Introduction to Remote Sensing
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Lecture 03
Different platforms of remote sensing

Hello everyone! Welcome to this third lecture in the series of this introduction to remote sensing. In this particular lecture we will be discussing different platforms of remote sensing in much more detail. I have already introduced so wherever we will find some overlap we will skip and otherwise we will go in detail about these platforms.

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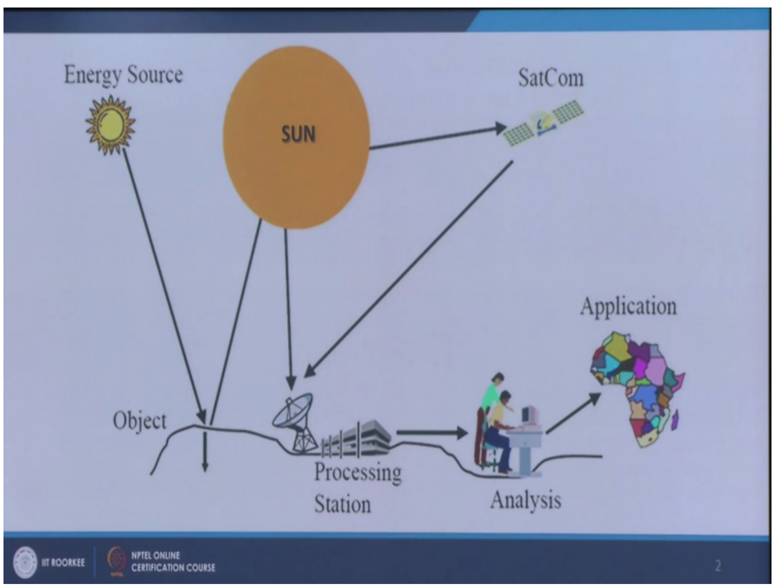

As we have also seen there is energy source then there is earth surface or objects then energy source and sun is there, then satellite and so on so forth. The main which we are going to discuss about the different satellites.

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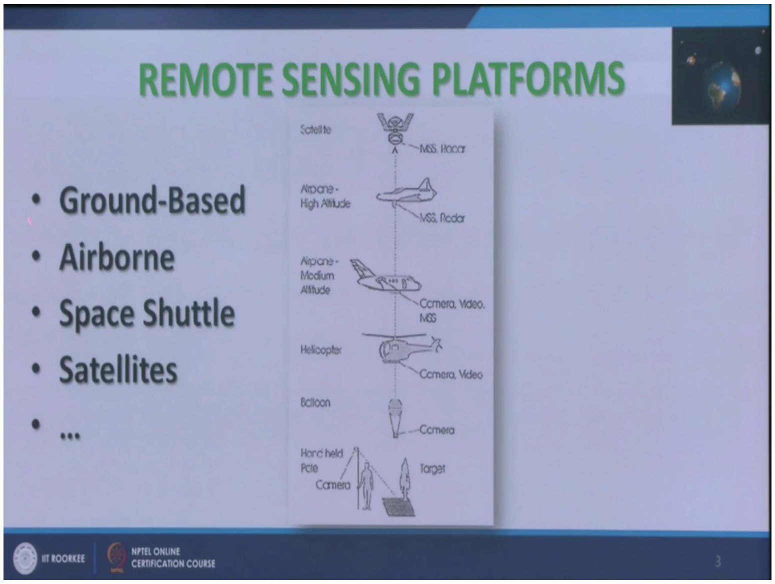

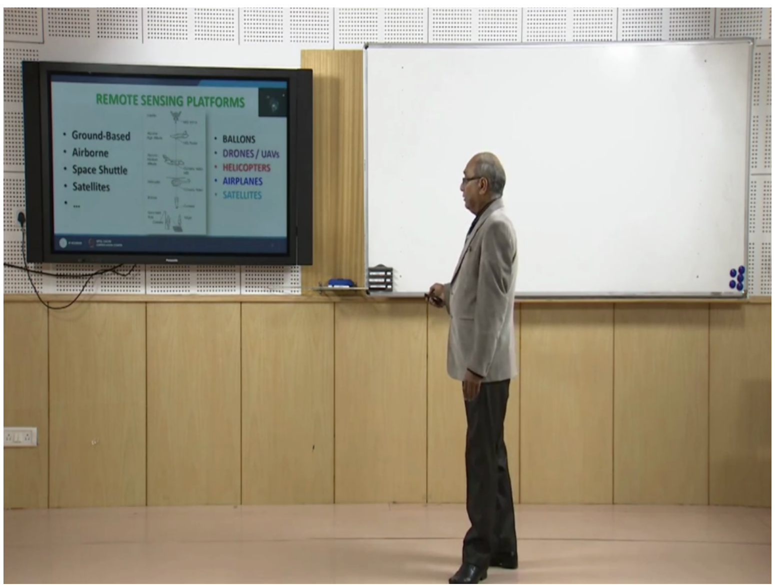

As you know the for remote sensing life by human you need not go to space and by being on ground that can be done. So there is ground way remote sensing, then the remote sensing can be airborne, remote sensing or remote sensing can be through shuttle missions and remote sensing can be space borne or through satellites as well.

So far from ground to space we have reached but maybe in future we might be having other types of remote sensing that is why I have not exhausted this list and at the same time we also had not really ground based but airborne through balloons in history as well and even today some people resort to that. Most popular one nowadays is through UAVs and drones which is being done now days in this country in marriages or some cultural functions.

People have started using these drones or UAVs putting video cameras, getting light transmissions from these UAVs based cameras to the earth and then same time it is being broadcasted as well. This has become very popular in recent years. Through helicopters and aircrafts can also be done which is near earth orbit quite close to, maybe 1km or 2km depending on the terrain and that can also be done almost live. In many, in US, in many hot pursuits people are using helicopters for that so that kind of remote sensing is also there.

Then of course through aero planes it is being done, can be done and then ultimately which we are here for is the satellites. So that is continuously being done this kind of remote sensing. So satellite based remote sensing having several advantages and it is being done regularly.

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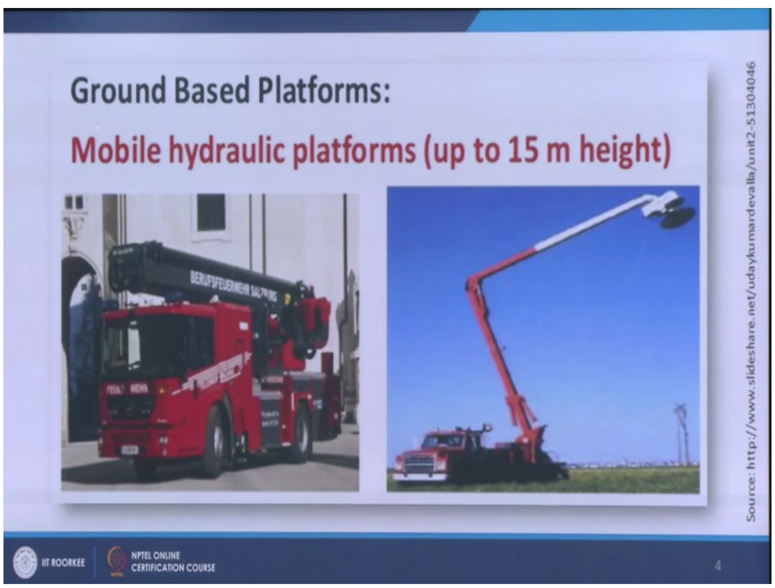

First we will start with ground based. There are different methods available. Now days people use mobile hydraulic platforms which can go upto 15 meter 20 meter and then remote sensing can be done for some crop related studies or some disaster related studies.

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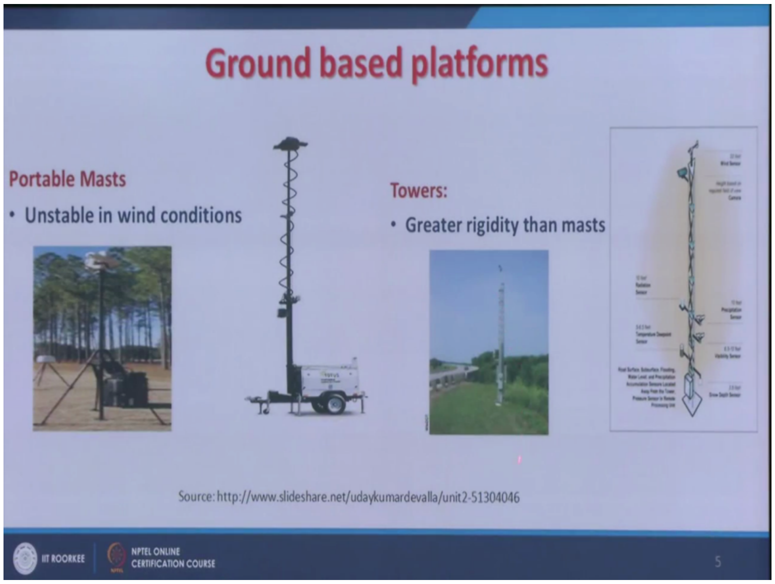

Ground based platforms can be some temporary platforms or can be some permanent platforms like here the towers can be installed with greater regidivity than mast and then this mast then can provide, it can have some sensors at different heights and can provide the data maybe the temperature, wind speed or precipitation and wind direction so on so forth. That is also some kind of remote sensing and on a scale this temporary portable mast are not that stable so depending on the application people go for these ground based studies.

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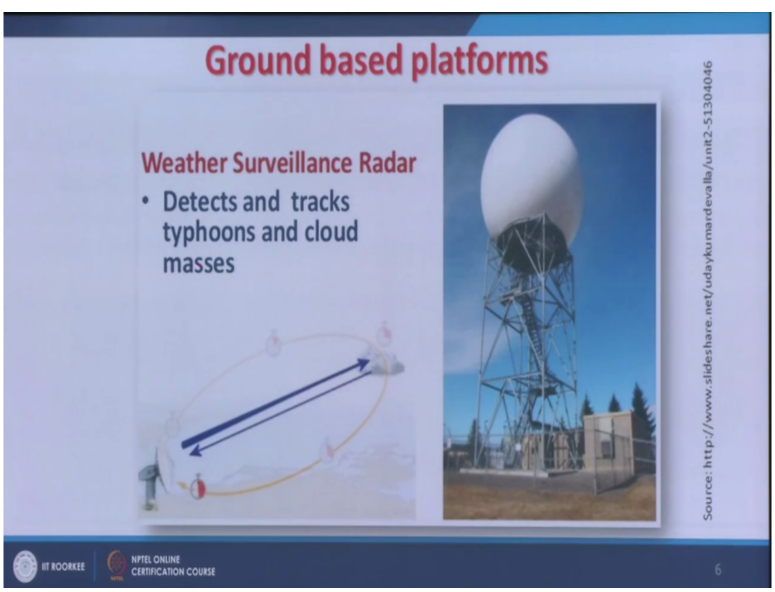

Then there are weather surveillance radars especially in airports or if weather is dynamic, we will go for these kinds of systems. It tracks typhoons, cloud masses and India is also considering these weather surveillance radar in case of cloud burst specially in Himalayan terrain so that kind of ground based platforms are also being used extensively depending on the application.

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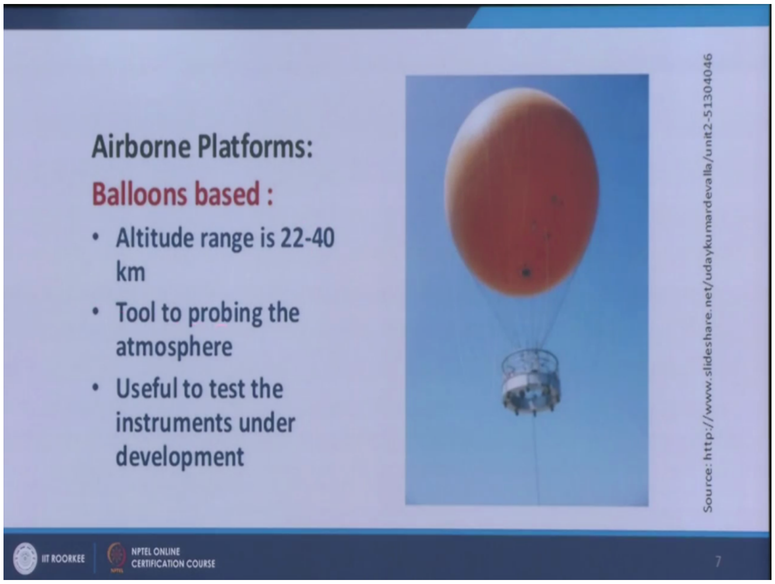

Air borne platforms maybe balloon based which height may not be much but up to 40 meter and tool to probing atmosphere, lower atmosphere which is really very close like a fog phenomenon or smog or pollution which is very close to the earth can be sensed by these sensors on board of these balloons. They may be manned balloon or maybe unmanned even and useful to test instruments under development. That is also being used before you go for space borne.

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UAVs as I have mentioned have become very popular and these are completely unmanned vehicles where you can put normal cameras and take the photographs as shown here in the series or you can put video cameras and take pictures, change the height through remote controls and can record things so these have become very popular in case of natural disasters or even different types of construction in civil engineering and so on so forth.

These are the quiet stable and very now-a-days very cost effective, so so these are being used extensively wherever very high resolution data is required and for small area data is required then UAV can be implied. People have also started now implying these UAVs for underwater studies as well but that is different kind of remote sensing.

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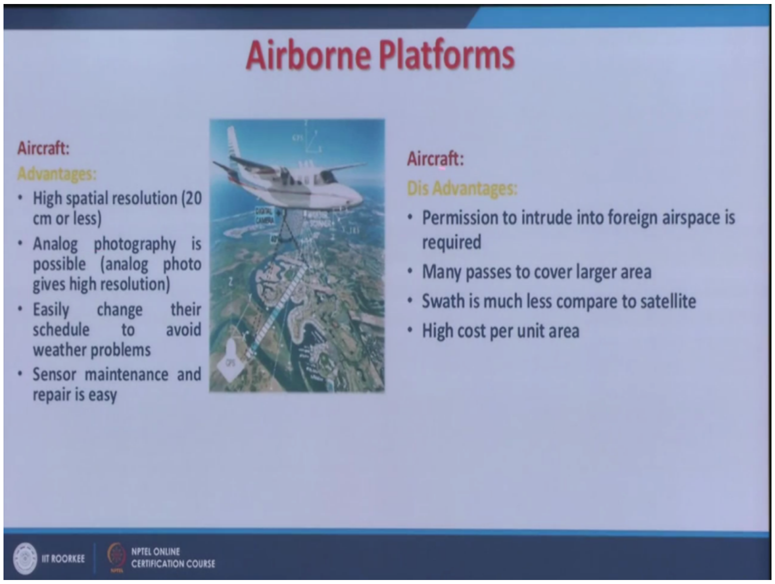

Aircraft has already been there and there are certain advantages that aircraft (())(6:49) higher spatial resolution, it can provide high spatial resolution data but generally it has analog photography or digital photography can also be done but generally these are the snapshots so one has to remember so that sort of disadvantage. They easily change their schedule to avoid weather problems if there are clouds or fog conditions may not require the data at that time.

So but with satellites you can't change so that is the advantage of aircraft and sensor maintenance repair is easy because aircraft will go and collect data and comeback and later on everything can be done on that graph whereas in case of satellite once it is launched, it is launched, nobody can go there and repair, except from ground you can do some maneuvering of the sensors but not to much extent and there are certain some disadvantages with airborne remote sensing platforms.

Sometimes you have to acquire permissions from neighboring countries or foreign countries to fly these aircrafts, many passes to cover a large area because of high spatial resolution, you require many SOTs to cover even a small area. Suppose a large mine is there then there might be many SOTs required or for certain explanation of water or flooding, that requires.

Swath is much less compared to the satellites because satellites far deeper in space can cover a large area that is why we use the word synoptic view which satellite data can provide. Aircraft cannot provide that kind of synoptic view so swath is much less in case of aircraft and cost per unit is much more in case of aircraft satellite data.

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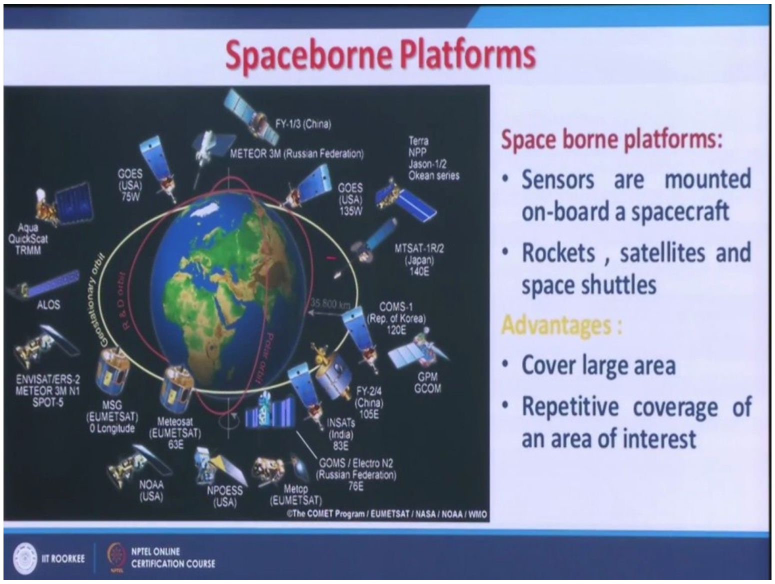

Space borne platforms and satellite remote sensing or satellite based remote sensing is now-a-days the most popular one. Many countries are having their own satellites including India so sensors are mounted on board air spacecraft and these are launched by certain vehicles or maybe rocket, satellites or even space shuttles have also been used for different kind of data collections.

There are various advantages as in case of satellite data, synoptic view that covers a large part of the earth in just one go depending on the resolution, then repetivity of the area is very much possible in case of air craft, every time it has to fly same area almost in the same manner, may not be possible but if satellite once it put in a appropriate orbit it will keep acquiring the data till it stay in the space so that is big advantage with space craft.

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There are different types of orbits are there and we are familiar with few orbits and we will go in detail little bit on that. The normal remote sensing is being done through the sensors which are put in sun synchronous orbits which are around 840 km and away from earth in space and which are near polar orbit and there are some other orbits like geostationary orbits which are far deeper maybe 36000km away, 3600 km away from earth and they keep looking at the same part of the earth all the time. So as the earth moves, the satellite moves, that is why they are called geostationary and some satellites like GPS satellites they are called geo-synchronous orbits so there are three main types of orbits. One is polar orbit or sun synchronous, another one is geostationery and other one is geosynchronous.

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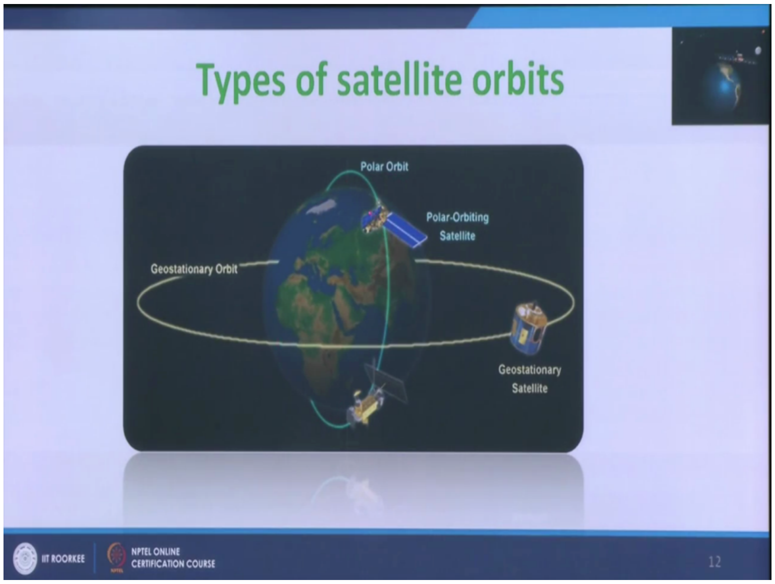

Here two types of orbits which are popular and apart from GPS which is not here that geo stationery orbits which are like communication satellites which are now days also having capabilities to acquire images of the same part of earth on regular basis maybe every half an hour you can have snapshot, a satellite over sitting over India's inset or Kalpana series of satellites can provide the snapshot of India and surroundings after every half an hour, so that is the biggest advantage with geostationary satellites.

So repetivity can be enhanced to whatever the requirements are there and whereas polar orbiting satellites they are having fixed orbits and below these orbits the earth rotates so repetivity is not in our hands as per the design of the orbit and they are near polar orbiting satellites. Means not exactly from north to south but having roughly 9 degree inclination they keep orbiting the earth so there are two main, and this is polar orbiting or near polar orbiting or sun synchronous satellites.

These are the satellites in which remote sensing sensors are there and the most of the remote sensing which we are going to discuss or have been discussing is mainly about this near polar orbiting one. Why is it called sun synchronous? Because whenever it will pass over the area of earth, the local time is going to be the same. Suppose this satellite is designed to overpass say over Rourkey at 9.30am so whenever it will visit, it will overpass local time 9.30 that is why it has been synchronized with the sun and with that kind of time.

So when we compare one image of say 1980 and 1990 we know that the sun conditions if season is same then sun conditions might be the same as well because the time is same so this is another advantage of having synchronous satellites. Lower series of satellites are also polar orbiting, near polar orbiting satellites and set series, video set in Kalpana all these are geostationary satellites. They are different in orbit, different in depth and so on so forth.

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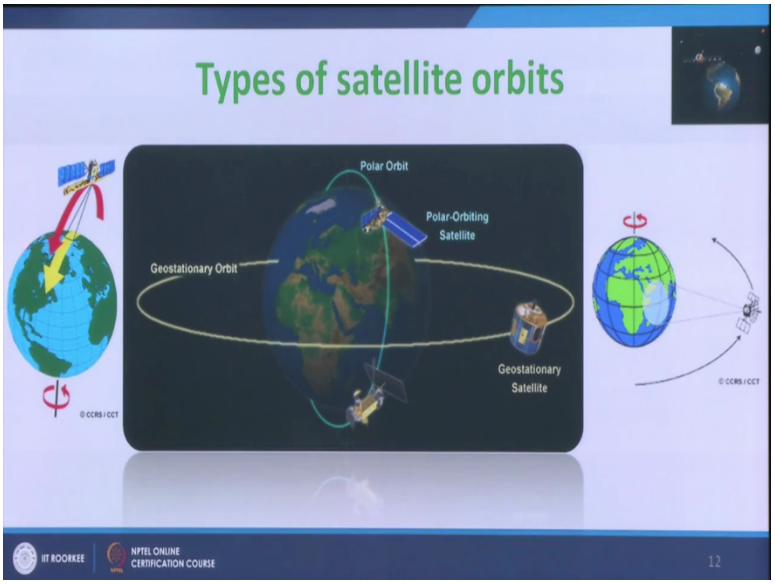

So as earth rotates, these satellites also rotate in the orbit and keep looking at the same part of earth every time. So that is why they are relatively stationary with earth whereas these satellites are near polar orbiting satellites, earth rotates and these keep orbiting the earth and this yellow part is the swath or the coverage on the part of the that strip which is going to cover by these satellites so the orbits are different, their purpose are different and therefore their applications are also different.

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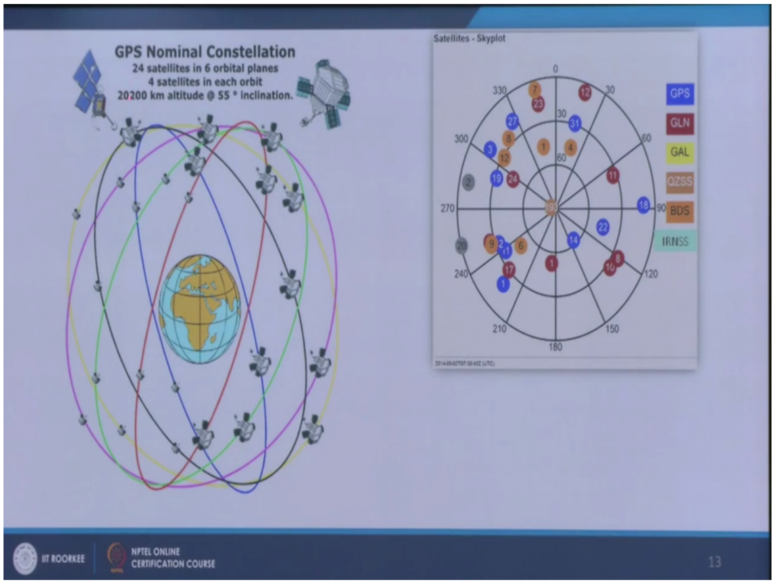

Third type of orbits is the geo synchronous or GPS satellites which are having very far distance like 20200 km and GPS of course is a American system. India is also having their own navigation system so this American system is having different orbits, basically there are six orbital planes and in total in each orbit you are having four satellites and in total you are having 24 satellites orbiting the earth different inclinations at 20200km and this sky plots basically shows the navigation data from different types of navigation systems.

Blue dots are blue circles are showing GPS, Glonass, Galileo, this is QZSS is Japanese system, then BeiDou which is Chinese system and IRNSS. So having a simple receiver if it is capable of receiving signals in different frequencies then now days it is possible to get signal from three or four navigation systems and positional accuracy improves highly so you can get few centimeters could receive in terms of horizontal position.

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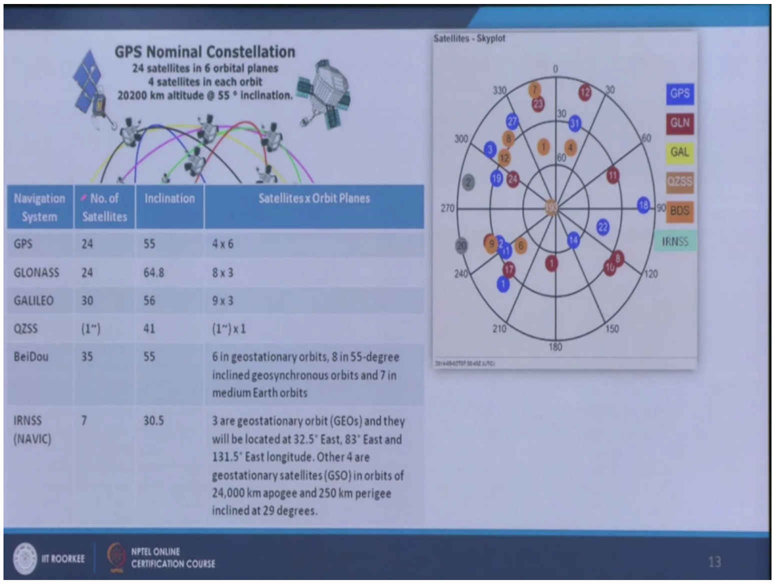

The GPS satellites, there are number of satellites as mentioned 24, then Glonass is global system and it is having Russian system and it also has 24 satellites. Galileo is regional system mainly focused for Euro but they are having 30 satellites whereas Japanese is purely regional system so they are having 1 satellite, BeiDou is global system, they are having 35 satellites planned. In India there is IRNSS or Navic is also a regional system so we have planned for 7 satellites and three are in geostationary orbits and four are geostationary orbit at different locations and some are having different locations. So different countries as per their requirements and not having dependency on American system have developed their own navigation system like India, china, Russia, japan and other countries.

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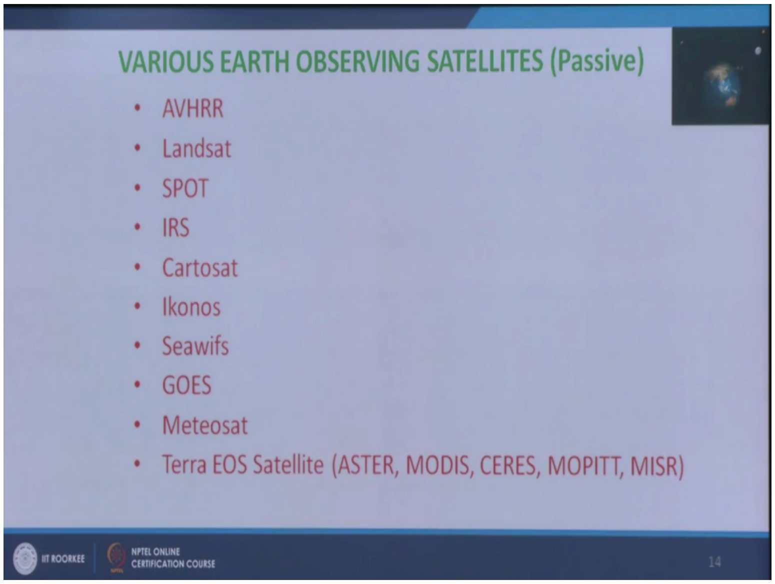

So various earth observing satellites especially in passive region, passive remote sensing region, and the very popular one and still continue since 70s is NOAAAVHRR and then we are having Landsat, a complete series is there, NOAA 19 is currently in orbit. Also data can be acquired form NOAA 18 or 19 and Landsat 8 is in operational. SPOT is there, IRS is there, they served the purpose. Now they are not there but the Cartosat, Resourcesat.

Ikonos was a private satellite launched by American company provided data at 1meter resolution, very high resolution data of that time then there are some other satellites like Seawifs, GOES, Meteosat. Meteosat is geostationary satellite and then another very popular which is still there and providing lot of good data sets is coming from this terra earth observing satellites, specially it is having MODIS sensor on two satellites, Terra and Aqua then you are having ASTER satellite and other satellites are available which are mainly in near polar orbit, sun synchronous orbit and providing data at different resolutions.

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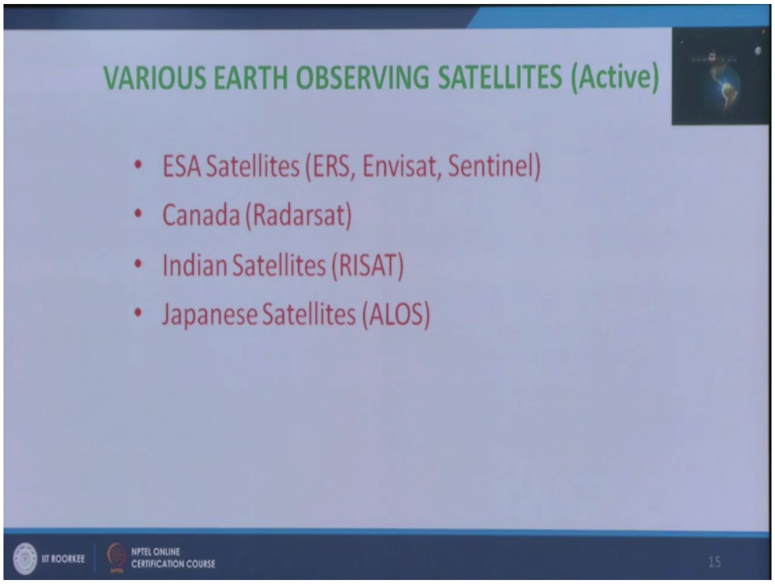

Now if we look for active remote sensing and not as many as passive but there are few satellites which the series basically the active remote sensing or space borne remote sensing started with European space agency by satellite ERS. It served its purpose for some years then Envisat came, that is also not functional but the new series in this one, the sentinel one which is working and providing good active remote sensing of microwave data and specially this is equipped with SAR interferometery so it can provide data in pair.

And another good advantage, the data is free so it can be utilized extensively for many application specially applications where one is looking for changes on the surface of the earth, maybe changes induced by earthquake maybe land subsidence maybe landslides and even in the flood conditions because microwave region, the clouds cannot create any problem and therefore you get clean picture, so radar remote sensing has got its own applications.

Earlier Canada also had its own radar active remote sensing satellite which was named as Radarsat, India has also our own satellite RISAT but it doesn't have SAR interferometery capabilities but still it is quite useful. Then you are having Japanese satellites ALOS, Palsar, Palsar is having sensor which is having SAR interferometery capabilities and still in operation and many more satellites might be coming this one but the most popular one now-a-days is the sentinel because data is free and ALOS of course it costs lot but still the data is being used for different purposes.

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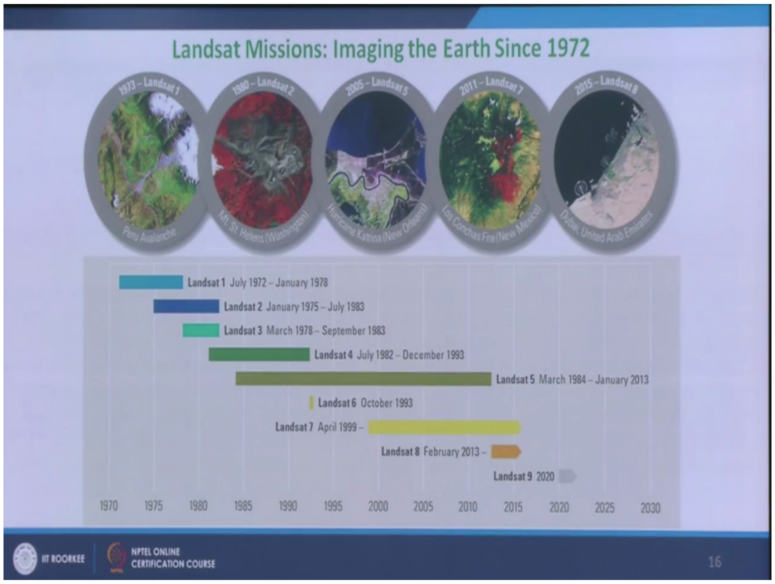

This slide I have already covered in previous lecture which gives your glimpse about the history of landsat. It started in 1972, still it is continuing, Landsat 8 was launched in February 2013. There have been overlaps, there might be this may continue for long time then in 2020 Landsat 9 has been planned. Landsat has really changed the remote sensing scenario of the world.

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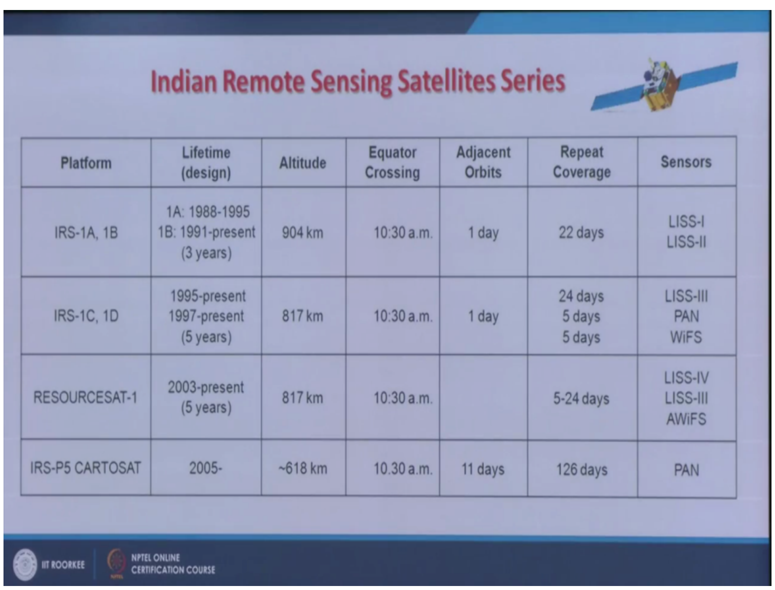

Platform	Lifetime (design)	Altitude	Equator Crossing	Adjacent Orbits	Repeat Coverage	Sensors
IRS-1A, 1B	1A: 1988-1995 1B: 1991-present (3 years)	904 km	10:30 a.m.	1 day	22 days	LISS-I LISS-II
IRS-1C, 1D	1995-present 1997-present (5 years)	817 km	10:30 a.m.	1 day	24 days 5 days 5 days	LISS-III PAN WiFS
RESOURCESAT-1	2003-present (5 years)	817 km	10:30 a.m.		5-24 days	LISS-IV LISS-III AWiFS
IRS-P5 CARTOSAT	2005-	~618 km	10.30 a.m.	11 days	126 days	PAN

Our own India has also made lot of contribution in case of remote sensing specially in passive remote sensing through IRS series then Resourcesat series then IRS p series, Cartosat series and so on so forth. There are few things which are mentioned; I will like to go in detail here. Like IRS 1a and 1b, they had this altitude distance from the earth was 904km, the local, the acute crossing time was 10.30, and local crossing time might be different.

Adjacent orbits were just 1 day different, the repetitivity that means the temporal resolution was 22 days but if you are having two satellites in tandem this can be reduced to half means 11 and it was possible with IRS 1a and 1b for a few years. This IRS 1a and 1b had two sensors LISS 1 and LISS 2. Later IRS 1c and 1d had three sensors PAN, WiFS and LISS 3 sensor. These three was having 23.5 meter resolution and there was provided good quality of data.

The orbit was lower and two in the series IRS 1c and 1d they lasted for 5 years. Then came Resourcesat so it had new sensor LISS 4, it continued with LISS 3 and advanced sensor was also there and then Cartosat was mainly for stereo data in order to prepare high resolution digital elevation model and that had 4 meter resolution so likewise all 2.8 meter resolution data was provided through these Indian systems.

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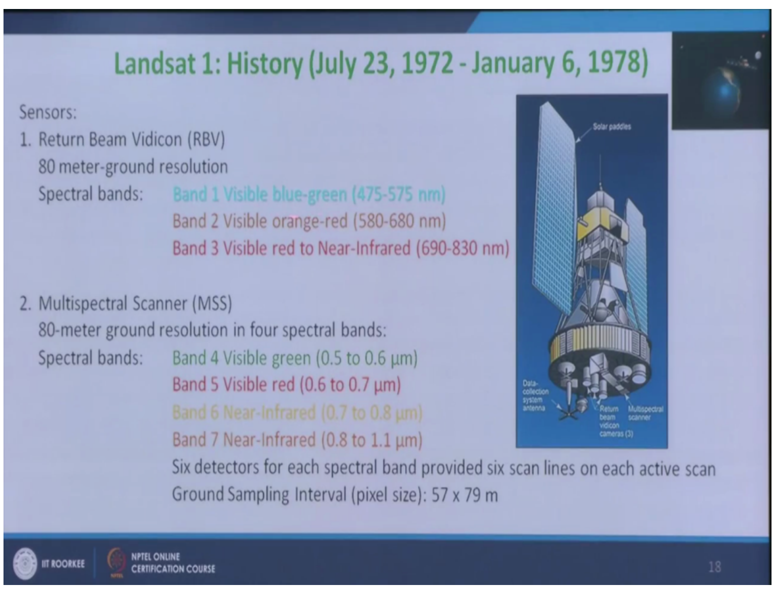

Landsat had two sensors initially, they were RBV sensor and it has visible and all three channels were visible different parts of visible parts of EMS spectrum, multi spectral where there some infrared, near infrared channel were there, visible were also there and the systems which we have developed had a different resolutions here.

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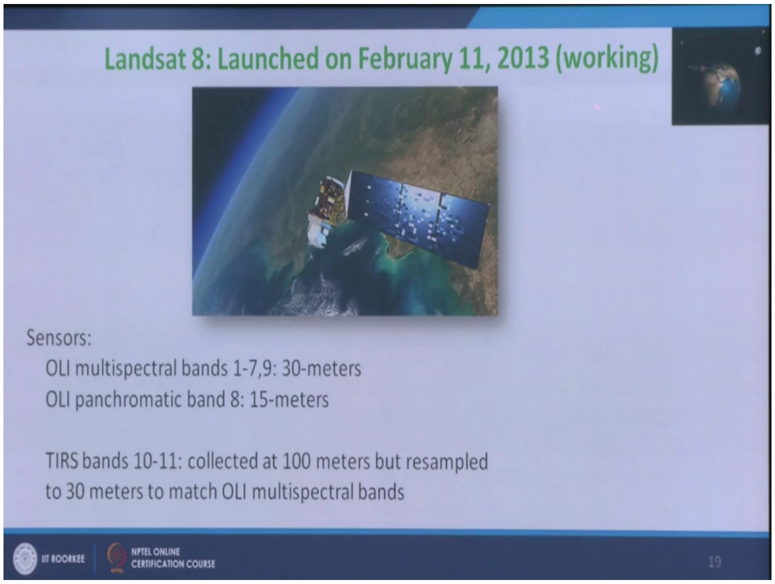

Later on the latest in the series the landsat 8 which is also called OLIs is having many sensors. Some sensors are providing data at 30 meter resolution, some sensors some bands are providing data at 10 meter resolution and so depending on the requirements and the capabilities of the sensors, different special resolution from the same platform data is being available now. This data is also free. Landsat data 1, 2, 3 all these were costing lot of money but now Landsat 8 data is free and almost in real time you can get the images through net at your desktop so that is the biggest advantage of Landsat 8.

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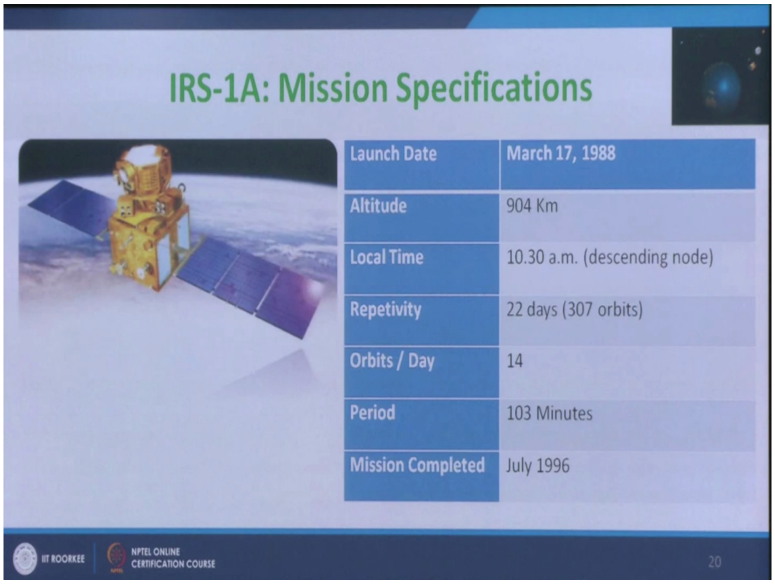

IRS 1a mission which was there and we have already covered this part so going to skip.

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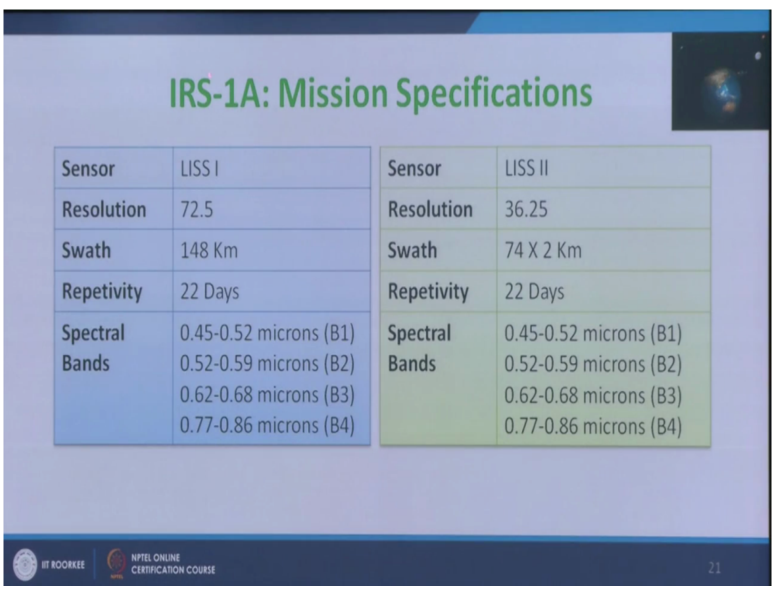

But just to compare these two sensors which became very popular and changed the Indian remote sensing. LISS 1 and LISS 3 have resolution of 72.5, LISS 2 having 36.25 and then swath was very wide here but because of high spatial resolution it became less and then the repetivity of course was same and it had almost same channels, same bands were there for LISS 1 and LISS2. But they had two different resolutions so that was the biggest advantage.

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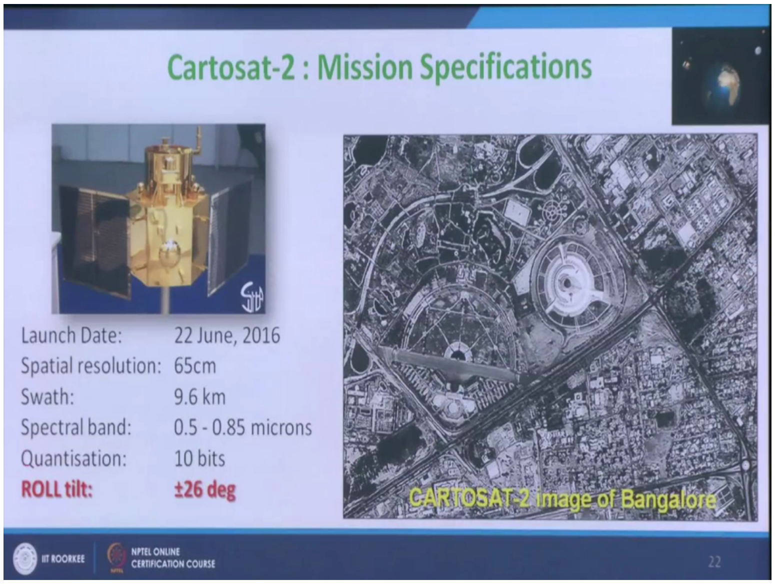

Cartosat of course the resolution you can see, is spatial resolution 65cm the latest in the series Cartosat 2 which provided the data earlier was different and then the swath is very less. This thing one has to understand that when you increase the spatial resolution of satellite or sensor, the swath will reduce so there is reverse relation. Higher the special resolution less the swath means the ground coverage. The strip which is going to cover is going to be very less.

So let me give you a comparison like NOAA AVHRR which is having swath of about 3600km, sorry 2800km but the spatial resolution is 1.1km. That means 1100 meters. In case of Cartosat the swath width from 2800 km has been reduced to 9.6km and whereas spatial resolution is 0.65 meters so if you improve the spatial resolution of the sensor then the swath width will reduce and then the repetitivity will also reduce because then today if it has covered very small width of the earth or a swath 9.6km wide strip of the earth then it will take long time to come back again and cover the same part of the earth.

So high spatial resolution will create a few problems for particularly about the narrow swath and more poor temporal resolution. The repetivity will reduce drastically so these things, this is a kind of trade off, high spatial resolution, less swath or more swath and relatively less spatial resolution as in case of NOAA AVHRR.

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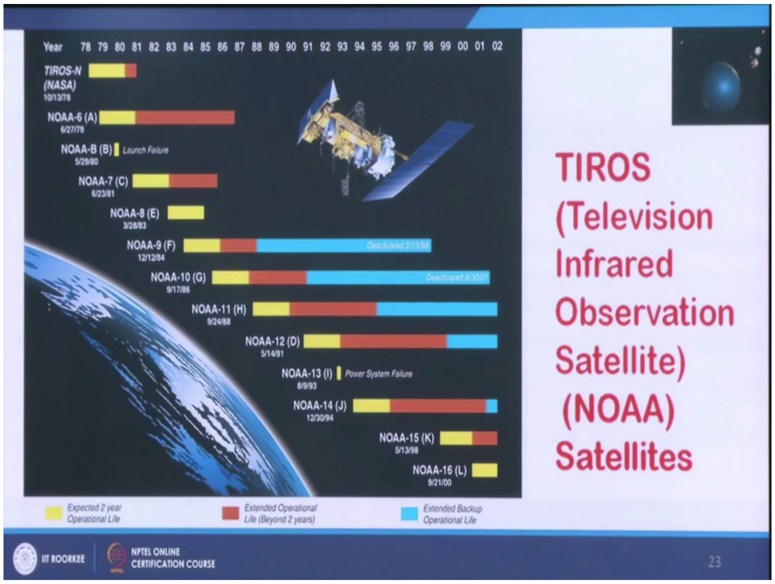

Now this NOAA series I have been mentioning started with TIROS and later on it was named NOAA 6 and it continued 7, 8, 9, 10, 11 and even 19. NOAA 18 and 9 are in operational, in that way it is not a complete figure but what it is trying to tell that in tandem sometimes we have even three satellites. I mentioned which I am going to show you very soon, the satellite station of NOAA which we have at IIT Rourkey, operational since 2002.

We started covering that time we had data from NOAA 14, even NOAA 12, NOAA 11 and then continued to 15, 16 and so on so forth. Slowly these satellites completed their sort of tenure or lifetime but new satellites have taken place and the current one is upto 19. After that NOAA series will stop working.

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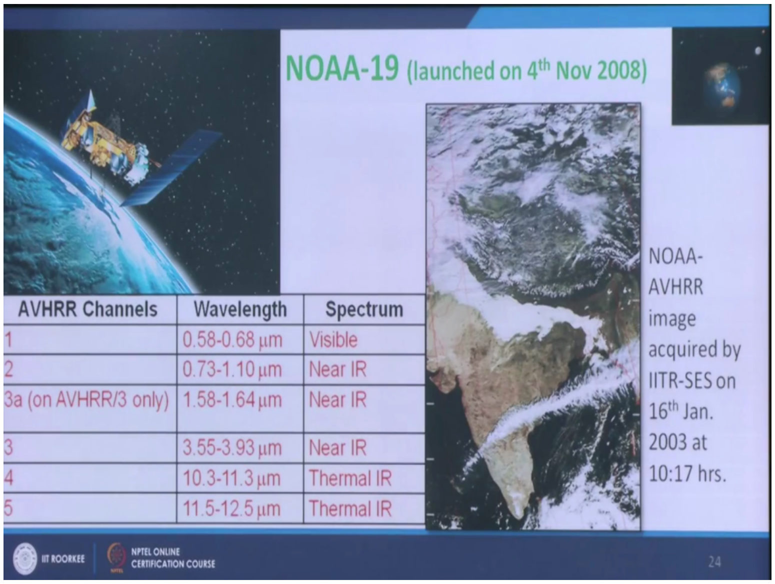

NOAA 19 was launched in 2008 and still working, still acquiring data. It is basically 5 channel data and there are visible channel, near infrared channel, three infrared channels and then you have two thermal infrared channels means though they are working in passive one but in night time also they can work. That provides a good advantage and this image of India and surrounding countries was acquired by our own earth station on 16th January 2003.

Where you can easily identify the fog belt, you can identify Himalayan Mountains, and you can identify clouds and associated shadow and many-many objects very easily without even much processing of the remote sensing data. So that the swath is much larger, 2800 km wide swath compared to 9.6 km swath in case of Cartosat, so the swath is very wide so you can cover a phenomena like a fog, you can look that from how big area has been covered. But if you are having a small strip then you cannot imagine what kind of this phenomena exists.

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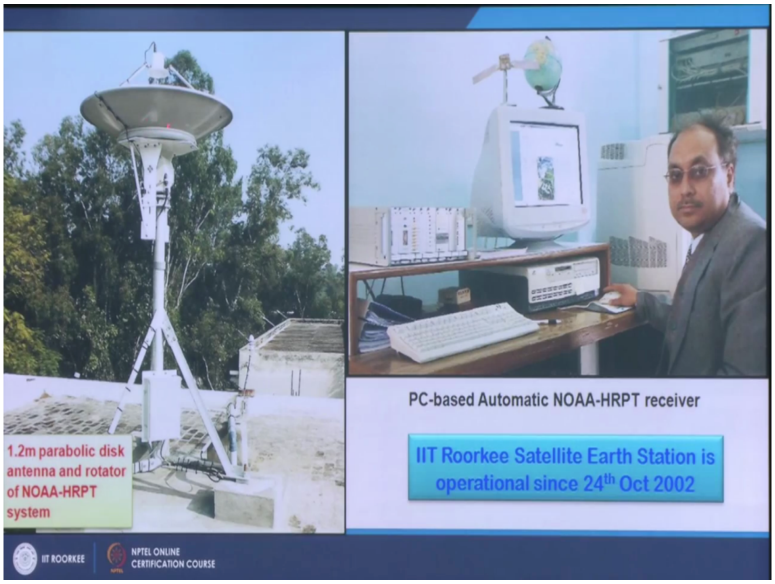

This is having receiver, external antenna which is tracking antenna and not a fixed one. It tracks the satellite depending on where it is, 7.2 parabolic disc antenna and it is controlled by simple PC, personal computer and it is having receiver and software which basically having program or it gets orbital parameters that when the data when the satellite will be over passing over this area and then accordingly it will align, wait for the data which will come from the satellite and once the data start coming.

It will lock with the movement of satellite and keep tracking satellite till it disappears at the other side of the horizon and that way it covers acquires a image like in this case it has done. So it might acquire, satellite might be going north bound or south bound. Suppose it is north bound, image will start building up from the bottom and from the south and till the satellite will remain in the range of antenna which is installed here.

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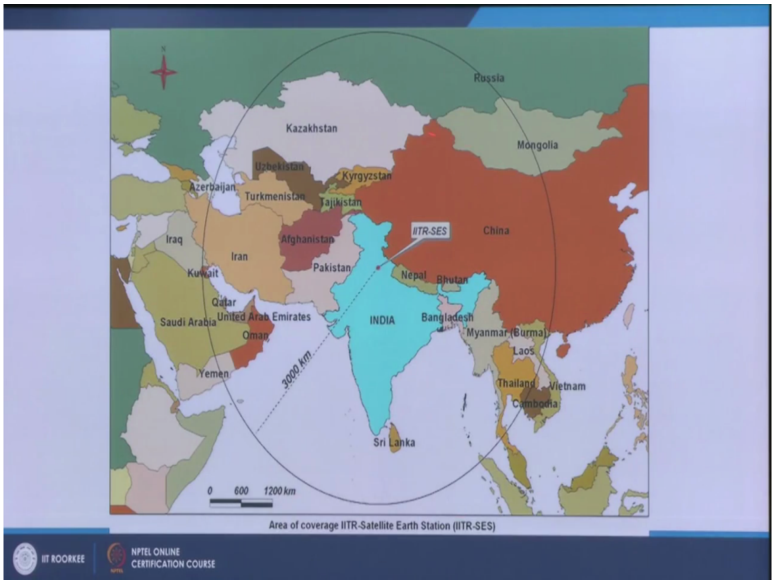

This is swing footprint of a satellite. Footprint means here that if satellite is over passing like this then still the station which is located here in IIT Roorkee an acquire the data. Even if its passing over Roorkee then it will acquire very long seam, long data but it's the oblique angle that means the antenna has to look sideways then the length of the data, the part of that strip is not going to be as long as overhead overpass means like when satellite is over passing from almost center of the circle. So it depends because the signal quality will reduce, will reduce if it is passing sideways but still it can acquire and as you can see that sitting at Roorkee we could acquire the data or have been acquiring data since October 2002 of all these not only of India but many surrounding countries which are falling under this circle.

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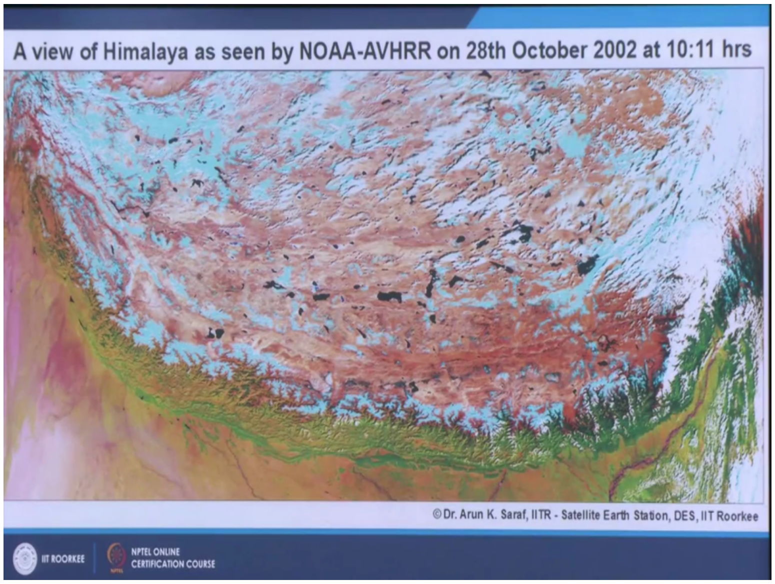

At one go sometimes, if its near head overpass seen then you can cover almost entire Himalayas which is more than 3000km width and you can cover in just one go. So Brahmaputra is there, Ganga is there, Yamuna is there and all these Mansarovar lakes and mountain peaks, Everest and everything was acquired juts in one go and because of having relatively poor special resolution but have wide swath so there are advantages with having sometimes relatively low special resolution data.

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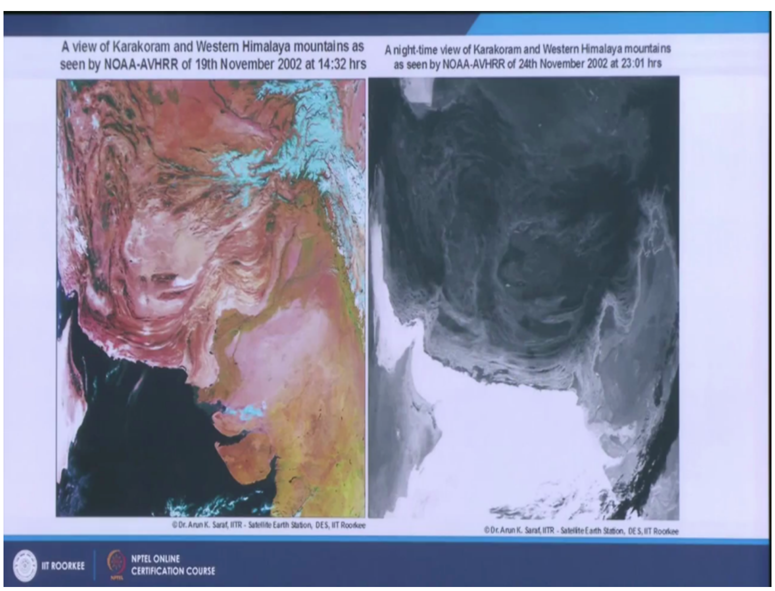

This is the data which is acquired in daytime and the same area was also covered, night time through thermal channel looks like an x-ray of that thing and of course it is recording the emittance which is coming out from the different objects which are present on the earth at that time. So these images have to be interpreted and analyzed in completely different manner than the normal visible channel images and that is a different thing.

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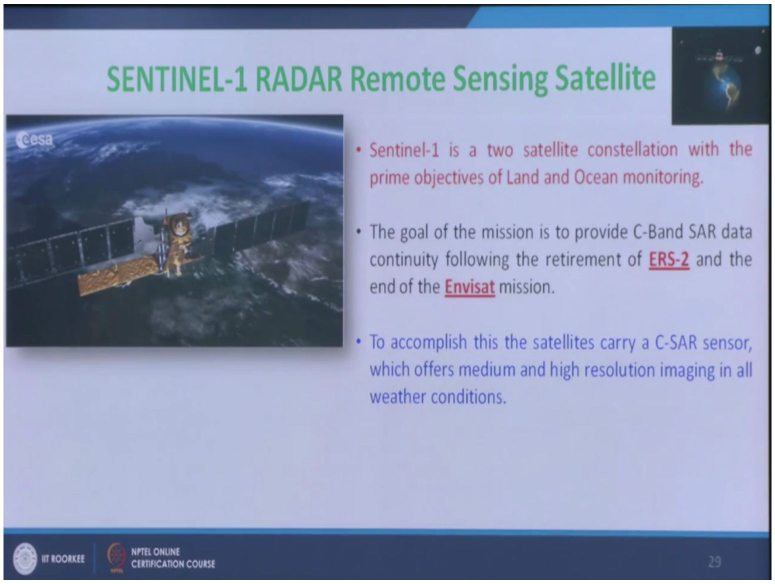

Now the last in this one is the radar satellites and I am going to cover the live one which is the sentinel. The data is free; there are live sentinel 1 and 2 satellite constellation with prime objective of Land and Ocean monitoring and this mission is to provide the data in C band data and it is a continuity following the retirement of VRS 2 and Envisat because these ERS 1 and 2 were first launched and they completed their tenure then Envisat was there and the new series sentinel started so it is a continuity of that data but of course after Envisat and before sentinel there were some gap but nevertheless now the data from sentinel, all these data from ERS, Envisat and sentinel are having capabilities of interferometery.

So these are having very good use specially at accuracy and covers entire globe, completes this satellite carry a C- SAR sensor offers, which offers medium and high resolution imaging in all weather conditions because radar remote sensing, the atmospheric distortion, clouds, fogs will not create any problem so they can acquire data in daytime, night time doesn't matter because the sensor itself will send the energy and that is the reflected back and collected by the satellite so you don't have to depend on external energy source like sun.

C-SAR capable of obtaining night imagery as well as detecting small movement on the ground which makes it useful for land and sea monitoring. These small movements on the ground here the SAR interferometery is playing very-very important role specially movements, ground formation causing by earthquake events, maybe landslides, maybe subsidence due to mining, maybe subsidence in long term due to over exploitation of ground water and so on so forth so there this SAR interferometery is playing very important role.

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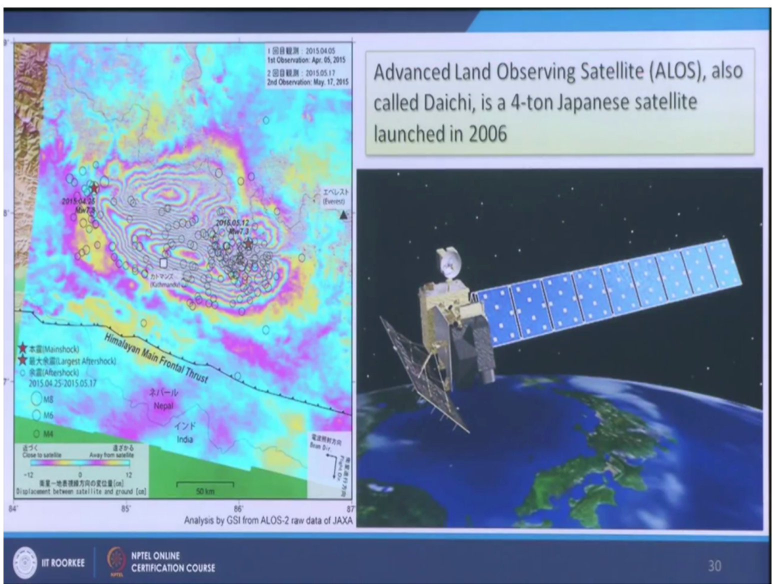

This is one example that how SAR interferometery data from ALOS which is Japanese satellite and sensor Palsar was used and here the ground deformations of about 1 meter were measured which were induced by earth quake event which has occurred in May 2015 and there were another one so both of locations of these epicenters are shown and these ground deformation and different color fringes are also shown.

So this is how SAR interferometery can basically measure very accurately at the ground formation in a short time or in a long time which might have caused by earthquake or landslide, mining subsidence or ground water subsidence, over exploitation of ground water and so on so forth. So this has become a very vital tool to measure ground formation in long term as well as short term so this brings to the end of these different types of platforms in remote sensing. Thank you very much!