Introduction to Remote Sensing
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Lecture 06
Interaction mechanism of EM radiation with ground and spectral response curves

Hello everyone and welcome to this 6th lecture. In this course there is introduction to remote sensing and in this particular topic we will be discussing the interaction, mechanism of electro magnet radiation with the objects which are present on the ground especially vegetation, bare soil, water bodies and their response spectral response curves, which we will see how this curves of different objects different wavelengths they behave.

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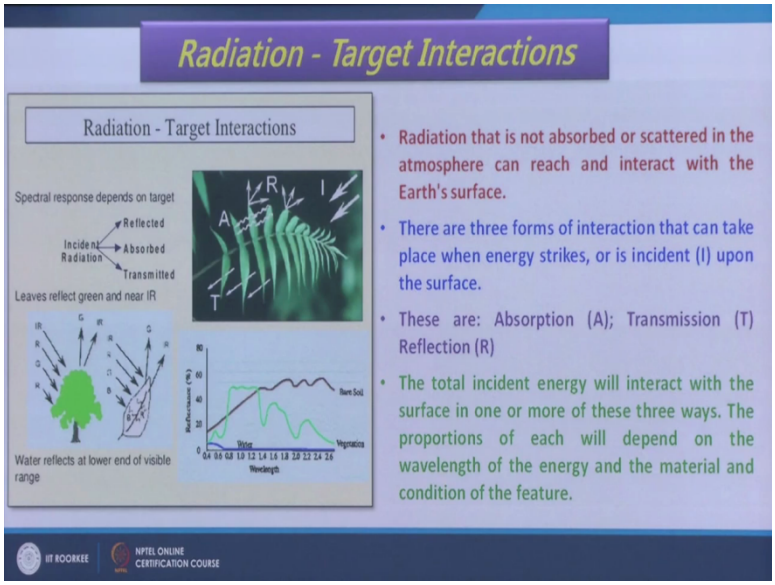

For example when there is a when this solar radiation interacts with the target and example here of a vegetation then there might be reflection from the vegetation, there might be some absorptions of solar energy by the plants and there might be transmission. So, all these three things will keep occurring whereas special leaves specially if they are having chlorophyll content then they will have a different response in visible part compared to the infrared channel and so on. As we can see in this small spectral curves of three types of objects which are shown here and these are more or less standard spectral curves wavelengths on the x axis and reflection in percentage is given in the y axis.

But we see that the bare soil shows the maximum reflection around 1.4 to 2.6 micrometer and whereas the vegetation which is very important to notice that suddenly around 0.7 it jumps and it shows the very high reflection compare to other parts of spectrum. Whereas the water only shows in a very small part of EM spectrum some reflection and then there is a sort of complete absorption.

So, all these reflection absorption and transmission phenomena will occur together and different objects in different parts of EM spectrum will behave differently as we are seeing here we will see these things in much more in details. Radiation that is not absorbed or scattered in atmosphere can reach and interact with the earth surface and remember that when the solar radiation is coming some part of some portion of that is absorbed within the atmosphere but remaining part may reach to the earth surface and can interact with the objects which are present there. And the three forms of interaction can take place when the energy strikes or it is the incident upon the surface and these three are absorption which we have discussed transmission and reflection.

So, the total incident energy will interact with that surface in one or more these three ways. The proportions of each will depend on the wavelength of energy that is very very important and the material and the conditions of the features. Condition of the features means if the vegetation is very healthy having high chlorophyll content it will behave differently but the same vegetation if it is not having this drying up or having some disease it will behave differently in different part of EM spectrum. That is why it is mention is the condition of feature.

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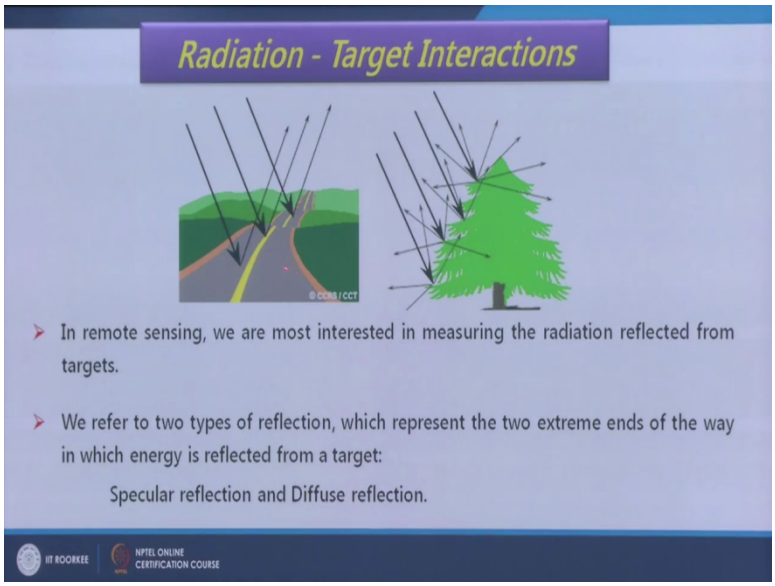

Now this radiation or interaction there might be two ways that one is this reflection and there might be a reflection by the man made surfaces or some natural surfaces and which we call as a specular reflection and there might be a defuse reflection maybe because of vegetation maybe bare soil some rocks and other thing. These will affects the signatures or their presence in satellite bends images get different bands. Two types of reflection which are observed may leave which are two extreme ends the way energy interact and the reflected by one is specular reflection maybe from the roads, maybe from it come water surface and so on. Whereas the defuse reflection maybe from the vegetation in other places.

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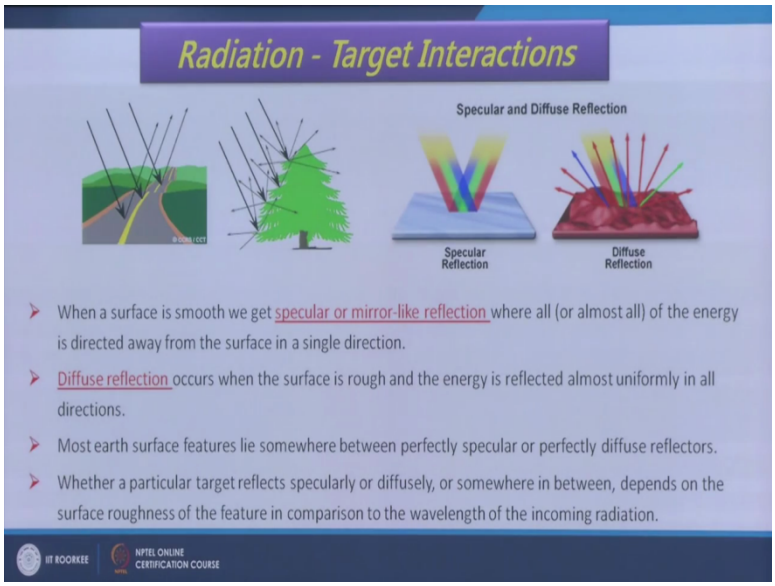

So, specular reflection the maximum energy is reflected back whereas defuse reflection some and it is scattered all around. So, when the surface is smooth we get specular or mirror like reflection where all or almost all of the energies are directed from the surface is in the single direction and whereas defuse reflection occurs when the surface is rough and the energy is reflected almost uniformly in all directions. And most of the earth features which are not really perfect specular reflectors or neither defuse reflectors.

Most of the features falls in between of these two categories and whenever a particular target reflects (())(5:49) or defusely or somewhere in between depends on the surface roughness of the feature in comparison to the wavelength of incoming radiation.

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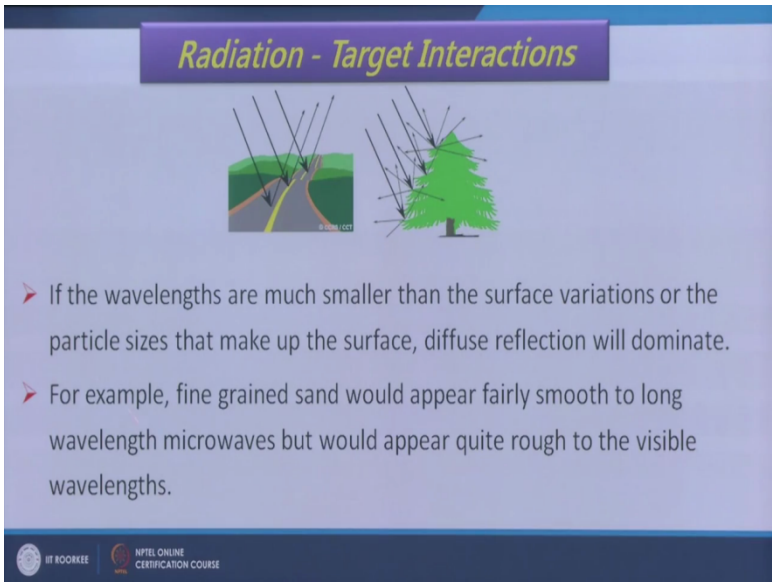

And the example here is the wavelength as much smaller than the surface variation on the particle size that make the surface defuse reflection will dominate. For example fine green sand specially present in the desert areas could appear fairly smooth to long wave micro waves but would appear quite rough to the visible wavelength. So, it depends the same surface but depend on the wavelength in which wavelength or in which part of EM spectrum you are looking or which band of the satellite image you are looking. The same object will look very smooth or in a larger wavelength but may look rough in visible wavelengths.

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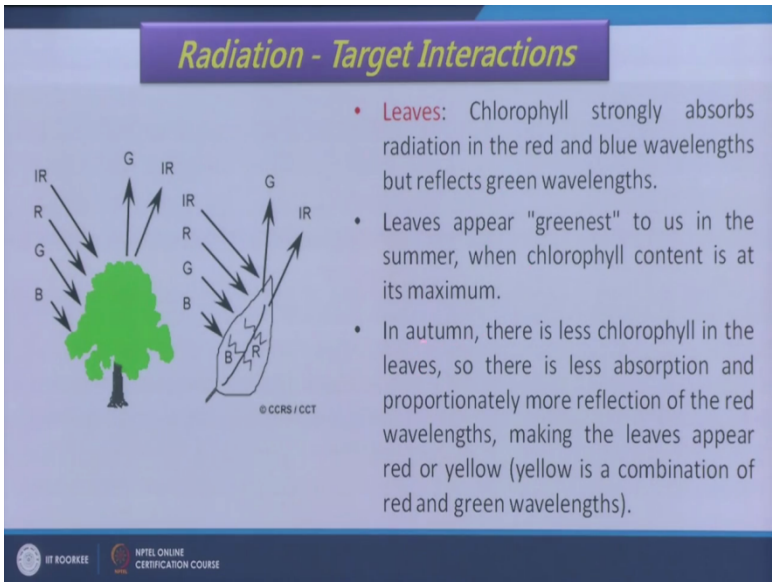

Similarly the leaves say plant leaves chlorophyll strongly absorbs radiation in the red part and the blue wavelengths but reflects green wavelength that is why we see in the visible part that is why we see vegetation healthy vegetation generally green because the red portion the blue portion are absorbed whereas the green is reflected. Leaves appears greenest to most of us in summer when chlorophyll content is at maximum depending on the season of different areas in the country or world all over whereas in autumn when there is a less chlorophyll content so there is less absorption and proportionally more reflected of red wavelength and making leaves appear either yellow or red and yellow is a combination of red and green wavelength. So, when chlorophyll is less then the green is not reflected and whereas the red is reflected or yellow or green is reflected and that makes us yellow.

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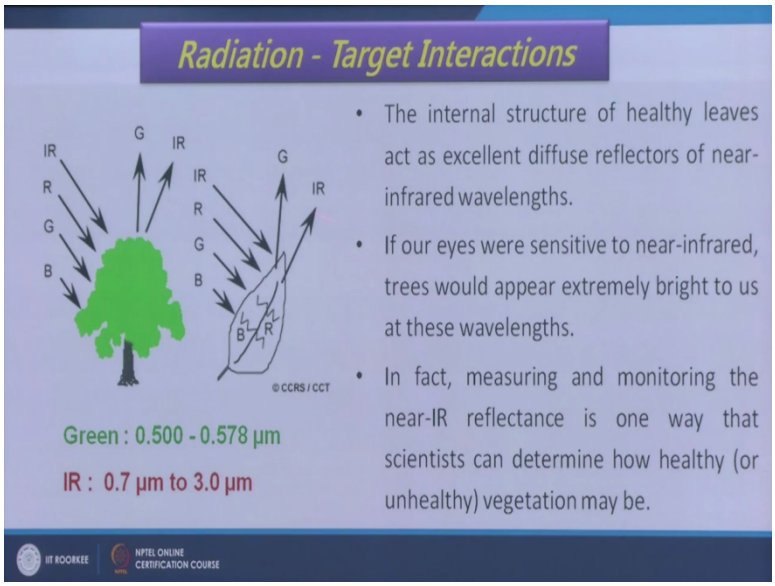

Similarly in this in this healthy vegetation eye act as a excellent defuse reflectors of near infrared bands infrared wavelengths and that is why you know though in our eyes its different but in infrared radiation in infrared bands the vegetation is having maximum reflection so, our eyes were sensitive to basically near infrared trees would appear extremely if at all these our eyes would have been but we are having sensors near infrared and therefore we get very high reflection and infact measuring and monitoring near infrared reflection is one way that scientist can determine how healthy or unhealthy vegetation maybe.

And this people exploit specially for crop estimations or health of a forest area and so and so forth that if you are getting very high reflection through infrared channels of an area which is completely vegetated or having some agricultural crop you can assess that area is enjoying the growth of plants or good chlorophyll content present in the leaves but if a this near infrared reflection is less than there might be some problem with the plants.

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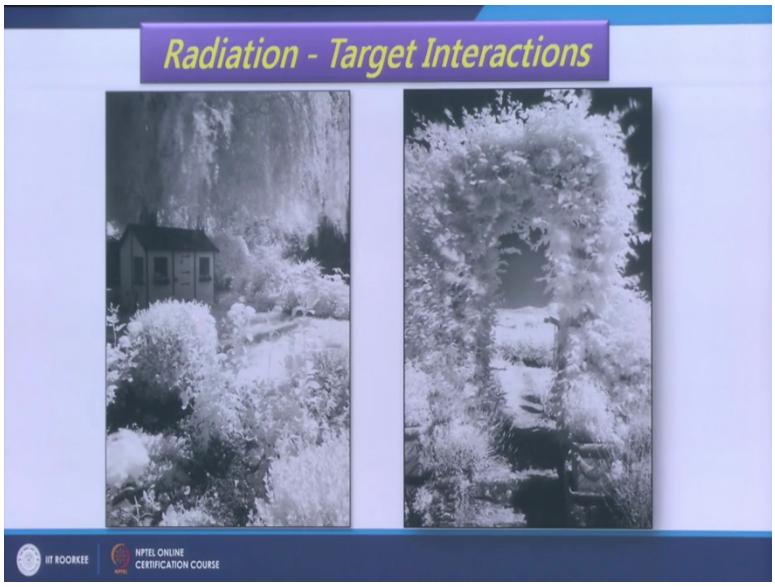

As you can see that these are the plants seen through the infrared channels and they are showing very high reflection whereas the roof of a house or a window are showing very low reflection. So, this property of plants we exploit in our remote sensing data and we use the combination to create certain products which we can apply for different kind of applications.

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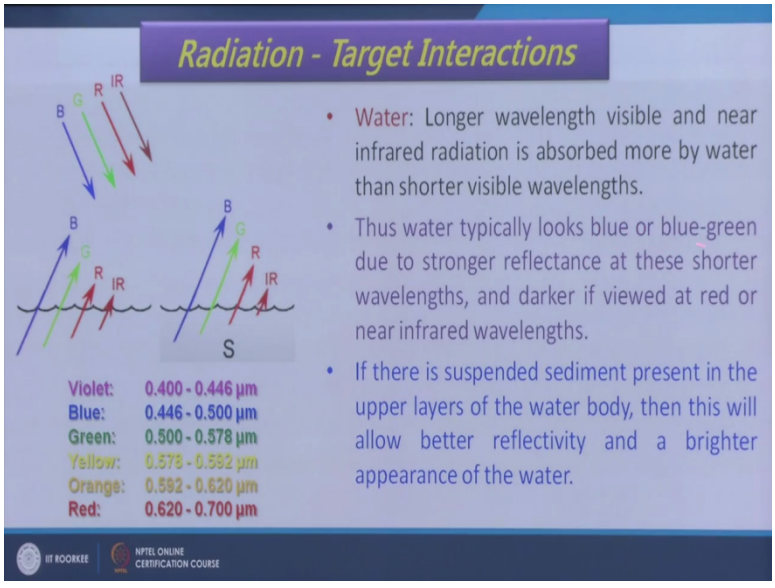

Now we take the water then longer wavelength visible in near infrared radiation is absorbed

more by water than the shorter visible wavelength. As you saw earlier in spectral curve of water in the shorter wavelengths there is some reflection by the water otherwise in the longer wavelength it is completely absorbed. And that you can see here also that this is completely absorbed, water typically looks blue green dues to stronger reflection at this shorter wavelengths and darker if viewed in red and infrared so, whenever we see infrared images in which the water bodies is present generally a water is pure it will completely appear black or dark because there is no reflection in that part of EM spectrum.

Whereas we look the visible part of shorter wavelengths we might see some reflection of water especially in the blue portion of EM spectrum or blue or green that is why we see generally water though you know that pure water doesn't have any color but these colors are coming because of reflection in the different part of EM spectrum and if there are suspended particles present in this upper layer of water body when this will allow better reflectivity and brighter appearance of the water. So, if it is not pure like here suspended particles are shown here then you will get a larger reflection in this parts and same maybe little more in the red and infrared maybe less so this kind of changes will occur when we are having suspended sediments or we also call it turbidity present in the water bodies.

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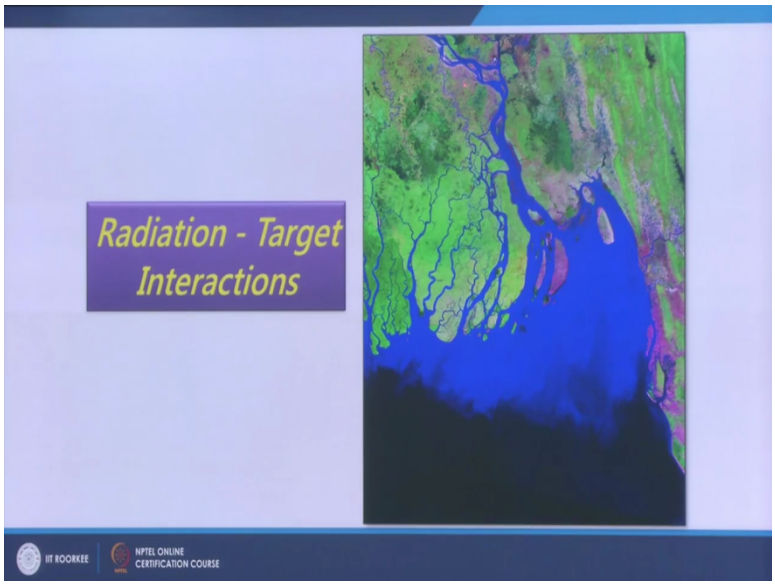

And this is the example is shown here this is delta which is shown here and Ganges in

Brahmaputra basically are coming here Sundarban delta and they are bringing sediments and mixing with this Bay of Bengal and what is happening because of its presence of suspended particles and high and due to that high reflection especially in the blue part of EM spectrum and therefore in a land set TM near near real color images we see a blue portions and that is directly indicating high concentration of a sediments present whereas you don't have much sediments present then hardly your having reflection and therefore there true color images they are appearing as black.

So, this is how the interpretations can be made of satellite images whereas the green is of course vegetation and there are water bodies, in land water bodies which may not be having suspended particles and therefore they are appearing black. So, the quality of water can also be assessed through such interpretations of satellite data.

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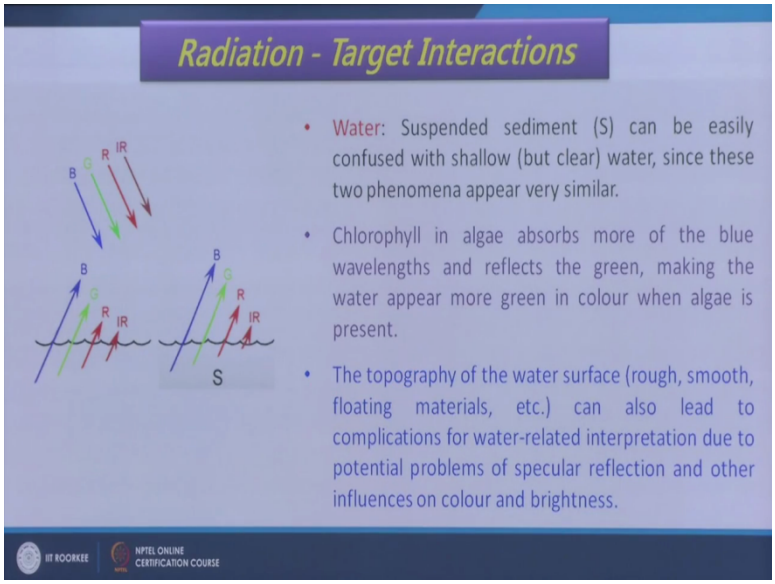

As I have already mentioned that suspended sediments which shown here which can be easily confused with the shallow but clear water but these two phenomena appear very similar that means that if water conditions are very shallow then the bottom of say there is a lake it is very shallow then there the bottom of the lake will also reflect. So, one should not get confused with that kind of thing. Shallow the less column of water may also reflect whereas the same time the suspended particles can also reflect. So, one has to ground check whether this is because of the

suspended particles or shallowness of a lake or a water body.

And in normal condition one may find the algae and other things which are present in the water which will again because algae might be having chlorophyll so, chlorophyll in algae absorbs more blue wavelengths and reflect green making the water appear more green in color when algae is present. And this type of growth of algae is specially in sea water and detection of this algae is used to find certain type of fish which may preferred that kind of algae.

So, this is how remote sensing can be implied to find a certain type growth of algae and then associated fish might be there and sometimes the undulations or ruggedness or topography of the water surface that is if it is not standstill water or rough or depending on the rough or smooth or floating material etc can also lead to complication for water reflected interpretation do potential problem of specular reflection and other influences on the color and brightness.

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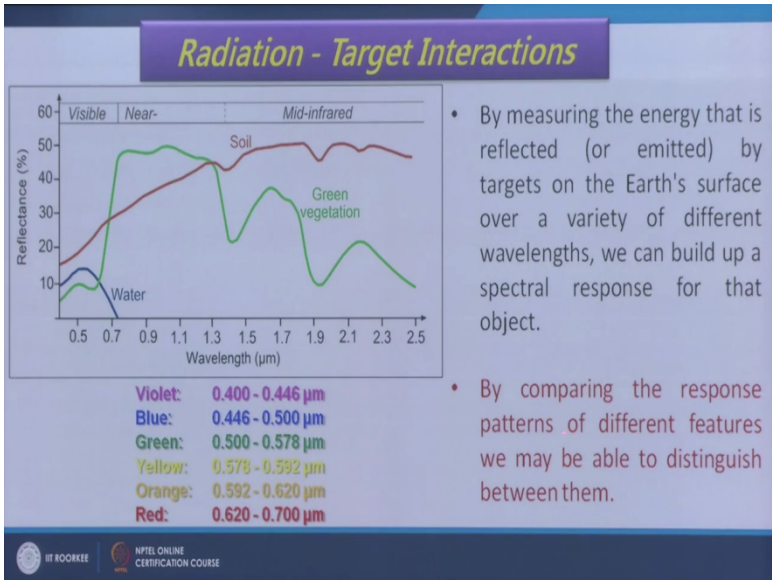

This curve spectral curves of three main very standard curve which we have seen already in a small portion that generally water will reflect only in the shorter wavelength near 0.4 to 2.7, 0.1 or 2 and then it is completely absorbed. So, only in the first part of visible part of EM spectrum and maximum you would see around blue that is why pure water in color composite may appear as blue. Whereas bare soil it increases very smoothly and in mid infrared reaches to the maximum and therefore you don't see much reflection of bare soil in early part of EM spectrum

specially visible near infrared.

Whereas the vegetation is having altogether different there is a absorption of vegetation but starting from 0.7 to about 1.2 or 1.3 it is having maximum peak. Where you get the maximum reflection by healthy vegetation green vegetation and if there is a vegetation not healthy then there might be a shift curve in a and curve may shift towards the left so, we also use this to find out whether vegetation is healthy, enjoying good health chlorophyll content is normal or abnormal if there is not high reflection which one is getting near infrared.

So by measuring the energy that is reflected or emitted by the target on the earth surface over variety of different wavelengths we can build up a spectral response for that object. These are the standard generalize spectral curves of three different types of earth objects which you are seeing here. By comparing these response pattern of different features like here soil vegetation in water we may to distinguish between them. As you can see that all three different objects are showing completely different signatures or curves or behavior in this part of EM spectrum specially in visible near infrared and mid infrared.

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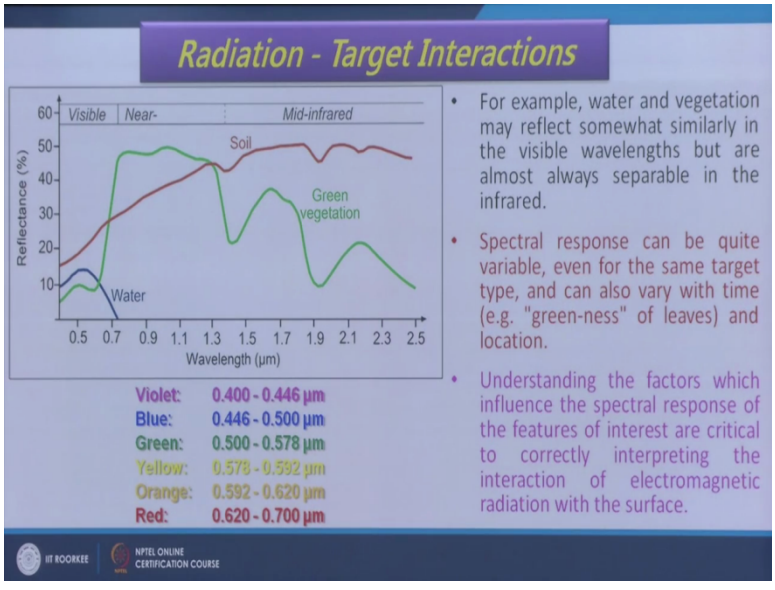

As we have seen like water and vegetation may reflect somewhat similarly in visible wavelength but are almost always separable in infrared so, in particle channel or band you may not differentiate certain objects, two objects but if you start looking the different channels you will

find a completely different signatures or there pixel values completely different in different channels. Spectral response can be quite where even vary on same target type and can also vary with the time especially talking abortions the vegetation so, the same vegetation may reflect differently in different season of a year.

So, understanding of these factors which influence the spectral response or features or interest are critical and they makes once we start understanding these spectral curves of different features especially in mineral exploitation or in other mapping then we can make our interpretation much more reliable.

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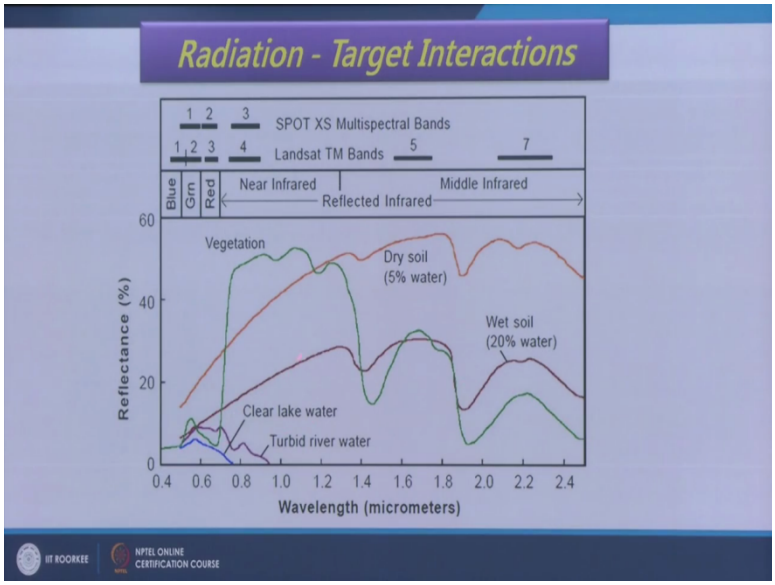

Here few more curves have been also added and then corresponding bands or channels of different few satellites are also shown mainly spot and land set. So, let me go one by one. When you are having clear water lake... lake water which is standstill. Clear means you don't have the suspended particles you may not be having any algae or any chlorophyll content then the maximum reflection will come around 0.6 micrometer and then there is a total absorption in beyond this range. Whereas if water is turbid that means there is (())(19:55) there are suspended particles are present then the reflection may continue even up to 2.9 or very close to 1 even in near infrared part.

Similarly in case of wet soil or dry soil this behavior of this soil depending on the content of

water they may show completely different reflection curves. As we can see here that initially they are showing like dry soil will always have more reflection as compared to wet and there are some portions where you are having maximum difference. So, two examples are shown 5% water dry soil and which is be consider 20% wet is and as soon as soil becomes wet it is showing a less reflection in almost between 0.4 to 2.4 micrometer.

Throughout this visible infrared and mid infrared vision whereas vegetation if it is healthy vegetation it will show very high reflection between 0.7 to 1.1 or 1.2 micrometer and in between also there are some other peaks are there but otherwise this is the standard one. So, initially Landsat 1 was design we also call ERTS and the sensors MSS at that time these bands were did bands had the same width in the continuous fashion. So, like 0.4 to 0.5, 0.5 to 0.6 likewise but later on it was realized that such approach is not good and therefore wherever for whichever phenomena which we were looking to discriminate or the objects which we wanted to discriminate very easily so, then these bands and there width were changed.

Like in case of land set TM bands as you can see that the land set 1 and 2 are in the blue and green part, 3 is in the red part then 4 is having much more larger width as compared to 3 and 3 is having very thin band compared to 1, 2 or 4 and then because of in between nothing was kept because if 1 is looking the vegetation then the band 4 is the best in that sense. If 1 is looking for water bodies and other things then 1 and 2 or even 3 upto 3 are good.

So, then the large gap in EM spectrum was left and then the 5^{th} one was kept here to see the differentiation and specially another peak of vegetation and then again the band 7 was kept here to catch the peak of wet soil dry soil as well as the vegetation. But in between 5 and 7 the large gap was left. Band 6 which is missing here falls in the thermal infrared part that is why it is not shown here. Whereas in case of spot which was a satellite multi spectral bands which are quite similar to the land set TM bands but there is some shifting of band 1 instead of starting from 0.4 or 0.45 it really started at 5.5 to 0.6 and very small gap between band 1 and 2 but there is some gap between band 2 and 3.

So, later on people realized that based on these spectral curves instead of having continuous bands and having uniform thickness bands it is better to have bands based on these spectral curves where we can discriminate or record these different objects which are present on the earth

in a different way rather than having uniform slicing and same size or location or continuous slicing. So, that was a intelligent move later on once people realize through the experience of land set MSS.

So, this brings to the end of this particular topic about the how this solar radiation and tracks in different parts of EM spectrum with different objects which are present on the surface of the earth. We mainly focused on the water bodies bare soils and vegetation and how this absorption phenomena and atmospheric windows which are available and how different satellites and their sensors have been designed and kept at different locations so we can capture all the important features or objects which are present on the surface of the earth. Thank you very much.