Modern Surveying Techniques

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Lecture - 6

Remote Sensing Introduction

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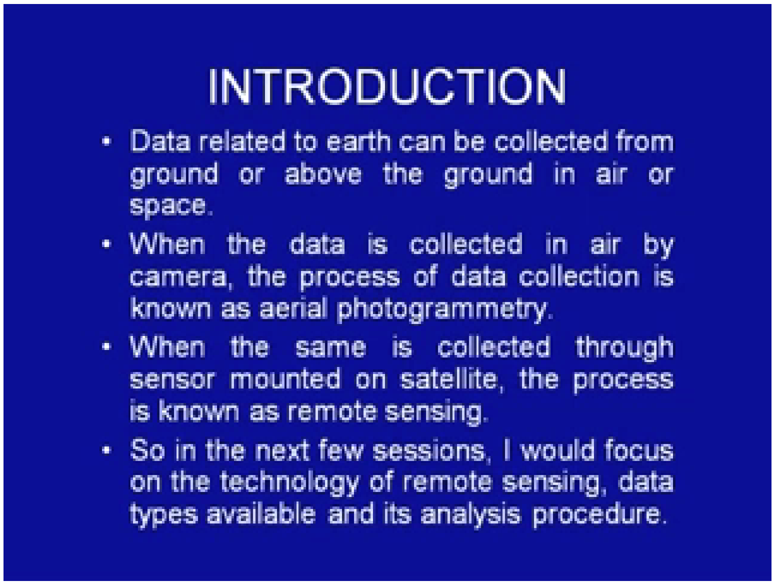

Data related to earth can be collected from ground or above the ground in space or in air. When the data is collected in air by camera, the process of data collection is known as aerial photogrammetry. When the same is collected through sensors mounted on satellite, the process is known as remote sensing.

So, in the next few sessions, I would focus on the technology of remote sensing data types available and its analysis procedures. First of all, let us look at the definition of remote sensing.

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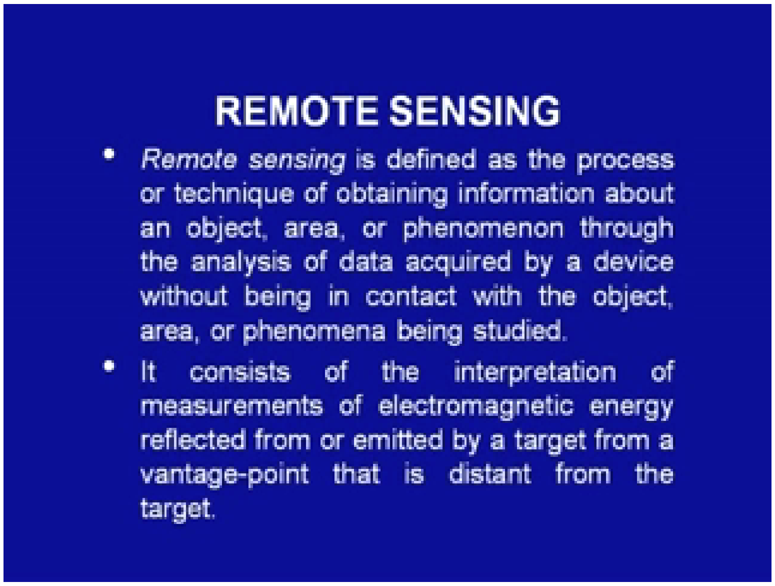

Remote sensing is defined as the process or technique of obtaining information about an object, area or phenomena through the analysis of data acquired by a device without being in contact with the object, area or phenomena being studied. It consists of the interpretation of measurements of electromagnetic energy reflected from or emitted by a target from a vantage - point that is distant from the target itself.

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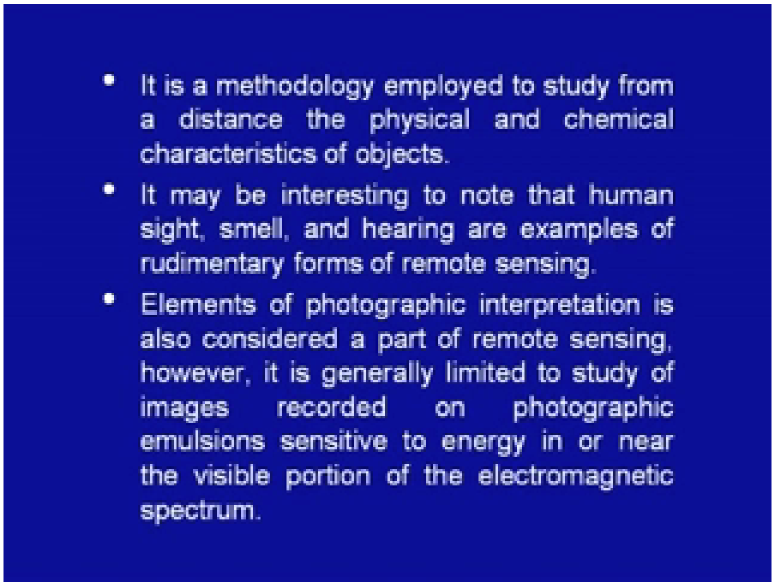

It is a methodology employed to study from a distance, the physical and chemical characteristics of an object. It may be interesting to note that human sight, smell and hearing are examples of rudimentary forms of remote sensing. Elements of photo interpretation are also considered a part of remote sensing. However, it is generally limited to study of images recorded on photographic emulsions sensitive to energy in and near the visible portion of the electromagnetic spectrum. Before we proceed ahead, it is it would be prudent to understand the utility of remote sensing in terms of another upcoming technology which is known as the GIS.

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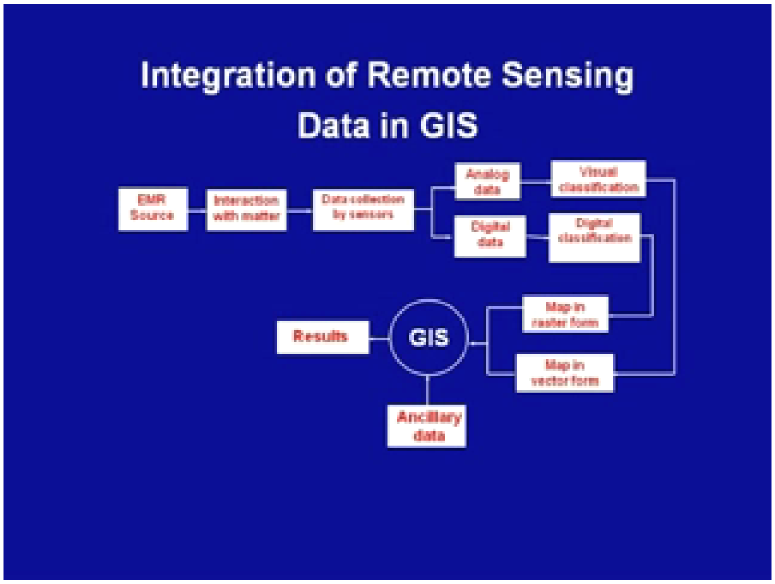

So, let us look at the integration of remote sensing data in GIS. In the process of remote sensing, we require an electromagnetic source. This source provides energy which interacts with the matter. After interaction with the matter, the energy gets reflected and it is collected by sensors. The data collection can be in two forms; it can be either be analog or it can be digital.

If the data is analog, then the process of analyzing the information is known as visual classification and it results in an output which is a map in vector form. In case, if the data is digital, then digital based classification with the help of computers is performed and the resultant output is a map in raster form.

Whichever form the data is available, now this can be used as an input into GIS wherein, we may have other ancillary informations also inputted into the GIS. So, that certain decision making activities can be carried out within the frame work of GIS and the net result can be obtained as desired by the user. So, this defines the ultimate goal to which a remote sensing analyzed data can be put to.

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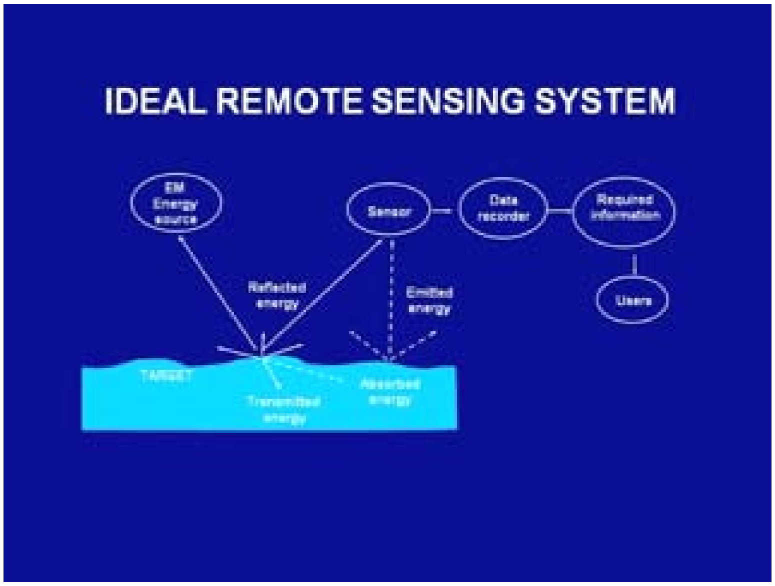

First of all, let us look at what is the ideal remote sensing system. This particular slide, it shows that there is an electromagnetic energy source which strikes the earth on the earth surface. It gets reflected and it is collected by the sensor. There could be some emitted energy also coming from the earth surface which could also be recorded by the sensor.

The data is collected and stored on data recorders and then it is transmitted back onto the earth surface through the process of telecommunication where the required information is stored on the ground. This required information is then subsequently passed over to the user community which does the analysis of the data. So, let us took at this one by one.

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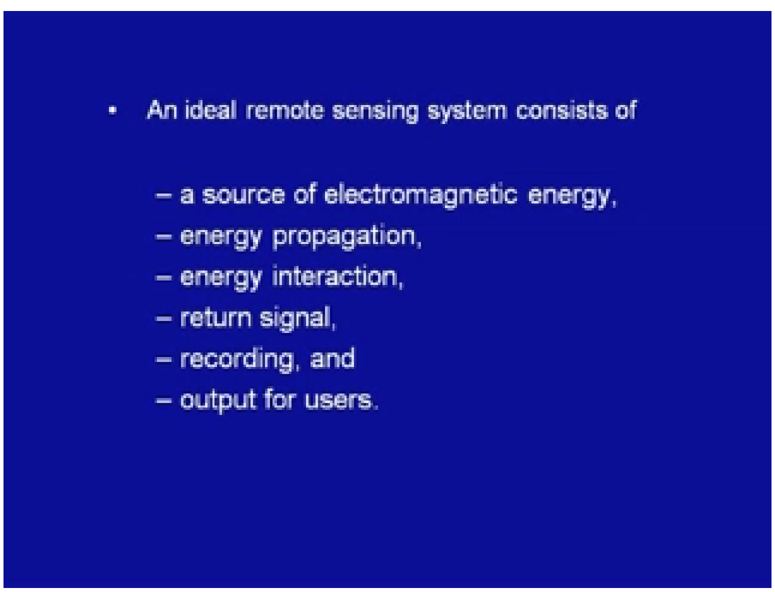

So, an ideal remote sensing system would consists of a source of electromagnetic energy, energy propagation, energy interaction, a return signal, recording and output for users.

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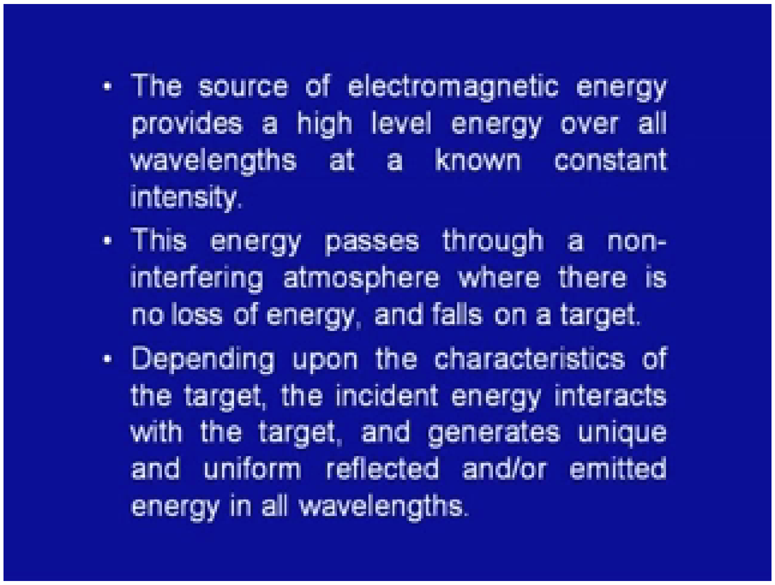

The source of electromagnetic energy provides a high level energy over all wavelengths at a known constant intensity. This energy passes through a non interfering atmosphere where there is no loss of energy and it falls on a target. Depending upon the characteristics of the target, the incident energy interacts with the target and generates unique and uniform reflected and/or emitted energy in all the wavelengths.

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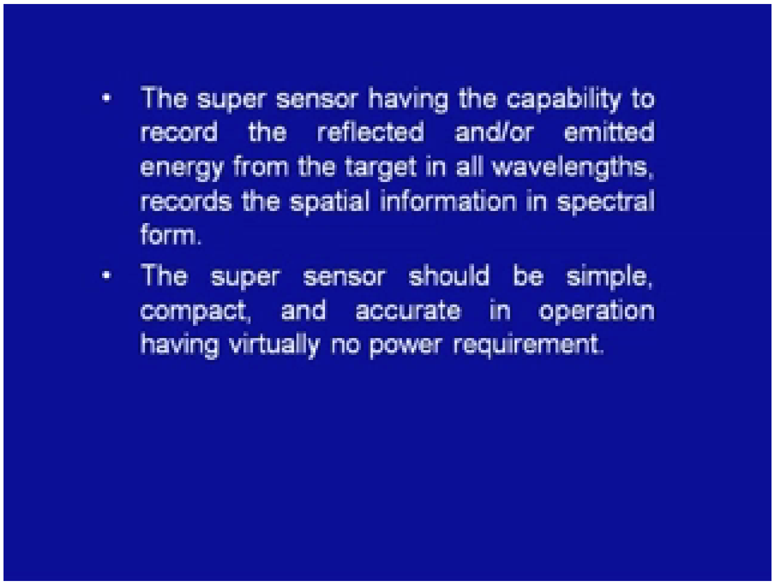

The super sensor having the capability to record the reflected and/or emitted energy from the target in all the wavelengths, records the special information in spectral form. The super sensor should be simple, compact and accurate in operation having virtually no power requirements.

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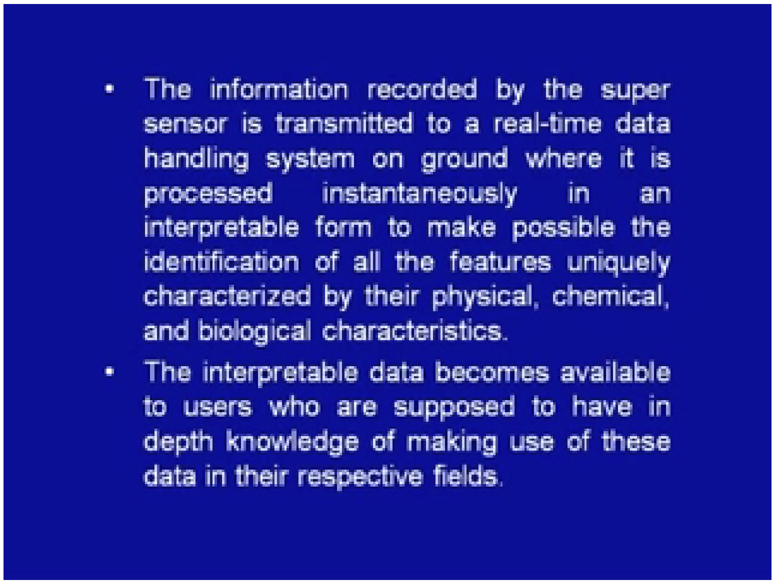

The information recorded by the super sensor is transmitted to a real time data handling system on the ground where it is processed instantaneously in an interpretable form to make possible the identification of all the features uniquely characterized by their physical, chemical and biological properties.

The interpretable data becomes available to a user who is supposed to have an in depth knowledge of making use of these data in their respective fields. However in reality, the picture is much more different then what the ideal system portrays.

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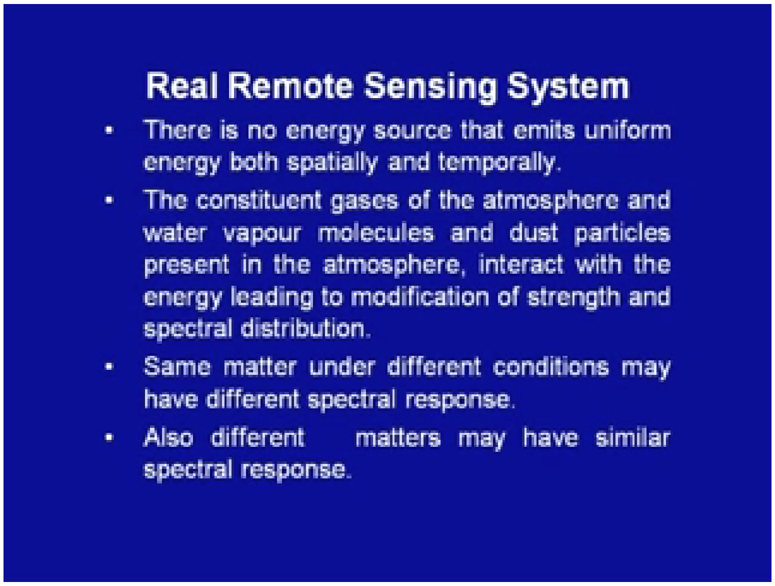

So, let us look at the ideal remote sensing system which exists. First of all, there is no energy source that emits uniform energy both specially and temporally. Since, the sun is the source of electromagnetic energy, we all know that there are variations in the sun activity which takes place and this leads to a variation in the transmitted energy which is coming from the sun's surface.

Further, while the energy traverses through the earth's atmosphere which consists of gases and water vapour molecules and dust particles, it interacts with the energy leading to modification of the strength and spectral distribution. The same matter under different conditions may have different spectral response. Also, different matters may have similar spectral response.

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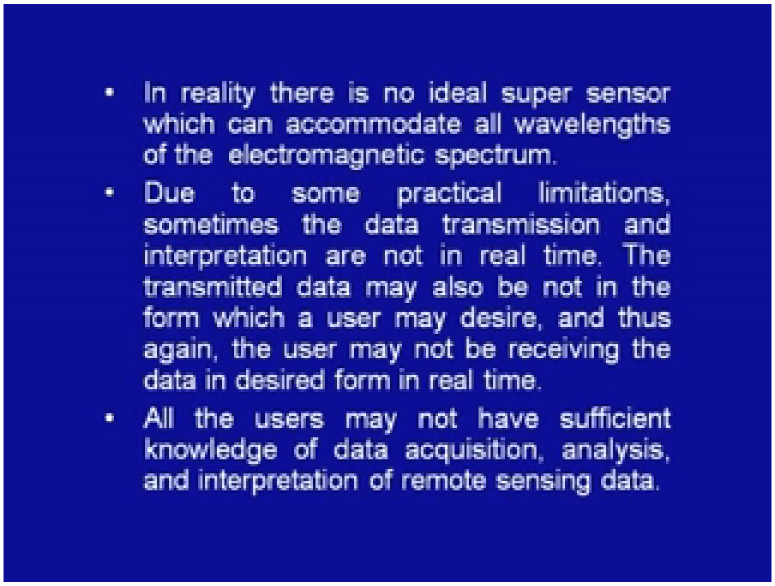

In reality, there is no ideal super sensor which can accommodate all wavelengths of the electromagnetic spectrum. Due to some practical limitations, sometimes data transmission and interpretation are not in real time. The transmitted data may also not be in the form which a user may desire and thus again, the user may not be receiving the data in desired form in real time.
All the users may not have sufficient knowledge of the data acquisition analysis and interpretation of the remote sensing data.

So, we can see the deviation of the real remote sensing system in comparison to an ideal remote sensing system.

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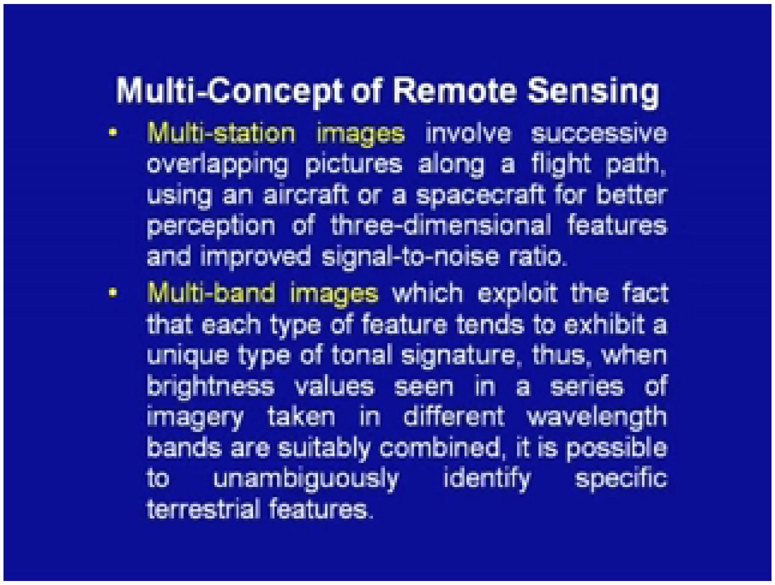

Before we proceed ahead, it would be prudent to understand the concept of remote sensing because it involves a multifarious activities and multifarious forms of data collection. This has been called as the multi concept of remote sensing.

First is multi- station images; involves successive overlapping pictures along a flight line using an aircraft or a spacecraft for better perception of 3D features and improved signal to noise ratio.

Then, multi band images which exploit the fact that each type of feature tends to exhibit a unique type of tonal signature. Thus, when brightness values seen in a series of images taken in different wavelength bands are suitably combined, it is possible to unambiguously identify special terrestrial features.

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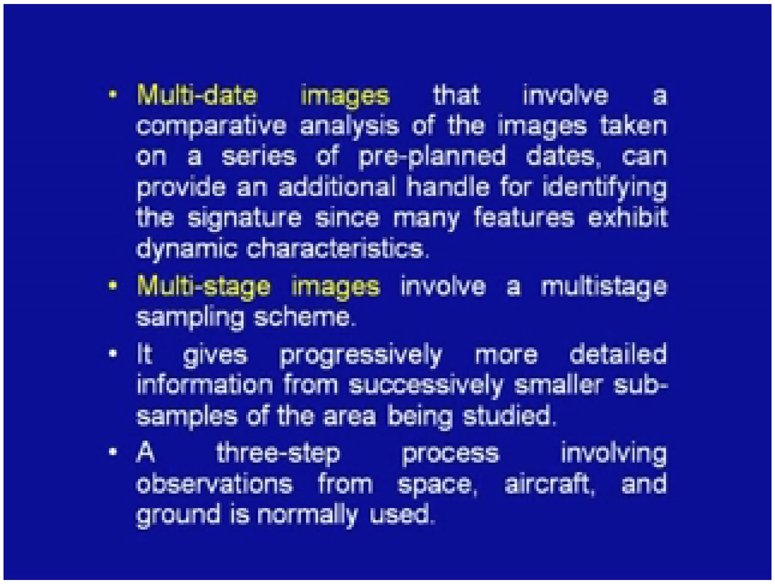

Multi date images that involve a comparative analysis of the images taken at on a series of preplanned dates can provide an additional handle for identifying the signature, since many features exhibit dynamic characteristics. Multi stage images involve a multi stage sampling scheme. It gives progressively, more detailed information from successively lower sub samples of the area being studied.

A three step process involving observations from space aircraft and ground is normally used.

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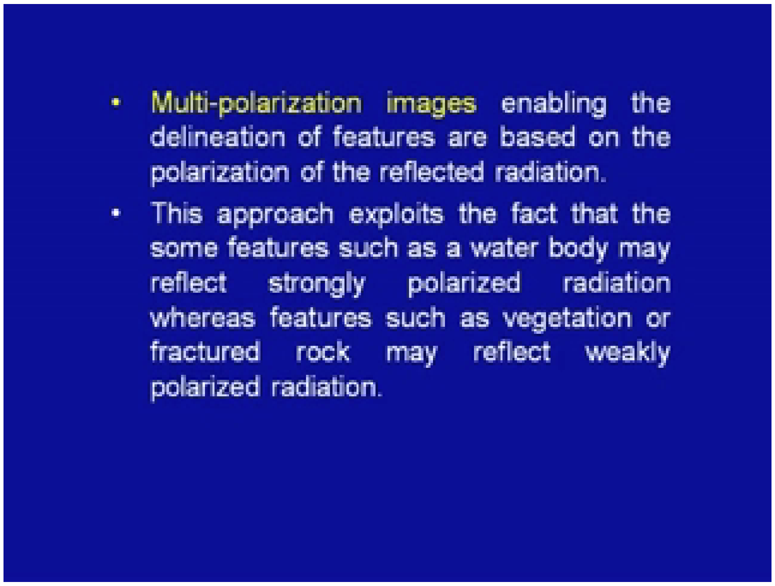

Next is multi polarized images. This enables the delineation of features are based on the polarization of the reflected radiation. This approach exploits the fact that some features such as water bodies may reflect strongly polarized radiations, whereas, features such as vegetation or fractured rocks may reflect weakly polarized radiation.

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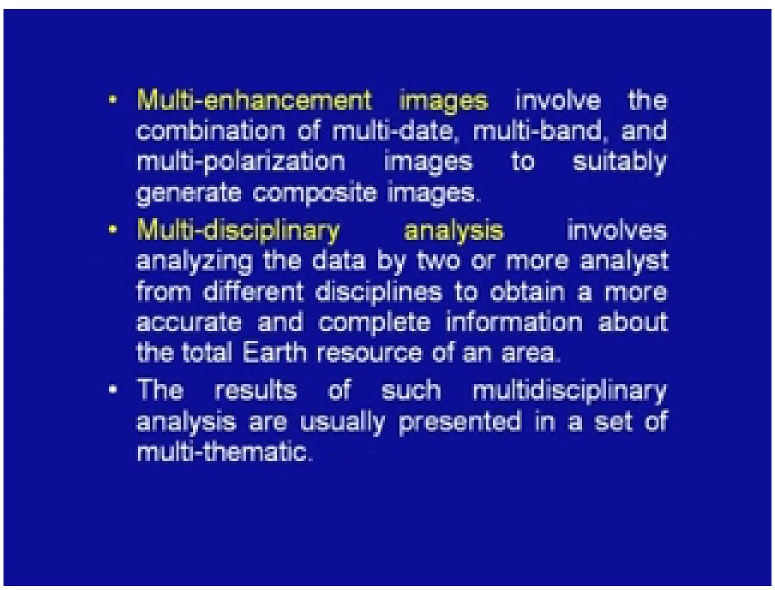

Multi enhancement images; this involves the combination of multi date, multi band and multi polarized images to suitably generate composite images. Multi disciplinary analysis involves analyzing the data by two or more analyst from different disciplines to obtain a more accurate and complete information about the total earth resource of an area. The results of such multi disciplinary analysis are usually presented in a set of multi thematic information.

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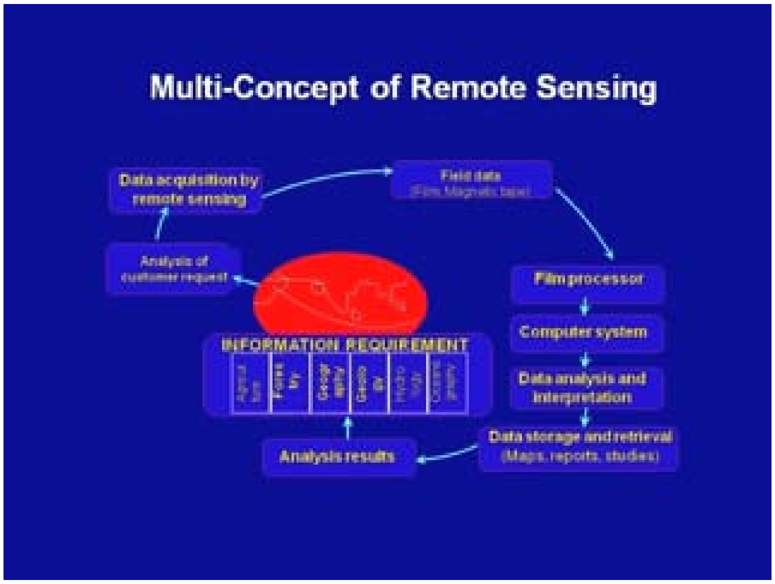

This particular slide portrays the multi concept of remote sensing. Here, from the earth an analysis of the user request is made which on the basis of which data acquisition by remote sensing is carried out. Along with this there could be some field data which could be utilized in order to analyze the data. The data can be converted through a field processor and also analyzed by a computer system if it is in digital form.

The data analysis and interpretation process could be both visual and digital and subsequent analysis analyzed data could be stored and placed in the form of map, reports and studies which will help us in analyzing the type of results that a user wants; whether he is related to agriculture, forestry, geography, geology, hydrology, oceanography and other areas which could be of importance.

So, before I proceed ahead, it would be good that we look at the advantages and disadvantages of remote sensing so that we can appreciate the limitations of this particular technology.

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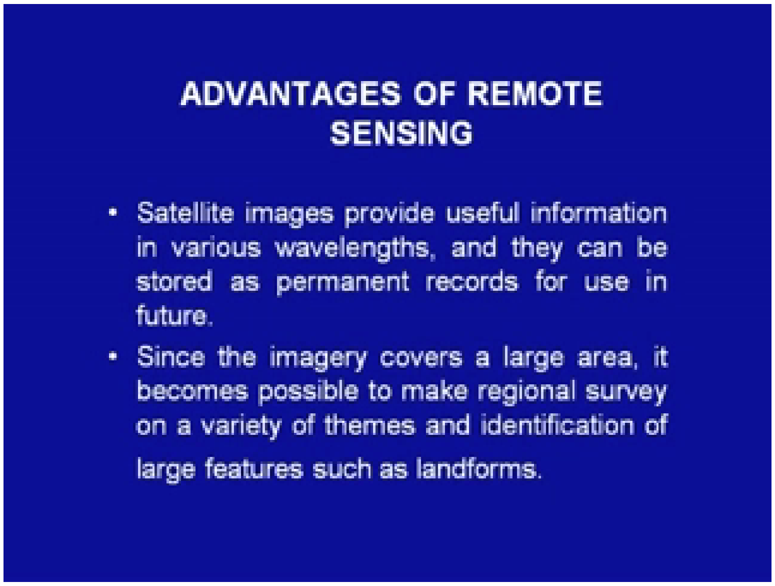

Satellite images provide useful information in various wavelengths and they can be stored as permanent records for use in future. Since, the imagery covers a large area, it becomes possible to make regional survey on a variety of themes and identification of large features such as landforms.

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Repetitive coverage provides monitoring dynamic themes like water, agriculture, land degradation, urban development etc which are encompassed under natural and human induced effects. It is also possible easy identification of data over inaccessible areas. Remote sensing provides data acquisition at different scales and resolutions.

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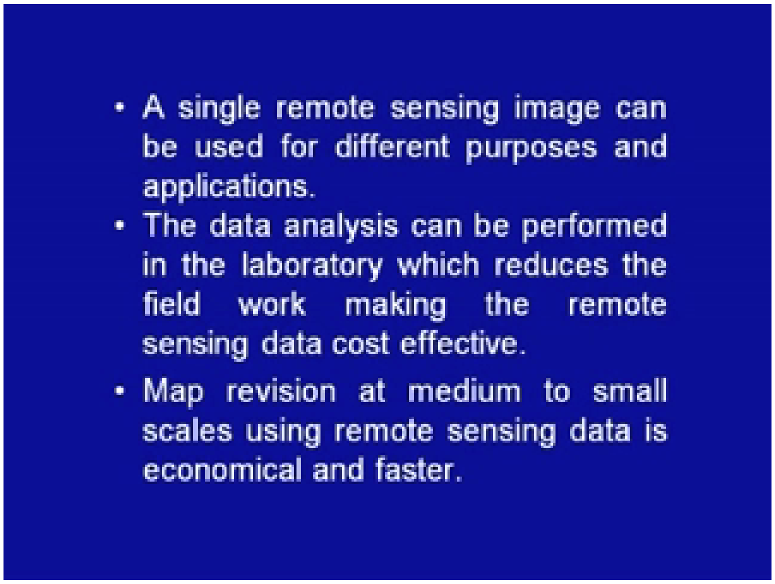

A single remote sensing image can be used for different purposes and applications. The data analysis can be performed in the laboratory which reduces the field work, making remote sensing data cost effective. Map revision at medium to small scales using remote sensing data is economical and faster.

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Color composites produced from three individual band images provide better analysis than using a single band image or aerial photograph. A three dimensional analysis can be carried out using stereo satellite data. The remote sensing data being in digital form, processing and analyzing can be done faster using computers. Now, let us look at some of the disadvantages of remote sensing.

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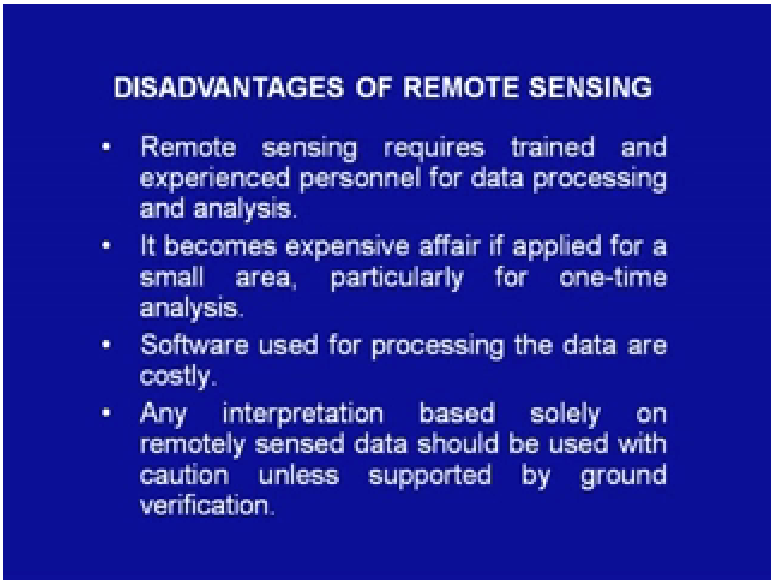

Remote sensing requires trained and experienced personnel for data processing and analysis. It becomes expensive affair if applied for a small area, particularly for one time analysis. Software used for processing the data are costly. Any interpretation solely on remotely sensed data should be used with caution unless supported by ground verification. Now, let us come to some of the application areas to which remote sensing can be put to.

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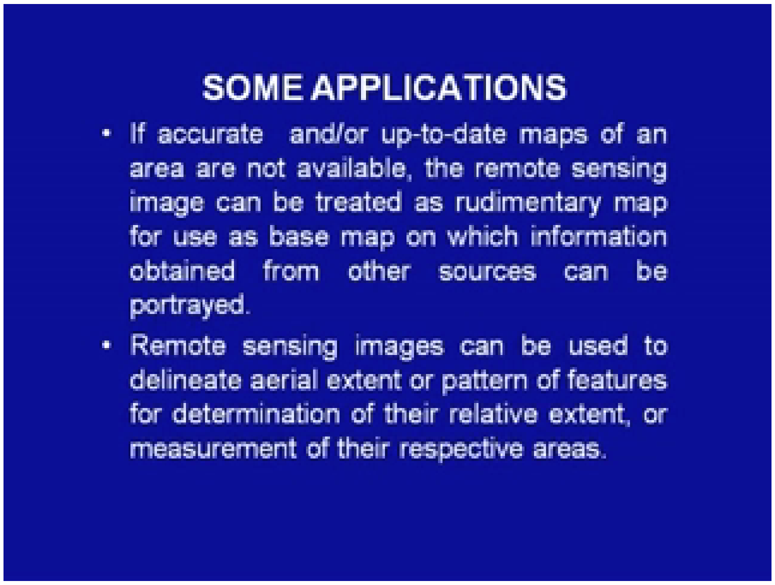

If accurate and/or up to date maps of an area are not available, the remote sensing image can be treated as a rudimentary map for use as base map on which informations obtained from other sources can be portrayed. Remote sensing images can be used to delineate aerial extent or patterns of features for determination of their relative extent or measurement of their respective areas.

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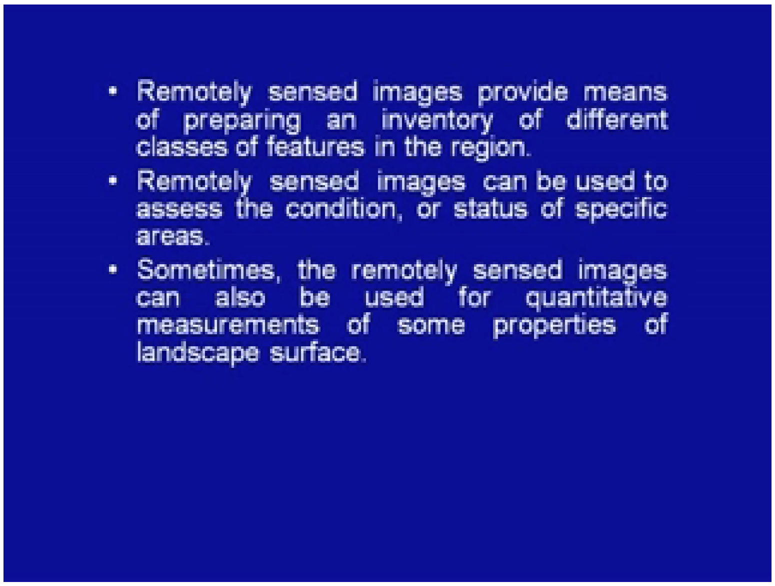

Remotely sensed images provide means of preparing an inventory of different classes of regions features in the region. Remotely sensed images can be used to access the condition or status of specific areas. Sometimes, the remotely sensed images can also be used for quantitative measurements of some properties of landscape surfaces.

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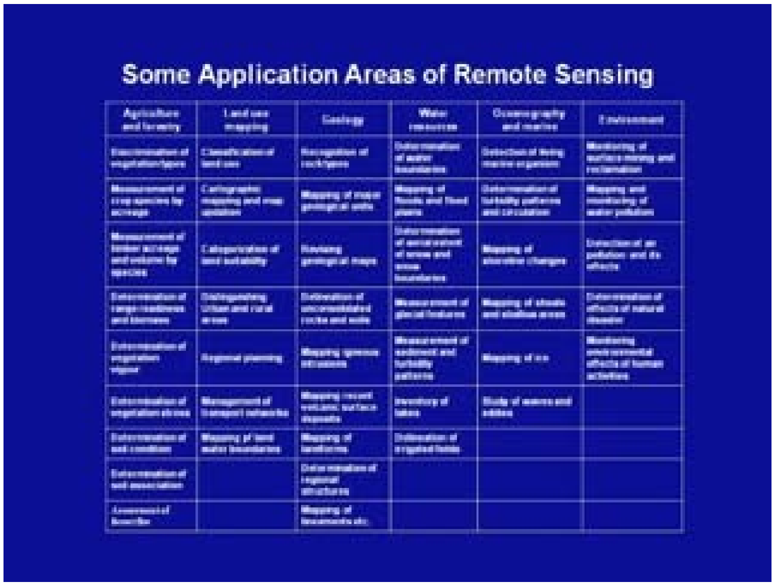

In this particular slide, the broad areas of application have been shown. In the areas of agricultural and forestry, land use and land use mapping, geology, water resources, oceanography and marine and environment.

This slide shows some of the common application areas of remote sensing. For example; in the area of agricultural and forestry, one can undertake the determination discrimination of vegetation types, measurement of crop species by acreage, measurement of timber acreage and volume by species, determination of range readiness and biomass, determination of vegetation vigour and determination of vegetation stress ,determination of soil condition, determination of soil association, assessment of forest fires.

In the area of land used mapping, it is possible to undertake the classification of land use, cartographic mapping and map updation, categorization of land suitability, distinguishing urban and rural areas, regional planning, management of transport networks and mapping of land water boundaries.

In the area of geology, it can be used for recognition of rock types, mapping of major geological units, revising geological maps, delineation of unconsolidated rocks and soils, mapping igneous intrusions, mapping of recent volcanic surface deposits, mapping of land forms, determination of regional structures, mapping of lineaments etcetera.

In the area of water resources, it can used for determining the water boundaries, mapping of flood and flood plains, determination of the aerial extent of snow and snow boundaries, measurement of glacial features, measurement of segment and turbidity patterns, inventory of lakes, delineation of irrigated fields.

In the area of oceanography and marine, it can be used for the detection of living marine organisms, determination of turbidity patterns and circulation of ocean currents, mapping of shore line changes, mapping of shoals and shallow areas, mapping of ice, study of waves and eddies.

In the area of environmental engineering, it can be used for monitoring of surface mining and reclamination mapping of and monitoring of water pollution, detection of air pollution and its effect, determination of the effects of natural disasters, monitoring environmental effects of human activities.

Well, this is a small list. However, this can be still much longer and it all depends upon the ingenuity of the analyst in terms of extraction of information and also the user community to the extent to which it desires the information.

Well, with this, now let us look at some of the components of remote sensing which play a crucial role.

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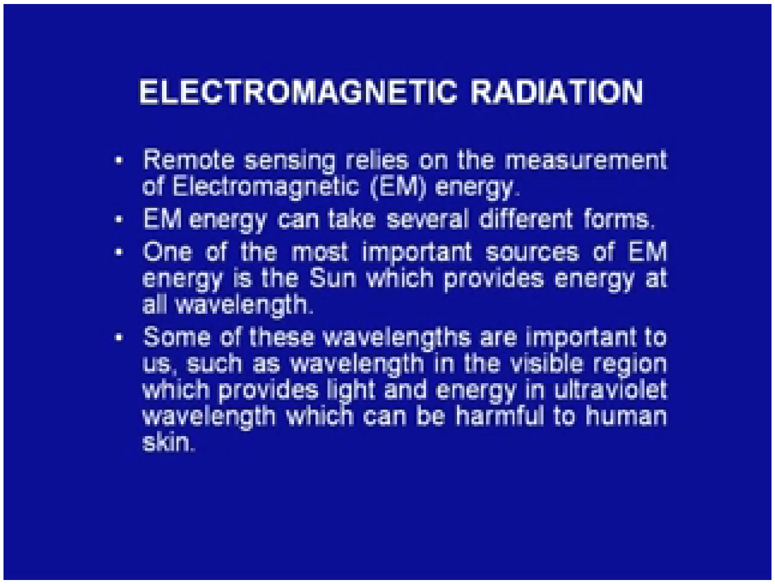

First of all, the whole process of remote sensing is based on electromagnetic radiation. So, let us focus on what actually is electromagnetic radiation. Remote sensing relies on the measurement of electromagnetic or what we call it as EM energy. EM energy can take several different forms.
One of the most important sources of EM energy is the sun which provides energy at all wavelengths. Some of these wavelengths are important to us such as the wavelength in the visible region which provides us light and energy in the ultraviolet wavelength which can be harmful to the human skin.

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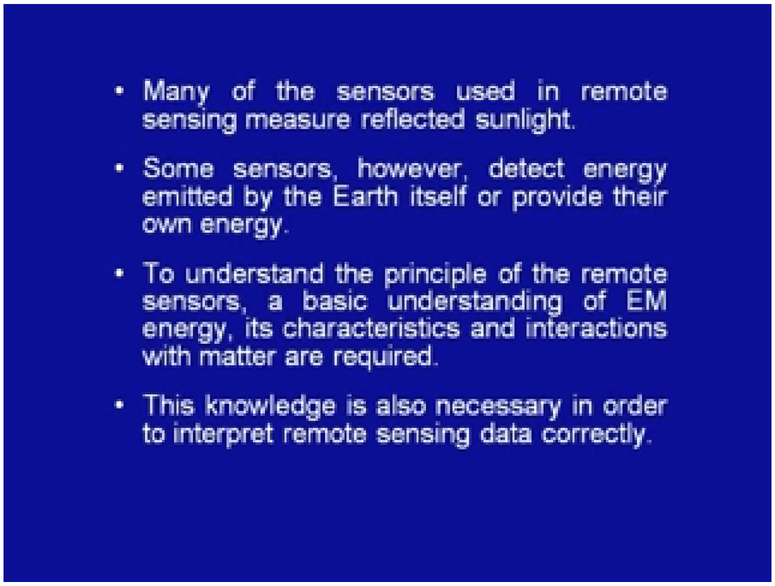

Many of the sensors used in remote sensing measure the reflected light. Some sensors however detect energy emitted by the earth itself or provide their own energy. To understand the principle of remote sensor; a basic understanding of EM energy, its characteristics and interaction with matter are required. This knowledge is also necessary in order to interpret remote sensing data correctly.

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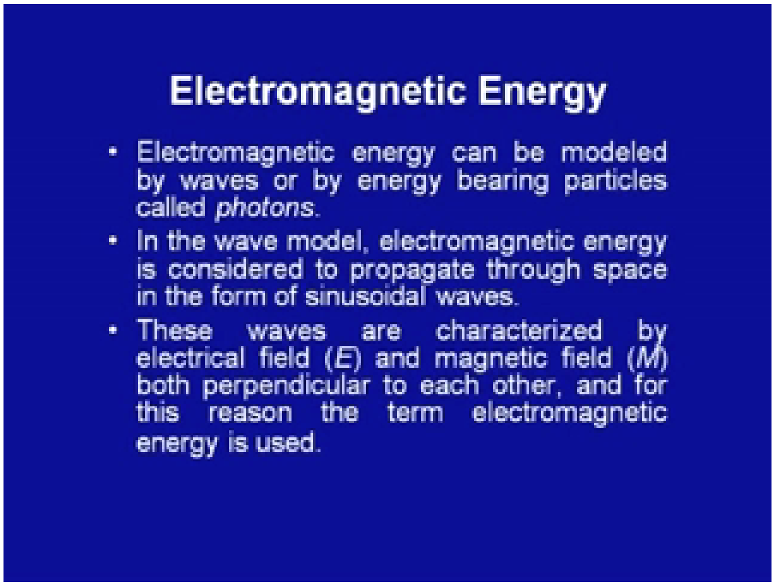

Electromagnetic energy can be modeled by waves or by energy bearing particles called photons.
In the wave model, the electromagnetic energy is considered to propagate through the space in the form of sinusoidal waves. These waves are characterized by electrical field E and the

magnetic field M both perpendicular to each other and for this reason, the term electromagnetic energy is used.

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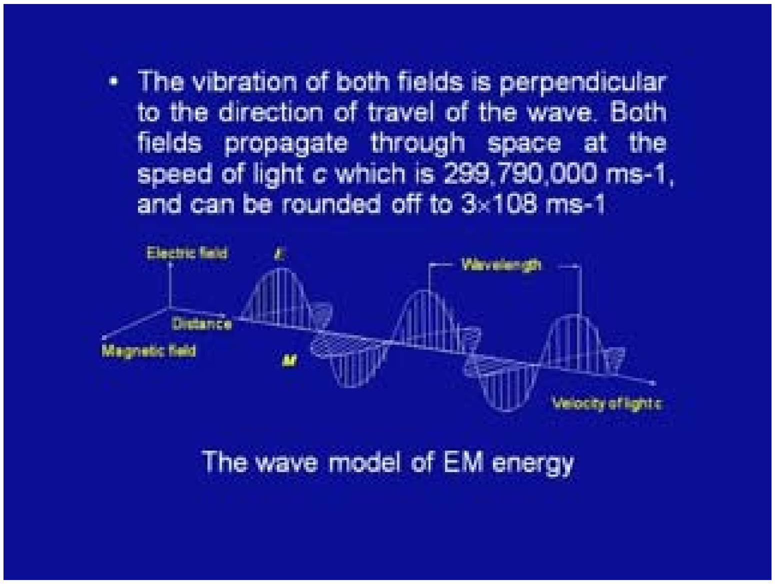

The vibrations of both the field is perpendicular to the direction of travel of the waves. Both the waves propagate through the space at the speed of light c which is it which is equal to 299,790,000 meters per second and can be rounded off to 3 raised to the power 10 3 into 10 raised to the power 8 meters per second.

The figure below shows is schematic layout of the two electromagnetic radiation fields. That is the electric field E and the magnetic field M and the manner in which these waves propagate through the space at is velocity of light.

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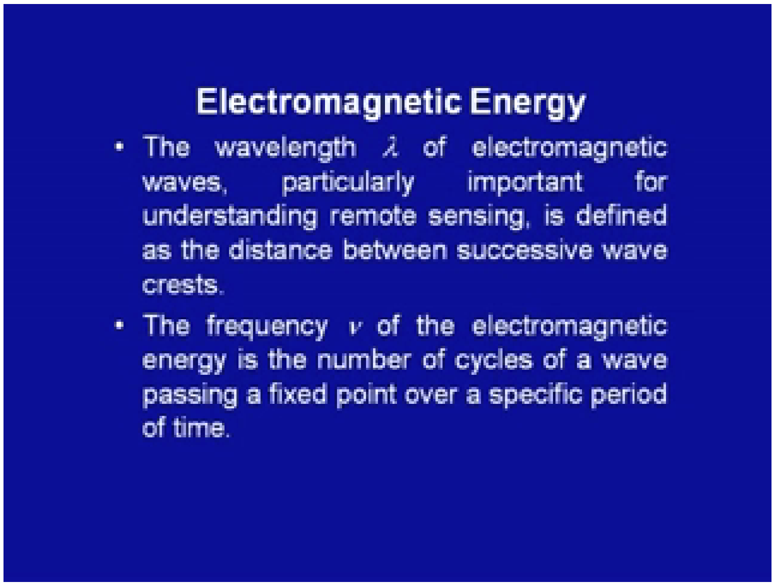

The wavelength of electromagnetic waves particularly important for understanding remote sensing is defined as the distance between the successive wave crests. The frequency v of the electromagnetic energy is the number of cycles of a wave passing a fixed point over a specific point of time.

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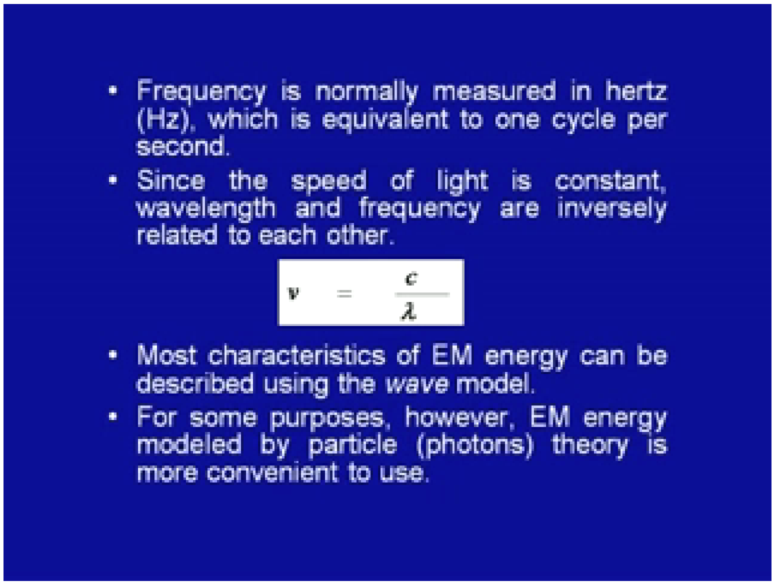

Frequency is normally measured in hertz which is equivalent to one cycle per second. Since the speed of light is constant and the wavelength and the frequency are adverse inversely related to each other by the relationship as shown below, most characteristics of the electromagnetic energy can be described by using the wave model.

For some purposes however, electromagnetic energy modeled by particle that is the photon theory is more convenient to use.

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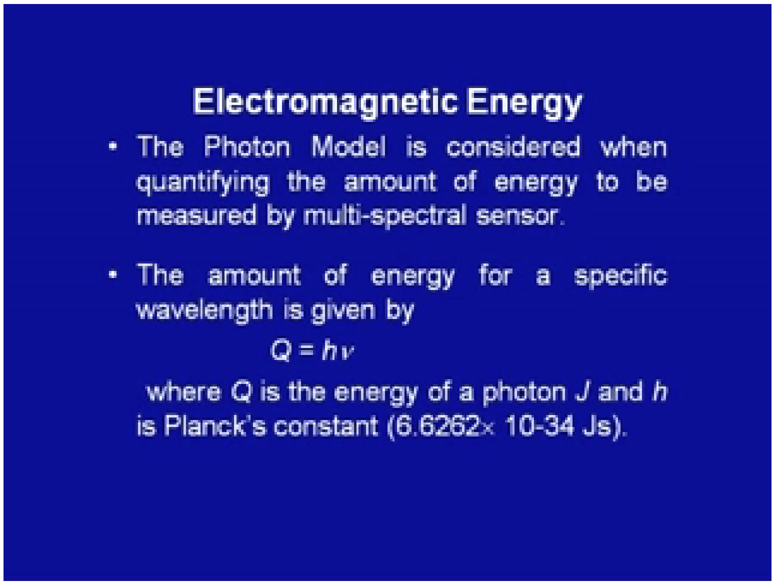

The photon model is considered when quantifying the amount of energy to be measured by a multi spectral sensor. The amount of energy for a specific wavelength is given by the equation Q is equal to h nu where Q is the energy of the photon expressed in Joules and h is the Planck's constant which is equal to 6.6262 multiplied by 10 raised to the power minus 34 Joules second.

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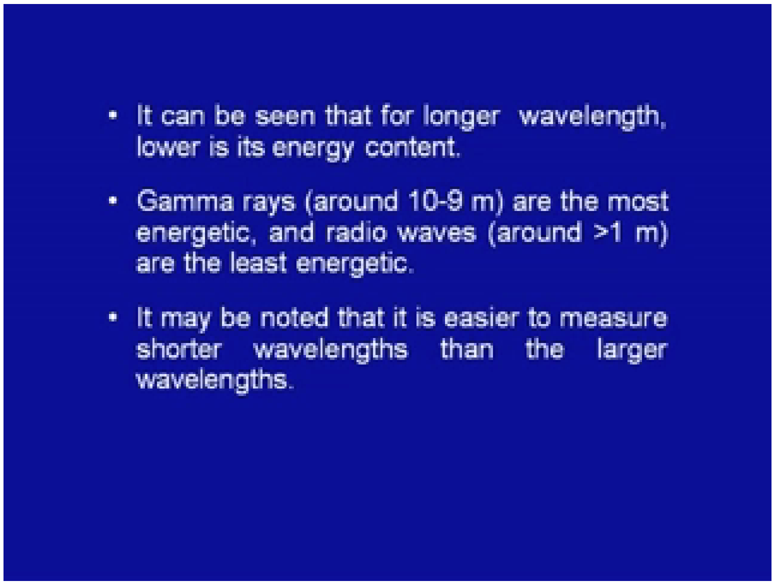

It can be seen that for longer wavelength, lower is its energy content. Gamma rays around 10 to the power minus 9 meter are the most energetic and the radio waves around greater to 1 meter are the least energetic.

It may be noted that it is easier to measure shorter wavelengths than the larger wavelengths.
So, let us look at the electromagnetic spectrum and its characteristics.

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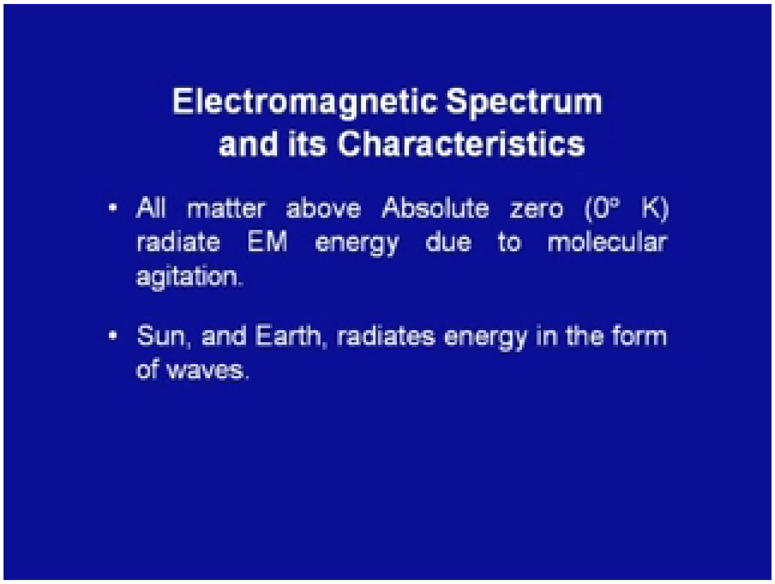

All matter above absolute 0 that is 0 K, radiate electromagnetic energy due to molecular agitation. Sun and earth radiates energy in the form of waves.

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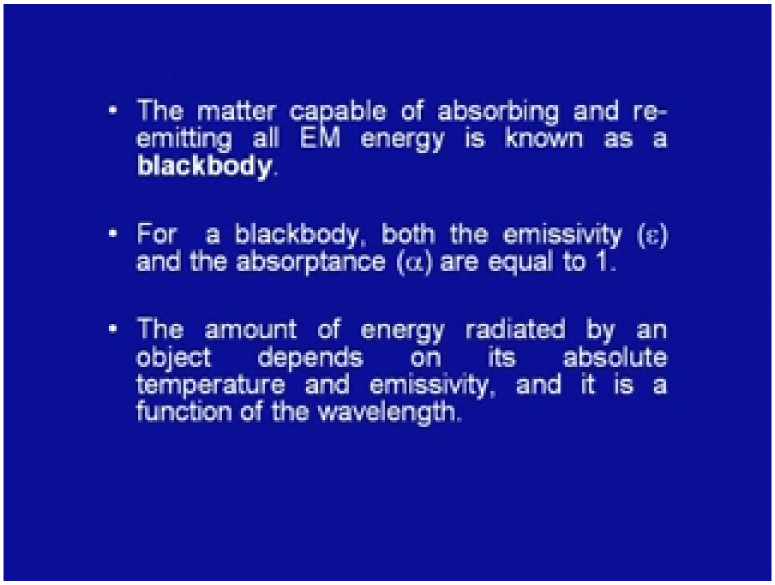

The matter capable of absorbing and reemitting all electromagnetic energy is known as a blackbody. For a blackbody, both the emissivity xi epsilon and the absorption alpha are equal to 1. The amount of energy radiated by an object depends upon its absolute temperature and the emissivity and it is a function of the wavelength.

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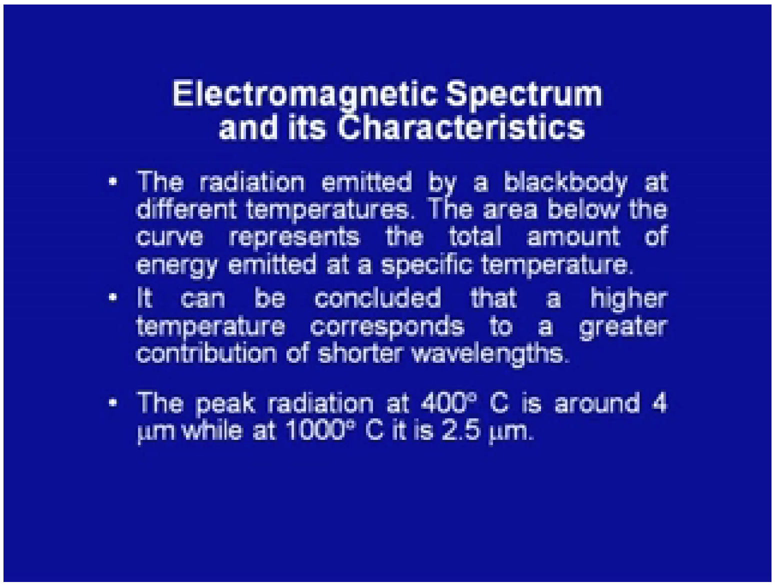

The radiation emitted by a blackbody at different temperatures can be easily measured by looking at the next curve which is there. This is the nothing but the area under the curve and here one can see the temperatures at which the manner in which the amount of energy varies.

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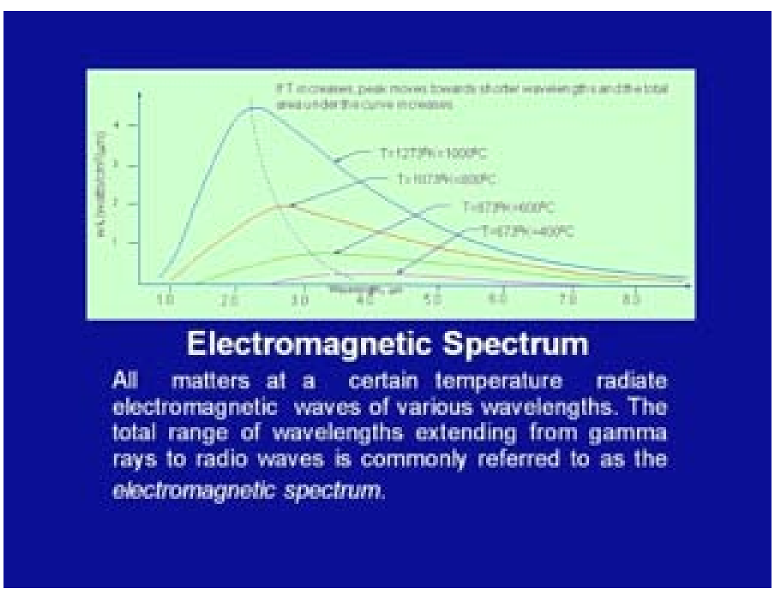

It can be concluded that a higher temperature corresponds to a greater contribution of shorter wavelengths.

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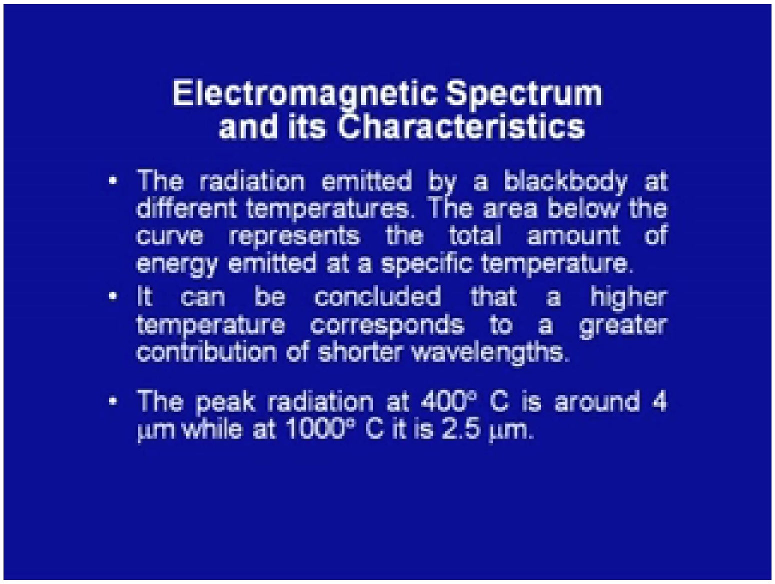

The peak radiation is at about 400 degree centigrade which is around 4 mu meters. While at 1000 degree centigrade, it is 0.25 mu meters.

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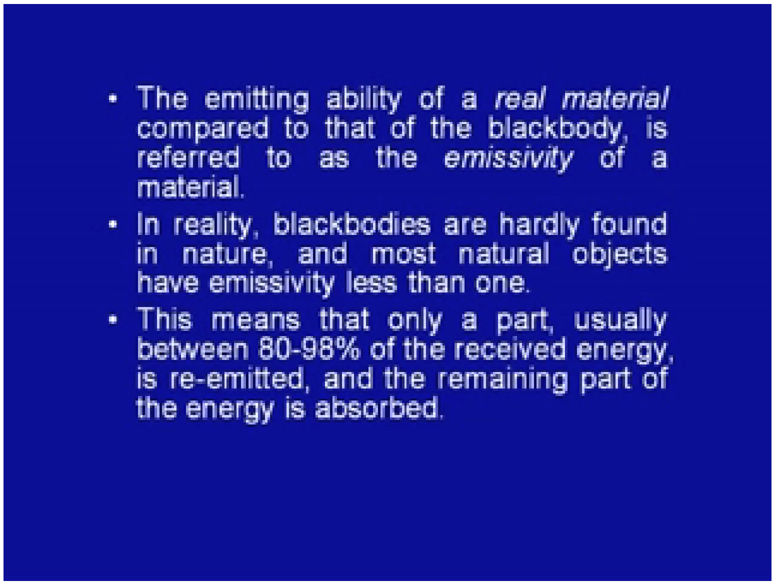

The emitting ability of a real material compared to that of the blackbody is referred to as the emissivity of a material. In reality, blackbodies are hardly found in nature and most natural objects has emissivity less than 1. This means that only a part usually between 80 to 98% of the received energy is reemitted and the remaining part of the energy is absorbed.

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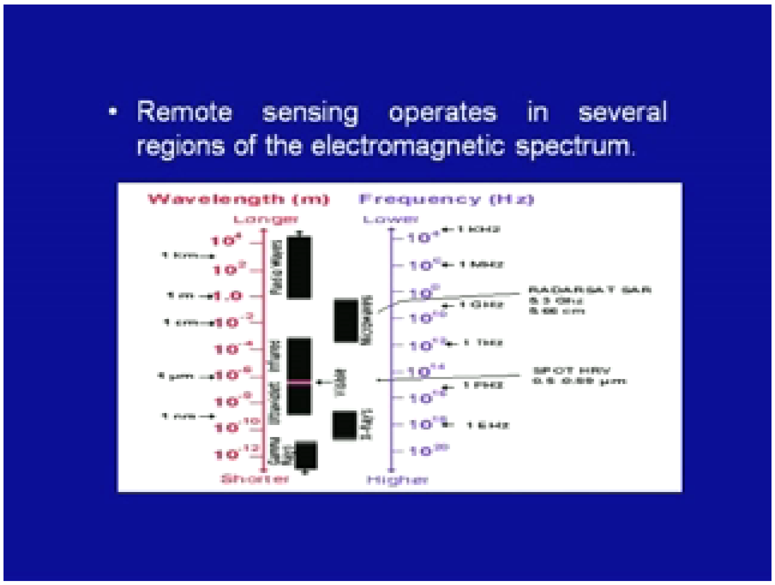

Remote sensing operates in various regions of the electromagnetic spectrum. This particular slide as a matter of fact shows a brief layout of the different regions of the electromagnetic spectrum, their wavelengths and the frequency at which the energy is radiated. Let us now focus on to some of the specific regions of the electromagnetic radiation.

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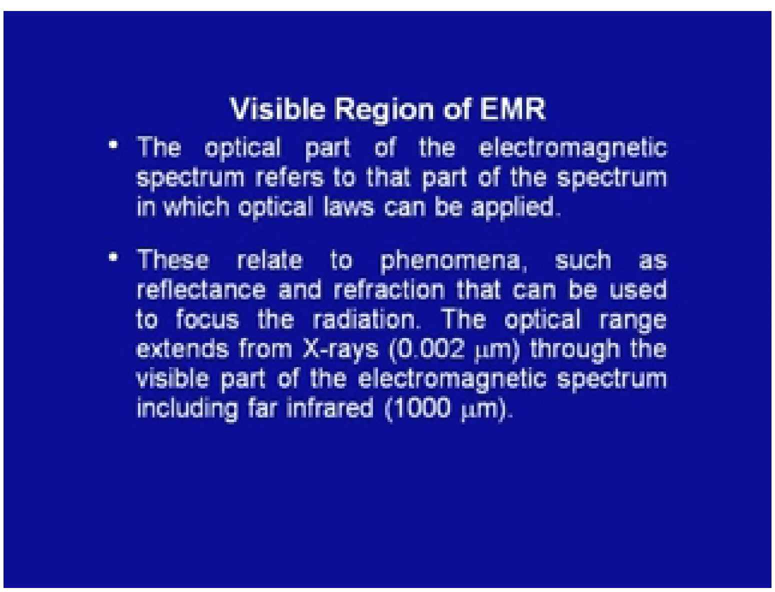

First is the visible region. The optical part of the electromagnetic spectrum refers to that part of the spectrum in which optical laws can be applied. These relate to phenomena such as reflectance and refractions that can be used to focus the radiation. The optical range extends from X rays that is 0.002 mu meters through the visible part of the electromagnetic spectrum including for infrared that is at 1000 mu meters.

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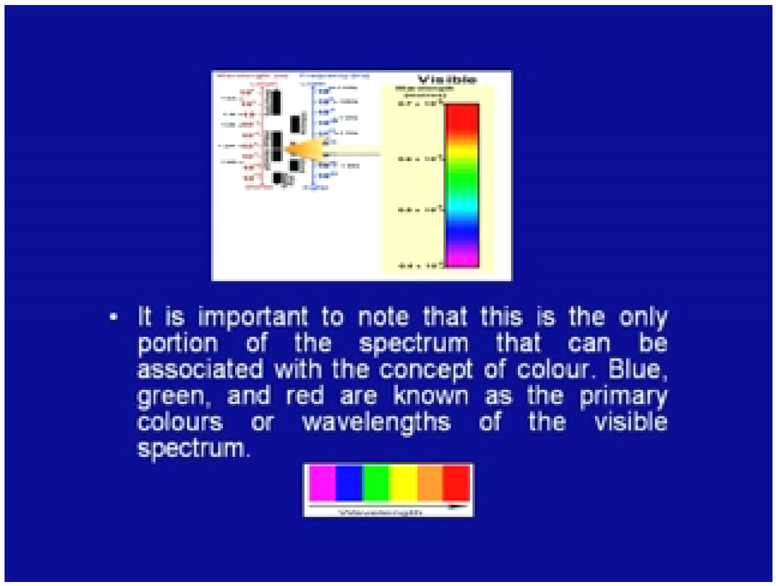

Here, we can see the range at which the visible portion of the electromagnetic spectrum, the various wavelengths and the frequencies at which it emits energies. It is important to note that this is the only portion of the spectrum that can be associated with the concept of colour. Blue, green and red are known as the primary colours or wavelengths of the electromagnetic wavelengths of the visible spectrum.

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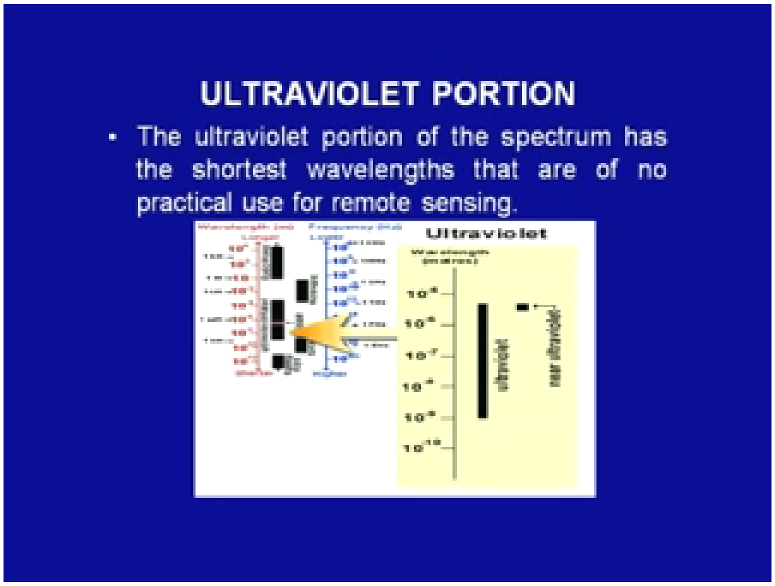

The next portion is the ultraviolet portion. The ultraviolet portion of the spectrum has the shortest wavelengths that are of no practical use for remote sensing.

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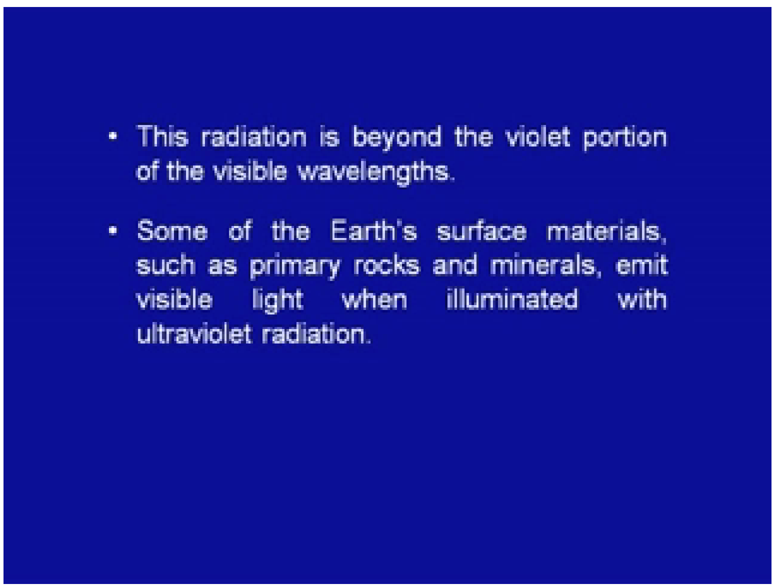

This radiation is beyond the violet portion of the visible wavelengths. Some of the earth's surface materials such as primary rocks and minerals emit visible light when illuminated with ultraviolet radiation.

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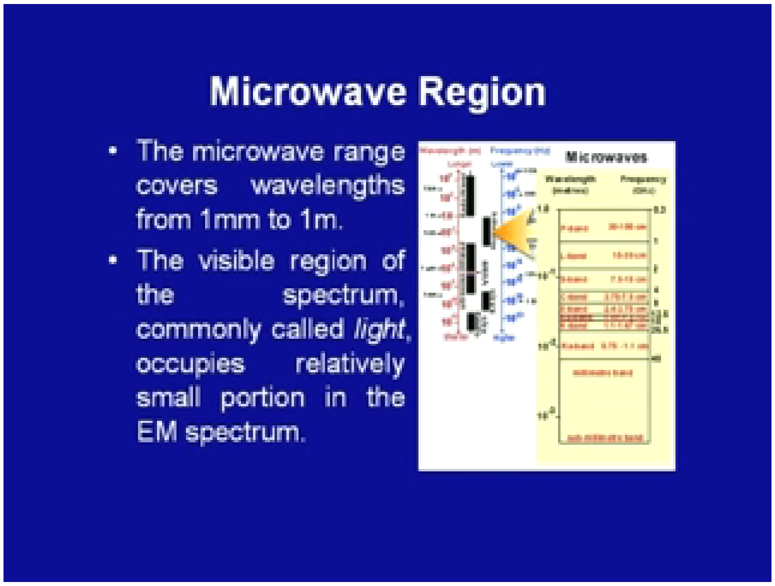

Another region important to remote sensing is the microwave region. The microwave region covers wavelengths from one millimeter to one meter. The region of the spectrum commonly known as light, occupies relatively small portion of the electromagnetic spectrum.

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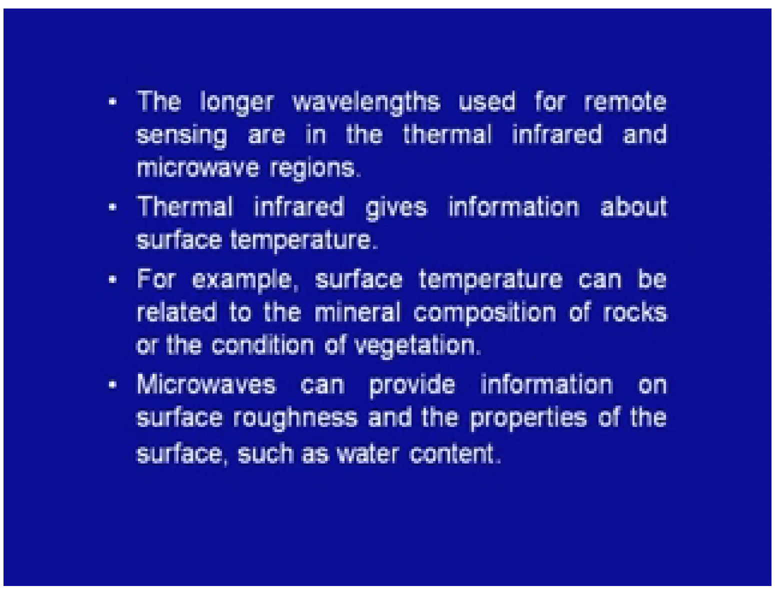

The longer wavelengths used for remote sensing are in the thermal infrared and microwave regions. Thermal infrared gives information about the surface temperature. For example; surface temperature can be related to the mineral composition of rocks or the condition of vegetation.
Microwaves can be can provide information on surface reference and the properties of the surface such as water content.

In the next session, I would discuss the interaction mechanism of the electromagnetic radiation with the earth's atmosphere and at the ground. This will allow us to understand the process of data collection and also how different objects under different conditions an electromagnetic wavelength behave.

Thank you.