Unit I
Basics of Remote Sensing

Session 7
Analogue Interpretation of Satellite Images

Department of Civil Engineering
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Session 7 – Analogue Interpretation of Satellite Images

Introduction

Elements of image interpretation are set out with details of simple analogue interpretation. We need to select different bands from the electromagnetic spectrum for different types of data to be observed and here the selection is discussed. Image analysis and the subsequent interpretation is discussed. matic analogic interpretation of satellite imagery.

Aim:

- To give an understanding of the multi-thematic analogic interpretation of satellite imagery

7.1 Elements of image interpretation

It is easy to interpret normal photographs. But there are certain reasons for the complex nature of image interpretation. The reasons are given by Campbell, 1990, as follows;

- Images are acquired from overhead (vertical or near vertical view)
- Electromagnetic wavelengths outside the visible spectrum are used in satellite imagery
- The Earth's surface is depicted at unfamiliar scales and resolutions

There are some basic characteristics with regard to the features, which are used for identification. The exact characteristics will depend on the application of course. But we can use a guideline of feature characteristics for normal interpretation purposes.

The basic feature characteristics used in **identification** are;

(i) Shape
(ii) Size
(iii) Pattern
(iv) Tone (or hue)
(v) Texture
(vi) Shadows
(vii) Site
(viii) Association
(ix) Resolution

Let us see what these are in brief.

(i) **Shape –** Refers to the general form, configuration or outline of features. In the case of stereoscopic images, the height also defines the shape. Similar objects have unique shape. Eg: buildings vs streets.

(ii) **Size –** Based on the scale of the photograph, the amount of space an object takes up. Size is used to distinguish objects with similar shapes from another. Eg. Houses vs barns. It is important to note the image scale when considering the size of the features.

(iii) **Pattern –** Refers to the spatial arrangement of the features. For example, you can recognize an agricultural plantation from forest due to the organised way in which the plants appear.

(iv) **Tone (or hue) –** is the relative brightness or colour of objects on an image. For example, tonal variations can be recognized on panchromatic (black & white) photographs or color variations (i.e. color images) taken on visible and infra- red wavelengths, of the same scene.

(v) **Texture –** is the frequency of tonal change on an image. Texture is a result of the aggregation of many factors. These factors can be shape, size, pattern, shadow and tone. Texture determines the overall visual 'smoothness' or 'coarseness' of image features. Very often you can distinguish between features giving similar reflectances based on their textural differences. (e.g. woods)

(vi) **Shadows –** Shadows can either 'aid' or 'hinder' the interpretation. When the outline of a shadow gives the profile view of the features, it aids in identification. But when the feature lies within a shadow and there is little or no reflectance from the feature, it hinders the identification.

(vii) **Site –** refers to the geographic location of the area under observation. This can be the latitude, longitude or its coordinates. The geography of the area will give the soil morphology and will often give a clue to the vegetation in the area.

(viii) **Association –** refers to the occurrence of certain features in relation to others.

(ix) **Resolution** – This can refer to spatial, radiometric, spectral and temporal resolution.

Other characteristics;

Height – The production of height or 'stereo' information can be achieved with cameras and line scanners through obtaining images of the same scene on repetitive passes. They can be of neighbouring orbits or of a forward-looking simple pass. Stereo pairs are also obtained by analysing the interferogram achieved from images with phase difference, on active microwave systems.

Scale - Image scale must be consistent with the application in hand. Small scales are sufficient for reconnaissance surveys and large scales are needed for detail surveys.

Table 7.1: Summary of feature characteristics of images

Characteristic	Relationship
Shape	Outline and dimension of features
Size	Depends on the image scale
Pattern	Tonal variations on the images indicating the spatial arrangement of features of interest
Tone: Colour, saturation Black & white; brightness	Brilliance or radiance of reflection
Texture	Arrangement of Tone within the image
Shadows	Can outline or obliterate features
Site	Gives geographic location information
Association/contrast	Tone relationship between the object & the surroundings
Height	Elevation effect
Resolution	Identification depends on spatial, radiometric, spectral and temporal resolution
Scale	Detailed identification depends on scale of the image

7.2 The image data

In this session, the data consists of satellite images.

The important question is 'How do we decide on the images depending in the application?'

Of course, we must first outline the project in hand and the observations to be made. We must understand what spectral, spatial, temporal and radiometric resolutions will be required for the application or study in hand. Do we need optical, thermal or microwave data?

To decide on the data, we must consider the following details with respect to the satellite orbit and the sensor system.

The details of the orbit will provide information on the spatial and temporal resolutions.
The orbit

- Is it polar orbiting and sun-synchronous or geostationary?
- Altitude
- Repeat cycle
- Scan width

The details of the sensor system will provide information on the spectral spatial and radiometric resolutions.

The sensor system

- What are the different bands of electromagnetic wavelengths available?
- What is the spectral resolution or spectral width of each band?
- What is the ground or spatial resolution?

You could refer the various sections in the course, which refer to the above-mentioned details for different satellites.

Here we shall outline the selection of the spectral bands for observation of data and the method of obtaining the data.

7.2.1 Wavelength of sensing

Now let us see how we can use the spectral signatures or spectral curves of some natural features and their limits within the spectral bands of the sensor, in the identification of features. (See figure 7.1 for the Landsat Thematic mapper.)

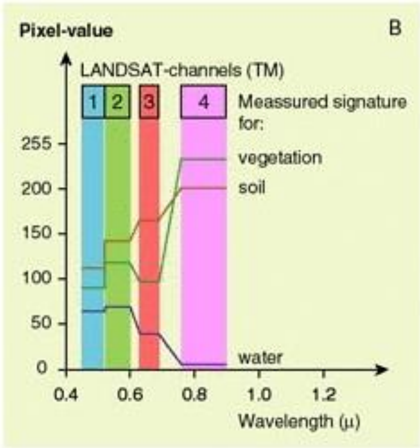

Figure 7.1: Thematic mapper spectral characteristics; numbers refer to TM bands (Lillsand & Kiefer 1979)

(Source: http://www.esa.int/images/04b_400.gif)

The study of this pattern is very important in the selection of the sensor for an application.

Using this figure and the spectral curves of other features we can draw up a table giving the following information for different sensors.
The 'Theme' or the feature to be identified and the 'degree' of identification using the specific bands available on the sensor.

The features can be 'water bodies', 'soil boundaries', 'urban areas', 'agricultural areas' or any other.

Degree of identification of the feature using a band can be 'good', 'medium', 'poor', or 'the particular band is not suitable'.

We can also use band combinations for identification of features. Using the combinations, we can arrive at a table of 'features' and a similar degree of identification or a ranking pattern.

The following tables Table 7.2 and 7.3 give such a guide to selection of bands and band combinations for the Landsat Thematic Mapper. The Tables are taken from the Training exercise by the FAO of the UN. 'Multi-thematic analogic interpretation of Landsat TM imagery for the Rome region.

Table 7.2: Suitability of TM single bands in relation to different themes

Themes/TM Bands	**1**	**2**	**3**	**4**	**5**	**7**
Water bodies	P	P	M	G	G	G
Water characteristics	G	G	P	N	N	N
Drainage patterns	P	P	M	G	G	M
Soil boundaries	P	M	G	M	G	M
Forested area	M	M	M	G	G	M
Agricultural areas	P	M	M	G	G	M/ G
Urban areas	M/ G	G	G	P	P	P/ M
Quarries	P	P	P	M	M	M

G: Good M: Medium

P: Poor N: Not usable

Table 7.3: Variation of TM False Color Combinations (FCCs) and their uses

Category/Band combination (in blue-green-red)	**234**	**123**	**235**	**345***	**354***	**543***	**347**
Urban features	1-2	6	5	2(4)	1	1-2	3
Water sediment patterns	2	1	3	5-6	5-6	4	5-6
Drainage	1	6	2	3(5)	2	4	3
Field boundaries	2	6	4	3	3	5	1
Water-vegetation boundaries	2	6	5	3(1)	1	4	3
Soil patterns	1	5	6	2-3	2	2-3	4
Forest vegetation types	2	6	5	1	1	4	3
Small ponds	4	6	5	3	3	2	1

In the scale of values, 1 represents 'most easily interpreted' and 6 represents 'least easily interpreted' (from Landsat Data User's Notes, No. 30. March 1984, modified).

The band combinations indicated by a star shows the same bands with different combinations. Hence the intensity of radiance will be the same for the three bands, with different RGB combinations.

7.2.2 Classification of data sets and dates of acquisition

It is required to acquire satellite images for an application. What are the questions you will be faced with?

How do we purchase the satellite images for this area?

Is there some classification so that we can order the image data?

What should be the dates of acquisition?

How do we decide?

Each satellite will have its paths, rows and quadrants and acquisition data specified on the images. So, it is possible to select the path, row and quadrant for the area under study.

When selecting the date of acquisition, it is important to consider the vegetation and crop growth stages. The effect of this makes it easier for identification of various crops in relation to the surrounding area.

The sun angle and the climatic condition are other aspects to consider in deciding the image dates.

As an example, for drainage studies it is better to obtain a low sun angle where possible and times when vegetation is scarce.

The scale of the image is another factor to be considered. This will depend on the application. It is usual to start with a scale such as 1:1,000,000 for a reference map. For more detailed study you can consider progressively larger scales.

Each satellite will have their orbit paths to cover the entire globe. Depending on the path we can observe the classification numbers of specific images that cover the area of interest.

Given below are some web sites of distributors, which help to select images of interest.

- http://earth.esa.int – "User services"- "Library"
- adcdaac.usgs.gov/dataproducts.html
- mapping.usgs.gov/www/products/1product.html
- www.spot.com
- www.euromap.de/prod_003.htm

European Space Agency (ESA) catalogues can be accessed as follows;

- http://odisseo.esrin.esa.it/eoli/eoli.htmlearth.esa.int

7.3 The study methodology

Having outlined the broad issues, we shall now study how they can be applied with respect to the spectral, spatial and temporal composition of the images.

The methodology will consist of the following;

- selection of the bands of data to be used,
- the possible combinations for false colour images
- the digital enhancements for better identification and
- printing on high quality paper or film

Since we are dealing with analogue interpretation we shall leave out the digital manipulations.

The study methodology is based on two important steps;

- Analysis – Separating or breaking up of any whole into its parts
- Interpretation – Explanation of the meaning or significance of any part with respect to the whole

(Trautwein and Taranik, 1978)

What is the data that is displayed on the images?

It is the spatial data and the radiometric data.

- Spatial data refers to the size of the sample and the relative distances in space.
- Radiometric or spectral data refers to the strength of the radiation signal.

Following are the important aspects to be considered on the images, by the person doing the analysis & interpretation.

- Spectral aspects
- Spatial aspects

What are the characteristics on the image used in analysis?

The image characteristics given in the tables 7.2 & 7.3 can be then used to carry out the analysis. In general, an analysis is carried out for the following;

- Drainage
- Landforms
- Lineament (geologic)
- Land cover (extended and point type of features)

Images can be taken all times of the year.
Images can be taken of the same area in many different spectral bands.

In analysing the data for an application how do we decide on the images we need to examine?

We resort to a multi-concept approach. This consists of the following;

- Multitemporal approach
- Multispectral (multiband) approach
- Multilevel (multistage) approach (the effect of spatial resolution)

Multitemporal approach – The features on the surface of the Earth keep changing with time. Can you think of some changes? Think of the vegetation and how the growth pattern gives a different surface texture and reflectance with time. Also think of urban development. The landscape gets covered with man-made structures with time.

In this approach, we compare the images obtained on a certain band length at different periods in time. We can view three different single band images obtained on a given scene on three occasions, through red, green and blue filters. If there are no changes in the scene the combined image will be back and white. This is because all three components of red, green and blue will be the same on all three images. Hence the combination will be a gray scale image.

But if there are changes in any of the features between the dates of observation, the amount of red, green or blue reflection will not be the same. This will result in colour on the combined image. So, what we do is analyse the coloured features and make an interpretation. So, we can use images taken on three different dates and compare the surfaces

Multispectral (multiband) approach – Can you remember the electromagnetic spectrum? How did the Earth's features reflect radiation in the different spectral regions?

Can you remember how a feature reflects differently in the different parts of the electromagnetic wave range?

This means that the same feature is indicated by different gray tones or digital values depending on the spectral bands. Images taken on different wavelength regions at the same time over an area of interest provides multiple information on the same scene, which facilitates identification of surface features. For example, vegetation is assessed using the NDVI where the red and near IR bands are used. Water is assessed on the blue, green and near IR bands. So, we can use images of the same scene taken simultaneously on different bands for complimentary information

Multilevel (multistage) approach – This refers to the macro and micro levels of area coverage. Image scale affects the level of useful information that can be extracted from images. At first level, the data can be in a small scale and cover a region of interest. Then you narrow it down to smaller areas progressively by obtaining images at larger scales for final, limited areas of interest. For example, you can use TM imagery of 1: 250,000 at first level and then at later stages use 1: 100,000 and 1: 50,000 scales for identification of vegetation cover and land use patterns.

In general, we can consider the scale of satellite images based on their ground or spatial resolution. So, we can use data of different scales for different purposes in an analysis

7.3.1 Analysis of images

To analyse images you need more than just the data on the images. Perceptual models, collateral material (on-site verification) and image analysis keys are some of the aids used in analysis.

Perceptual models – These refer to mental models, which the analyst should strive to attain. The analyst must understand the potential sources and magnitude of errors associated with information flows in remote sensing. You should also try to become an expert in application areas. It is also important to have a detailed thematic understanding of the area under study.

Collateral material – This will include literature, laboratory measurements and analysis, field work, ground and/or aerial photography etc. depending on the application and the cost constraints. Supportive collateral materials are also very useful, and these can include information such as meteorological or land use data collected by other organisations.

Image analysis keys – A key for identification can be by 'selection' or 'elimination'. In a selective key, the analyst chooses the example that most closely fits the unknown item. An elimination key provides a step-by-step method of possible identification, eliminating all incorrect choices.

7.3.1.1 Handling of imagery, stereoscopic viewing and methods of search

Image handling techniques are important in manual image analysis.
Since many images have to be handled at a time, an orderly method of handling prints should be developed. The transparencies used in analysis should be carefully handled. Stereoscopic viewing is mostly performed using vertical or nearly vertical aerial images acquired with conventional aerial camera systems. Stereoscopic viewing of imagery from side looking airborne radar systems will be discussed in Unit II session 3.

The following instructions should be followed to view vertical images with a pocket stereoscope or mirror stereoscope;

(i) Mark with a dot or pinprick the principal point (geometric centre) of each image. This point is located at the intersection of perpendicular lines between the fiducial marks at opposite edges of the image.

(ii) Mark on each image, or on a transparency the principal point of the other photograph of the stereoscopic pair (conjugate principal point). On both photographs draw a straight line between principal point and conjugate principal point. This line is a segment of the flight-line.

(iii) Overlap the images so that the flight-line segments and corresponding images are superimposed and extend from left to right with respect to the observer. Then move the images apart in a direction parallel to the flight line(x-direction), keeping the flight line segments aligned, until corresponding images are separated by a distance somewhat less than or equal to the observer's eye base. This is usually about 5 cm.

(iv) Place the pocket stereoscope over the images so that the lenses are aligned with the flight line and above the two images to be viewed. When using a mirror stereoscope, the distance between images will be equal to the distance between the centres of the wing mirrors. The focal length of the lenses need eventually to be adapted as well as the distance between the lenses (mirror stereoscope).

The similar objects on the two photographs should 'fuse' with adjustments, when viewed.

When making vertical measurements with a height finding device you should carefully mark principal points and flight-line segments. The separation of the images should be checked against the optical separation of the instrument and the flight line segments should be adjusted along a straight edge.

Searching for features can begin with close examination of all details thought to be relevant. But it may be better to scan the whole area and make an intelligent understanding first. The image analyst should work methodically. He should proceed from general considerations to specific detail. He should proceed from known to unknown features. (Stone, 1956) He can resort to probabilities and thus work more efficiently. This requires experience and he will search only areas where the objects are likely to be found. Mapping is done on a transparency overlaid to the right (or left) photograph using different colour pens.

7.3.1.2 Examples on analysis of features

The following refers to both aerial photographs and satellite images.

Analogic analyses of drainage patterns, landforms, lineaments and land cover can be carried out as follows.

- Drainage analysis – Water related features such as rivers, lakes, lagoons, canals etc. are identified first. The drainage system of an area will depend on the slope, soil materials and the underlying lithology. Drainage is studied using the following characteristics on the image as given in the table above. Namely, pattern, and its texture or density.

Drainage analysis provides information on the terrain morphology, lithology, geological structure and permeability of surface materials.

- Landform analysis – Landform analysis is important since it provides information on lithology, rock type, mineral content, vegetation cover, water resources, soil associations and human activities.

In landform analysis the size, shape, spatial arrangement and association of topographic elements of the landscape are considered. The satellite image is subdivided into units of landforms having the same physiographic significance. So, each of these units will show different natural aspects with respect to topography and drainage, *but uniform within each unit.*

Landforms are dependent on the past and present geologic and climatic influences as well as intervention by man, and these landforms are most suitable for location and assessment of natural resources. The different landscapes, which can be identified are, coastal landscape, fluvial landscape, volcanic landscape, hilly landscape, mountainous landscape etc.

- Lineament analysis – This refers to the alignment of various features in an area. Continuous linear stream channels, elongated or aligned lakes, elongated or aligned patterns of native vegetation and alignment of dark or light soil tones all play a part in identifying aquifers of relatively high capacity.

- Land cover analysis – This can further sub divided into land cover and land use. Land cover refers to 'the rock and soil as well as the vegetational and artificial constructions covering the land surface' (Burley, 1961) and Land use refers to 'man's activities on land which are directly related to the land' (Clawson and Stewart, 1965).

What you first visualise from the natural and artificial cover on the images is the 'land cover'. In the second stage, the interpreter will then use patterns, tones, textures, shapes and site associations to derive information about 'land use' activities. Land cover can be identified as urban land, agriculture land, rangeland, forest-land, water, wetland, barren land etc.

7.3.2 Image interpretation

What is image interpretation?

We have done an analysis of the images by analysing the drainage patterns, landforms, the lineaments and the land cover/land use, without naming them separately but just mapping them. We have done this using the different spectral signatures.

Now we need to combine and assess all the data obtained from the above analyses to arrive at a meaningful interpretation of the data represented on the image. So, it is important that the interpreter has knowledge on the natural factors affecting the physical environment.

> ‘The type and amount of information which can be obtained from an image is proportional to the knowledge, experience, skill and motivation of the analyst-interpreter, the efficiency of the methodology used, and an awareness of the limitation imposed by the remote sensor system’ (Trautwein and Taranik, 1978).

- Landscape interpretation – ‘Identifying the landform commonly identifies the natural processes that formed it, and commonly limits the type of soils or soil characteristics that can be expected’ (Ray, 1969).

For each Landscape or Landform unit identified in the area under analysis, the following can be interpreted.

- The Landscape is divided into Land systems.

- Each land system will have the following features.
  - Drainage
  - Relief morphology
  - Vegetation/land cover
  - Lithology
  - Erosion/sedimentation processes
  - Soil development
  - Hydrologic situation

- Infrastructure interpretation – The main infrastructures of the area are identified. Some of these are buildings, highways, railways, airports, seaports, quarries, parks, dams, etc.

- Land-use and vegetation cover interpretation – Land-use refers to ‘man’s activities on land which are directly related to land’(Clawson and Stewart, 1965).

Land use interpretation can be better performed by enlarging parts of the original images to larger scales. By doing so we can identify land cover such as water, urban areas, forest, agriculture, pastures, quarry etc.

7.4 Examples of image feature identification

It is not intended to give a detailed description of image analysis at this stage. You will find more detail with regard to the areas discussed here, in the 'applications' sessions in the last Unit of this course.

7.4.1. Landsat image interpretation

What are the sensors aboard Landsat? You will be able to recall that the sensors are the Multi Spectral Scanner (MSS) and the Thematic Mapper (TM).

Landsat images have provided much information with regard to the areas of agriculture, biology, cartography, civil engineering, environmental monitoring, forestry, geography, geology, geophysics, land resource analysis, land use planning, oceanography and water resource analysis.

It is important to note the scale of these images since this will indicate the extent to which identification is possible. A LANDSAT scene (185 × 185 mm) of image scale 1:1,000,000 will cover an area of 34,000 km2.

How many aerial photographs at 1:20,000 scale, with no overlap will be required to cover the area of a single LANDSAT image? You will need more than 1600!

So, it is important to note the scale difference when analysing images for extraction of features. Both aerial photographs and LANDSAT images should be used in any complete survey of a given area, especially if the area is very large. The existence of some features, which extend for miles such as geologic features will not be apparent in aerial photographs which cover only a small area. But urban area studies will be better carried out using low altitude aerial photographs.

You should also note that most LANDSAT images can only be viewed in two dimensions (some parts of an image can be viewed in stereo). But most aerial photographs can be viewed in stereo.

The ground resolution cell size is about 79m for the MSS and about 30m for the TM.

Let us first consider the identification of vegetation on LANDSAT images.
Absorption of red and blue from the visible light by chlorophyll pigments, leaves the green to be reflected. Hence most vegetation is green in colour. There is also a strong

reflectance in the 0.75 to 1.35μm range (near-IR). The intensity of this reflection is much higher than for most inorganic materials. So, vegetation appears bright in the near-IR wavelengths. So now we can see why the vegetation appears as dark toned in blue and specially the red bands. Also, why it appears lighter in the green band and relatively bright in the near IR band.

Identifying vegetation also depends on several other characteristics. It can be the type of trees or leaves, the way the leaves are arranged in canopies etc.

Image interpretation involves the identification of radiometric patterns on imagery that correspond to landforms, drainage and cover type. In order to identify ground water hydrology, you need to analyse landscape patterns on imagery to interpret geomorphology. Geomorphologic relationships are then analysed to obtain structural and stratigraphic interpretations. Ground water interpretations are developed through the analysis of structural and stratigraphic relationships.

Geohydrology or the study of ground water by means of imagery is complex. This is because the object of study is not directly indicated on the data. The geohydrologist has to infer subsurface hydrological conditions from surface indicators. These indicators can be geological features and structures, vegetation, streamflow characteristics, soil moisture contents, vegetative types and their distribution, springs etc.

When it comes to urban areas, linear features, which are narrow and have a sharp contrast with the surrounding area such as roads, can be identified. Objects much larger than the ground resolution cell size may not be apparent on the images. Features visible in one band may not be visible in another band.

Let us see how we can compare the features on the 7 different bands of the same scene obtained with the TM. In general, if we compare the sceneries obtained simultaneously from the 7 LANDSAT Thematic Mapper (TM) bands, we can broadly identify the following categories. See Table 7.4.

Table 7.4: 7 LANDSAT TM bands

Feature	**Identification in LANDSAT bands 1,2,3,4,5,6,7**
Blue-green water	Moderate reflectance in 1 and 2. (blue and green) Little reflection in 3 (red) Almost no reflection in 4,5,7 (near and mid-IR)
Roads, urban streets, quarries etc.	High reflection in 1,2,3 (blue, green, red) Least reflectance in 4 (near-IR)
Agriculture and other vegetated areas	Highest reflectance in 4 (near IR)

A detailed table on feature identification and normally used 'colour composites' for identifying various features are given in the Tables 1 and 2 in section 7.2.1.
Thermal infrared imagery becomes most important in identifying urban features.

What is the reason for this? Most modern day human activity involves the emission of heat into the atmosphere. How can we measure this heat and identify features?

The band 6 scene has less distinct appearance than the other bands since the ground resolution cell size of this band is 120 m (thermal IR).

Let us consider an image taken in the daytime during a hot season. Due to the absorption of heat, concrete structures such as urban areas have the highest radiant temperature and water bodies have the lower radiant temperatures, and vegetation have the lowest.

In the Landsat TM thermal images, darker image tones represent surface features with relatively warmer radiant temperatures. In meteorological applications, light tones represent appearance of clouds.

Water appears cooler and hence darker than its surroundings in daytime thermal images. In the evening, the water appears warmer than the surrounding land features, which have cooled by this time. So, water appears warmer and lighter than the other areas in an evening image.

But in the case of water surrounded by frozen or snow-covered ground, water will appear warmer both day and night.

Trees appear cooler than their surroundings during the daytime and warmer in the night. Paved areas appear warmer both day and night.

Panchromatic band images taken by the landsat 7 ETM+ (15m resolution) can be merged with 30m resolution data from ETM+ 1,2,3,4,5 and 7 to produce 'pan sharpened' colour images with 15m resolution.

MSS band 6 infrared (0.7-0.8), and band 7 infrared (0.8-1.1) have demonstrated operational value in the near-infrared for vegetation, open water and cultural delineation.

Multispectral Scanner Systems (MSS) have been used in the 1970s for obtaining much information on urban applications. The following bands have been useful in urban identifications.

MSS band 5 red (0.6-0.7) is the fundamental band for indicating boundaries between natural and cultural features.

The infrared portion of the spectrum has three parts. The near or reflected infrared (0.7-1.1). the middle infrared where both reflected and emitted infrared moves through an atmospheric window at 3.5-5.5 μm, and the far infrared where emitted radiation produced by the molecular activity of materials moves through a second atmospheric window at 8-14 μm. These emitted radiations are sensed as 'heat' or the radiant temperature of the object sensed. Depending on the information required, you can select the thermal imagery obtained in either the middle infrared (fires) or far infrared (ambient temperature) window.

Some examples of the use of LANDSAT imagery are in the identification of land cover and of geologic features amongst many others.

7.4.2 ENVISAT image interpretation

ENVISAT of the European Space Agency has many sensors operating in many regions of the spectrum. They include advanced SAR, radar altimeter, ocean colour and ocean temperature instruments.

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The Medium Resolution Imaging Spectrometer (MERIS) is the optical sensor on board ENVISAT. The primary mission of MERIS is the measurement of ocean colour. Ocean biology and marine water quality can be monitored through global observations of ocean colour.

The ocean colour data can be applied in the following areas.

The ocean carbon cycle
Mapping of chlorophyll content, sediment, yellow stuff etc.
The management of fisheries
The management of coastal zones

MERIS can also obtain the following information as its secondary mission.

Cloud type, top height and albedo
Top and bottom of atmosphere vegetation indices
Photosynthetically available radiation
Surface pressure
Water vapour total column content for all surfaces
Aerosol load over land

There are changes in chlorophyll content in the ocean, which need to be measured. Ocean colour responds in a non-linear way to these changes. It is depicted by the ratio of blue-to-green radiation backscattered by the ocean, with the ratio that is most sensitive based on wavelengths of 445 and 565 nm. It varies within a range of 1 to 20 for the types of pigments considered and decreases almost linearly with the logarithm of the concentration.

The upward radiance at any visible wavelength from coastal waters, is composed of contributions from many dissolved and suspended substances which determine the marine ecology. Suspended matter usually enhances the upward radiances while dissolved organic molecules reduce radiances mainly in the blue.

The sensors on board ENVISAT provide ways of monitoring the constituents in the atmosphere, aerosol loading in the stratosphere and the amount of water vapour in the atmosphere. The operations of the land surface will allow the measurement of vegetation parameters, surface water and soil moisture, surface temperature, elevation and topography. Global scale measurements of 1 km resolution will provide critical data sets for improved climate models, estimates of albedo, vegetation productivity and land surface fluxes.

MERIS data will be more accurate than that provided by AVHRR since the spectral bands are narrower and less sensitive to atmospheric effects, and higher in number. Hydrology models require detailed spatial and temporal information on a wide range of land surface parameters. ENVISAT can provide land surface temperature, vegetation state, soil moisture, surface roughness, and terrain. Because of its narrower bands and improved radiometry, MERIS may be better suited to providing vegetation parameters for hydrology than other instruments such as AVHRR.

The high frequency of global coverage makes MERIS useful also for hazard monitoring such as earthquakes, volcanic eruptions, floods and fires-smokes.

Vegetation monitoring provides the required information for accounting the global changes due to the cycling of carbon. Global vegetation is based on low resolution (1km) data. However, vegetation products such as land-cover, leaf-area index, and biomass are validated using data at higher resolution.

The Advanced Synthetic Aperture Radar (ASAR) instrument can retrieve a variety of geophysical measurements.

The ERS programme of the European Space Agency (ESA), has demonstrated the ability of satellite radars, to identify crops and monitor seasonal land cover changes independent of weather conditions. Multi temporal techniques are used and a similar method will be used with ENVISAT data using the ASAR.

The Advanced Along Track Scanning Radiometer (AATSR) is an instrument designed to measure Sea Surface Temperature (SST) to the levels of accuracy and precision required for the monitoring and detection of climate change. AATSR has thermal infrared channels which measure upwelling radiance from the sea surface and the atmosphere at 3.7, 11 and 12 µm. AATSR also includes three visible/near infrared channels centred at 0.55, 0.67 and 0.87 µm and are used for land remote sensing, specially for the study of vegetation. The AATSR channels can provide information on the location, extent and structure of clouds. The dual views provided by AATSR also provide stereo viewing capability. This can be used to discriminate between the different layers and structures within the cloud and to estimate cloud top height.

The following sensors aboard ENVISAT provide information, which will help understand the behaviour of the atmosphere, measuring the content of ozone and of other trace gases.

The Global Ozone Monitoring by Occultation of Stars (GOMOS)
The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)
The Scanning Imaging Absorption Spectrometer for Atmospheric ChartographY (SCIAMACHY)
See technical specifications of ENVISAT.

Review Questions

Answer the questions set out below.

1. Explain the meaning of Analogue image interpretation giving the types of maps to be studied
2. Explain why image interpretation is more complex than the interpretation of normal photographs
3. There are several feature characteristics used for identification and each will depend on the particular application. Explain each of the characteristics giving at least one reference application.
4. Study of the characteristics is carried out using the spectral, spatial and temporal composition of the images. Explain the multispectral, multilevel and multitemporal approach to selection of the images we need for interpretation.
5. What are the four major items to be identified in the analogue analysis of images?

Summary

The basic feature characteristics used in identification of analogue images has been discussed; namely, shape, size, pattern, tone, texture, shadows, site, association and height. Selection of bands and band combinations for identification of different features for the Landsat Thematic Mapper was set out. Analogue analyses of drainage patterns, landforms, lineaments and land cover and Landsat image interpretation have been outlined in brief.

Learning Outcomes

At the end of this session you will be able to briefly explain:

- the methodology to be used in a simple analogic interpretation
- how to select the bands for different applications to obtain the 'data'
- imagery analysis, which broadly refers to drainage analysis, landform analysis and land cover or land use analysis
- the interpretation of the images using the results of the analyses
- the interpretation of images obtained by some common satellite sensors.

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