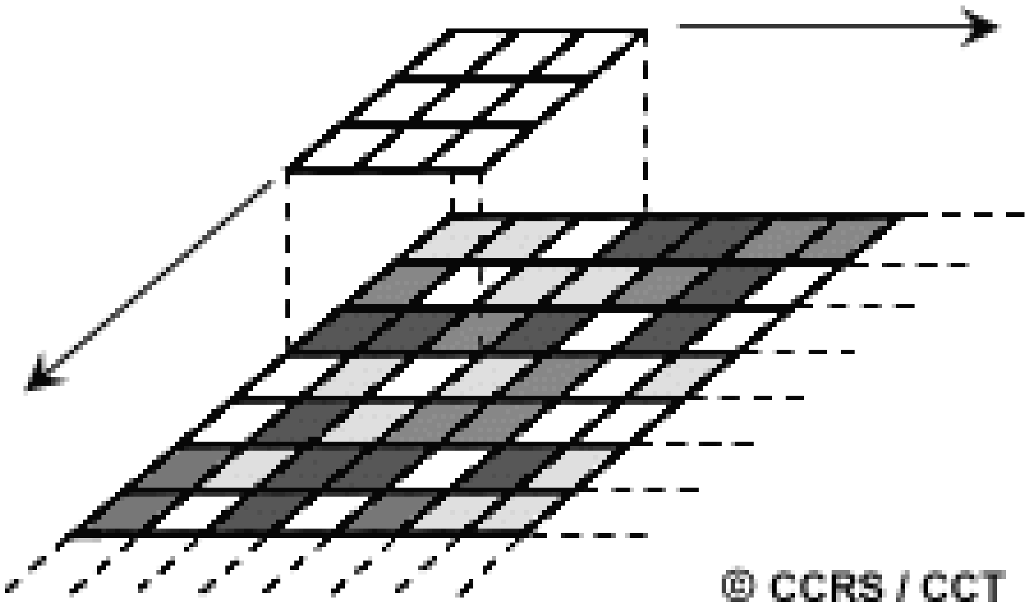


Local Operations

- Pixel value is modified based on the values surrounding it.
- Spatial Filtering - is the process of dividing the image into its constituent spatial frequencies, and selectively altering certain spatial frequencies to emphasize some image features.
- Process of suppressing (de-emphasizing) certain frequencies & passing (emphasizing) others.
- This technique increases the analyst's ability to discriminate detail.
- used for enhancing certain features
- removal of noise.
- Smoothening of image

Spatial frequency is related to the concept of image texture. **"Rough" textured areas** of an image, where the changes in tone are abrupt over a small area, **have high spatial frequencies**, while "**smooth" areas** with little variation in tone over several pixels, **have low spatial frequencies.**

A common **filtering procedure** involves moving a 'window' of a few pixels in dimension (e.g. 3x3, 5x5,
the image, applying a mathematical calculation using the pixel values Under that window, and replacing the central pixel with the new value.



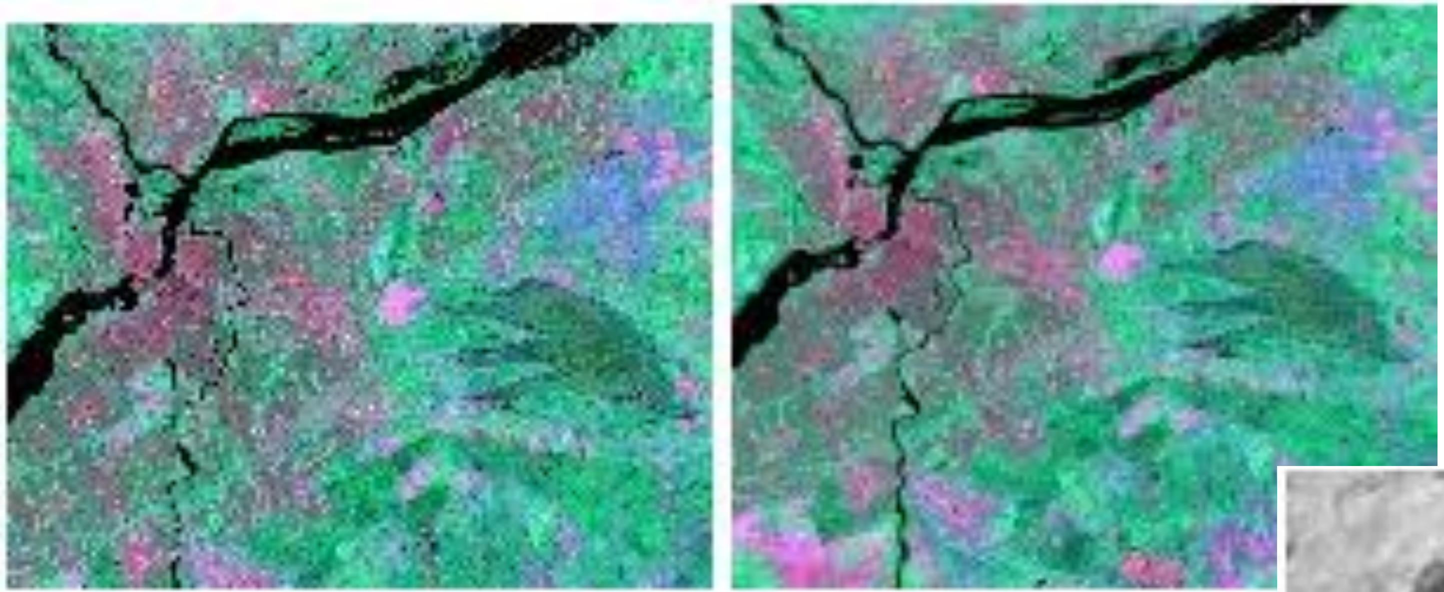
A **low-pass filter** is designed to emphasize larger, homogeneous areas of similar tone and reduce the smaller detail in an image. Thus, low-pass filters generally serve to smooth the appearance of an image. Average and median filters, often used for radar imagery are examples of low-pass filters.

High-pass filters do the opposite and serve to sharpen the appearance of fine detail in an image. One implementation of a high-pass filter first applies a low-pass filter to an image and then subtracts the result from the original, leaving behind only the high spatial frequency information.

Directional, or edge detection filters are designed to highlight linear features, such as roads or field boundaries. These filters can also be designed to enhance features which are oriented in specific directions. These filters are useful in applications such as geology, for the detection of linear geologic structures.

Filter Types

- ## Low Pass Filters
  - block high frequency details
  - has a smoothening effect on images.
  - Used for removal of noise
  - Removal of "salt & pepper" noise
  - Blurring of image especially at edges.
- ## High Pass Filters
  - Preserves high frequencies and Removes slowly varying components
  - Emphasizes fine details
  - Used for edge detection and enhancement
  - Edges - Locations where transition from one category to other occurs



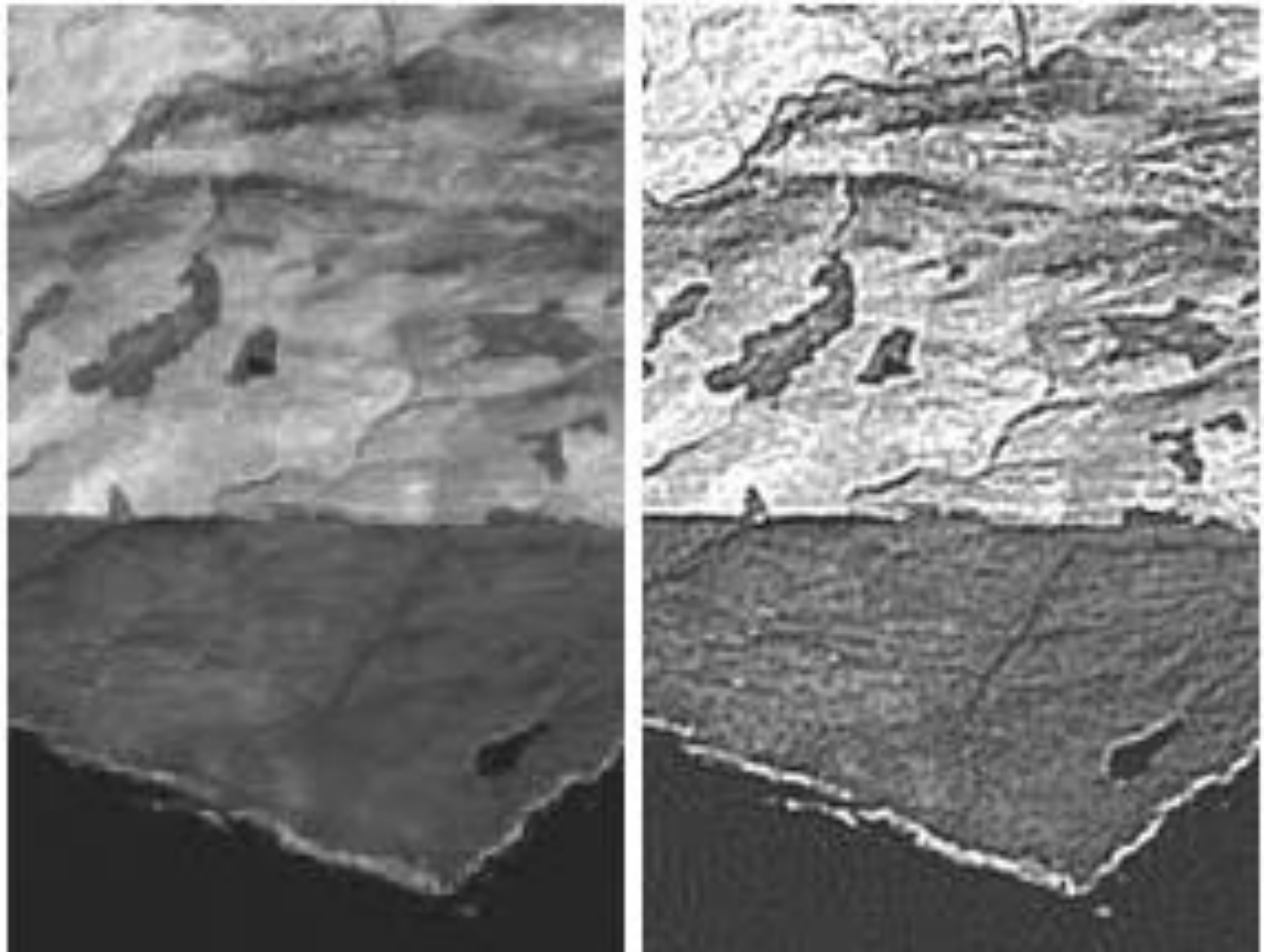


Image Transformation

- Image transformations typically involve the manipulation of multiple bands of data, whether from a single multispectral image or from two or more images of the same area acquired at different times (i.e. multitemporal image data).

- Either way, image transformations generate "new" images from two or more sources which highlight particular features or properties of interest, better than the original input images

Image Division/spectral ratioing

- The most common transforms applied to image data.
- On a pixel-by-pixel basis carry out the following operation
  - Band1/Band2 = New band
  - Resultant data are then rescaled to fill the range of display device
- Very popular technique, commonly called **'Band Ratio'**

Mathematically $BV_{i,j,r} = BV_{i,j,k} / BV_{i,j,l}$

Where

$BV_{i,j,k}$ Brightness value at the location line i, pixel j in k band of imagery

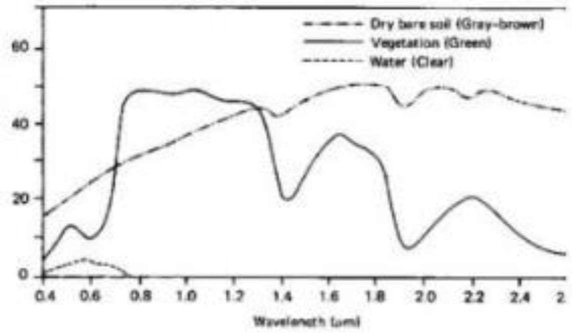
$BV_{i,j,l}$ Brightness value at the same location in band l

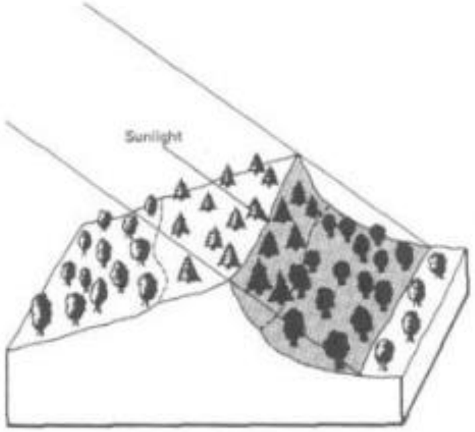
$BV_{i,j,r}$ Ratio value at the same location

(Note: If Denominator is 0 (zero) then Denominator BV is made 1)

Reasons / Application of Ratios

- Undesirable effects on recorded radiances (e.g. variable illumination) caused by variations in topography.
  - Sometimes differences in BV's from identical surface material are caused by topographic slope and aspect, shadows or seasonal changes
  - These conditions hamper the ability of an interpreter to correctly identify surface material or land use in a remotely sensed image.
- Ratio transformations can be used to reduce the effects of such environmental conditions





To reduce topographic effect

Landcover/ Illumination	Digital Number		Ratio
	Band A	Band B	
Decidous			
Sunlit	48	50	.96
Shadow	18	19	.95
Coniferous			
Sunlit	31	45	.69
Shadow	11	16	.69

Principal Component Analysis (PCA)

- Different bands of multispectral data are often highly correlated and thus contain similar information.

- We need to Transforms the original satellite bands into new “bands” that express the greatest amount of variance (information) from the feature space of the original bands

- PCA is accomplished by a linear transformation of variables that corresponds to a translation and rotation of the original coordinate system.

IMAGE FUSION/Image merging

- Most of the sensors operate in two modes: multispectral mode and the panchromatic mode.
- The panchromatic mode corresponds to the observation over a broad spectral band (similar to a typical black and white photograph) and
- the multispectral (color) mode corresponds to the observation in a number of relatively narrower band.
- Usually the multispectral mode has a better **spectral resolution** than the panchromatic mode.
- Most of the satellite sensors are such that the panchromatic mode has a better **spatial resolution** than the multispectral mode,
- Better is the spatial resolution, more detailed information about a landuse is present in the imagery
- **To combine the advantages of spatial and spectral resolutions of two different sensors, image fusion techniques are applied**

Panchromatic Image - 1 m spatial resolution, IKONOS

Multispectral Image - 4 m spatial resolution, IKONOS

Merged PAN+ Multispectral

Multi-temporal data merging

- Same area but different dates → composites → visual interpretation
  - e.g. agricultural crop
    - *NDVI from Landsat-7 ETM+*
      - March 7 → blue
      - April 24 → green
      - October 15 → red
    - *GIS-derived wetland boundary → eliminate the interpretation of false positive areas*
  - Enhance the automated land cover classification
    - *Register all spectral bands from all dates into one master data set*
      - More data for classification
      - Principal components analysis → reduce the dimensionality → manipulate, store, classify,

Multi-sensor image merging

- Multi-sensor image merging
  - IHS multisensor image merger of SPOT HRV, landsat TM and digital orthophoto data
- Multi-spectral scanner + radar image data

Supervised classification

Unsupervised classification

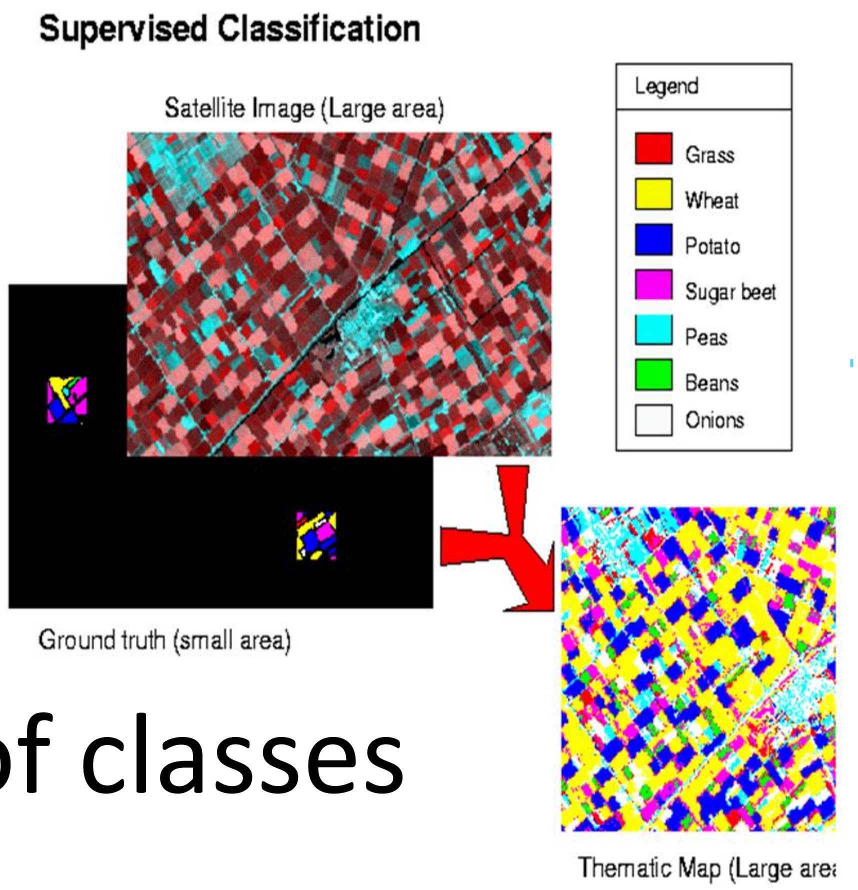
IMAGE CLASSIFICATION

Why classify?

- **Make sense of a landscape**
  - **Place landscape into categories (classes)**
    - ***Forest, Agriculture, Water, etc***
- **Classification scheme = structure of classes**
  - **Depends on needs of users**

What is Digital Image Classification

- Grouping of similar pixels
- Separation of dissimilar ones
- Assigning class label to pixels
- Resulting in manageable size of classes



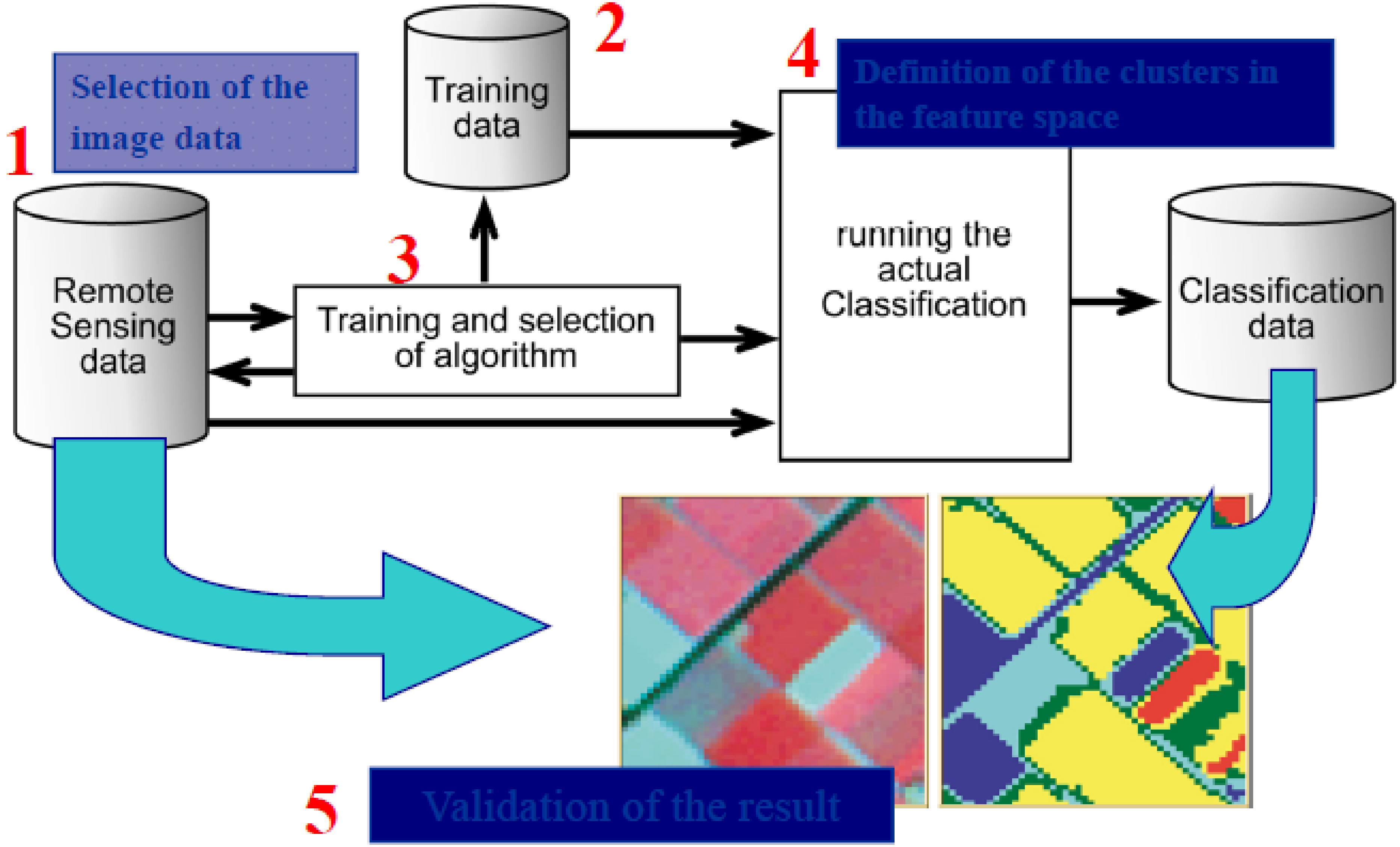
A human analyst attempting to classify features in an image uses the elements of visual interpretation to identify homogeneous groups of pixels which represent various features or land cover classes of interest.

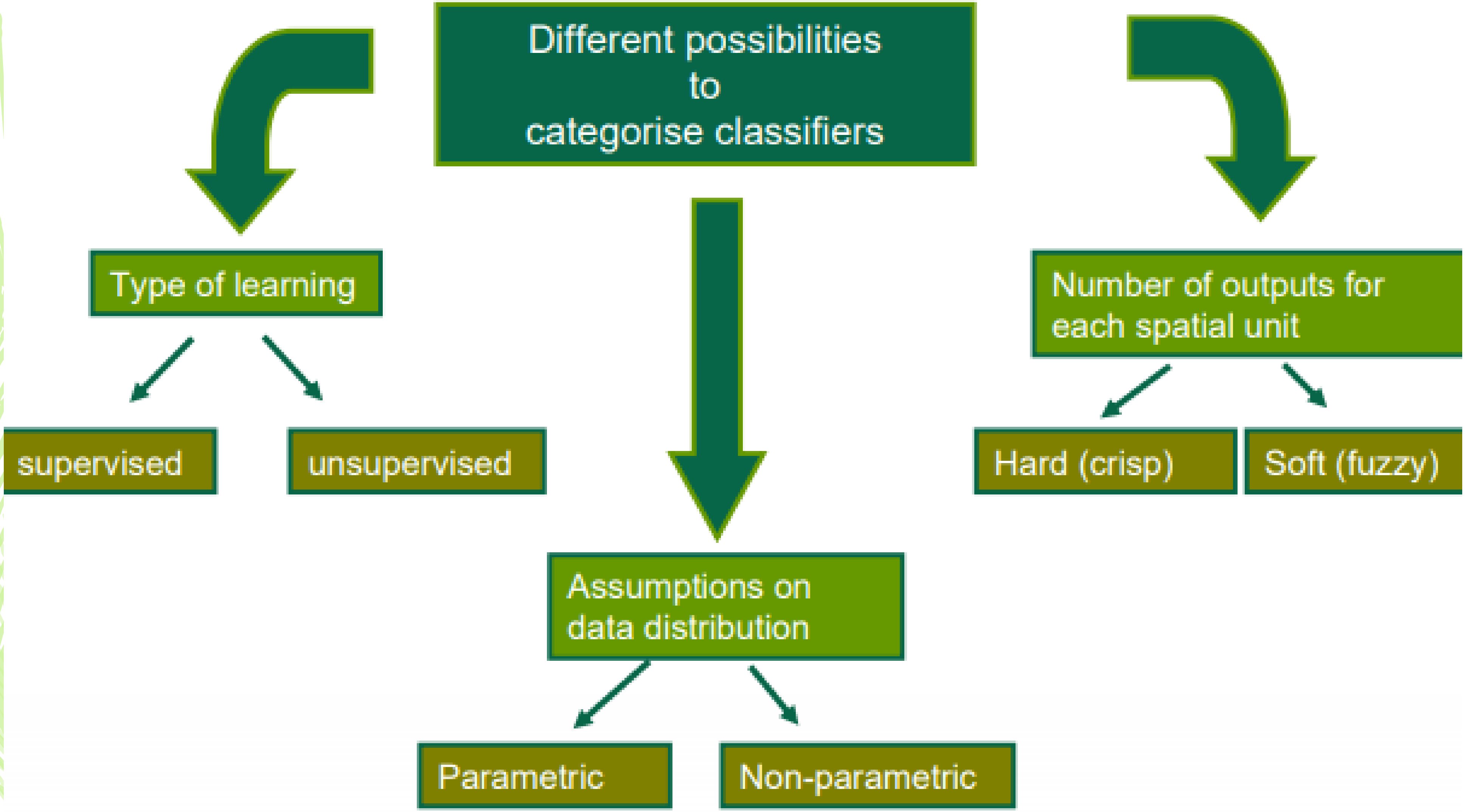
Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information.

In either case, the objective is to assign all pixels in the image to particular classes or themes (e.g. water, coniferous forest, deciduous forest, corn, wheat, etc.).

The resulting classified image is comprised of a mosaic of pixels, each of which belong to a particular theme, and is essentially a thematic "map" of the original image.

Image classification process




Different possibilities
to
categorise classifiers
Type of learning
supervised
unsupervised
Assumptions on
data distribution
Parametric
Non-parametric
Number of outputs for
each spatial unit
Hard (crisp)
Soft (fuzzy)

SUPERVISED CLASSIFICATION :

- The identity and location of some of the land cover types such as urban, agriculture, wetland are known a priori through a combination of field work and experience.
- The analyst attempts to locate specific sites in the remotely sensed data that represent homogenous examples of these known land cover types known as **training sites**.
- Multivariate statistical parameters are calculated for these training sites.
- Every pixel both inside and outside the training sites is evaluated and assigned to the class of which it has the highest likelihood of being a member.

SUPERVISED CLASSIFICATION

- In supervised training, you rely on your own pattern recognition skills and a priori knowledge of the data to help the system determine the statistical criteria (signatures) for data classification.

- To select reliable samples, you should know some information—either spatial or spectral— about the pixels that you want to classify.

In a **supervised classification**, the analyst identifies in the imagery homogeneous representative samples of the different surface cover types (information classes) of interest.
These samples are referred to as **training areas**. The selection of appropriate training areas is based on the analyst's familiarity with the geographical area and their knowledge of the actual surface cover types present in the image. Thus, the analyst is "supervising" the categorization of a set of specific classes.

The numerical information in all spectral bands for the pixels comprising these areas are used to "train" the computer to recognize spectrally similar areas for each class.

The computer uses an algorithm, to determine the numerical "signatures" for each training class. Once the computer has determined the signatures for each class, each pixel in the image is compared to these signatures and labeled as the class it most closely "resembles" digitally.

Thus, in a supervised classification we are first identifying the information classes which are then used to determine the spectral classes which represent them.

Training Samples and Feature Space Objects

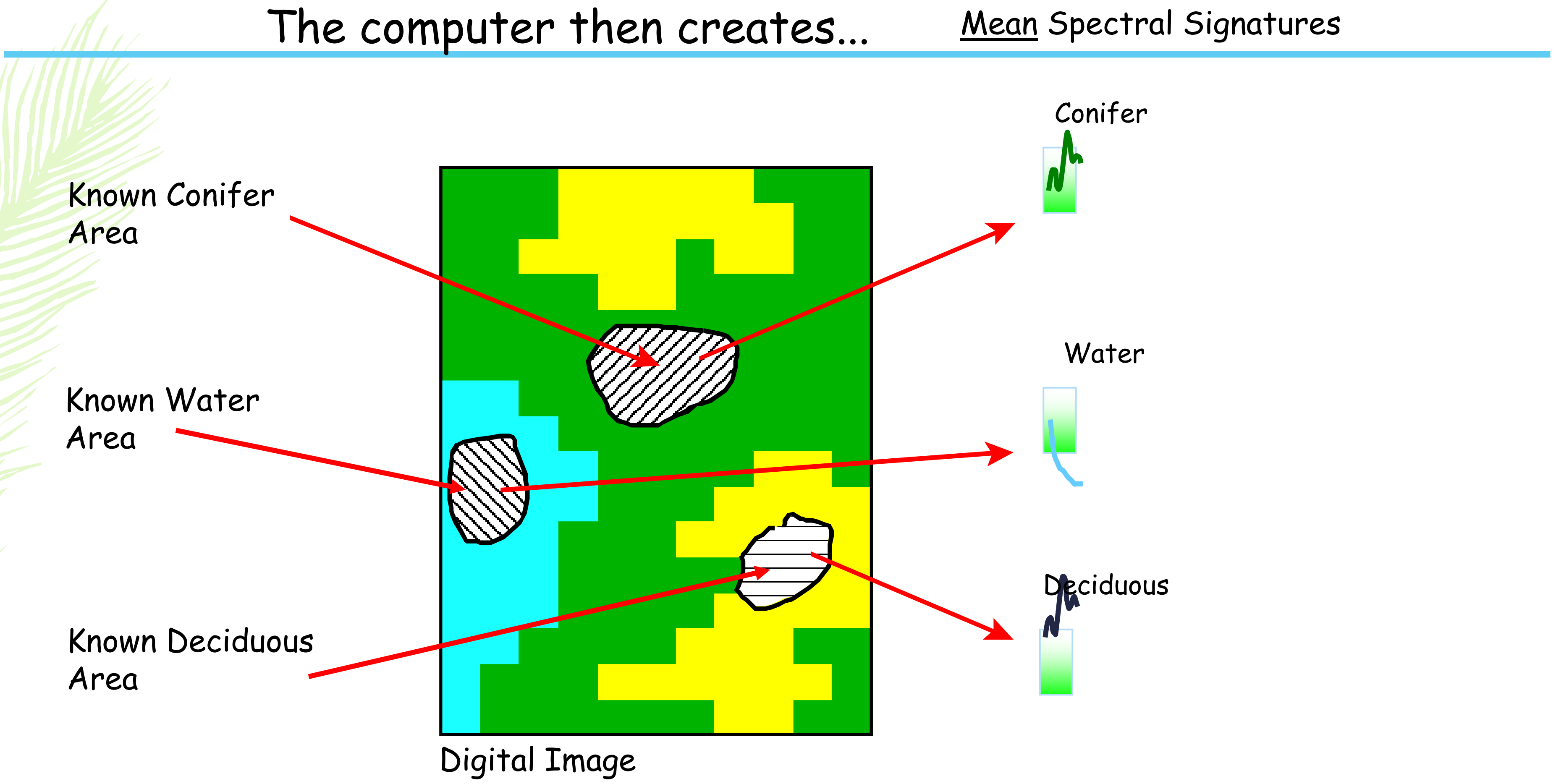
- Training samples (also called samples) are sets of pixels that represent what is recognized as a discernible pattern, or potential class.
- The system calculates statistics from the sample pixels to create a parametric signature for the class.

Selecting Training Samples

- Training data for a class should be collected from homogeneous environment.
- if training data is being collected from n bands then >10n pixels of training data is to be collected for each class.

Supervised Classification

Supervised classification requires the analyst to select training areas where he/she knows what is on the ground and then digitize a polygon within that area…



SUPERVISED CLASSIFICATION.

Classification stage

Scatter plot using two band data for the training area training data set.

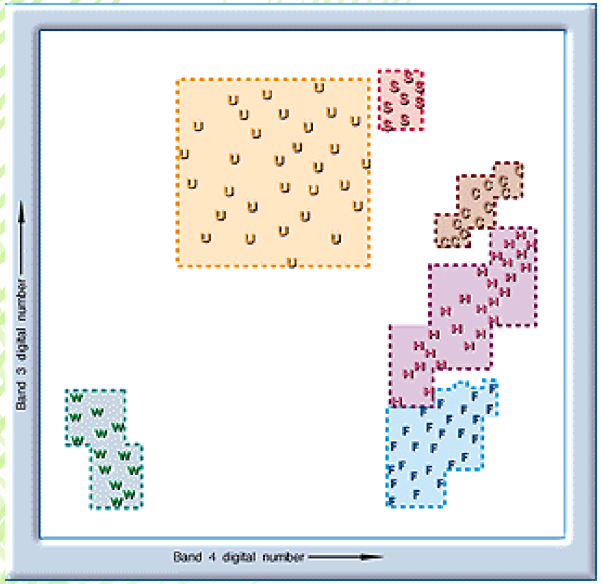
TYPES

Minimum Distance to Mean Classifier

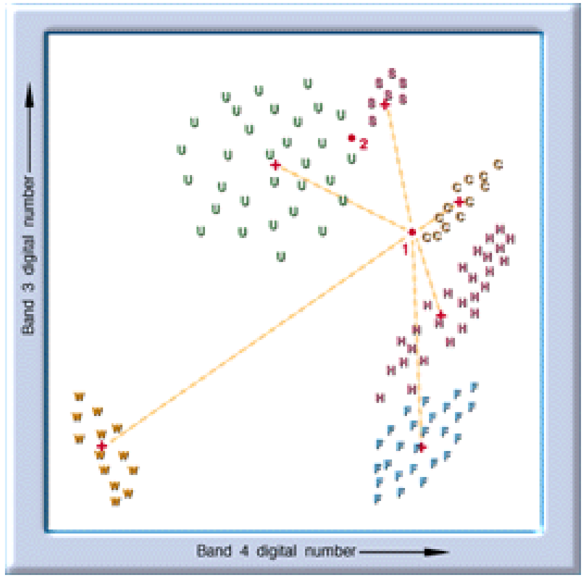
Parallelepiped Classifier

Gaussian Maximum Likelihood Classifier

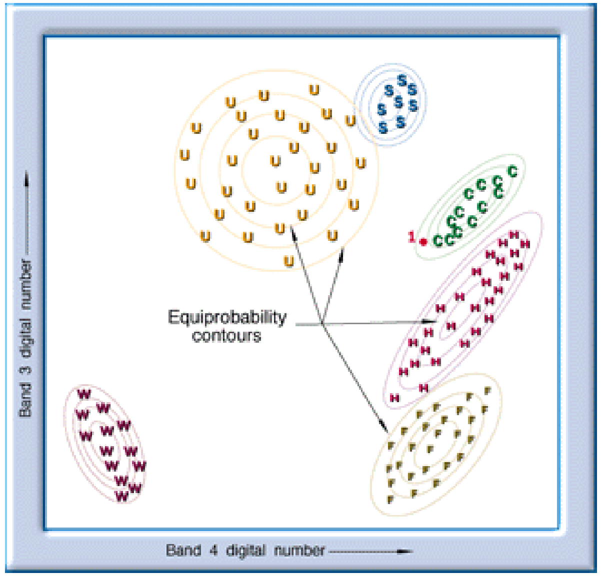
Decision Rules
in Spectral Feature Space



Parallelpiped



Minimum Distance to Means



Maximum Likelihood (Discriminant Analysis

Minimum Distance & Maximum Classifier

Training set scatter plot

Mean DN Calculation for each class and plot.

Find the distances from unknown pixel to all mean values.

Minimum Distance class/category is assigned to unknown pixel.

Advantages & Disadvantages in MD & MC

Mathematically simple & computationally efficient.

Insensitive to different degrees of variance in the spectral response data

So not widely used – where **spectral classes are close**.

Minimum Distance & Maximum Classifier

Training set scatter plot

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MAXIMUM LIKELIHOOD CLASSIFIER

Quantitative evaluation of variance and covariance

Assumption Training data set is normally distributed

Under this assumption - each category described by

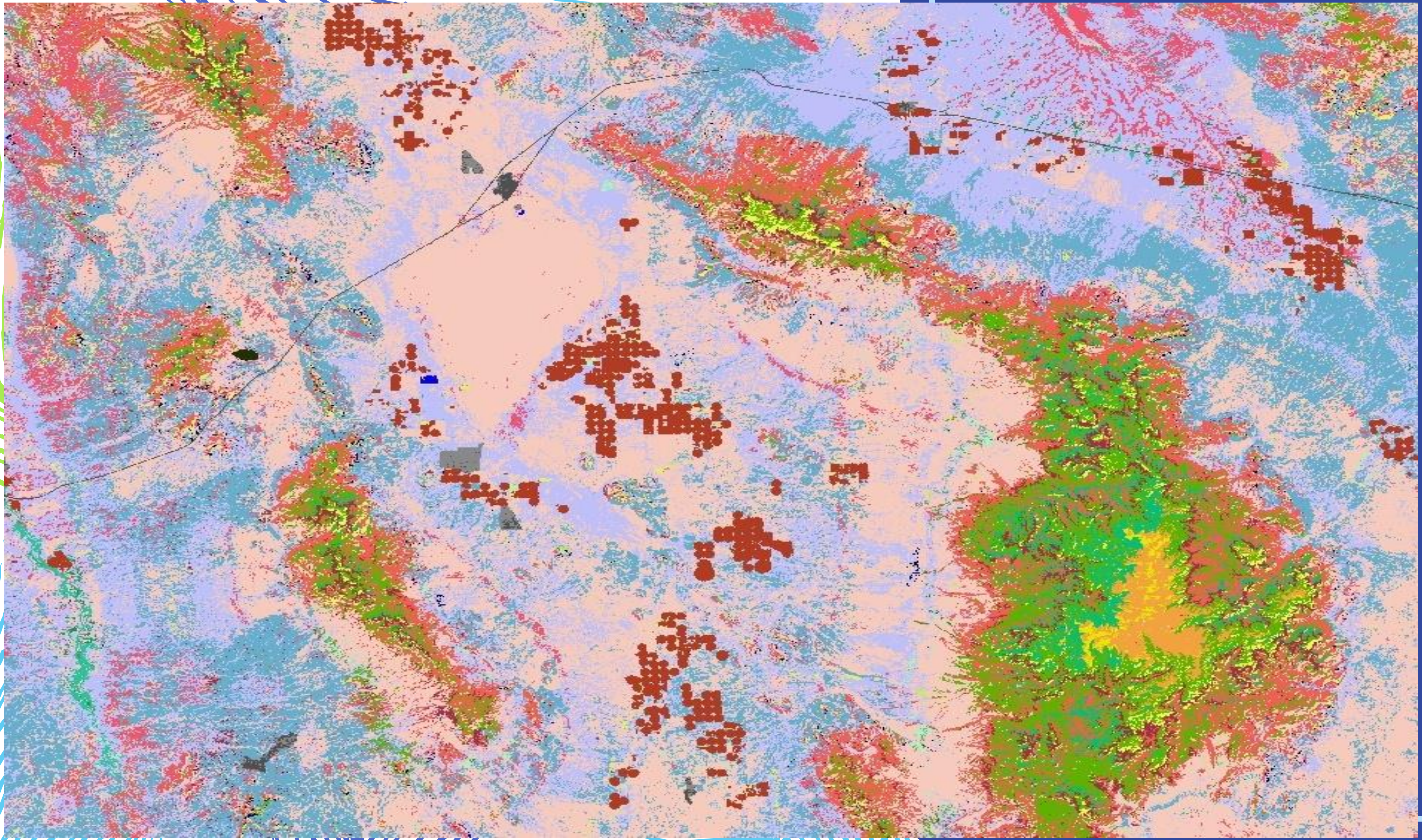
- **Mean Vector**
- **Covariance Vector**
- Computate – statistical probability

Three dimensional curve preparation

Band A DN
- Two Horizontal axis
Band B DN

Probability – Vertical Axis

Land Cover Classification



Defining the pieces that make up the puzzle

UNSUPERVISED CLASSIFICATION in essence reverses the supervised classification process.

Spectral classes are grouped first, based solely on the numerical information in the data, and are then matched by the analyst to information classes

Programs, called **clustering algorithms**, are used to determine the natural (statistical) groupings or structures in the data.

Usually, the analyst specifies how many groups or clusters are to be looked for in the data. In addition to specifying the desired number of classes, the analyst may also specify parameters related to the separation distance among the clusters and the variation within each cluster.

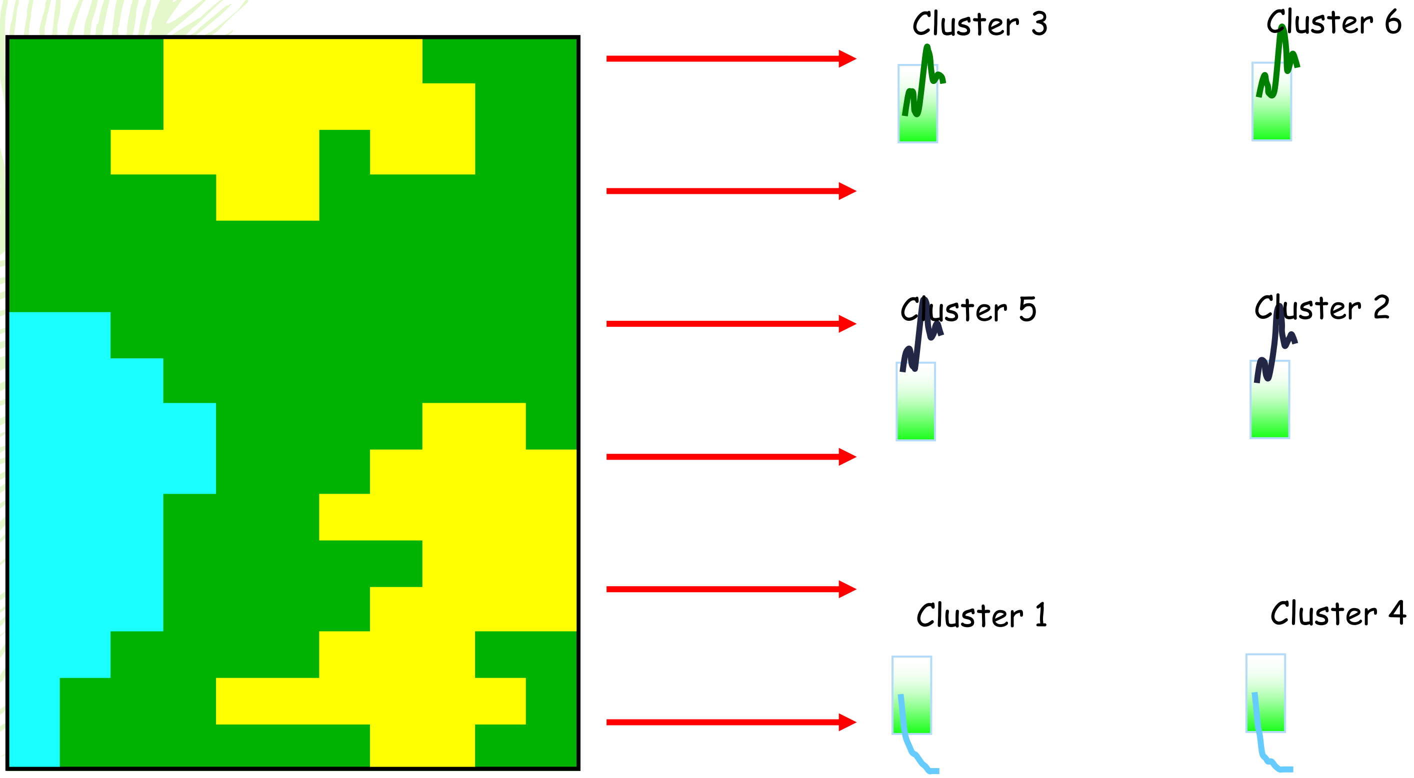
The final result of this iterative clustering process may result in some clusters that the analyst will want to subsequently combine, or clusters that should be broken down further - each of these requiring a further application of the clustering algorithm.

Thus, unsupervised classification is not completely without human intervention. However, it does not start with a pre-determined set of classes as in a supervised classification.

Unsupervised Classification

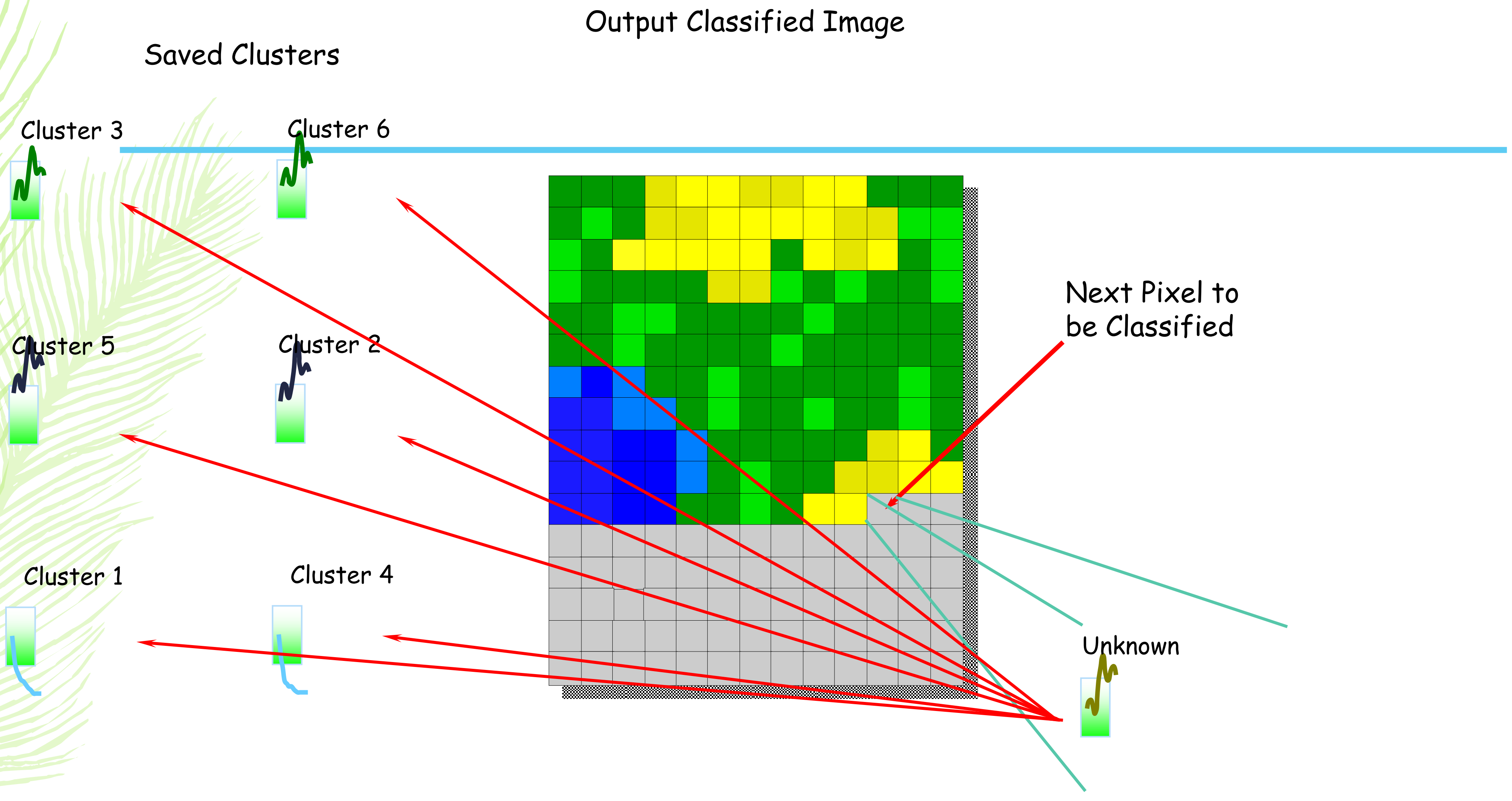
The analyst requests the computer to examine the image and extract a number of spectrally distinct clusters…

Spectrally Distinct Clusters



Digital Image

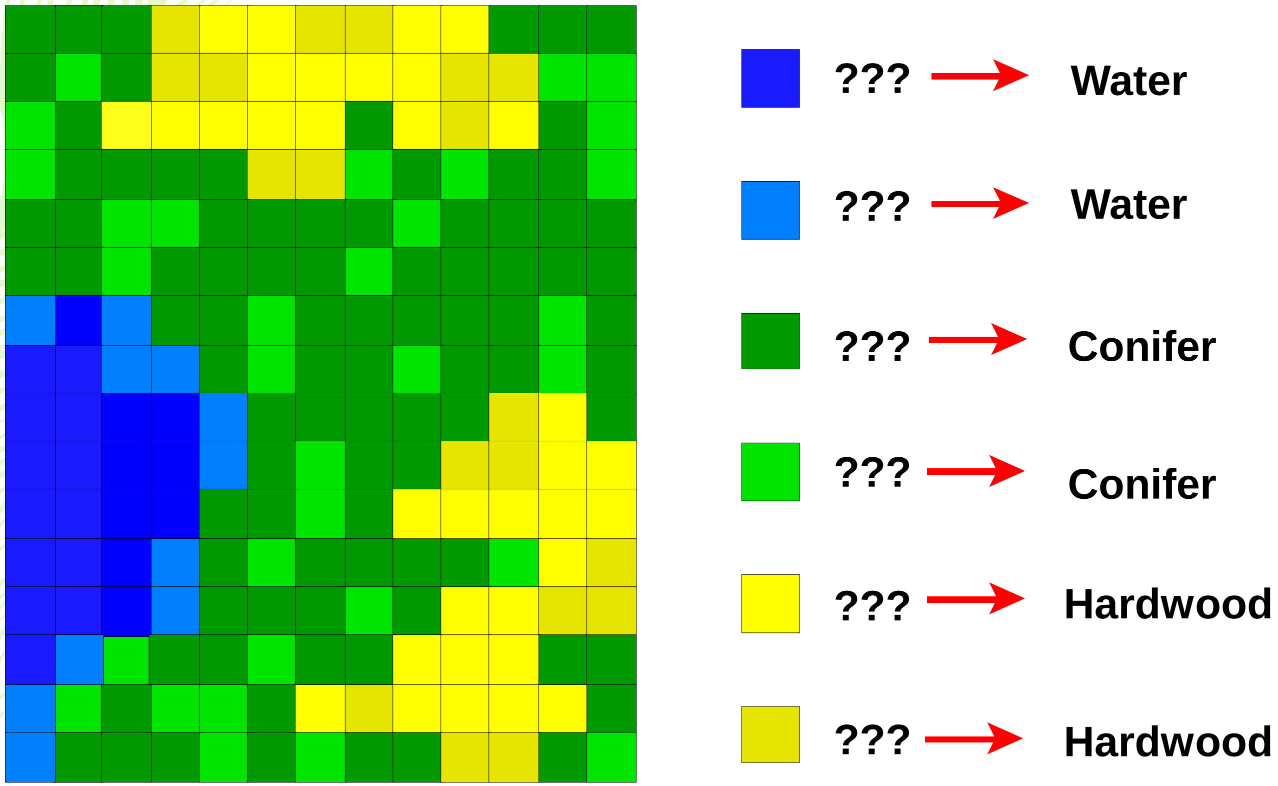
Unsupervised Classification



Unsupervised Classification

The result of the unsupervised classification is not yet information until…

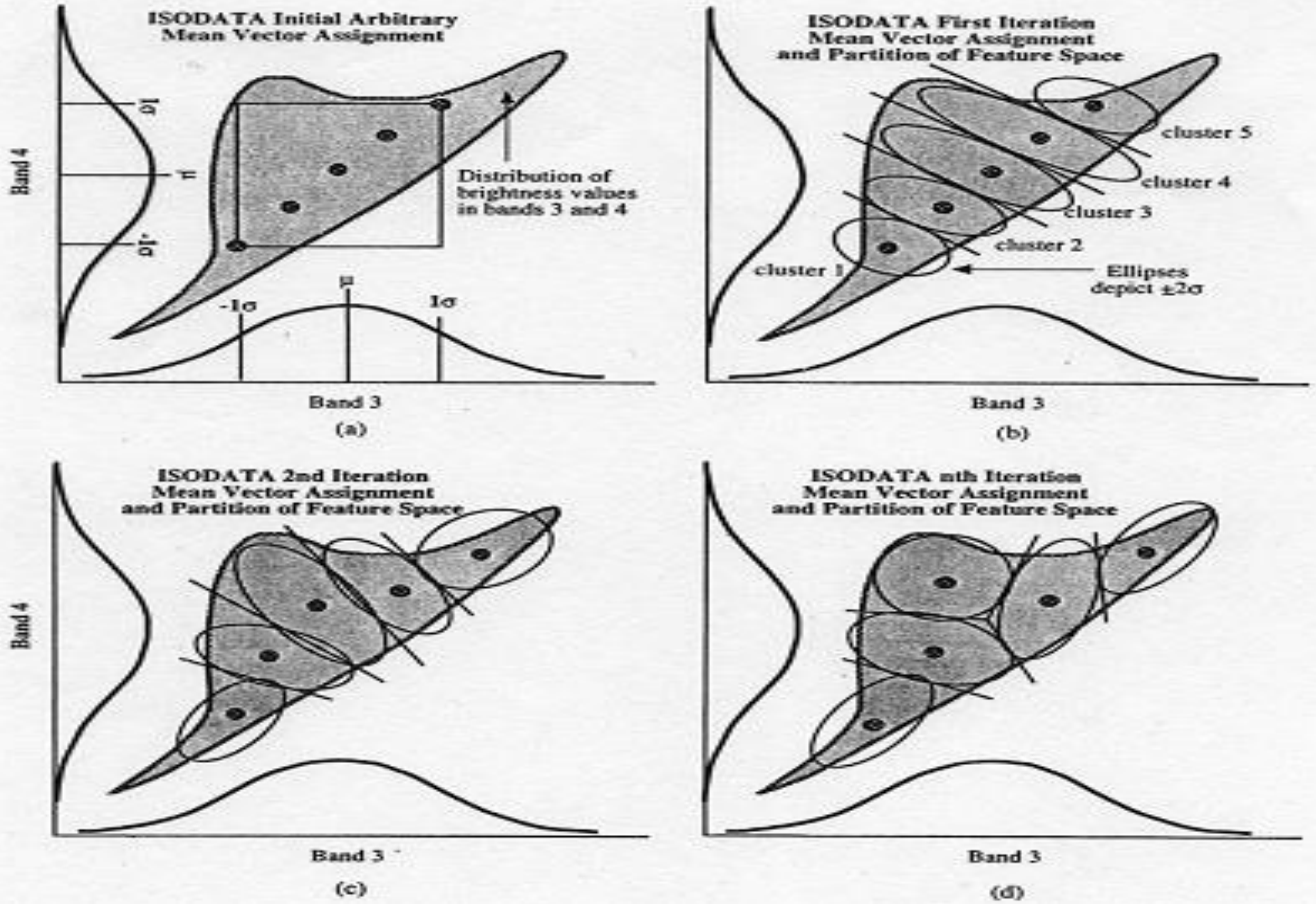
The analyst determines the ground cover for each of the clusters…



ISODATA Procedure

The Iterative Self-Organizing Data Analysis Technique (ISODATA) represents a comprehensive set of heuristic (rule of thumb) procedures that have been incorporated into an iterative classification algorithm.

- Aarbitrary cluster means are established,
- The image is classified using a minimum distance classifier
- A new mean for each cluster is calculated
- The image is classified again using the new cluster means
- Another new mean for each cluster is calculated
- The image is classified again...



ISODATA Initial Arbitrary Mean Vector Assignment
Band 4
1σ
μ
-1σ
Distribution of brightness values in bands 3 and 4
-1σ
μ
1σ
Band 3
(a)
ISODATA First Iteration Mean Vector Assignment and Partition of Feature Space
cluster 5
cluster 4
cluster 3
cluster 2
cluster 1
Ellipses depict ±2σ
Band 3
(b)
ISODATA 2nd Iteration Mean Vector Assignment and Partition of Feature Space
Band 4
Band 3
(c)
ISODATA nth Iteration Mean Vector Assignment and Partition of Feature Space
Band 3
(d)

Pattern recognition

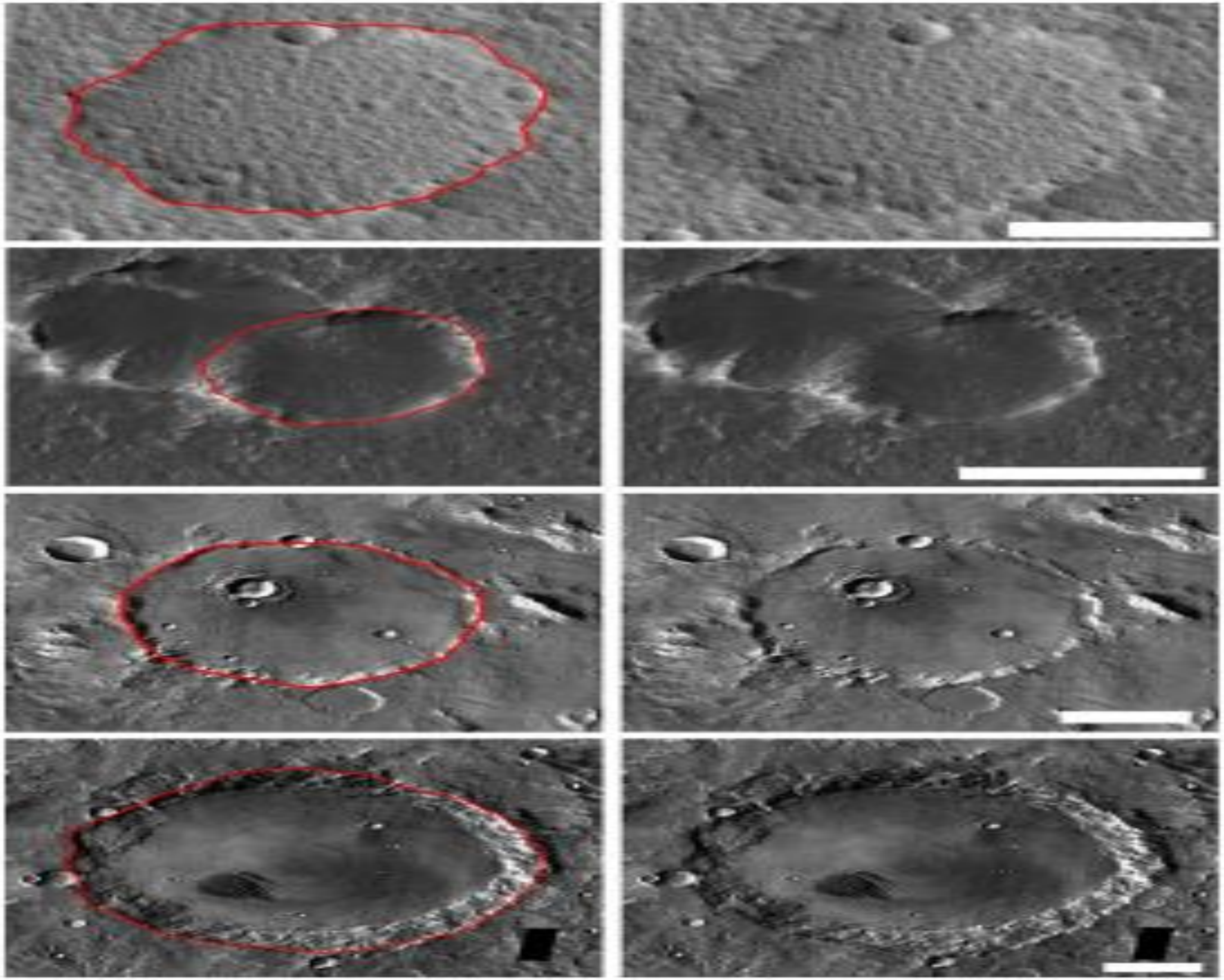
Change detection

Advantages

Pattern Recognition

- Change detection in an image sequence
  - Detecting abnormal patterns/shapes
  - Detecting changes in motion patterns
- Classification, retrieval, recognition
  - Faces, objects, activities, handwriting,…
- Shape analysis, matching
  - Learning statistical models for shapes of groups of points or of continuous contours, their dynamics over time
  - Matching: shape classification

Fig. 1. (a)(b)-Lunar image with craters



Shape Analysis: Shape is a geologically important characteristic of rocks. However, the shape of a rock is a complex property that can be difficult to describe precisely. A great deal of geological work has been conducted on classifying and categorizing the general appearance of microscopic particle grains with respect to various properties [1-5], and the same basic concepts remain applicable when scaled to the macroscopic realm of Martian rocks. In particular, the concepts of sphericity and angularity provide indicative measures of a rock's shape that could be used by a rover to obtain valuable information about the specimen's geologic origins and history [7].

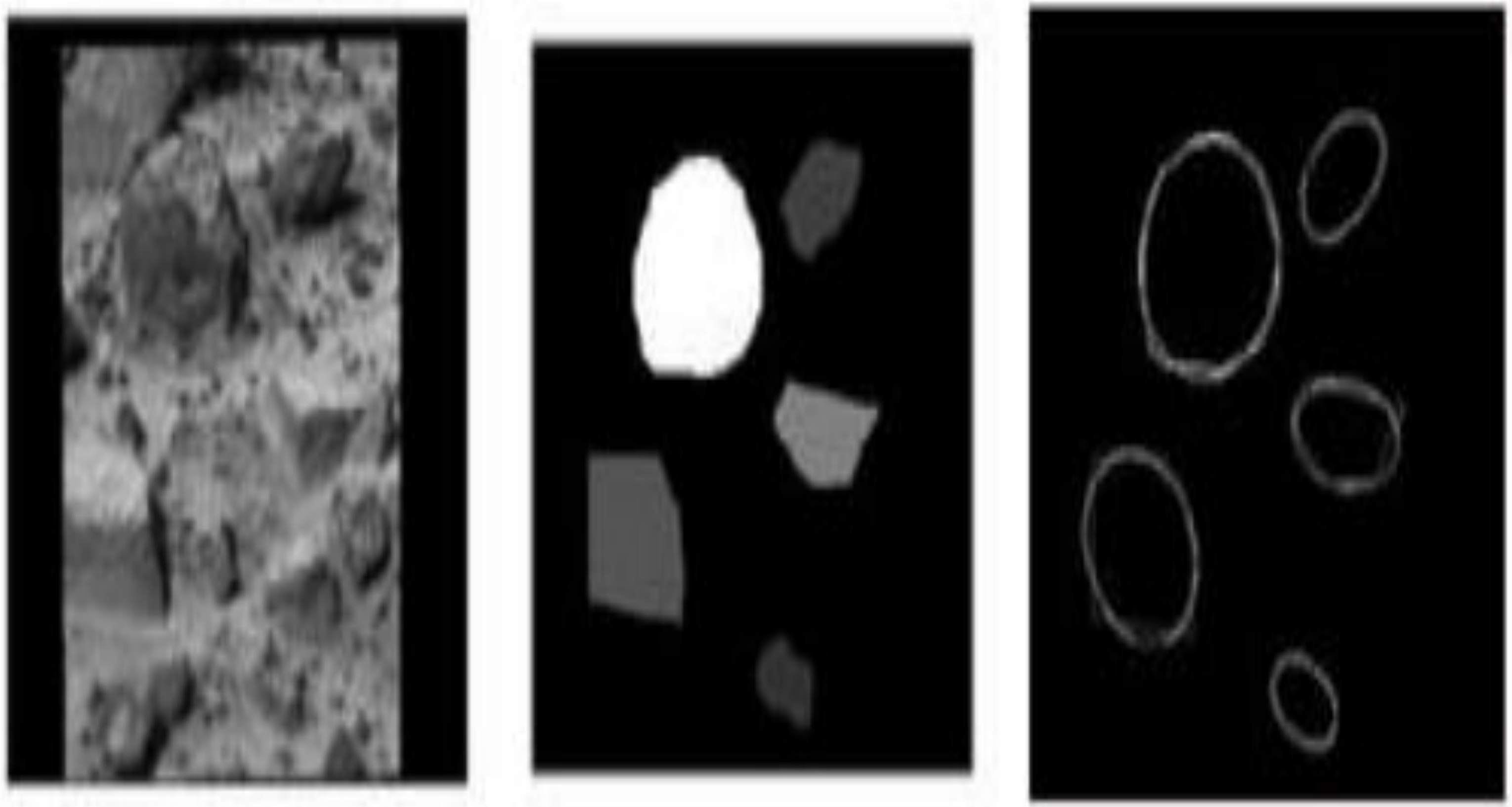


Figure 1 a) Original image taken from the Mars Pathfinder landing site, b) rocks identified from image, c) ellipses fitted to rock outlines.

c. Change detection

- involves use of multitemporal images to discriminate land cover change between dates
- can be short term change eg. flooding or vegetation ripening, or long term eg.urban growth or desertification or sea level change
- imagery should be comparable eg. same sensor, bands, spatial resolution, time of day
- anniversary dates minimise seasonal and sun angle differences
- accurate spatial registration of images important eg. 1/4 to 1/2 pixel

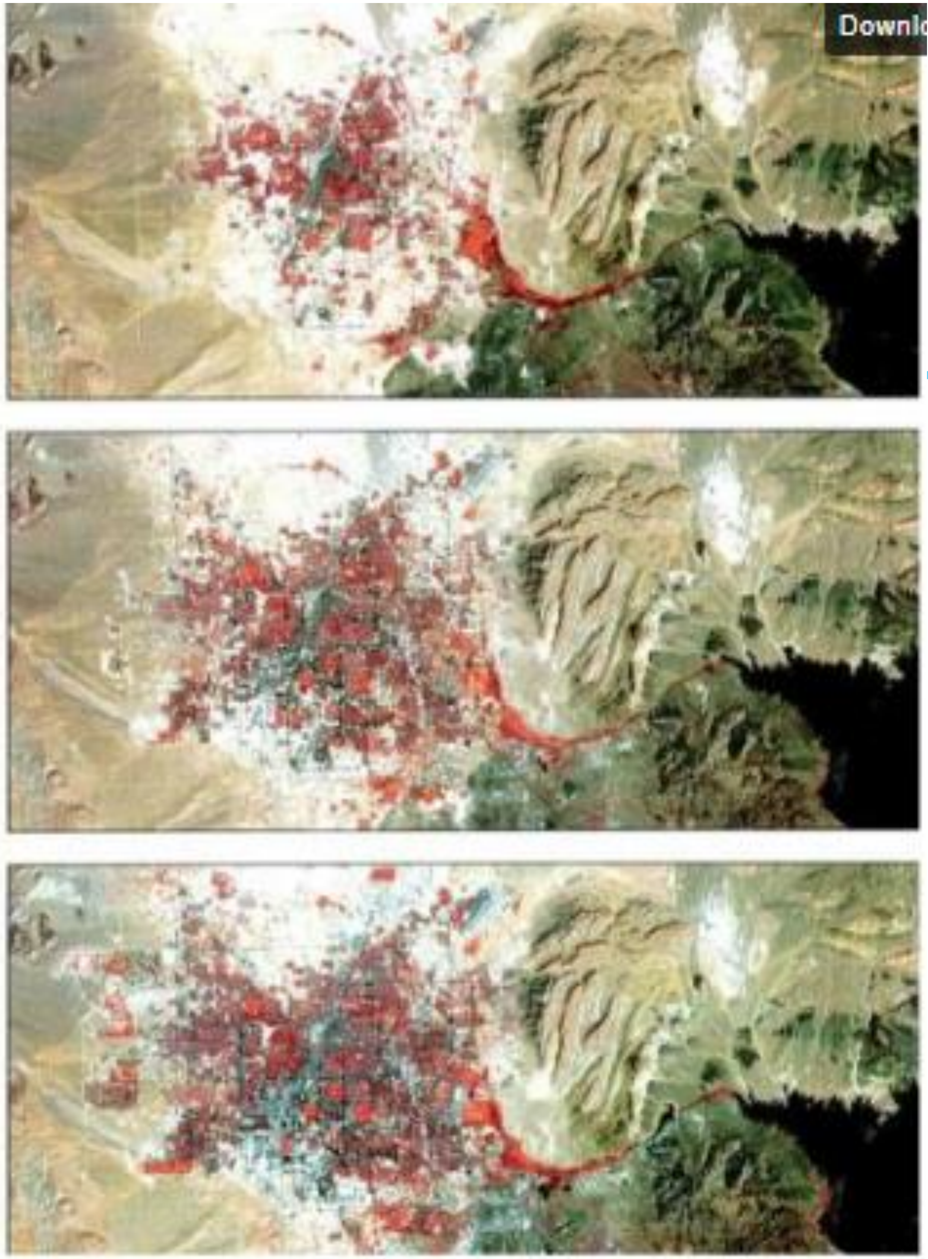
Change detection process

- two approaches -
  - postclassification comparison
  - temporal image differencing

1972

1986

1992

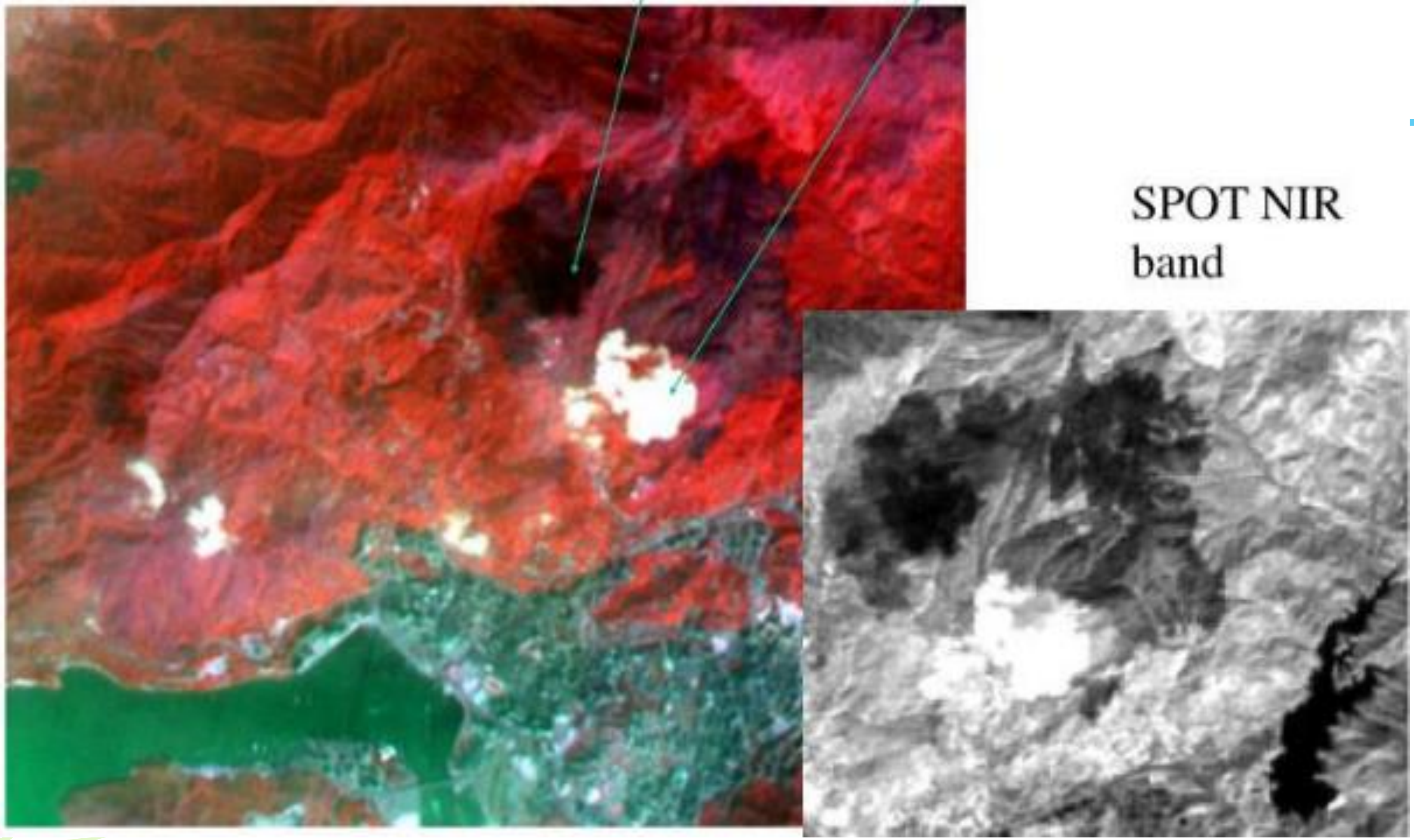


Temporal image differencing (single band)

- co-register images of different dates
- do atmospheric correction
- convert to radiance
- subtract image pixel values ⟶ change image
- no change - change image values near zero
- areas of change give larger negative or positive values
- possible values -255 to +255: rescale by +-, /2, +127
- determine threshold for change
- change will be within tails of histogram distribution

SPOT FCC image of Tai Mo Shan,

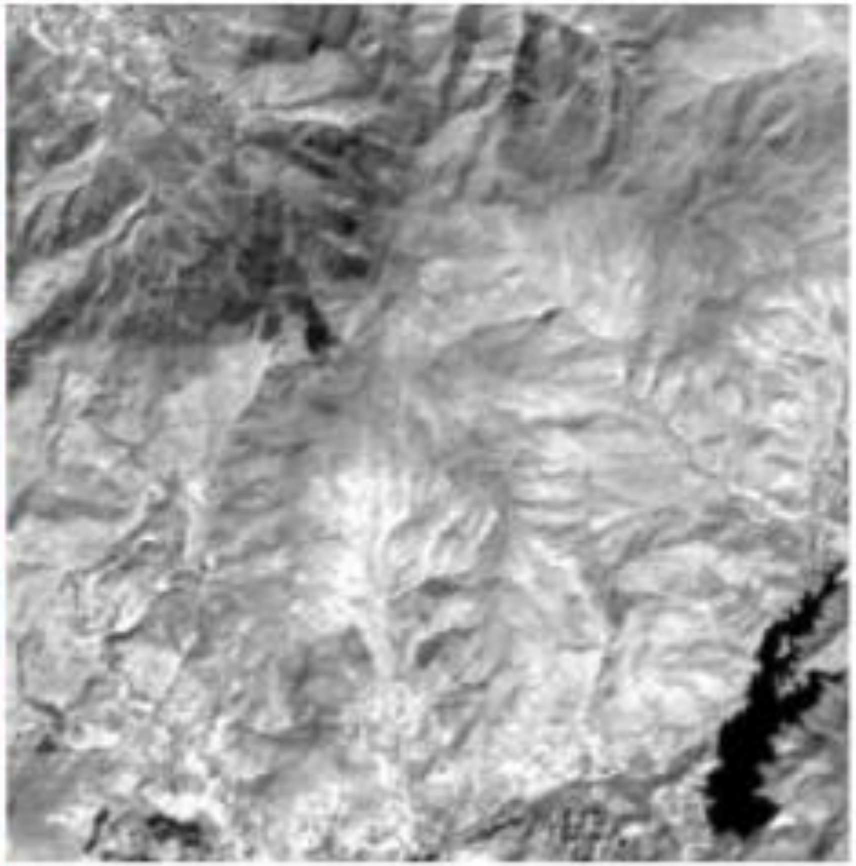
Dec, 1991 showing burn



SPOT NIR band

SPOT February 1995

NIR band



Increase in NIR reflectance over burne area from Dec 1991 to Feb.1995