Laboratory Practices in Earth Sciences: Landscape Mapping
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So, welcome back to the last lecture we were talking about. So, here we have a few more slides on radiation and the terminologies which have been used. So, several terminologies are used for electromagnetic radiation. So, radiated energy is given in joules radiated flux or the power is the radiated energy per second that is in watt. Spectral radiation is equal to the radiated radiant energy per unit per unit time, that is the energy area per second. Black body radiation as we have already discussed is your Stefan Boltzmann law.

So further all matters above absolute 0-degree Kelvin and that is the temperature which is minus 273 degrees centigrade and emits radiation continuously. So, in the cooler regions we will have if the absolute value is less than like or above 0 degrees Kelvin then we will have continuous reflection. Whereas, further the emitted radiation from any object will depend upon the composition and the temperature of the object. For example, black body is the one that absorbs all radiation incident on it without any reflection.

So, it is a complete absorption you will see if you are having a black body. Further the atmospheric scattering occurs because of diffusion or diffuse multiple reflections of the electromagnetic radiation and what we have partially discussed is that if you are having the suspended particles in the atmosphere it will diffuse. And there are two types of basic scattering which will occur in what we call the atmospheric scattering. One is the non-selective scattering and another is the selective scattering. So, in non-selective scattering all wavelengths are equally scattered, that is the radiation which is coming in with different wavelengths.

For example, then all are equally scattered and it is caused by dust, cloud and fog. And that is one of the reasons that we get or we see the image appears white. So, as all visible wavelengths are equally scattered, clouds and fog appear white. So, this point you can keep in mind when we are talking about the interpretation and this is the kind of non-selective scattering. Amongst the selective scattering the most common is the Rayleigh scattering also called molecular scattering which occurs due to interaction of the radiation with mainly gas molecules and tiny particles.

Another type is your maze scattering which is a scattering caused by large size spherical particles. So, as we understand, the atmosphere will have suspended particles and gas molecules. So, depending on that we will see these two types of scatterings and one more is your maze scattering. So, electromagnetic radiation and the matter interaction if we take it further than the electromagnetic energy incident on the earth surface may be reflected, absorbed and or transmitted. So, for example, if you are having the energy which has been incident on the surface it may be reflected, absorbed or transmitted back into the atmosphere.

So, mostly what we are looking at is the reflected or we can say the transmitted energy. Even other than that the absorption is also important for the interpretation of the landforms and the landscape. So, basic law of conversion of energy if we take the energy balance can be written as E i lambda is equal to E r lambda plus E a lambda plus your E t lambda and where E i is the spectral incident energy and E r lambda E a lambda and E t lambda are the components of a reflected energy absorption and transmitted respectively. So, the reflectance of these components differs from different objects at different wavelengths and also depends upon the local relief. Local relief we are talking about the topography actually.

So, that will be another important point which you should keep in mind. So, this is what we call the mechanism of scattering in multiple directions if you are coming across uneven surfaces. So, common geometric configuration if you look at then what we see is that important part is again that at what angle your energy is been incident on a given surface. So, this is the reflection sensing. So, we have solar reflection sensing, SLR reflection sensing and LIDAR.

So, these are the three different reflection sensing one can have. Either you can measure it or record it by sensors or by SLR lens or maybe through LIDAR. Now fundamental principle of remote sensing: if you take the basic principle involved in the remote sensing method in a wide range of electromagnetic spectrum with different wavelengths, different types of objects reflect or emit a certain intensity of light. Now as we have also discussed before, this, like what we are talking about the reflections or the emission, will depend upon the physical composition, that is the physical nature of the object composition, surface texture, color, moisture content etcetera. So, for example, here this is a typical spectral reflectance curve of different material here or you can say the like for example, the vegetation how you will see about the dry soil and if you are having limonites.

So, the spectral curve showing the intensity of light emitted or reflected by the object at different wavelengths is called the spectral response curve. So, what we see here is the spectral response curve. So, further if you look at this is what you can observe when you are having the different material like for example, you are having water. So, mostly in this water you are having in this wavelength you will see mostly the water is not having any sort of and mostly it is absorption is taking place reflection is not much here. But in case of like if you are getting into the near infrared domain then you see the vegetation what you are having.

So, vegetation is having good reflection. Whereas, in the visible light spectrum you will have mostly the absorption of the vegetation and similarly of the soil you are having and good reflection comparatively if you are comparing the visible and near infrared zone then you are having good reflection here. Whereas, soil is giving good until or in intermediate infrared also and then further it shows an absorption. So, these are the reflectance spectral response curves of different material or objects that you see on the land sets. Now, if you look in nature, usually what we see is different types of minerals.

Rock forming minerals are, we say , more than 70 percent of earth's crust is made up of elements of oxygen and silicon. So, in order of abundance if we take because whatever the reflections we are getting from the surface this surface of the earth is composed of the material which is derived from different rocks. That means, this constitutes or comprises different minerals. So, in order to understand mostly as the first bullet says that 70 percent of the earth crust is made up of oxygen elements like oxygen and silicon. And in terms of the abundance if we take then silicates are the most abundant rock forming minerals followed by oxide carbonates, phosphate sulfates etcetera.

And all these minerals have different reflectance and that is what we will see after 2-3 slides. So, now if you look at the silicate minerals the silicate minerals then we are having which comprises say O4s and their minerals are mainly feldspar, pyroxene, amphibole, all been garnet, quartz, clay, mica etcetera. Quartz is most abundant in this and then we are having non-silicate minerals which are oxides, sulfides, carbonates, sulfate, gypsum. We are having examples of sulfate and phosphates that we are having an appetite for. And this is what we are having the silicate structures of different minerals.

Now the shape of the minerals or the crystal form is also important when we are talking about the reflections and all that and of course, the color also. So, we will see in a few slides what we are looking at. So, for example, this one spectral curve depends upon the composition crystal shape. What we were looking at here in the previous slide here is that this is the crystal shape of that of different minerals. And we are having here also, for example, the different minerals are having different crystal forms.

So, depending on that crystal from internal atomic structures you will see a different spectrum. So, here what is the emission in terms of the reflection and then you are having on the y axis the wavelength. So, most of the minerals here you see in there show absorption in this band that is between 8 and you can say 12 micrometer you see mostly the absorption. So, for different other minerals what we are talking about is the carbonates and non-silicate minerals mainly. So, carbonate shows prominent absorption at 7 micrometer sulfates displace bands near 9 and 16 and phosphates like 9.

25 and 10.3 and oxides occupy the same range as that of SiO 8 to 12. So, if you look at nitrates having 7.2 and the nitrites having 7.2 and the nitrates at 8 and 11.8 micrometers. So, this is what you can see that you are having carbonates you are having the the absorption is at 7 micrometers then the nitrite you are having it to 11.8 and so on. So, these are the different values which can be used to identify different minerals from the spectral data. So, laboratory reflectance spectra of selected rocks have been shown here, that is your igneous metamorphic and sedimentary rocks. So, that is how we will look at the spectral curves of different rocks and different types of rocks.

Now, the major region of the electromagnetic spectrum if we take the most we are using the visible every region and that is your wavelength ranging from 0.4 to 0.7 micrometer and this is available for remote sensing the earth can be imaged with photographic film and so on. It has been given for other regions also like infrared reflected infrared thermal and microwaves and all that. So, for example, if you are having a wavelength greater than 100 centimeters not normally used for remote sensing, but this has been used for the radio here.

So, different colors if you take them because these are what we call the multispectral data. So, it is a set of multispectral images in green, red and near infrared bands. So, you are having different bands here and you can have not only just 3, but you can have more bands, but mostly you can classify in this. So, the bands are of the same area which you have shown here indicates that various features may appear differently in different spectral bands. So, in short what we can infer here is that not all bands will show you the prominent landforms.

So, you need to identify that and based on your interest and requirement what type of landforms you want to extract from this multispectral data depending on that you can select your bands. So, if you look at that in the third field here this is what we are having in the near infrared: the channels or the river streams are seen prominent whereas, in these two the red and green you are unable to see that very clearly. So, this is how this data is been used and the information using this information from one or more wavelength ranges it may be possible to differentiate between different type of objects example dry soil, wet soil, vegetation etcetera and based on the requirement the maps can be prepared and you can have a detailed geomorphic map based on that. And mostly what we are going to do is to look at what has been done is that we use these bands that are your red, green and blue and try to generate different false colors composite to enhance or you can say to bring out the prominence of the landforms or depending on that which are of our interest. But generally, if we look at what is composed of three colors that is what we have the primary additives.

Colors are red, green, blue; these cannot be created by adding other colors together, that is, these are termed as additive colors; the others are subtractive color models that are magenta, cyan and yellow. So, adding all three primary additive colors of light produces a color white. So, this is again useful when we are combining different bands here. So, coming to the black and white usually in normal language we talk about the black and white image and all that. So, photographic films are usually the panchromatic films versus visible radiation. Let us see what exactly we can learn out of this.

So, photographic film is sensitive to visible radiation and also to the radiation of longer and shorter wavelengths than visible light. That is, we are looking at 0.4 to 0.7 micrometers of range. The best used film to get the black and white photographs with greater detail of the terrain are the panchromatic films.

So, these are the usually we are using the panchromatic data for identifying or differentiating different landforms and all that. So, photographic film is sensitive to light of all colors including red. So, they are they are they are in particular they are very sensitive in terms of recording your reflections. So, panchromatic refers to black and white imagery or photographs exposed by all visible light. So, the visible light spectrum is what we are talking about.

So, we talked about the atmospheric transmission or atmospheric window and here what we are looking at is the visible spectrum is mainly the 0.4 to 0.7. And for conventional aerial photography we are using this range of the wavelength. So, this is what we are having is that again the ultraviolet, blue, green, red and infrared.

And so, human eyes are only sensitive to a particular type of electromagnetic radiation known as your visible radiation that we all understand or light. However, it comprises light with different colors or bands of different wavelengths. When passed through a prism it gives a visible light spectrum.

So, the wavelength ranging from 0.4 to 0.5 micron appears blue, 0.5 to 0.6 green, 0.6 to 7 red and radiation with shorter wavelength then 4 is ultraviolet whereas, with longer wavelength greater than 0.

7 micron is your infrared. So, in terms of the electromagnetic radiation which is inversely proportional to the wavelength, the red light with the longest wavelength has the lowest energy. So, in terms of the energy it is, it is low. So, different between the panchromatic and normal film if you take. So, on the left-hand side you are having ordinary film whereas,

on the right-hand side it is panchromatic from the panchromatic film it is when the photograph has been printed from the panchromatic data. So, you can easily make out what is the difference here and as we are talking about that the panchromatic image or the films are very or sensitive to all like the range of the visible spectrum and that gives a very good detail identifying different colors.

So, here if we take that the red in ordinary film appears dark, but in panchromatic data it is not, it is slightly different. Navy blue here is giving a lighter color, but it gives a darker color here in the panchromatic data. So, ordinary film is mainly sensitive to violet and blue light only, very slightly sensitive to yellow and green and not at all sensitive to red that what you can see here. It is not at all sensitive to red here, but this is sensitive hence giving a different tone tonal variation here. Further, there is a picture taken with ordinary film, violet and blue are only reflected color lights.

Whereas, other colors may no longer be reflected in color lights. Whereas, other colors may not make any impressions and therefore, shows black on the screen and that is what we see here that it is showing black here mostly because they are not sensitive at all. The result with the pan is very different. A picture with a panchromatic film you get correct color values in varying shades of gray because the pan is sensitive to all colors, not only to the violet and blue as we have seen in normal ordinary film. So, this is the range which has been given about the sensitivity, the range of panchromatic film is all spectrum you are talking about the visible light whereas, the ordinary film will be sensitive to only these three colors.

So, pan data is usually seen in one of the two formats, one is your aerial photographs or you can say high resolution digital satellite imagery that also is done and mostly we see in black and white aerial photos and often used in the stereo vision capability for geological and topographic mapping. So, images with the pan data will be quite clear as well as it will have a good amount of the reflections as they are sensitive to all colors. So, because of the development in photo interpretation techniques, since the increase of photo geology, a wide range of electromagnetic spectrum was used to procure the satellite data, new scanners or sensors were used of which the MSS multi spectral scanner was used extensively. An earth resource technology satellite ERTS later named Landsat was launched in 1972 to get better results and this is what the MSS multi spectral scanner was used for. And this is what we have tried to build a sort of history of how everything evolved and when the different satellites were launched.

So, I will just browse through this, but I would like you to just keep in mind that this is the MSS multi spectral scanner which was launched. So, I will just browse through this, but I would like you to just keep in like go through this that will help you and in some other way. So, this is the timeline of the artificial satellites and space probes which were launched. So, on the left hand side you start with your year origin name status that indicates whether it was successful or failed and description. So, it started in 1957 USSR Sputnik, the first satellite in space and so on and then what we see is the USSR USA and all that.

So, mostly you see that it started with the USA and then the USSR and then Italy France Canada they started putting in their satellites in space. And that is how the first satellite by India was Ari, but. So, I am just moving scrolling down this slide, but you will get this. So, you just can go through it and you know that recently also many satellites have been launched by the Indian space center. So, you have like the multi spectral scanner if you talk about.

So, is a scanning device which has capability to scan the terrain to produce different synchronous images each at different wave bands. So, different wave bands have different wavelengths and these are what we have. So, band numbers we can say and the wavelength range and what is the application purpose we can use in different ones. So, for example, for topography features and vegetative cover you can have 0.

6 to 0.7 range of the wavelength and 0.5 to 0.6 excellent for identification of different depth or turbidity of the water around the coastal regions. And this one 0.7 to 0.8 and that falls in band 6.

So, here different bands have been given a number. So, this gives good tonal variation used for land use pattern drainage study soil geology etcetera. Band 7 0.9 to 1.1 microns you have good form from differentiating land and water best for hydrological studies. So, with this I will stop here and we can continue further with other applications in the next lecture. So, for now, thank you so much. Thank you.