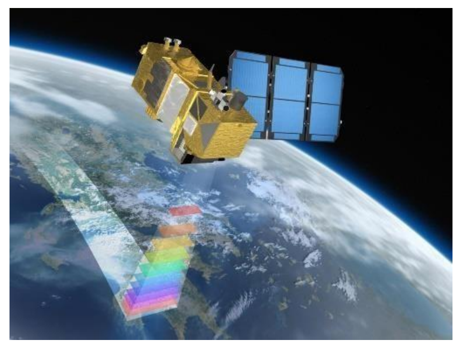
MODULE1:REMOTESENSING

BASICCONCEPTS: Remotesensing(AnEYEintheSKY)isthecommonmethodsusedtocollectdata at a distance from the object by recording devices. The use of remote sensing techniques is increasing rapidly,findingnewfieldsofapplicationastechnologyadvancesindevelopingtheremotesensingsystems. The human eye collects information from only a part of the electromagnetic radiation (visible light) reflectedfromtheexternalobjects.Theinformationcollectedontheretinaistransmittedtothemind,which physiologically processes these signals to form a complete picture.

i. RSisanobservationtooltoidentifyobjectsormeasureandanalyzetheircharacteristicswithout directly contacting the targets.
ii. RSutilizeselectromagneticradiationsasamediumfortheidentification,measurementandmonitoring of the earth surface features.
iii. Itisbasedonthefactthatallmattersreflects,observes,transmitsandemitstheEMRinauniqueway with respect to wavelength.
iv. ThisuniquepropertyofEMRiscalledasspectralcharacters/signatures.
v. Cameraorscannersaremountedonthesatellitesensors,aircraftsandgrounddronesusedinthedata collection process.



REMOTE SENSING: "The Art and Science of obtaining information of earth's object without any physical contact". This records the data, the energy interaction and target in electromagnetic radiation. Human's eye is an example of RS in the basic form, it collects the information about various objects and the human brain interprets it.

Withgrowingpopulation&raisingstandardofliving,pressure on natural economic resources are increasing day by day. Hence this technique became a necessary task to manage the available resources effectively and economically. It requires periodic preparation of accurate inventions to natural resources which may be renewable or non-renewable that can be mapped and monitored periodically for its sustainability.

HISTORYOFREMOTESENSING:

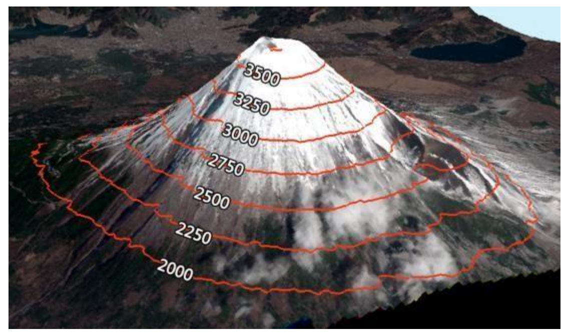
1839-First photograph
1858-Firstphotofromaballoon 1903
- First plane
1909-Firstphotofromaplane 1960 –
Space Satellite Sensor.

IndiabegandevelopmentofanindigenousIRS(IndianRemoteSensingSatellite) program to support the national economy in the areas of *Agriculture, Water resources, Forestry, Ecology, Geology, Water sheds, Marine fisheries and* Coastal management. With the advent of high resolution satellites new applications in the areas of Urban sprawl, Infrastructure planning and large scale applications for mapping have been initiated.

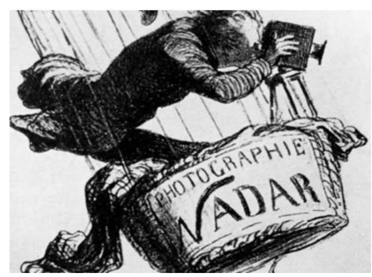
DATA & INFORMATION: Remotely gathered data is available from a range of sources and data collection techniques and is not always easily found within the public domain. This is largely due to the fact that most of this data is acquired by equipment that is expensive to build and maintain. However, therearemanytypesofbasicimageryofhigh-quality that are readily available at largely subsidized costs. Remote sensing satellites are characterized by their *altitude*, orbit *and* sensors.

i. Themain purposeof theGeosynchronous MeteorologicalSatellite(GMS)withanaltitudeof36,000kmismeteorologicalobservations.
ii. Landsatwithanaltitude of about700km,in apolarorbit,is mainlyforlandareaobservation.
iii. Satellite with an altitudeof 850 km in a polar orbit is mainly designed for meteorological observation but is also successfully used for vegetation monitoring.

Remote Sensing is being used to collect the information about agriculture, forestry, geography, archeology, weather & climate (meteorology), marine environment, hydrogeology, water resource management & assessment, civil engineering and so on. It provides meaningfulandvaluableinformationinvariousfieldssuchas natural disaster such as floods, volcanoes, earthquakes, landslides, tsunami etc.



REMOTE SENSING DATA COLLECTION: This has started in 1860 with James Wallace Black's photograph of Boston from a balloon. Most of the remotely sensed data used for mapping and spatial analysis is collected asreflectedelectromagneticradiation,whichisthenprocessedintoadigital form. This helps to detect and classify objects on the Earth's land surface, atmosphere and oceans.



a. **Satellites:**Satelliteshavebeenusedforcapturinggeospatialinformation for over 60 years now mainly for weather forecasting, mapping, environmental research, military intelligence and more.
b. **AerialPhotography:**Itisoneoftheearliestformsofremotesensingandisstilloneofthemostwidely used and cost-effective methods of remote sensing. The advent of drones, Unmanned Aerial Vehicles have made aerial photography easier for commercial and non-commercial purposes.
c. **LiDAR(LIGHT DETECTIONANDRANGING):** It is aRemoteSensing method that uses light in the form of pulsed laser to measure variable distances to the earth. These light pulses combined with other Airborne System generate precise 3-Dimensional information about the earth’s features and its characteristics.TheinstrumentusedforLIDARmethodiscalledasLIDARscanners,LIDARdetectors.
d. **RADAR (Radio Detection and Ranging):** It’s also a Remote Sensing method that detects the speed, distance and direction of an aircraft, ships and other objects. By sending out pulses of radio waves which are reflected off the object back to the sources. High power RADAR using large dish antennas has been used to measure distances to the Moon, other planets, asteroids and artificial satellites.

e. **UAV (Unmanned Aerial Vehicle):** Drone is an aircraft without human that can be controlled by an operator from the ground. They are originated mostly in military applications, but are rapidly utilized for commercial, scientific, recreational, agricultural, traffic monitoring, disasters monitoring and others.

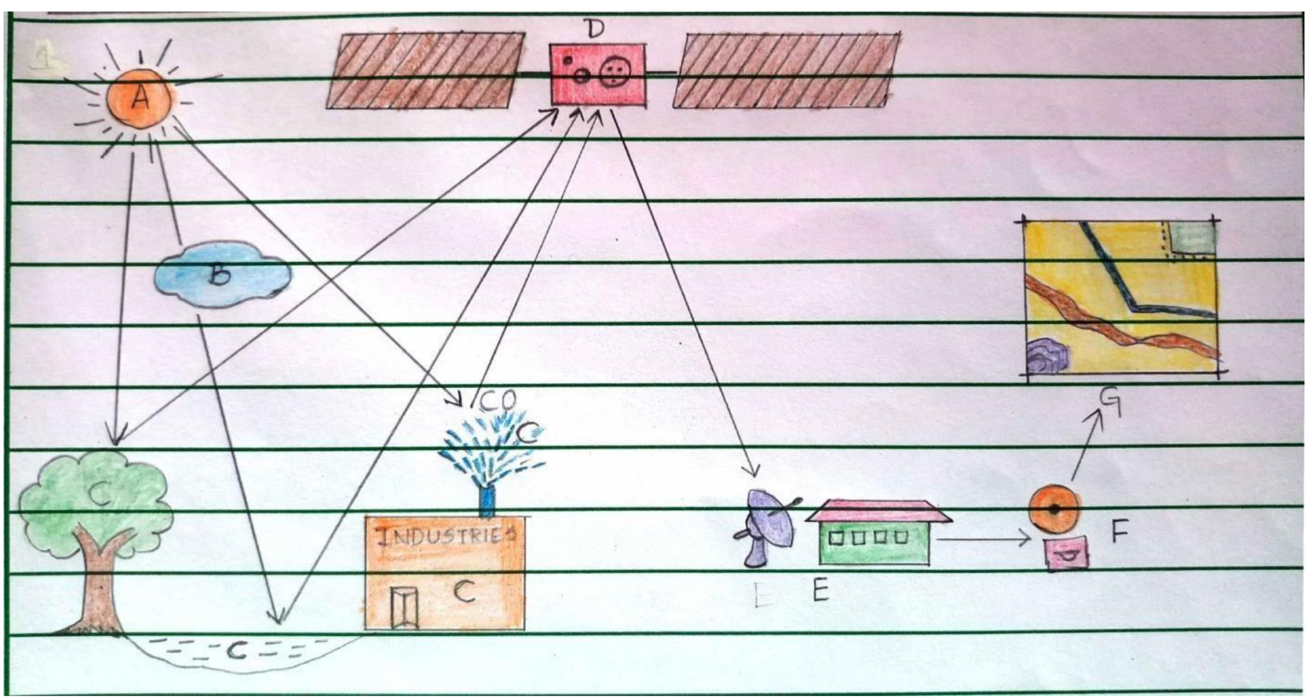
REMOTESENSING ADVANTAGES

i. ***Geology:***Geologicalandstructural mapping.
ii. ***Hydrology:***Mappingofsurfacewaterbodies,monitoringwetlands,snowcoversandglaciers.
iii. ***Agriculture:***Croptype,croprotation&itsconditionanalysisandsoilmoisturemeasurements.
iv. ***Forestry:***Mappingofexactforestboundaries,biomassestimation,speciesidentificationandfirescar mapping.
v. ***Oceanography:***Seaiceidentification,coastalwind fieldandwaveslopemeasurements.
vi. ***Shipping:***Navigationoftypesofship,itsdetectionand classification.
vii. ***CoastalZone:***Shorelinedetection,sea-freshwaterintrusionsandgeneralvegetationcover.
viii. ***Military/SecurityApplications:***Detectingtheexactlocationandspeedofthewarplanes.

LIMITATIONSOFREMOTESENSING

a. Remotesensingisafairlyexpensivemethodof analysisespeciallywhenmeasuringsmallerareas.
b. RequiresaspecialkindoftrainingforeffectiveinterpretationofRemoteSensingtechnology.
c. Itisexpensivetoanalyze repetitive photographs.
d. Instrumentalerrormayleadto un-calibratedRemoteSensingdata.
e. Theinformationprovided byRemoteSensing datamay notbe complete and may betemporary.
f. LargescaleengineeringmapscannotbepreparedfromsatellitedatawhichmakesRemoteSensingdata collection incomplete.

PROCESSOFREMOTESENSINGSYSTEMS



A=Naturallightsource(Sun);B=Atmosphericelements(clouds;COemission);C=Surfacefeatures; D= Satellite sensor; E= Observation station; F= Disk/ floppy; G= Processed Images

1. Energy Source (A):- Sun is the main source of light energy which strikes the earth surface features through Electro-Magnetic Radiation (EMR).

2. Radiation and Atmosphere (B):- EMR interacts with the atmospheric elements while traveling from its source to the target. This may obstruct the accuracy of the data collection.

3. Interaction with the Target (C):- Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface. Different objects return different amount of energy depending on the physical, chemical & optical properties.

4. Recording of Energy by the Sensor (D):- After the energy has been emitted from the target, the reflected wavelength will be collected and recorded by the sensors. Error may occur during the data collection due to difference in surface roughness, angle of incidence, intensity, and wavelength of radiant energy.

5. Transmission, Reception, and Processing (E):- The energy recorded by the sensor will transmit the datain electronic form to thenearest observation station. Then thedetection and discrimination of earth's feature will be done to form final image.

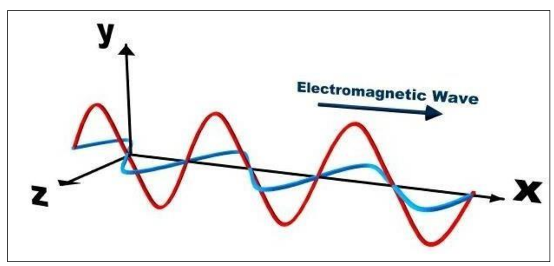
6. Interpretation and Analysis (F):- Later the processed image will be interpreted visually and digitally to extract specific information of the particular features.

ELECTROMAGNETICSPECTRUM

Electromagnetic Radiation (Waves): Electromagnetic Radiation is the combination of electric and magnetic fields that propagate together at the speed of light. But this energy can be detectable only when reactswithanyobject.Thisiscommonlyspokenofasthevelocityoflight,althoughlightisonlyoneform of electromagnetic energy.

Speedofthelight(C) =3x 10^8m/s

Sunisanaturalsourceofelectromagneticradiationthatcantravelinvaccum.Anelectromagneticwave is characterized by

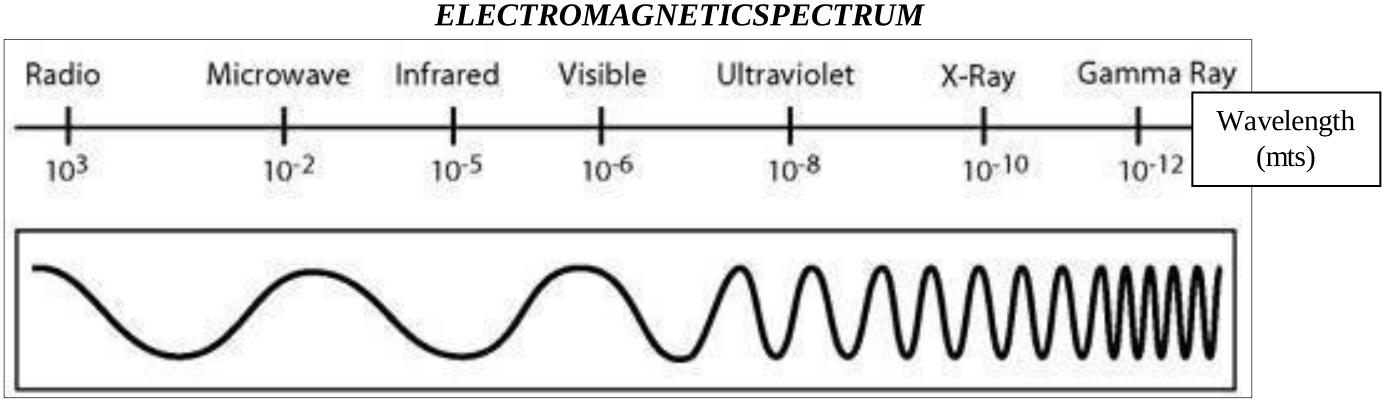


i. ***Frequency(f):*** It is the numberofwaves that pass in an interval of time. Hertz is the unit for a frequency of one cycle per second.

ii. ***Wavelength(λ):***Itisthedistancebetweensuccessive crest or troughs in the wave measured in standard metric system.

$C = f \times \lambda$ or $f = C / \lambda$

ELECTROMAGNETICSPECTRUM



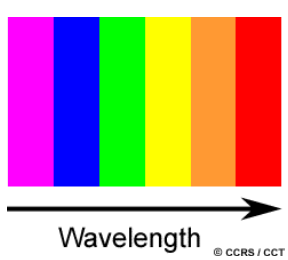
1. Theelectromagneticspectrumistherangeof allpossiblefrequenciesofelectromagneticwaves.
2. Themaincomponentsoftheelectromagneticspectrum are
   a. Gamma-rays *b.X-rays* *c.Ultra-violetrays* *d. Visible light*
   e.Infra-Red rays *f. Microwaves* *g.Radio waves*
3. Lowest frequencies are recorded at the one end of radio waves, while highest frequencies are recorded on the other end of gamma rays.
4. Wavelength and frequencies are inversely proportional to each other as the frequencies increases on the EM spectrum wavelength decreases.
5. Visible region of the spectrum lies in the spectral rays of 0.4 – 0.7 μm wavelength. The energy reflected by the earth and other objects during the day time is recorded in this range. This is only region which is visible to human eye.
6. Reflected Infrared radiation ranges from 0.7 – 3 μm wavelength. These are recorded by infrared sensor systems.
7. Thermal Infraredradiationrangesfrom3–5μmand8-14μmrepresentinggreaterintensity.
8. Micro-waveregionrangesfrom1–300mmwhichcanpenetratethroughrain,fogandclouds.Both active and passive sensors are capable of taking images using this sensors.
9. Gammaraysranges lessthan10 pictometer.
10. X-raysranges from10^{-5}– 10^{-3} (0.000001nm).
11. Radio-waveshavelongestwavelength greaterthan10^{6}usedforRemoteSensingin someradars.

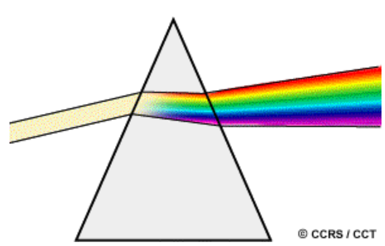
WAVELENGTHREGIONSIMPORTANTTOREMOTESENSING

1. **Ultraviolet or UV:** Ultraviolet (UV) light has wavelengths of approximately 1 – 380 nm. Near andmiddle UV wavelengths have information about ozone, sulfur dioxide, and trace gases in thetroposphere and stratosphere (0–50 km) of interest to the atmospheric and volcanic sciences. Far andextreme UV wavelengths have information about airglow and auroral emissions from thethermosphere (>100 km) of interest in aeronomy and space weather. Few earth surface rocks and minerals emit visible radiation when illuminated by UV radiation.

2. **Visible Spectrums:** The visible wavelengths cover a range from approximately 400 – 750 nm or 0.4 to 0.7 μm. The longest visible wavelength is red and the shortest is violet. The visible portion of the spectrum is used extensively in remote sensing and energy is recorded using photography. Common wavelengthsofwhatweperceiveasparticularcolorsfromthevisibleportionofthespectrumarelisted below.**Red,Green**and**Blue**arethe**primarycolors**inwhichallothercolorscanbeformedinvarious proportions. Although we see sunlight as a uniform or homogeneous color, it is actually composed of various wavelengths of radiation in primarily the ultraviolet, visible and infrared portions of the spectrum. The visible portion of this radiation can be shown in its component colors when sunlight is passed through a **prism**, which bends the light in differing amounts according to wavelength.

Color	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm





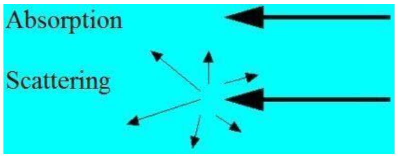
3. **Infrared (IR):** This covers the wavelength range from approximately 0.7 µm to 100 µm (750 nm - 10,000 nm) more than 100 times as wide as the visible portion. The infrared can be divided into 3 categories as follows

Sl No	Categories	Wavelength range	Applications
1.	NearInfraRed (NIR)	0.7µmto 1.3 µm	Toexposeblack&whiteandcolor-infraredsensitivefilm
2.	Shortwave InfraRed(SWIR)	1.3 to 3.0 µm	Usedtoobservethehealthofvegetation,soilcompositionand moisture content.
3.	ThermalInfraRed (TIR)	3.0µmto 100 µm	Wavelengthsfrom8to15µmarebestforstudyingthelongwave thermal energy radiating from the Earth.

4. **Microwave:**Microwavesareessentiallyhighfrequencyradiowavesandhavewavelengthsthatrange 1mm to 1m. Mid-wavelength microwaves can penetrate through haze, light rain & snow, clouds, and smokearebeneficialforsatellitecommunication,flightmovementandstudyingtheEarthfromspace. Radar technology sends pulses of microwave energy and senses the energy reflected back.

Sl No	Region	Wavelength	Remarks
1.	Gammaray	<0.03 nm	Incomingradiationiscompletelyabsorbedbytheupperatmosphere and is not available for RS
2.	X-ray	0.03 to 3.0 nm	Completelyabsorbedbyatmosphere.NotemployedinRS
3.	Ultraviolet	0.3 to 0.4µm	Incomingwavelengthslessthan0.3µmarecompletelyabsorbedby ozone in the upper atmosphere.
4.	Photographic UV band	0.3 to 0.4µm	Transmittedthroughatmosphere.Detectablewithfilmand photodetectors, but atmospheric scattering is severe
5.	Visible	0.4 to 0.7µm	Imagedwithfilmandphotodetectors.Includesreflectedenergy peak of earth at 0.5 µm
6.	Infrared	0.7 to 1.00µm	Interactionwithmattervarieswithwavelength.Atmospheric transmission windows are separated.
7.	Reflected IR band	0.7 to 3.0µm	Reflectedsolarradiationthatcontainsinformationaboutthermal propertiesofmaterials.Thebandfrom0.7to0.9µmisdetectable with film and is called the photographic IR band.
8.	ThermalIR	3 to 5 µm	Principal atmospheric windows in the 8 to 14 µm thermal region. Images at these wavelengths are acquired by optical mechanical scanners and special vidicon systems but not by film. Microwave 0.1to30cmlongerwavelengthscanpenetrateclouds,fogandrain. Imagesmaybeacquiredintheactiveorpassivemode.
9.	Radar	0.1 to 30 cm	ActiveformofmicrowaveRSRadarimagesareacquiredatvarious wavelength bands.
10.	Radio	>30cm	Longestwavelengthportionofelectromagneticspectrum.Some classifiedradarswithverylongwavelengthsoperateinthisregion.

ENERGYINTERACTIONSWITHTHE ATMOSPHERE

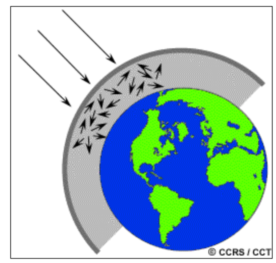


Theconstituentsoftheatmospherecanbedividedintotwogroup's viz. (a) pure gases and (b) particulates. Pure gases in the atmosphere comprise nitrogen (78 %), oxygen (21%) and traces of argon, CO, water vapourand ozone. Theparticulates in theatmosphereincludeparticlesof varioussizesoriginatingfrom smoke,dustandrock debris.EMRhasto travelthroughsomedistances through these constituents in the earth's atmosphere before reaching the surface. Atmospheric gases and particles may affect the incoming light and radiation caused by the mechanism of **absorption** and **scattering.**

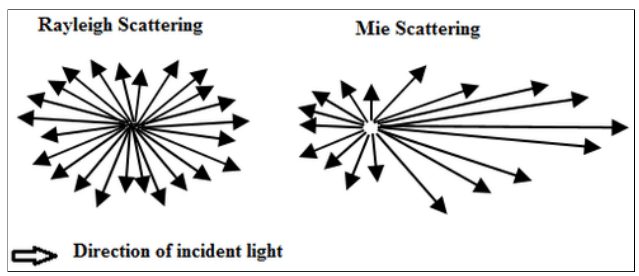
1. ABSORPTION: Ozone,carbondioxide,andwatervaporarethethreemainatmosphericconstituents which absorb radiation. **Ozone** serves as protective layer all living organisms which absorb the harmful UV radiation from the sun. Without this protective layer in the atmosphere our skin would burn when exposedtosunlight.**Carbondioxide**referredtoasagreenhousegasthattendstoabsorbradiationstrongly in the far infrared region and serves to trap heat inside the atmosphere. Water vapor in the atmosphere absorbs much of the incoming long wave infrared and shortwave microwave radiation (between 1.4, 1.9 and2.1µm).Thepresenceofwatervaporin theloweratmospherevariesgreatlyfromlocationtolocation and at different times of the year.

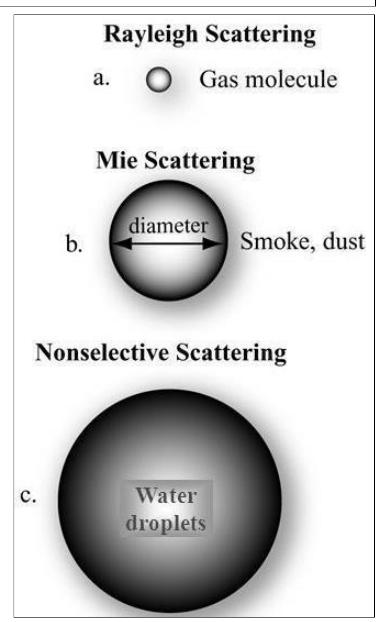
E.g., airmassaboveadesertwouldhaveverylittlewatervaportoabsorbenergy,whilethetropicswould have high concentrations of water vapor (i.e. high humidity).

2. SCATTERING: The atmospheric elements such as gas molecules of 10^{-4} µm insizeandhaze(waterdroplets)varyinsizefrom10^{-2}µmto10^{2}µmmayaffectthe frequency,intensity,spectraldistributionandchangestheradiationpath. Itreduces the image contrast, and reflectance characteristics of ground objects as seen by the sensor.Thisdependsupontherelativesizeofatmosphericparticles.Therearethree (3)types ofscattering which takeplace.



i.RAYLEIGHSCATTERING: Rayleigh scatteringoccurswhenverysmallparticlessuchas small specks of dust or nitrogen and oxygen moleculesbysizeof10^{-4}µminacleanatmosphere. Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere and causes shorter wavelengths. The fact that the sky appears "blue" during the day is because of this phenomenon. At **sunrise and sunset** the light has to travel farther through the atmosphere than at middayandthescatteringoftheshorterwavelengthsismorecomplete; this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere.





i.MIE SCATTERING: It occurs when the particles are just about the same size as the wavelength of the radiation. Dust, smoke, water vapor and other particles ranging from a few micron to several microns in diameter arecommon causeswhich tendsto affectlongerwavelengths. Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant and dominates when cloud conditions are overcast. The amount of Mie scatter is greater than the Rayleigh scatter and wavelengths scattered are larger.

i.NON-SELECTIVESCATTERING: Thisoccursintheother extremecasewhentheparticlesizeis verymuchlargerthanthewavelengthanddoesnotdependonthewavelengthofradiation.Thewhitish appearanceofskyunderheavyhazeconditionsisduetonon-selectivescattering.TheeffectofRayleigh component can be eliminatedby using minus bluefilter. This typeofscatteringcauses fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities (blue+green+red light = white light).

Eg: Rainbows.

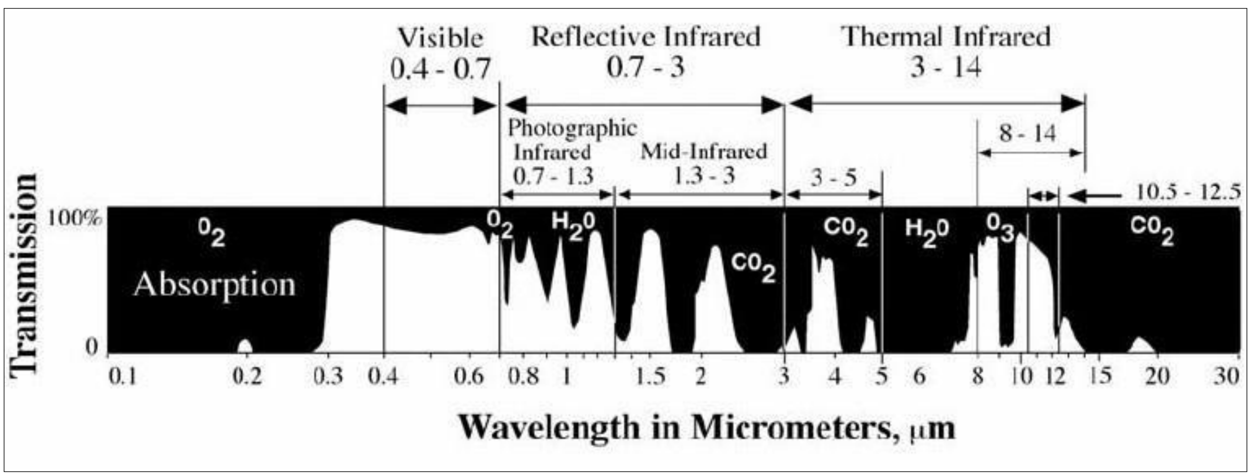
ATMOSPHERICWINDOWS

Regions of the electromagnetic spectrum in which the atmosphere is transparent are called atmospheric windows. These wavelengths corresponding to atmospheric window are used in Remote Sensingtoacquiregoodqualityimages.Inthevisibleandinfraredbandsatmosphericwindowsexist in the following regions:

Visible and Near IR - 0.4 µm to 1.3 µm

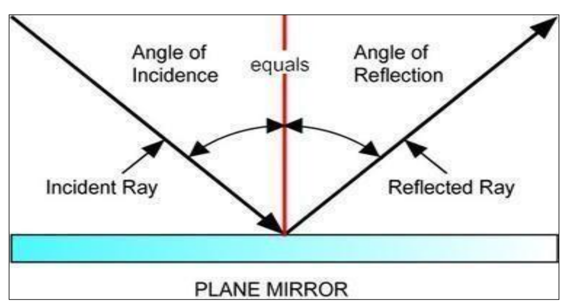
Thermal IR- 3 µm to 5.5 µm 8.5 µm to 14 µm

WhenEMRistransmittedfromthesuntotheearthsurface,itpassesthroughtheatmosphere.Here, electromagnetic radiation is scattered and absorbed by gases and dust particles. Besides the major atmosphericgaseouscomponentslikenitrogenandoxygen,otherconstituentslikewatervapour,methane, hydrogenandheliumcompoundsplayimportantroleinmodifyingelectro-magneticradiation.Thisaffects image quality. Some of the commonly used atmospheric windows are shown in thefigure.



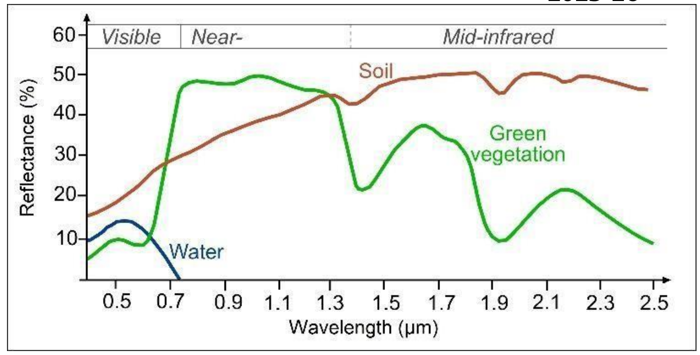
AtmosphericWindowintheElectromagneticSpectrum

SPECTRALSIGNATURECONCEPTS-TYPICALSPECTRALREFLECTANCE CHARACTERISTICS OF SOIL, WATER AND VEGETATION



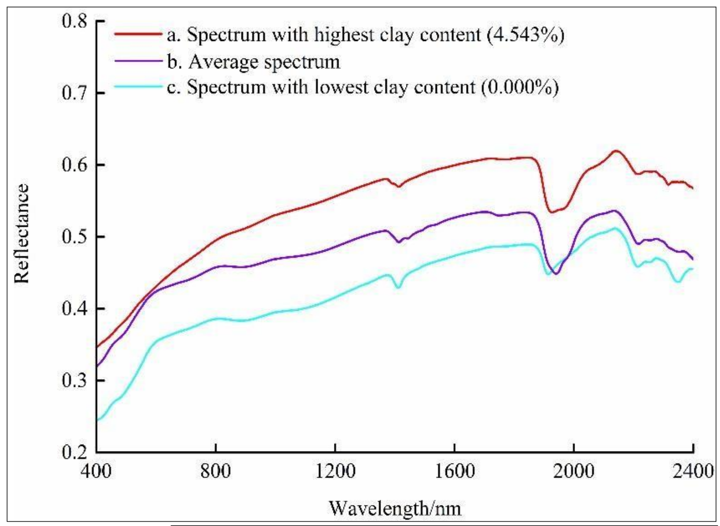
Each earth surface object has its own spectral characteristic manner of interacting with incident radiation described by the spectral response of the electromagnetic spectrum.Thesetargetsinaparticularwavelengthregion,in turn depends upon certain factors, namely orientation of the sun (solar azimuth), the height of the Sun in the sky (solar elevationangle),thedirectioninwhichthesensorispointing relativeto nadir(thelookangle) andnatureofthetarget,that is,state ofhealth of vegetation.

SpectralReflectivity

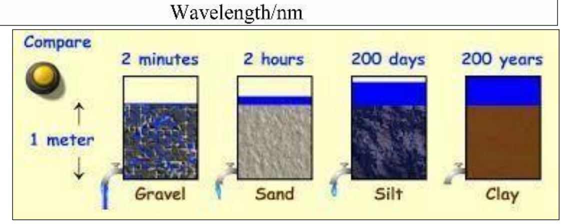


- Reflectivityisthefractionofincidentradiation reflected by a surface.
- The reflectance characteristics of Earth's surface features may be quantified by measuring the portion of incident energy that is reflected.
- This is measured as a function of wavelength (λ) and is called spectral reflectance (rλ).
- Chlorophyllstronglyabsorbsenergyinthewavelengthbandscenteredatabout0.45µm(blue)and0.67 µm (red).
- Our eyes perceive healthy vegetation as green in color because of the very high reflection of green light.

i. Spectralreflectanceof Soil

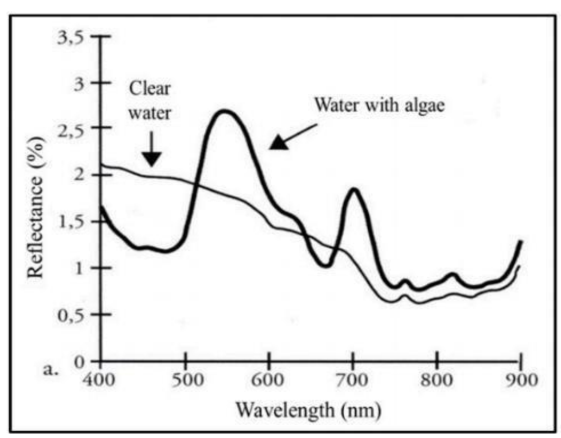


- Thefactorsthatinfluencesoilreflectanceact over less specified spectral bands.
- Factors affecting soil reflectance are moisture content, soil texture (proportion of sand, silt and clay), surface roughness, presence of iron oxide and organic matter content.
- The presence of moisture in soil will decreaseitsreflectance-thiseffectisgreatest in the water absorption bands at about 1.4, 1.9, 2.2 and 2.7 µm.
- Baresoilgenerallyhasanincreasingreflectance,with greaterreflectance in near-infrared and shortwave infrared.

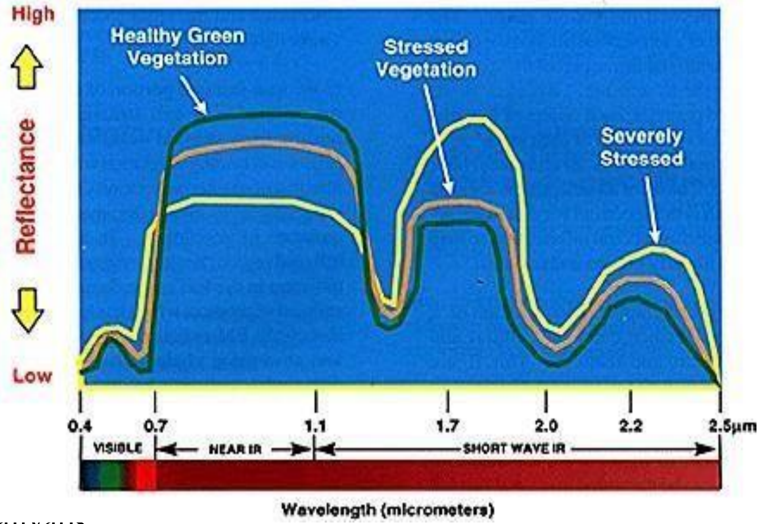


ii. SpectralreflectanceofWater

- Water (in soil, vegetation or water bodies) absorbs radiation at near-IR wavelengths and beyond (strong absorption bands at about 1.4, 1.9 and 2.7 µm).
- Reflectance from a water body can stem from an interactionwiththewater'ssurface(specularreflection), with material suspendedin thewater,orwith thebottom of the water body.
- Water hasrelativelylowreflectance,withclear water having the greatest reflectance in the blue portion of the visible part of the spectrum.

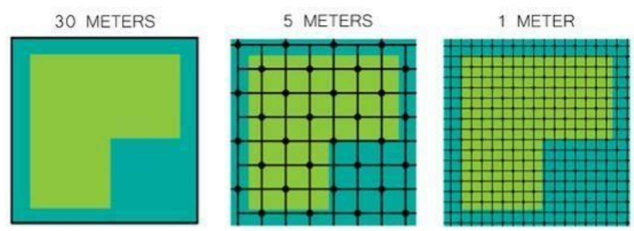


SpectralreflectanceofVegetation



- Intherangeof0.7to1.3µmaplantleaf typicallyreflects40-50%oftheenergy incident upon it primarily due to the internal structure of plant leaves.
- This helps in discriminating different plants and trees in various fields.
- Manyplantstressesalterthereflectance in this region, and sensors operating in this range are often used for vegetation stress detection.
- Beyond 1.3 µmenergyincidentuponvegetationisessentiallyabsorbedorreflectedwithlittletonotransmittanceofenergy.
- Dipsinreflectanceoccurat1.4,1.9and2.7µmduetostrongabsorptionofwaterbyleavesatthese wavelengths (*water absorption bands*).
- Reflectancepeaksoccuratabout1.6µmand2.2µmbetweentheabsorptionbandsthroughouttherange beyond 1.3 µm, leaf reflectance is approximately inversely related to the total water present in a leaf which is a function of both the moisture content and the thickness of a leaf.

RESOLUTION



Resolution refers to the smallest size an object or detail can be represented in an image. Higher resolutionmeansthatpixelsizesaresmaller,providing more detail. Imagery satellites provide different types of resolutions, revisit rates and carry different information.Somehavelowerresolutionsbutcover large areas with daily revisits while other offer very high-resolution resolution images from specific locations.

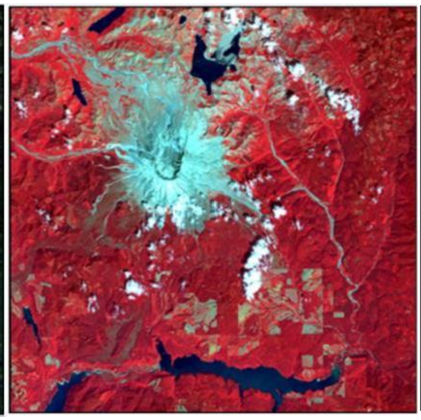
Thedatacanalsobefull RGBbandsas well as black andwhiteimagesor non-visiblebands.Very high-resolutionsatellites usuallycoverlessthan1mperpixel. Theirlevelofdetailmakesthemsuitableto apply algorithms to monitor changes, detect objects, or spot trends. They are very useful to track human activitiesaswellasremotenaturalareas.30mresolutionsatelliteimagerycancapturedetailsontheground that are greater than or equal to 30m by 30m. Anything on the ground that is less than that size will be blended with the surrounding area to make a 30m by 30m square.

IMAGEREGISTRATION

It is theprocess oftransforming thedifferent set ofdatainto one coordinatesystem. This process helps in overlying two or more images of same place taken at different times, from different viewpoints or from different sensors. Image registrationisthe firststeptowardsusing remotesensedimages foranypurpose. Toposheet of 1:50,000 scale from Survey of India will be considered as base map for any satellite image registration.Theseimagesaregeo-rectifiedbyconsideringpermanentfeaturessuchastemples,major roads (NH/SH), drainages, power-lines, railways, settlements, co-ordinates, forests and village boundaries. A fieldsurveyhastobeconductedforgroundverificationofdoubtfulareaswiththehelpofGPSonhilly terrains and remote places where accessibility is difficult. This technique majorly utilized in the field of medicine, cartography, climatology, archaeo-survey, hydrology, hydrogeology, pattern recognition etc.

FALSECOLOUR COMPOSITE

FCC allow us to visualize the wavelengths the human eye does not see (Near infrared range). The use of bands,suchasnearinfrared,increasesspectralseparationandcanenhancetheinterpretabilityofdata.False colorimagesarearepresentationofamultispectralimagecreatedusingrangesotherthanvisiblered,green, andblue,suchasred,greenandblueimagecomponents.Therearemanydifferentfalsecoloredcomposites that can be used to highlight different features.



Composite Name	Bands
Natural Color	4 3 2
False Color (urban)	7 6 4
Color Infrared (vegetation)	5 4 3
Agriculture	6 5 2
Healthy Vegetation	5 6 2
Land/Water	5 6 4
Natural With Atmospheric Removal	7 5 3
Shortwave Infrared	7 5 4
Vegetation Analysis	6 5 4

NaturalColorComposite ***FalseColorComposite (FCC)*** ***Landsat-8Band combinations***

Band combinations are selected for a number of reasons and it is helpful to understand the spectral reflectance profiles of features. For example in the NIR false color composite shown above healthy vegetation appears bright red as they reflect more near infrared than green. In this type of FCC images vegetationappearsindifferentshapesofreddependingonthetypesandconditionsofthevegetation.Clear waterappearsasdarkblue(highergreenbandreflectance),whileturbidwaterappearcyanitmeanshigher reflectance of red compared to clear water. Bare soils, roads and buildings may appear in various shapes of blue yellowish to white depending on their compositions.

ELEMENTSOFVISUALINTERPRETATION TECHNIQUES

Asystematicstudyofaerialphotographsandsatelliteimageriesusually,involvesseveralcharacteristicsof features shownon an imageand it depend upon field ofapplication. Most ofthe applications consider the followingbasiccharacteristicsorvariationinthemwhichaidthevisualinterpretationprocessofsatellites imagery.

1. **Tone:-** Tone refers to the relative brightness or color of objects in an image. Each sensor records a specific color or range of colors that reveal particular features. Variations or shades of these tone/ colors provide better interpretation techniques. This becomes fundamental element to distinguishing between similar features.

2. **Shape:-** Shape refers to the structure or outline boundary of individual objects. Shape can be a very distinctive clue for interpretation. Distinct patterns appears due to human activities such as roads, railway tracks, power lines (line or linear), urban, agricultural lands (rectangular), forest edges etc. The shapes of forestboundariesaremoreirregularinshape,exceptwheremanhascreatedaroadareclearcuts. Coconut plantation shows regular shape with shadow due to its height.

3. **Size:-**Sizeoftheobjectsinanimageisafunctionofscale.Recognitionoffamiliarobjectsallowssize estimation of other features; size is an important aspect of association. Itis important to assess the size of a target relative to other objects in a scene. A quick approximation of target size can direct interpretation to an appropriate result more quickly. An area with a number of large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use. Size and shape information greatly influenced by image resolution.

4. **Pattern:-**refersto thespatial arrangement ofobjects ofdiscrimination. Typically an orderlyrepetitive object is a recognizable pattern. Urban streets with regularly spaced houses and agricultural activity with rectangular shapes are good examples of pattern.

5. **Texture:-** Areas of an image with varying degrees of ‘smoothness’ or ‘roughness’. Water appears as smooth while forest canopy results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.

6. **Shadow:-** Shadow effects change throughout the day and throughout the year. It helps to interpret relative heights and size of an object. Shadow is also useful for enhancing topography and landforms, particularly in radar imagery.

7. **Association:-** It identifies the relationship between 2 or more recognizable objects. Commercial properties may be associated with major transportation routes, whereas residential areas would be associated with schools, hospitals, parks and sports fields. Agricultural and irrigation activities will be associated with nearby perennial rivers and streams.

8. **Site:-** It refers to the characteristics of an object such as topography, soil, vegetation and cultural features.Physicalpositionofobjectfeature(topographicorgeographic),hillslopes,ocean,land,mountains etc. The extensive transportation network also a good key to identify theport.