Remote Sensing Essentials
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Lecture-01
Rudiments of Remote Sensing and Advantages

Hello everyone, and I am Arun Saraf from IIT Roorkee. And we will be discussing in this course essentials of remote sensing which I have given name is remote sensing essentials. Basically we will be looking in this course about the basics that is rudiments of remote sensing advantages and also various applications which we will be discussing in due course of time. So, this is 30 hours course, which we are going to have.

So in this series of lectures and I am going for first one, that is rudiments of remote sensing and advantages. So, very briefly in this lecture we will be going to discuss what exactly remote sensing and especially the formal definition of remote sensing as well. And then and different platforms and other things. And we will be also discussing. So let us start first with the word basically remote sensing, in the books or literature, this is how it is defined.

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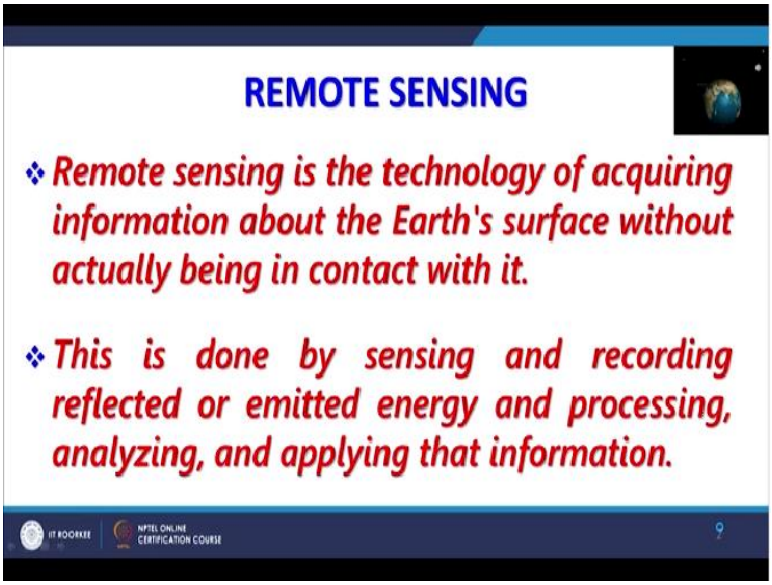

That is remote sensing is the technology of acquiring information about the Earth's surface without actually being in contact with it. And that means if I say in simple words, that anything

which we can sense film, our eyes or cameras or sensors, without basically coming into physical contact of it, and then we can say as a this that we are doing remote sensing. As you know that our eyes are very sensitive.

And though they work in the very limited part of EM spectrum, which we will be discussing in detail that is only visible part of the spectrum, but it is a very efficient remote sensor or a similarly, there are some other you know animals are also having different kind of or similar or different kind of capabilities of sensing things. And because human has designed sensors, which can not only work with the invisible part of EM spectrum.

But they can work in the thermal infrared, even in microwave regions and not only active microwave, but in passive microwave also. So, a large part of EM spectrum wherever atmosphere windows are available instruments are sensors have been developed, some are ground ways, some are aerial based, and many, many of them are a spacecraft based on satellites.

And also you know that now we are going for extraterrestrial remote sensing like going on moon putting satellites around the moon or mars and so on. So, all these things will be also discussing in brief in this course, this is the remote sensing as you know is done by sensing and recording. And that is a recording what recording that is the reflection or emitted energy, which is coming out of the surface of the earth.

And then we process it and analyze it and up and then use this data, these images for different applications. But as I gave the example of human eyes, we do not have that kind of recording facilities only it goes in memories, but we cannot replay, but using instruments or sensors it is possible to require record the reflection or emitted energy of the surface of the earth. And it is also possible to acquire that information or that data which has been sense by satellite, which is in orbiting around the Earth or moon.

And to Earth by through satellite earth stations. So, in this course also very briefly we will be also touching that aspect that how data is acquired from satellites and then they send the signals and so on. And then of course, whatever the data or images which we get generally are in raw

form. So, we need to do the image processing a lot of corrections are also performed. And we also analyze interpret the images and then use for different application. So, this is what is basically remote sensing in this one.

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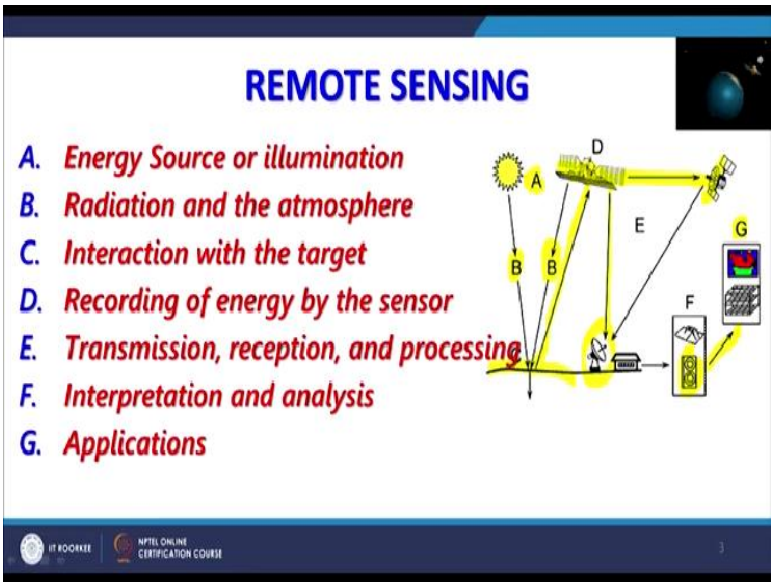

if we see different parts of remote sensing or different components of remote sensing, so, we will go a step by step that the E which you see here is the energy source or illumination, this is very much required that is essential especially for the reflected energy which we have just discussed in the definition of remote sensing that you need either illumination source or illumination or reflection that is possible in daytime or you need to emittance that is any object which is above absolute 0 will also emit energy.

That energy can be also detected by satellite. So, this is what it is shown here, that E is the illumination source, B is the radiation and the atmosphere, so that the energy which is coming from sun reaches towards the Earth, which is a C here and then some of this energy is reflected or emitted and then it reaches to the satellites and another D is also shown, because this is shown for the microwave and satellites.

In our sensors that the satellite itself they send the microwave signals towards the Earth and then whatever the work is capturing or the energy which goes back again is recorded by the satellite.

So, that is why here B is also shown. So, then the C part is the interaction with the target or the surface of the Earth in case of passive remote sensing and recording of energy by the sensor.

Whatever the signals which reaches or energy which reaches to the sensor, it is recorded by the satellites which are orbiting and the earth, moon or mars and then the transmitter this in these signals, whatever the data which they have acquired or satellite images they transferred towards the earth. So, this is the satellite Earth station and so these the receiving is done some first level or second level of processing is also done.

And then it is recorded here and then of course, it goes for processing analysis and interpretation. So, that part comes the G that is the application also. It is also possible that the satellite which has recorded a scene or an image can also transmit to some other satellite which might be orbiting over particular satellite earth station. So, almost in a real time that data though the satellite might be safe flying over India.

But the Earth station might be new is so through a satellite that transmission goes from one satellite to another and then and that signal goes to that station where it is located. So, all kinds of possibilities are there for data recording as well as all kinds of possibilities are there for sensing these signals either illuminated or emitted. So, this is all what we are having in remote sensing. Now, there are different types of platforms which are discussed in remote sensing which are considered as part of remote sensing.

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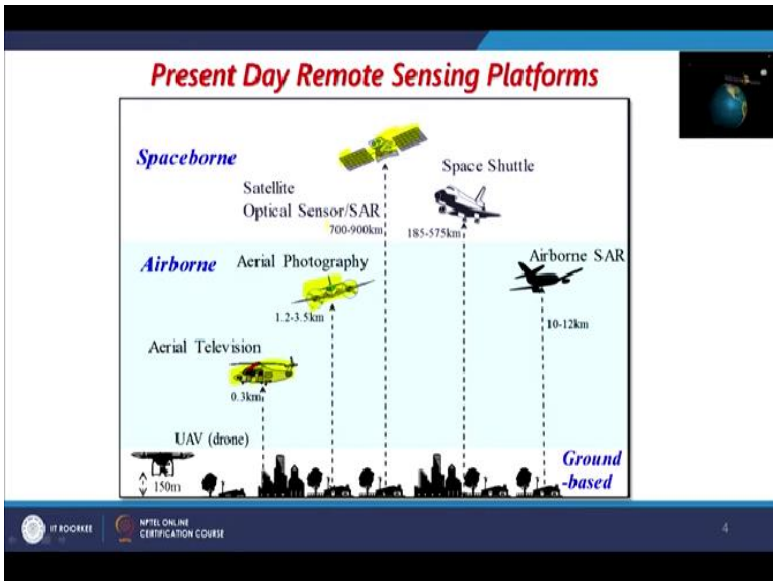

And this is a changing at a quite fast rate I would say that because initially we started remote sensing with balloons, so, some cameras were put on balloons, and though in this diagram is not soon because I am discussing here only the present day remote sensing platforms, and then later on then it came on the aircraft but these aircrafts are having their own limitations, helicopters are also their aircrafts are there.

So they can fly up to 1.3, 1.5 or maybe 10 kilometer in the air or in the atmosphere. But the more robotic platforms are the satellites which are very far around the 700 to 900 kilometer, these satellites I am talking about the remote sensing satellites roughly they are somewhere 840 50 kilometer + - 10 kilometer, these remote sensing polar orbiting or near polar satellites, these are the satellite which I am talking here.

Though there are different types of orbits are also they are in due course and time we will be might be also discussing some basic types of orbits which are used in a space or in satellite remote sensing. But the remote sensing which we discuss or I am going to discuss mainly will focus on the data or images which are acquired by these polar orbiting satellites, which are around 840 or 50 kilometer in space.

It is also possible to acquire data it has been done on the past using space shuttles, like one of the examples of through space shuttles or missions are there like a shuttle radar topography mission,

which was done using the space shuttle. So, that is also possible, they fly somewhere between 185 to 576 kilometer above the earth and then there are also possibility of airborne SAR, airborne aircraft are also shown here.

But airbornes are they fly much higher above the ground and the latest the new edition in remote sensing platforms is a this is what is UAV and unmanned aerial vehicles which are becoming very popular for different kinds of photography or imaging, and all kinds of payloads can be put depending on the capability of these drones. And though they cannot fly very high, they cannot cover a very large area.

But if somebody is looking for a very high resolution images and almost in real time and they would like to have the full control over it, then you will be can be one of the options and this is being used in case of disasters in agriculture and a lot of resources management also, currently you UAVs are being used, very popular in, very cost effective also sometimes. So, the different platforms are there at different heights to cover the various parts of the Earth.

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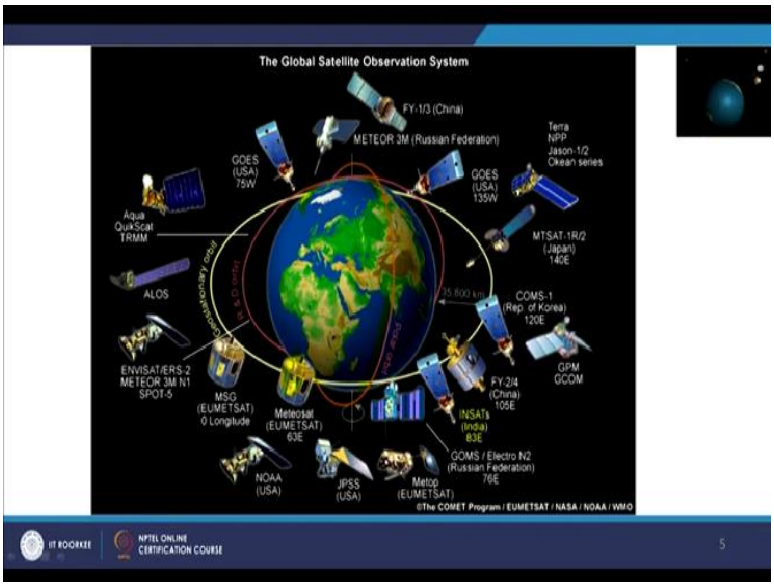

And as you know that then there are 100 of satellites orbiting and different depth in the space. And there are the satellites which we will be focusing as I have already mentioned, near polar orbiting satellites which are shown in these red color orbits, there are satellites which are

geostationary satellites, which are shown here like INSAT series of India. These are the geostationary satellites.

We are also having like these polar orbiting satellites, like IRS satellite, Landsat and meteosat and NOAA AVHRR, NOAA satellite, there are many such satellite which are orbiting in polar orbits. And there are some other different types of orbits are they , so very not all satellites are shown but many, many such satellites are shown which have been put by different countries in different orbits for completely, sometimes different purposes.

But most of the time, we are going to discuss about the polar orbiting or near polar orbiting and sun synchronous satellites, which are around 850 kilometer away from us. So as we have just discussed that remote sensing is the process which involves an interaction between incident radiation and the targets of interest.

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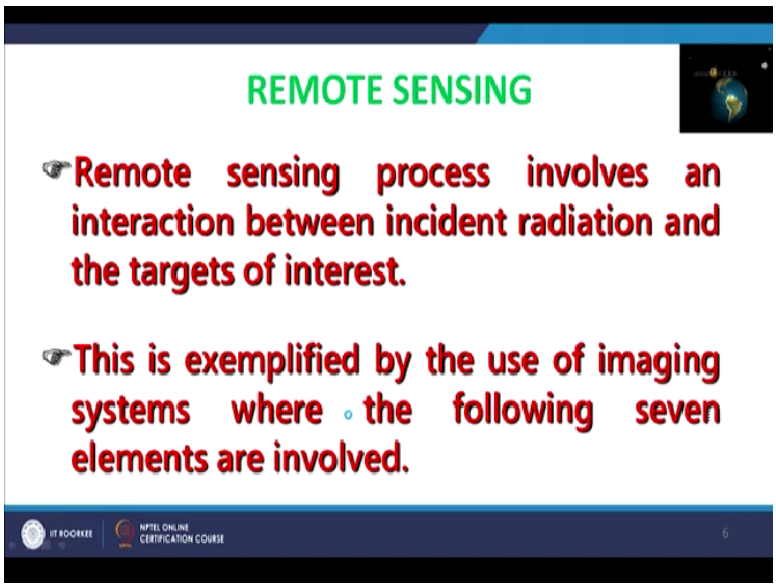

And this is exemplified by the use of imaging systems or sensors where these following 7 elements are involved.

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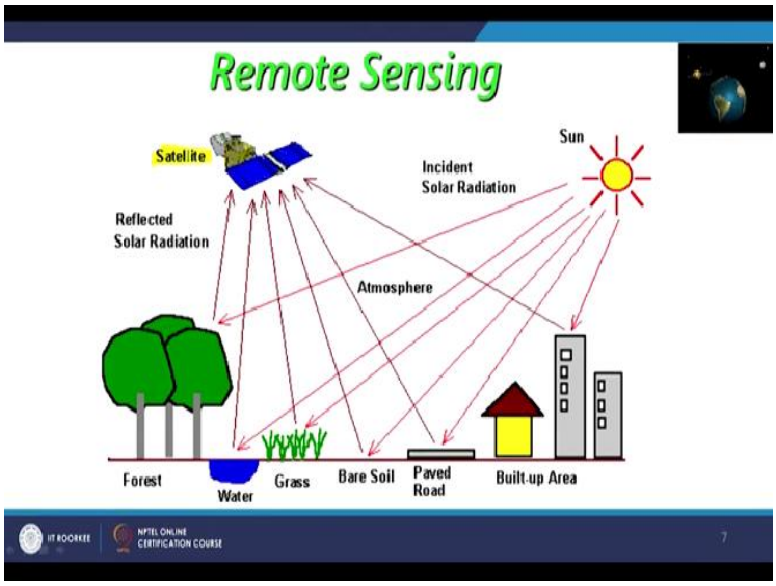

What are those 7 elements as we start with the satellite. So, there is a very important component of satellite based remote sensing, if it is drone, then drone is the some vehicle is required on which a payload can be put. So, that is what is required. So, instead of satellite we can say vehicle then of course there is a Earth and different objects on the Earth whether the water body is there, forest is there, grass is there, bare soil and so and so forth.

Of course, you need a energy source. So, we are having sun here illumination source. And then in between you are having atmosphere in between means, the between sun and Earth and between satellite and Earth and this atmosphere plays a very important role in field of remote sensing. And because though the solar energy is coming through the atmosphere, so, the entire energy is not reaching towards the Earth.

And the same way when it is reflected back and say to the satellite, then again entire reflection or emission is not reaching towards the Earth because in between there is atmosphere and this atmosphere while the energy or signals which are going back through the atmosphere there are a lot of distortions are created, and errors are introduced and we try to minimize by through our processing or techniques which are available currently.

We try to minimize these atmospheric errors as well. So that our images becomes much more useful quantitatively and qualitatively as well.

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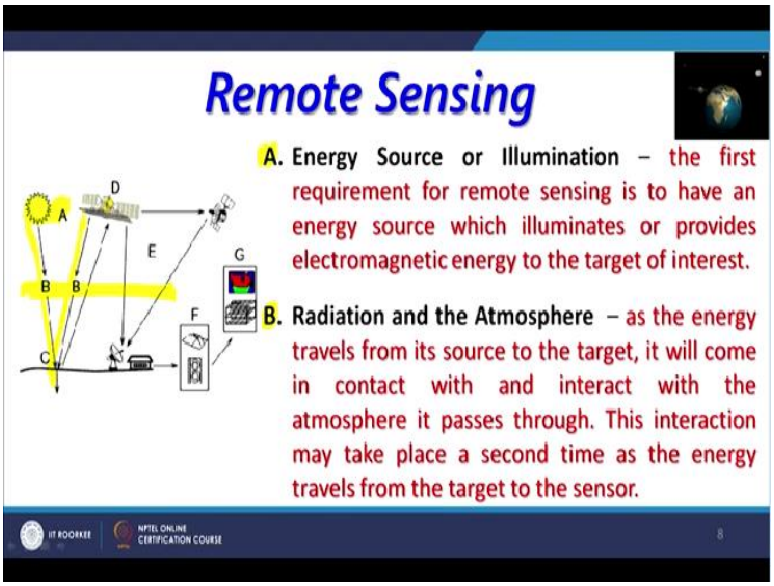

So, the 7 components are here, which are key elements in remote sensing also one by one we will be discussing these elements like a first as A is here shown also that energy source illumination, that is the first requirement for remote sensing is to have an energy source and which illustrates or provide electromagnetic energy to the target of interest. And that the second element or second important component of remote sensing is the radiation and atmosphere.

Of course, atmosphere is there, but if we talk about remote sensing of Mars or moon, then in those extraterrestrial bodies like mars, Mars has a very thin atmosphere. And therefore, the distortions or errors or you know the blurriness which might come in case of earth images, that is not very common in case of mars. So, that atmosphere there is thin and has got less role to play as compared to the earth.

But, when we are on the earth or we are talking about satellite images or remote sensing of the earth, then atmosphere plays a very important role as we know that when the energy travels from its source to the target, it will come in contact with atmosphere and interact with it and it passes through also some part of energy and this interaction may take place a second time as the energy travels from the target to the sensor.

By second time is I have already said that when it is coming from sun to the earth, it has to travel through atmosphere, which is in between, and when it goes back after illuminating the surface or image and energy, then again it has to pass through the atmosphere that is why it is second time. So, second time is more important in case of remote sensing of the earth.

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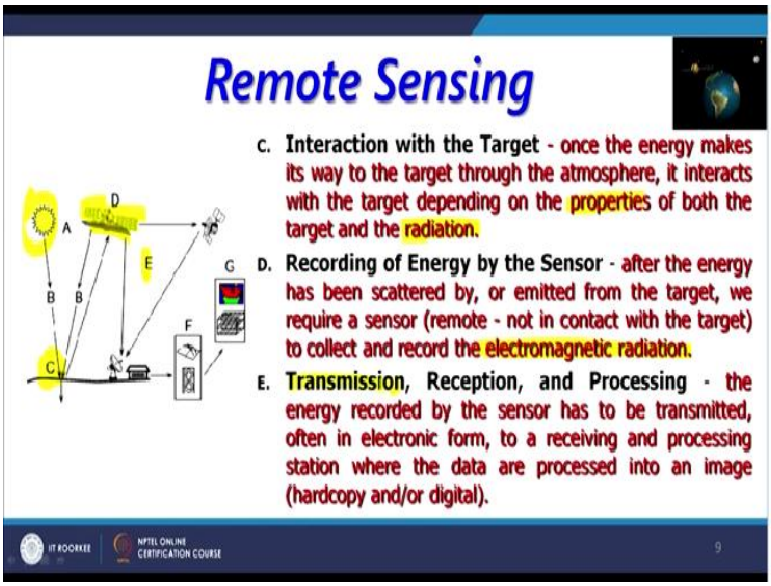

Then comes the C part that is the interaction with the target or interaction with the surface of the Earth. So, once that energy reaches its way through the atmosphere to the target through illumination source like sun and then it interacts with the target depending on the properties of both the target and the radiation. Here the properties means that target might be a water body might be ocean, or a land or a desert, or a dense forest, or a building or a similar objects or a mountain or a snow, peaks or glaciers.

So, different objects which are present on the surface of the earth will interact differently with the signals which are coming or the energy which is coming to the sun and then they will behave differently the radiation is will be going to be different and then whatever is reflected back or reaches to the satellite, that is what it is recorded by the sensor which are on board of the satellites, that is the D component.

And after the energy has been scattered or emitted from the target in between with the of course, it has gone through also and absorption or scattering within the atmosphere as well. And so, we

require a sensor that maybe a remote sensor and maybe own board of satellite or aircraft or helicopter to collect and record the electromagnetic radiation which has reflected or scattered back from the Earth.

So, you record a recording system also with that sensor and this transmission and then of course, then whatever is recording is done either it should be transmitted live that is by direct broadcasting or recording in direct broadcasting, all kinds of options are available with different types of sensors. So, transmission is also important component or remote sensing and these whatever the data it has collected, whatever the image is has collected, it has to transmit towards the satellite Earth station like soon shown here.

Then these restrictions received the data. So, the reception part and then of course processing first level processing, second and then satellite analysis, image analysis interpretations and of course applications. So, the energy recorded by the sensor has to be transmitted, of in form of electronic form and basically be receiving digital form. So, all the remote sensing images recorded in digital form not analog form nowadays.

And then processing stations or satellite this systems receives these data sets or images and then processing will take place and generally the outputs nowadays is very common is the digital one, but hard copies can also be prepared.

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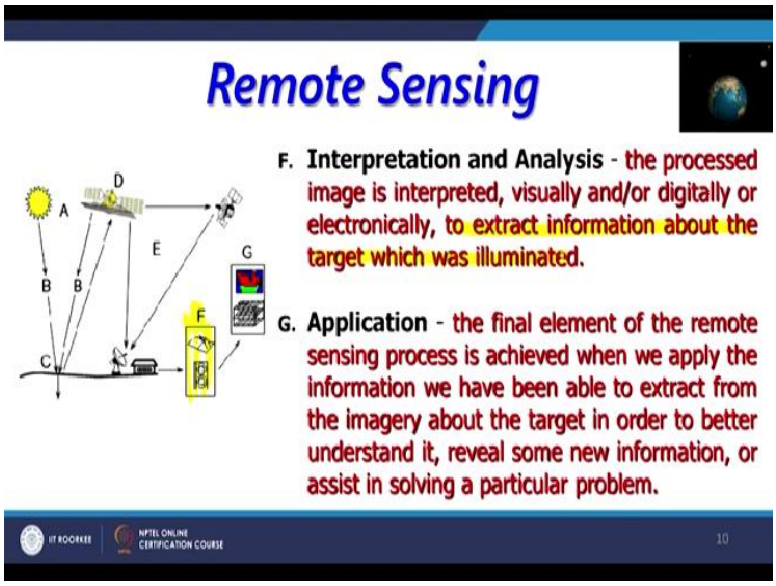

And then of course, after all this then we come to the interpretation and analysis part that is here and that is mainly in the lab work also. So, the processed image is interpreted by experts or for application scientists for different purposes. If one is civil engineer, then he might be using that image for civil engineering purposes. If somebody is geologists then he would be using for identification of some mineral deposits or coal or oil or gas or whatever.

And similarly for a scientists will be looking at different density of for us maybe different species of plants and so on. So the same image can be interpreted for different purposes. That is why also it is said that the remote sensing is a generic technology that means it can be applied in various applications of various domains. And then interpretation can be visually interpretations can be digitally based on the softwares or maybe more recent tools like neural network and basically classification based on fuzzy logic and other things.

And then ultimate purpose is to extract information of the earth objects from these images for different applications. So that is the main purpose. And then finally comes the applications that the final element remote sensing process is achieved when we apply the information, we have been able to extract from imagery about the target in order to better understand it reveal some few new information or assist in solving a particular problem.

You know that nowadays remote sensing images, though it is need not to be everyone is expert on remote sensing. But, from in day to day life we have started using remote sensing. For example, when we see the weather forecast is so whoever in the television or on net when it is displayed the satellite image is also displayed and clouds and if there are some cyclones are developing or other thing, they are also shown through these images.

So we start seeing images for different, so it can be also used for weather forecasting or natural disaster management and various other applications. So, these satellite images are becoming very common Google Earth is another product, which provides lot of images. And you can zoom it and as soon as you zoom it, you get higher and higher spatial resolution images of any location of the world. So, because thousands and millions of images have been put in that Google Earth database, which can be accessed by very easily by the users of their area of interest.

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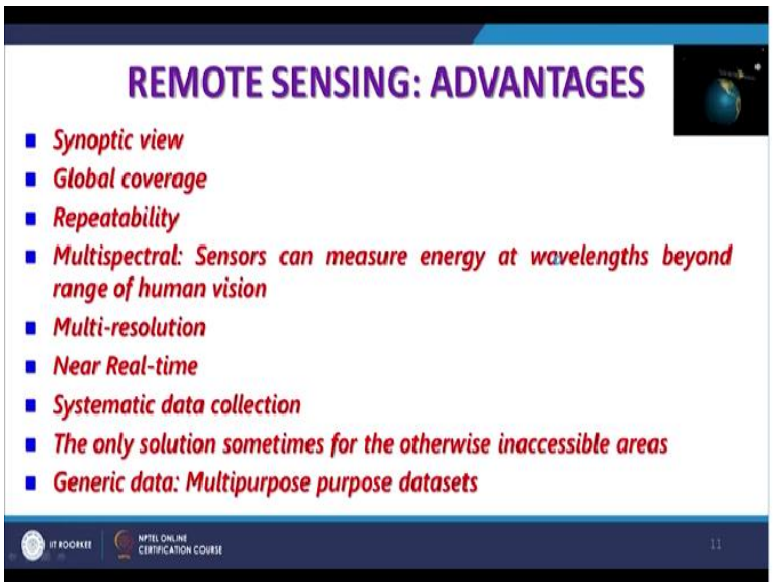

Now, what are the advantages, some you might have realized by seeing or while going through this discussion is the synoptic view that is the biggest advantage but because generally remote sensing is done from a distance. So when you go from an object away from object to the distance, you start covering a large area and so in one go you can cover a very large area of course, it depends on the spatial resolution of the sensor.

But nonetheless, it will provide a synoptic view. So, a large area can be covered in one go that is what meaning here is. So, suppose if I take example of NOAA AVHRR, NOAA is the name of satellite AVHRR is the advanced very high resolution radiometer and that having a spatial resolution about 1.1 kilometer and that covers about 2800 kilometer wide swath. So, in one image in one go you can cover a 2800 kilometer swath or a strip of the part of the Earth.

So, it provides a very large coverage, but as you go higher and higher spatial resolution, the size of this swath, the breadth of the swath reduces and if I take example of one meter resolutions say ikonos images, then the swath reduces to 11 kilometer. So, from 1.1 kilometer spatial resolution and 2800 kilometer swath you reduce to 11 kilometers swath, but the spatial resolution you are getting all 1 meter.

So, as you go for higher spatial resolution, the breadth of the swath reduces, but it is still that higher spatial resolution image will provide a synoptic view. So that is the one of the biggest advantages and the remote sensing in day to day nowadays, we are seeing these drones have become very common and whether it is a marriage or some function or some large programs there these videographers have started to have using these drones. And why they use to cover a large area. So they provide also the synoptic view, global coverage.

When you are going for satellite based remote sensing, not drone based of course, then satellite based remote sensing, then you can cover the entire globe is basically I am talking about a polar orbiting satellite like IRS Landsat port or many, many such satellites. So, they provide a completely global coverage sometimes except for polar regions, but otherwise they provide a complete global coverage.

Repeatability that is another best advantages with satellite based remote sensing, that each satellite will be coming or revisiting the same part of the Earth, maybe after a few hours like in case of new NOAA AVHRR or maybe after 30 days, 16 days, 18 days depending on the resolution and depending on the distance from the Earth. So, these repeatability is another best advantage of satellite based remote sensing.

So you can have coverage like that, and then you are having multispectral sensors, that is another very good advantage because in the beginning I mentioned that our eye work only in the visible part of EM spectrum. But if I want to scan a part of the earth, using infrared or thermal infrared and of course visible as well, then I can have different you know, bands or channels, then we call it the multispectral.

So, these sensors can be designed and been designed, they are already there are lot of different types of sensors are there, which can sense or measure the energy at different parts of EM spectrum, beyond the range of as mentioned, human vision. Multi resolution images are now possible. Within even 1 satellite different sensors are installed. Like I give the example of IRS so earlier in IRSV IRS-1Z 1D satellites.

We had 3 types of sensor, we have panchromatic sensors, which was giving black and white images. Then we have multispectral sensors like LISS 2, LISS 3, LISS 4 and so on, so forth. So, within one platform you can have different payloads and multi resolution images can also be acquired, it is a very common thing nowadays with satellite based remote sensing, it is also possible to have images data in near real time.

Once the satellite has acquired and there are satellites which can directly transmit towards the Earth. So, if you are having your own satellite Earth station in real time you can acquire the data, though the satellite is scanning of the sensor is just scanning that part of the Earth. If it is in range of your satellite Earth station or antenna, then in real time you can get the images and then systematic data collection because the repeatability is fixed and the coverage is fixed.

So, you get a complete sequence of data. So, the time series analysis is become very possible very much possible with the satellite based remote sensing. So, since the data collection is very systematic, it is not common the drone or any such or aerial or airborne remote sensing but mainly with satellite based remote sensing. The only solution sometimes for otherwise inaccessible areas.

This is another important point, because there are many parts in the world which are inaccessible to human, not easily reachable, but the satellites can reach that means they can acquire the data and provide to whoever needs for that time and especially in case of natural disasters, and satellite remote sensing plays a very important role. And finally, the generic data which I have already mentioned that one data set one image can be used by 10 or 20 types of applications.

So, there are multi purposes are associated with a single remote sensing data sets and that is another very big advantage like the first one the synoptic view, the last one the generic data and in between all are a big advantages with remote sensing and that is why remote sensing is being used from agriculture to natural disaster from civil engineering to our sciences or on the Earth or moon on mars or explore the universe. So, for all kinds of such missions remote sensing techniques are being used.

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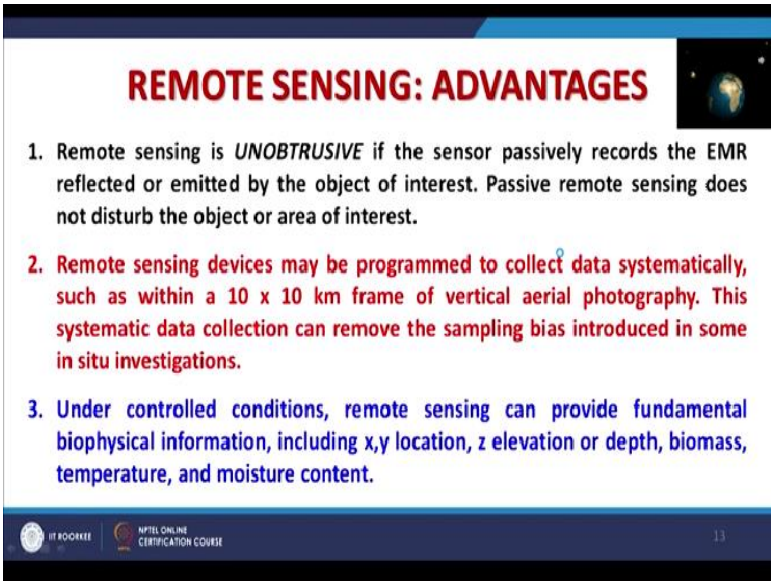

Another few more advantages of remote sensing and which is when we go at the processing level because data being acquired by these satellites, which is in digital form and therefore lot of processing either can be done in automatic manner or semi automatic manner. So, analysis and processing becomes very fun because originally generically the data in digital form. If we are working in microwave region, then microwave advantage with microwaves that it can penetrate through the clouds.

Because the waves or bender which we are covering in microwave, the waves are having a larger and you know larger wave length and therefore, they can penetrate the clouds and also sometimes in dry sand and then it can be used. This microbial remote sensing has been used in India to identify or locate the old lost courses of social theory in Rajasthan desert because the dry sand was there.

So, as soon as the moisture comes that can be imaged or mapped by these microwave sensors. And of course in a natural disaster conditions especially in flooding, and sometimes there are clouds or enduring flooding most of the time there are clouds. So, if we imply the microwave remote sensing, then these can penetrate the optical remote sensing may not work the thermal may not work in flood and may not work, but microwave remote sensing can work in such conditions.

It also optimizes field investigations it will note, it can never replace the field investigations, the field work or field investigates, site investigation have to be there a ground routing have to be there, but one can plan very well using remote sensing, one can optimize and one can take field investigation at a very fast rate by implying the remote sensing technology as it is happening in geological map or mineral exploration or in civil engineering.

First people nowadays starts exploding or seeing things on Google Earth, then the plan many field investigation side investigations just based on Google Earth data, which are the high resolution images, and then they go to that specific point which need to be checked on the ground. And therefore, it optimizes field investigations, updating or revision of existing maps is expensive and faster.

So, it is inexpensive that whenever there are old maps are there if you want to upgrade and then you imply the high resolution satellite images, and then these can be upgraded like survey of India, have you started doing this thing that they are now using in order to update the topographic maps they are using now satellite images to upgrade and that process because if everything has to be checked in the field and it is upgraded.

Then it is very expensive, but employing remote sensing data becomes inexpensive and faster and color composites because we are talking about multispectral remote sensing. So, therefore color composites can be created and they ensures the details of the area that we can I can identify very easily the water bodies, I can identify the turbidity in water, in pollution in water or forest I can identify density of forest.

I can identify different species of forests or if I talk in case of our sciences or in geology, then I can to some extent I can identify different types of rocks and geological structures if they are of larger scale. And then and there are advantages with remote sensing is in natural disasters studies and rescue missions. And then remote sensing based rescue missions can become easier and fast and this has become a normal practice.

And extensively it is being used when in 2015 Nepal earthquake occurred and people or different countries shared their whatever the satellite data, current satellite data they had, which was covering and the area which got affected by those series of earthquakes. And these rescue missions, use the data and could prepare a lot of plans and maps and then these operations were done like that.

And of course, so overall it is cost effective. And because they are doing things in the field getting updating information in the field is very expensive. And where is using remote sensing data, it becomes very much possible earlier when remote sensing is starting the real remote sensing like lens at one in 1972 at that time, the satellite life of the satellite used to be say 3 years, 4 years like that.

But nowadays, the technology has improved, electronics has improved, the solar panels have improved, the batteries have improved. And now a satellite when it is known sometimes they are lasting for more than 10 years. So, they are becoming further cost effective. So, these are the various advantages of remote sensing which can be used implied and lot of work can be done implying remote sensing data.

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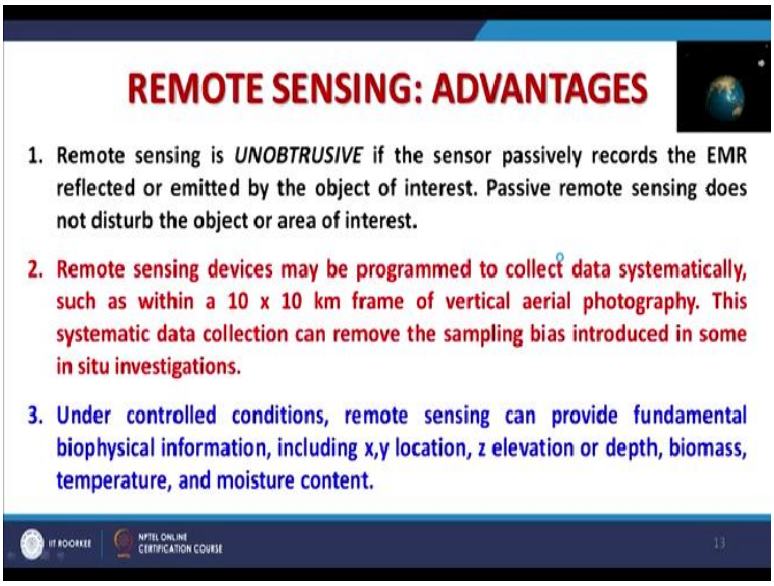

Now, there are some other little bit more discussion on this advantages that remote sensing is unobtrusive that is it is a passive thing. It does not destroy anything. So it records the reflected or emitted energy by an object and a passive it is most of the passive except that some part of microwave remote sensing which is active, but still it does not destroy anything of the object.

So, in that way it is unobtrusive that passive remote sensing does not disturb the object or area of interest, I can say overall the entire remote sensing does not disturb the objects or area of interest. So, in that way, it is also non invasive and advantages remote sensing devices may be programmed to collect the data systematically and such as within say 10 by 10 kilometer frame, vertical aerial photography.

And this systematic data collection can remove the sampling bias interlude in some institute investigations. Nowadays, a drones are also these UAVs are also being programmed and they are they too have started collecting data very systematically. So, the satellites and in between the platforms between say Earth and satellite that you are having drone, helicopters, aircraft and then different satellites in different heights.

And under controlled conditions remote sensing can provide fundamental biophysical information including x by location, z location, and that is these other types of satellites or navigation satellites. Also we can get the biomass, temperature and moisture content. Whatever

the research currently which is going on climate change, large part of or larger data huge data or big data is coming from remote sensing sensors be the temperature or say moisture content or say vegetation cover or a pollutants, aerosols.

All that information is coming from different types of satellites. So lot of the data input in these climate changes studies and modeling, all the data is coming from remote sensing or from different platforms. So this brings to the end of this initial discussion on remote sensing essentials, I try to cover in this one, what exactly remote sensing is, and what are different platforms.

And how this whole thing works, starting from sun to satellite in between Earth and atmosphere. And then very briefly, I have told what are the other processes involved and finally, I have also discussed in detail the advantages of remote sensing for various purposes. So this brings to the end of this discussion. Thank you very much.