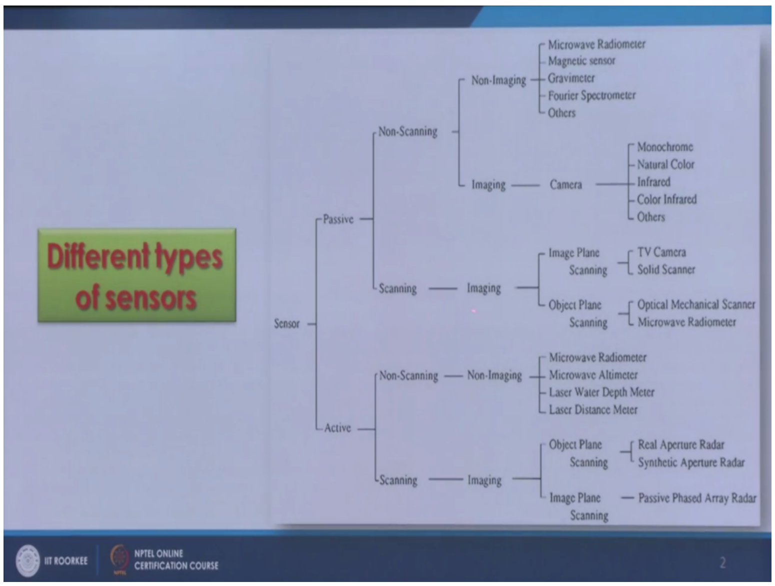
Introduction to Remote Sensing
Dr. Arun K Saraf
Department of Earth Sciences
Indian Institute of Technology Roorkee
Lecture 08
Multi-spectral scanner and imaging devices

Hello everyone and welcome to the 8th lecture on the in this course that is introduction to remote sensing and under in this particular lecture we will be discussing different multispectral scanners and different imaging devices which are very popular nowadays.

(Refer Slide Time: 0:45)



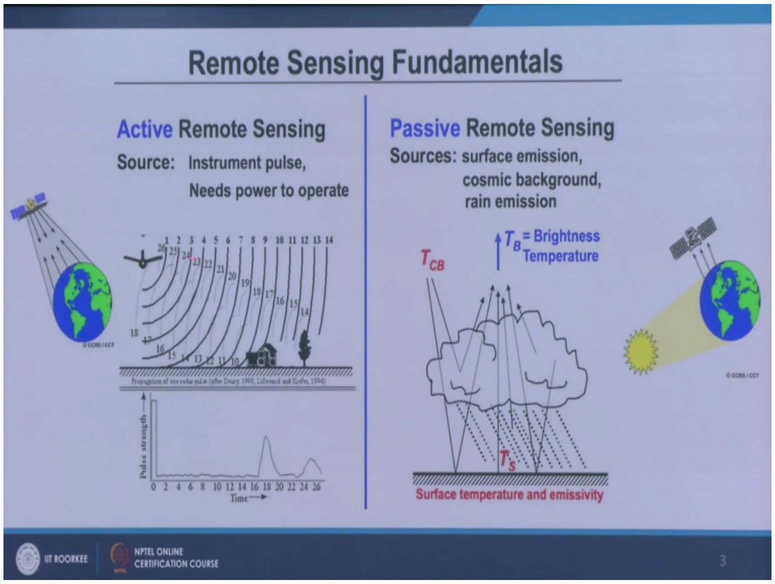
If you remember that we (di) discussed in previous lectures that 2 types of remote sensing is possible. One is passive remote sensing and then active remote sensing so the sensors are also accordingly there are 2 major categories of sensors, one is the passive sensor, a very popular one which we will see one by one and then active sensors, now both of these passive and active sensors, one are the non scanning, non scanning type. Similarly in case of active sensors some (or) some of them are non scanning and might be scanning sensors. Then we come for in this non scanning, we can have non imaging sensors, we can imaging sensors in case of a scanning, mainly imaging sensors.

In case of a non a non scanning non imaging sensors and scanning, imaging and different sensors are there. So especially if we take the sensors which are passive and then like microwave, a passive microwave radiometers or sensors are there which are passive sensors non scanning non imaging. There are some satellites like GRACE and others which are in the work for the (garvi) gravity um the gravity properties of the earth so they are non imaging non scanning sensors and similarly, in in case of non scanning imaging sensors, you are having cameras, maybe monochromatic cameras, natural color, infrared, color infrared and the others.

So these are the sensors which are on board of different satellites then scanning sensors are also there like imaging, image plane scanning, TV camera solid scanner, object plane scanning, optical mechanical sensors, microwave. So initially when remote sensing started, we had these optomechanical scanners. Now later on we are having non scanning imaging sensors like all these then in (ca) in the category, under the category of active sensors, 2 types scanning, non scanning, under this non scanning, we are having none imaging so like microwave radiometer, microwave altimeter and so on.

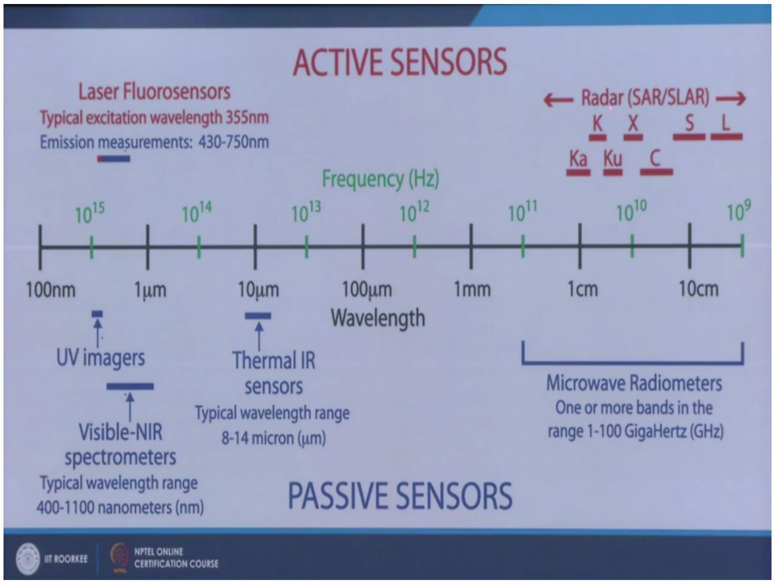
Similarly in case of active scanning imaging, object plane scanning real aperture radar or synthetic aperture radar so radar remote sensing and we the examples we saw about like RADARSAT or our Indian example RISAT and Envisat and Sentinel, all they work in this synthetic aperture radar that the that means the sensors is active the sensor is scanning and it is basically synthetic aperture radar having object plane scanning and the there might be (ima) this scanning imaging but image plane scanning so these are the different types of sensors are can be there but the most popular one are these ones optomechanical and they were there and synthetic aperture radar and other microwave sensors. We will see examples of these different types of sensors associated with different types of satellites in initial stages of (re) development of remote sensing and later.

(Refer Slide Time: 4:29)



As you can see that in case of active remote sensing, basically the pulse is sent by the instrument or on board the satellite and then whatever is returned back, it is recorded and this is how you you acquire data of radar data or active remote sensing data whereas in case of passive remote sensing the main source of radiation is available through or energy is available through the sun and then we record different type, different signatures having different kind of reflection emission and so and so forth. So 2 major types active remote sensing and passive remote sensing. The 80% or 90% of remote sensing is which we are doing is passive but nowadays because of SAR interferometry, active is also very popular, we will see the example how these have been applied.

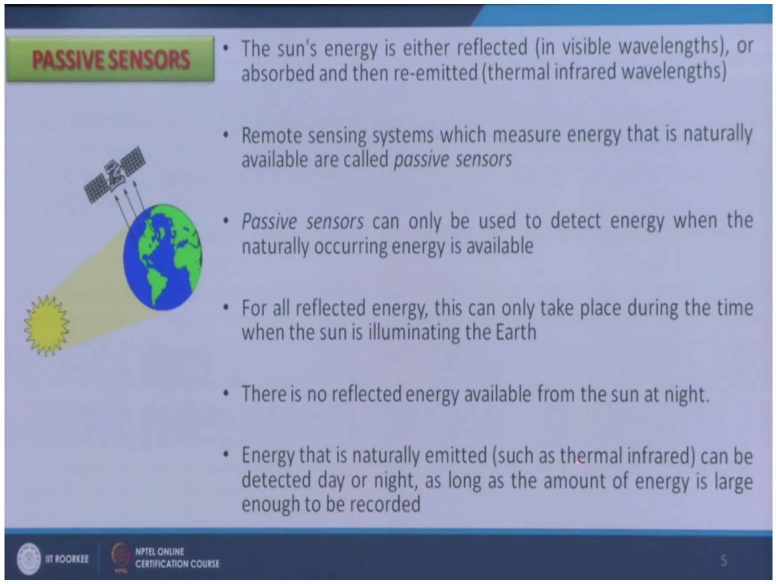
(Refer Slide Time: 5:33)



Active sensors some some in different part of spectrum EM spectrum which are there specially the radar the synthetic aperture radar side (lead) looking aperture radar are there and of different brands K, X, S and L band, K, Ku and C band, C band is very very popular, L band is very popular among radar remote sensing. Also X band but the C band example are many more and there are some other parts of EM Spectrum but may not be having satellite sensors onboard but may be through lower atmosphere or through aircrafts can be acquired data.

Whereas in case of passive sensors we are have most popular one are visible near infrared spectrometers are there in this range, that means the 0.4 micrometer and to 1.1 micrometer and 400 to 1100 nanometers. Microwave radiometers are there and then the thermal infrared sensors are also there which is having between 8 to 14 micrometer. So these are all passive sensors which are shown in blue color and these red ones are active sensors which are shown and (E) part of EM spectrum both frequency based and wavelength based is also shown here.

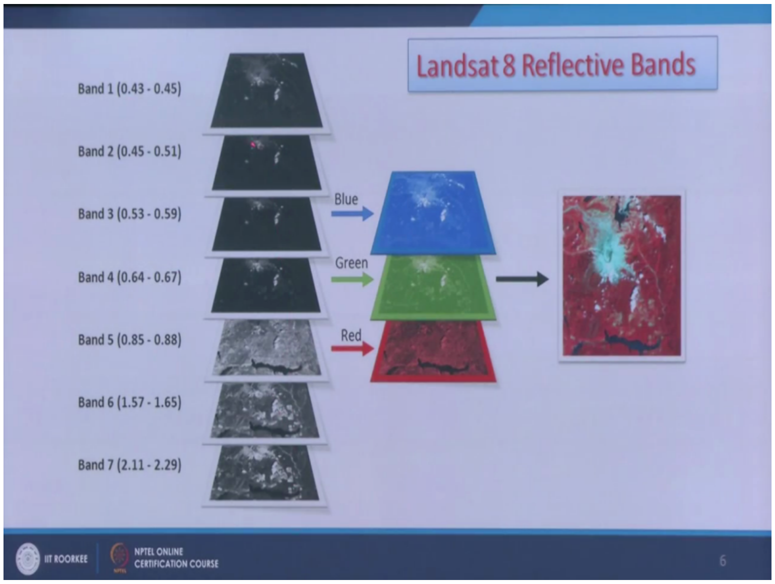
(Refer Slide Time: 7:03)



So as mentioned that the passive sensors the sun's energy is either reflected in the visible length and absorbed and then reemitted in the thermal infrared wavelength and the remote sensing systems which measure energy that is naturally available are called passive sensors. Passive sensors can only be used to detect energy when naturally occurring energy is available and for all reflected energy, this can only take place during the time when the sun is illuminating the earth. So only that means it is possible in the day time in case of visible near infrared images but in case of a thermal infrared that can (cum) work in night time as well.

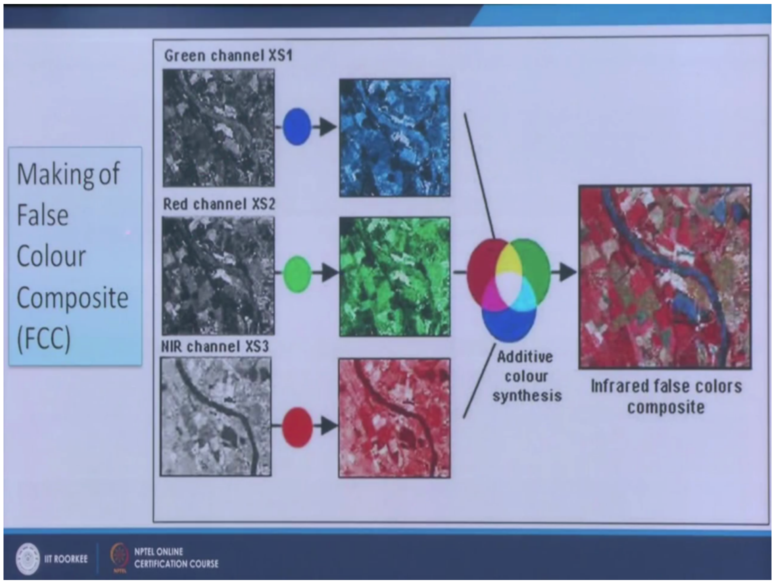
And there is no reflected available from the sun at the night and the energy that is naturally emitted such as the thermal in specially in the infrared portion of EM spectrum (coughing) can we detect a day or night time as long as the amount of energy is large enough to be recorded because during this emitted energy is not relatively very large and therefore it is the one has to get that much of energy so that it can be recorded by the sensors which are around 850 kilometer deep in a space.

(Refer Slide Time: 8:25)



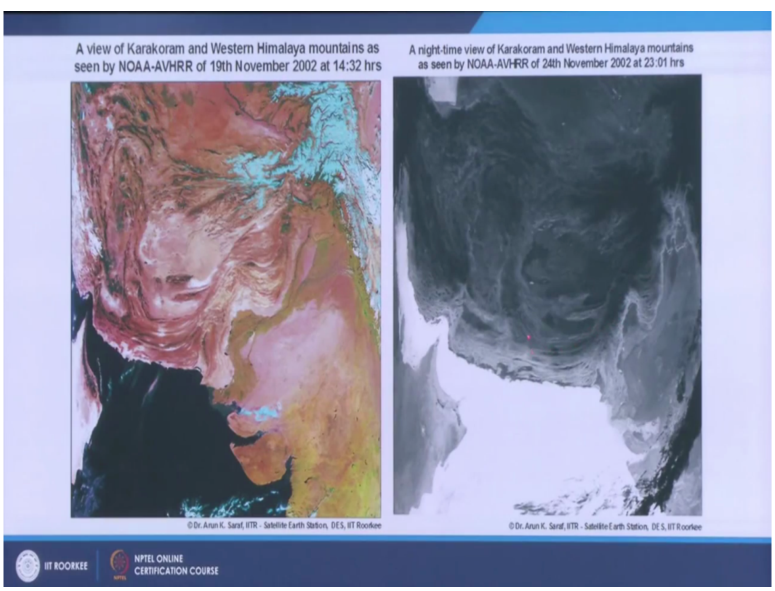
This is again passive example of passive remote sensing and especially with the Landsat 8 OLI series is given that different brands are collecting information, reflective information, reflective data at different part of EM spectrum like band 1 between 0.43 to 0.45 like band 7, 2.11 to 2.29 and different channels, the data is collected, one may create a false color composite. In the previous lecture we have discussed in length and how false color composites are created, what are the advantages of false color composite and why basically false color composites are created and ultimately you can create such colored false color images which are very useful for image interpretation.

(Refer Slide Time: 9:20)



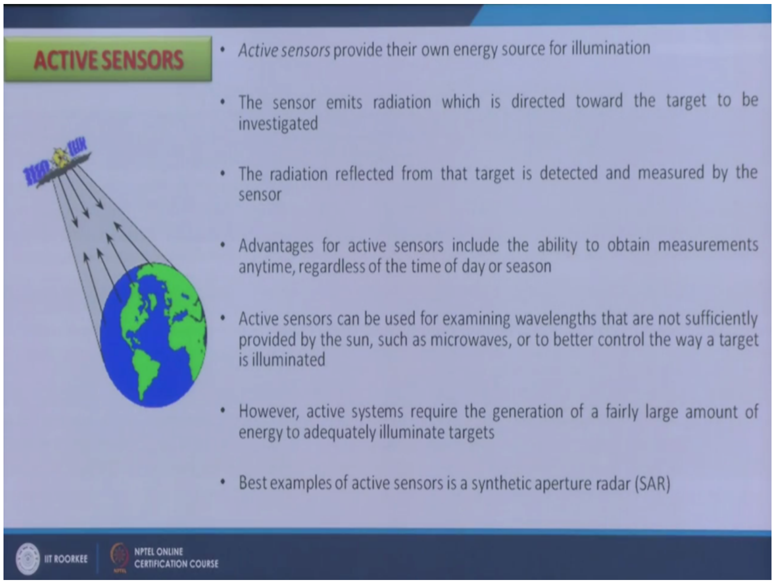
This we have already covered that you involve green channel, red channel in a standard false color composite and near infrared channel assigned blue, green and red color respectively and ultimately you end up with a standard false color composite image.

(Refer Slide Time: 9:40)



Now in a in a false color composite image the same area may look like this but in a in a thermal infrared image in the night time, the same area may look like this like an X-Ray kind of thing. So all together different appearance of of earth's objects in different part of EM spectrum also in daytime and nighttime.

(Refer Slide Time: 10:07)



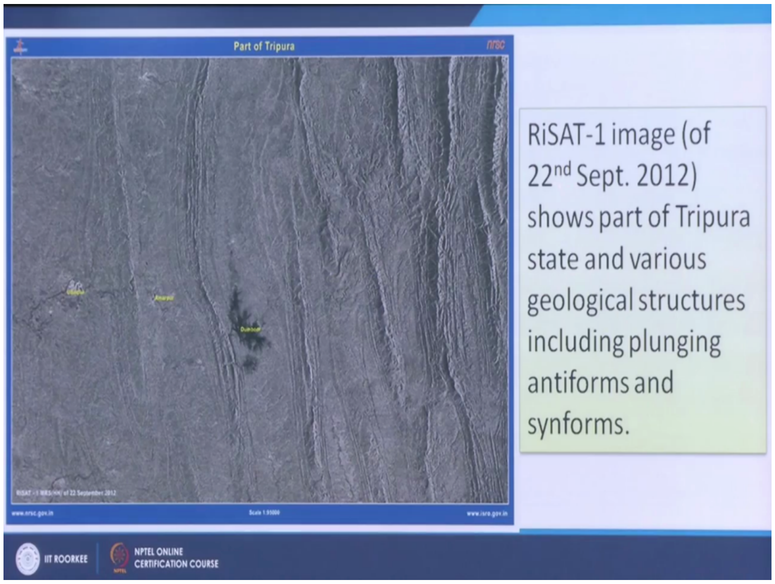
Whereas active sensors provide their own energy as mentioned earlier which they are having their own source of energy, they send the energy pulse, the sensor emits radiation which is directed toward the target to we investigate in and these are also called ranging devices and because the (re) the radiation reflected from that target is detected the return beam is detected and measured by the sensor, that is why they called your ranging devices.

Advantages of active sensors which includes the ability to obtain measurement anytime because the energy source is within your hands so whenever you want to measure, you send the pulse and whenever it will return, you record it and you measure the distance so and so that is the advantage that ability to obtain measurement anytime, it is a day or night time, also regardless of time of the day or season.

Another advantage of this thing is, that day, in microwave region where these (ac) most of the active sensors are there you you have the advantage that the wavelength is much larger so the clouds, guest particles, dust particles, dust particles will not (an) create any scattering or absorption and you get a very nice clear pictures and this through this radar remote sensing satellites. (Acsses) Active sensors can also be used to examine wavelengths that are not sufficiently provided by the sun such as microwaves or better control the way target is illuminated so the (wa) the way we want to illuminate a target, that can also be designed or decided by the sensor or operator of that instrument.

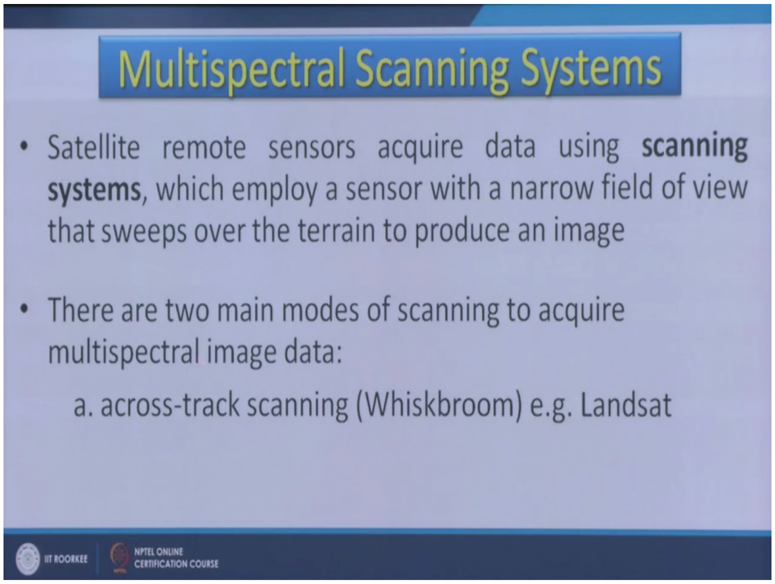
However the active sensor generation of a fairly large amount of energy to adequately illuminate targets because satellite onboard or at the sensors on board of a satellite may specially I am talking radar satellites and then large amount of energy is required and so that images can be acquired by that so that is one limitation of this thing and most common active sensors in a radar range of EM spectrum are synthetic aperture radar and as I mentioned like a Enviset, like Sentinel, like Radarset, Riset, all they use this one.

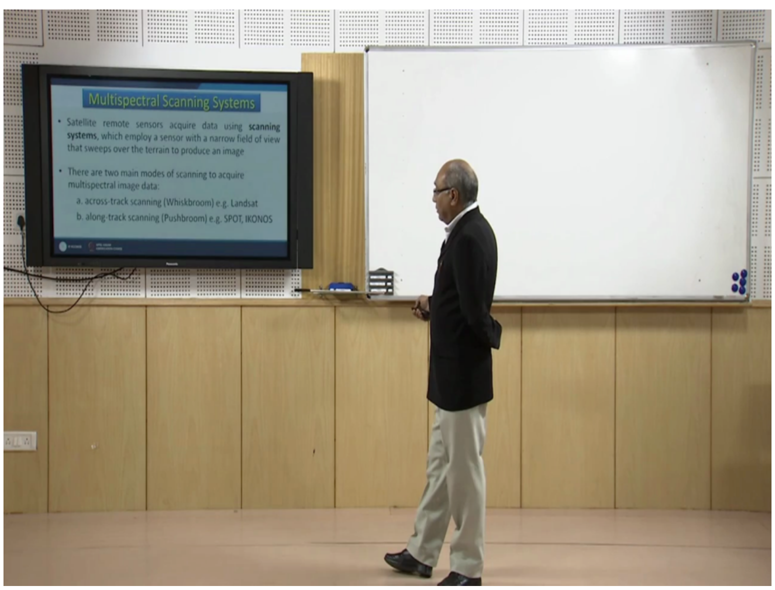
(Refer Slide Time: 12:48)



Example of our own Indian remote sensing satellite over part of Tripura from RiSAT 1 there is the image acquired on 22nd September 2012 and as you can see that there is no effect of any effect of atmosphere and the specially in this part of the country, most of the times you are having clouds in microwave region, in active remote sensing, cloud will not affect and therefore you see a complete clear terrain and all geological structures and you know plunging folds and plunging antiforms, informs can easily be identified on such images if you go for the corresponding images in a passive, passive satellite data invisible channels or near infrared, in near infrared, you would find that these parts are fully covered with vegetation say masking effect you will see and cloud problems are also very common in this part of the country whereas in radar remote sensing, clouds will not create problems and all these geological structures can be identified very easily. So there are various advantages of having active sensors.

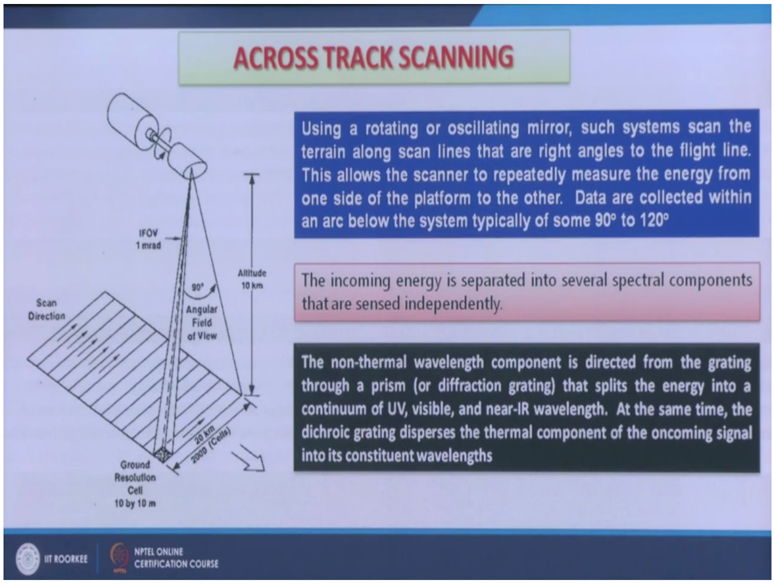
(Refer Slide Time: 14:05)





Now, there are multispectral scanners or sensors systems are there. We started with the MSS multispectral scanner with the Landsat 1 so these days scanning systems are employed or put on the satellite and the which covers a narrow field of U and sweep over a terrain to produce an image and there are 2 types of a multispectral data or sensors are there which acquire data, either across track scanning or which we can whisk broom like for example in case of Landsat sensor on the Landsat or along track scanning which was introduced through by a Spod and later on by Acanos so we call them as push broom so (whiks) whisk broom and push broom scanners, we will see in details what what are the advantages and disadvantages of these 2 types of scanning devices in passive remote sensing.

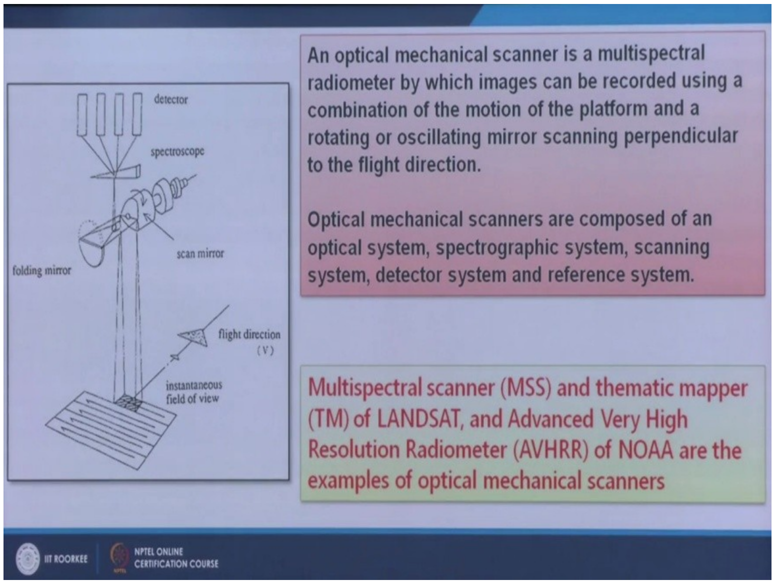
(Refer Slide Time: 15:10)



Across track you know that satellite is over passing like this, the the orbit is like this, then across track, the scanning is done and the pixel by pixel, there is there, there will be a rotating mirror and that you know acquire the images so these days using a rotating or oscillating mirrors, such systems can scan terrain along scan lines that are right angles to the flight line or orbital path and this allows the scanner to repeatedly measure the energy from one side of the to platform to another so once the satellite moves then it goes to the next line.

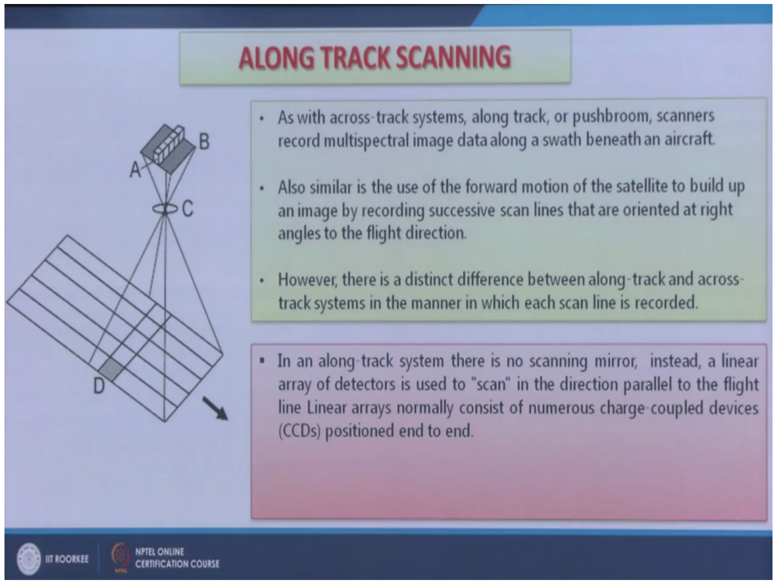
Then next line and likewise, it keeps a scanning and recording the data or sending data and to the earth stations and this way, the data is collected within an arc below the system typically or some 90 degree to 100 degree but these may introduce some complications or some problems which we will see little later. Incoming energy is separated into several spectral components that are sensed independently and non thermal wavelength component is directed from grating through or prism a different grating and it splits the energy into continue more visible an ultraviolet, visible and near infrared bands. At the same time the dichroic grating (di) dispurses the thermal component of incoming signal which is a constituent wavelength.

(Refer Slide Time: 16:55)



There were lot of complications were observed with such kind of a scanning devices. an optical optomechanical scanner is a multispectral radiometer by which images can be recorded using a combination of motion of platform and a rotating or oscillating mirror scanning perpendicular to the flight direction so because of this oscillating or mirror rotation lot of problems were observed especially in the Landsat and in the first generation that is Landsat MSS or the Landsat 1 which had MSS sensor. These optomechanical sensors are composed of al optical system, a spectrographic system and a scanning system, detecting system and then reference system so multispectral scanner, MSS I gave example thematic mapper of Landsat and NOAA AVHRR are also examples of optical mechanical scanners.

(Refer Slide Time: 17:55)

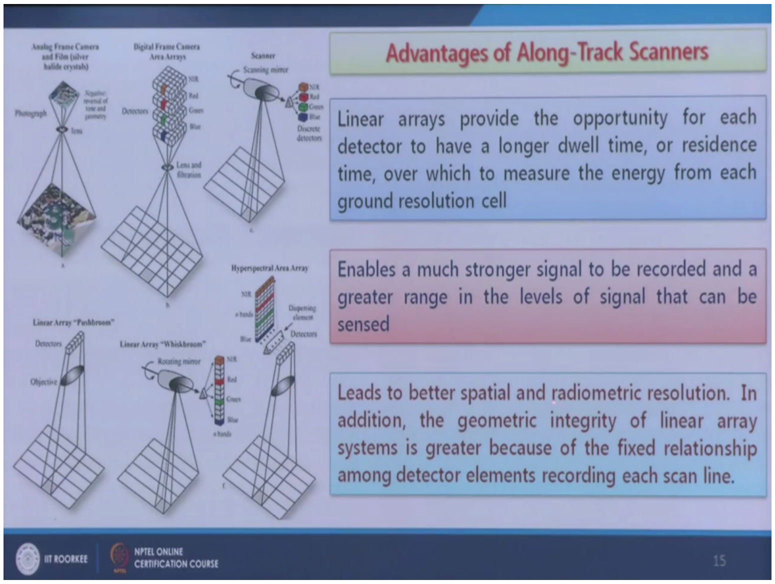


Another type of scanners not across track now along track is scanning which a as a across track system, along track or push broom scanners record multispectral image data along a swath beneath the aircraft, so you are having a array of sensors arranged like this and you acquire line by line and the this has made the things very easy so also similar to use of forward motion of satellite to build up by can image by recording successive scanning lines that are oriented at right angles to the flight direction however there is a (dis) a distinct difference between along track and across track system in the matter which each scan line is recorded here. The a an array in along system, there is no scanning mirror, no oscillating or moving object or optomechanical devices, it is a solid state kind of thing so instead of linear array of detectors used and which scans directly parallel to the flight line and array normally consists of numerous CCD devices which are positioned throughout this one.

(Refer Slide Time: 19:13)

So if I give the example like like you are having a CCDs are all situated here and this is the flight track or a orbital track of your satellite so it keeps moving and keeps scanning simultaneously all along the line so they because it doesn’t involve any oscillating or optomechanical devices that is why the images are of high quality. So e detector element is (di) dedicated to sensing the energy in its single ground resolution cell along any given scan line. This is and along track scanning devices are nowadays very popular and common in most of these new satellites.

(Refer Slide Time: 19:54)

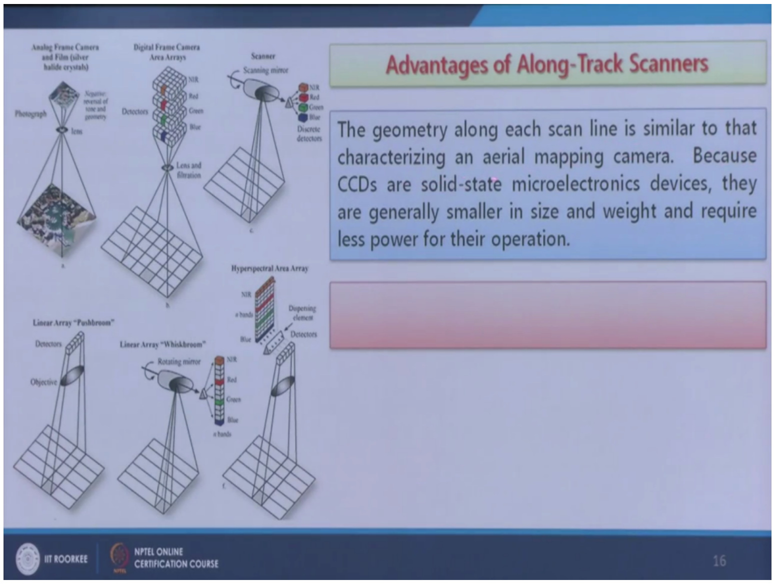


So the examples are shown here that the linear array or this the push broom, whisk broom, examples are shown and in hyperspectral area, then again the arrays are used so that along track scanning devices are used whereas in this one, this is rotating mirror so different channels are different pixels are gathered here whereas here the entire line or the swath is covered in 1 go so different way of collecting the data.

There are advantages with along track scanners and the linear arrays provide the opportunity for each detector to have a longer dwell time or residence time over which to measure the energy from ground cell, a resolution cell so that is the advantage with along track scanner. Enables much stronger signal to be recorded, a greater range of levels of signals can be sensed and this this concept array concept and along track scanning has allowed us to move from relatively coarser resolution data like MSS which was a optomechanical across track scanning to along track scanning system which has allowed us to go for higher and higher spatial resolution.

So this, this is because of it enables us for a stronger signal to be detected by these sensors because in stay time while a satellite is moving is more compared to across track scanners and this leads to better spatial and radiometric resolution and in addition, the geometric integrity, radiometric resolution basically here the meaning the quantization of the pixel so instead of having a 6 bit image, 7 feet image, it is possible to have, 8 bit, 10 bit even 11 bit images so the higher radiometric resolution, better spatial resolution became possible because of along track scanning systems. In addition, the geometric integrity, the (ge) is also better in case of along track scanning devices so that is why they became very popular in many many earth sensors onboard of different satellite.

(Refer Slide Time: 22:27)



Further advantage is the geometry along each scanline is similar to that of characterizing an aerial mapping camera because CCDs are solid state, there is no moving part and they are generally smaller in size and and a weight and require less power for operation so another advantage is that they are lightweight and they are compact and the the weight of a sensor onboard of a satellite is also less, it requires less power for operation.

However there are one disadvantage to push broom scanner is need to calibrate many more detectors because instead of 1 detector in case of across track, you are having arrays of detectors and now these detectors will perform uniformly and therefore before (lan) launching of any such sensors, such scanning devices, their calibration, very high quality calibration is required otherwise if 2 are 2 adjacent CCDs are performing differently, they will acquire data differently and your image will have lot of problems.

This problem was recently observed in case of a Landsat 8A images and then then these the corrections of such images becomes really very very difficult to this brings to the end of this different types of multispectral scanners, optomechanical devices, linear array devices, their advantages and disadvantages, thank you very much.