2Introduction to Atmosphere and Space Science
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Lecture – 09
Coupling of Solar Radiation with the Earth's Atmosphere

Hello. So, dear students, so far we have understood various aspects of Earth's atmosphere, various layers in the Earth's atmosphere, what is the reason for the existence of these different layers in the Earth's atmosphere, what is the primary chemical composition in each of these layers, how does it differ and how does this chemical composition decide the observed variation of temperature with respect to height in these layers things like that?

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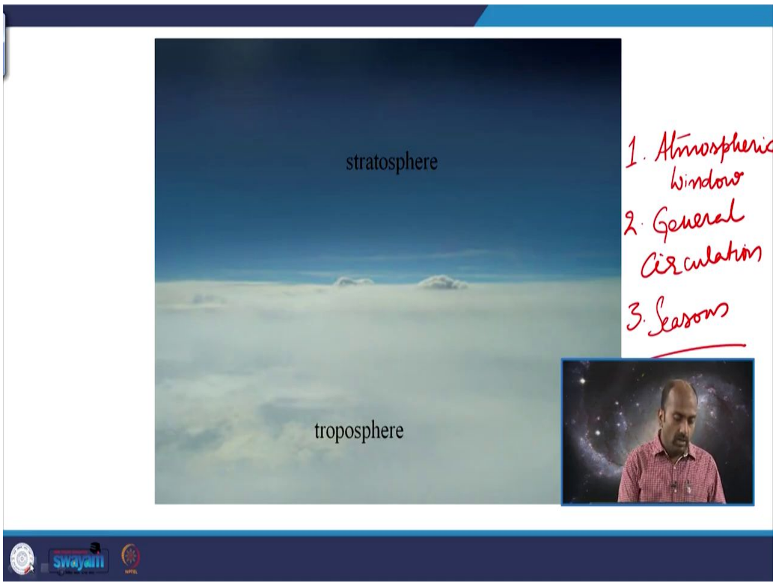

So, this is this picture just represents troposphere and stratosphere. So, from this picture you can see that all the weather or all the weather phenomena generally take place in the troposphere and only at times there may be some weather activity in the stratosphere ok.

So, today in continuation with the last class discussion which was about greenhouse gases and how is greenhouse effect demonstrated in the Earth's atmosphere or in general how the atmospheric greenhouse gas effect is different from a greenhouse which is used to use it for the planets or things like that ok. So, in continuation to that discussion what we will do is today we will try to understand what is what are the atmospheric windows. What are the atmospheric windows in terms of this window is in terms of radiation let us say?

Then, after the atmospheric window discussion we will try to understand what is the general circulation of atmosphere general. Why does this circulation come into picture because we have a fluid system which is bound to the gravity of the Earth and this fluid system has the natural tendency to travel or to between to flow from one point to other point that will that will lead to the idea of circulation. We will try to see how the basic or the very fundamental aspects of general circulation of the Earth's atmosphere ok.

So, then we will try to see how the seasons or these things will are coming into picture for the Earth ok. Now, so, like you see in the in the big picture is that the Earth's atmosphere spans over several hundreds of kilometers and 99.9 percent of the Earths atmospheric gas or by weight exists below 50 kilometer limit ok.

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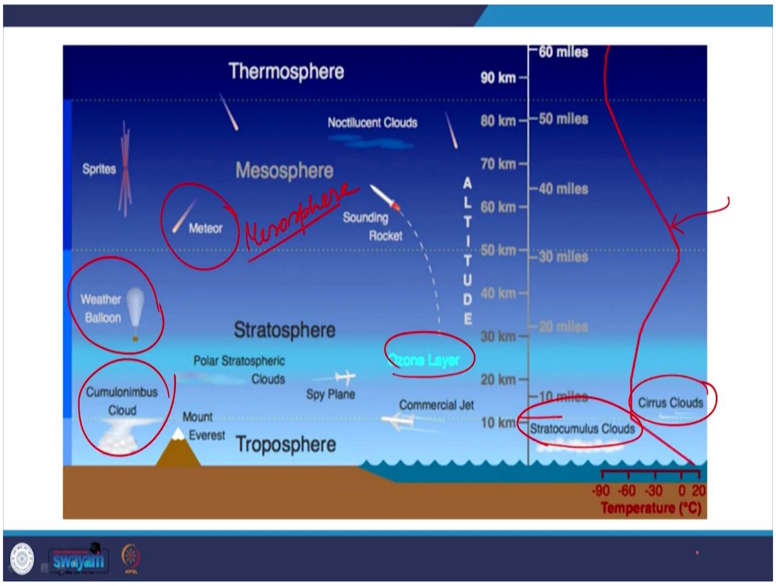

So, this picture shows many important things like many important systems like or many important aspects of Earth's atmosphere. So, what you see is, what we have discussed in detail is about this temperature variation right, we have discussed this.

So, now in this figure what you see? You see several different types of clouds – stratocumulus, cirrus clouds, cumulonimbus clouds. So, these are different types of clouds and they generally develop at different altitudes in the atmosphere and different set of physical processes are responsible for their formation. And, at the same time each of this cloud is different in terms of it is the amount of moisture that it contains or the amount of precipitation that it can bring in let us say.

So, because we will try to discuss several important aspects about the Earth's atmosphere in the entire course it is important that where do these different aspect aspects are formed I mean in this big picture ok. So, what you see is the commercial jets that you know generally they fly at an altitude of 10 kilometers and let us say. So, the ozone layer is between 30 to 50 or yeah 50 kilometers. So, these are the very important terms that all of us must have heard about.

And, let us say the incoming meteors we have already seen that the meteor ablation happens in the mesosphere. So, this is the mesosphere. So, whatever it be the existing density in the atmosphere atmospheric altitudes there is still enough for burning a meteor and weather balloons. So, these balloons are the ones by which measurements are carried out.

So, different types of measurements are carried out, I mean different using different methods and different equipment or different devices ok. So, because we know it for a fact I mean we know the right now we know how does the atmospheric constituent vary with respect to height, but at any given point of time different types of experiments can be revised to understand or to quantify several physical parameters in the Earth's atmosphere ok. So, this is a big this is the big picture where you see so many other things apart from the things that we have discussed ok.

Now, we talk about what is called as the atmospheric radiation right now. So, yesterday we have seen that at the it is mainly the infrared radiation which is trying to escape the Earth's atmosphere and which is originating the Earth the solid Earth is being trapped by the carbon dioxide and other greenhouse gases as a result we see that the temperature of the atmosphere, temperature of the planet Earth is significantly larger than what it should have been.

But, we have also learned that with the increase in the concentration of greenhouse gases the greenhouse gases are generally quantified in ppm, parts per million; with the increase in these gas concentrations the amount of heat that is to be trapped which was otherwise being escaped in to the space the amount of heat that is being trapped is increased and as a result we see that more the we see that the average temperature is going up and we call this as a global warming right.

Now, we will in this slides what we will do is, we will try to see what are the different windows in which we can see the atmosphere or what are the windows in which the atmosphere becomes transparent, what are the windows by which we can also probe the atmosphere things like that ok. So, radiation is generally what we have defined in our earlier classes also is that, is the mode of energy transfer. So, radiation is nothing, but the way in which energy transferred is taking place from one point to another point. So, energy transfer.

So, and we have also seen in the very first few lectures that the radiation is the most effective in vacuum, in the absence of any medium right.

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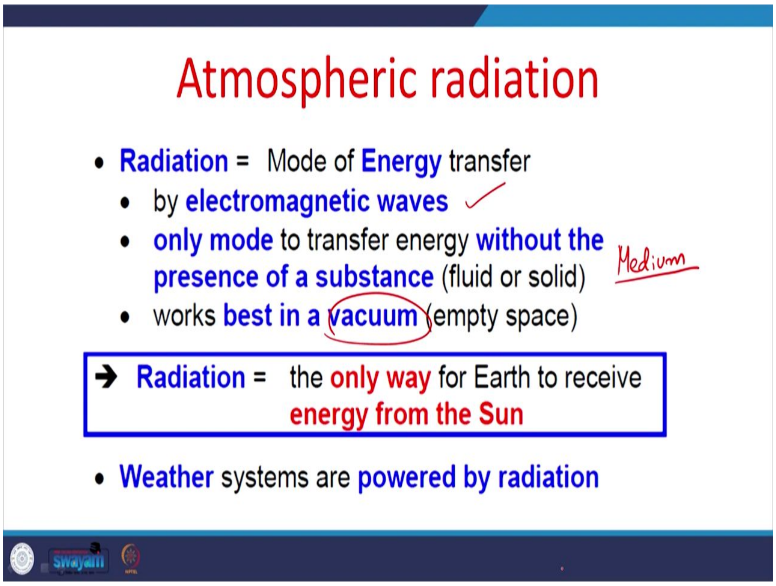

And, the energy transfer is achieved by electromagnetic waves; electromagnetic waves are the ones which will carry the energy from one point to another point. And, it is the only mode of transfer energy without the presence of a substance, without the presence of any material or any or in general without the presence of any medium; that means, even in absolute vacuum this means of energy transfer is achievable and works better or I mean the best in vacuum empty space ok.

So, we can say that the radiation, but most importantly the radiation is the only way in which the Earth receives the energy from the sun, there is no other way that we can receive the energy from the sun ok. And, by far all the weather systems all the everything that happens in the atmosphere, everything that happens in this get gas blanket is powered by radiation. So, this incoming radiation or 1300 watts 1340 watts of power that we get per unit area from the sun is what drives the entire atmosphere. It drives the weather systems; it drives every other thing. So, this is this is the basic aspect ok.

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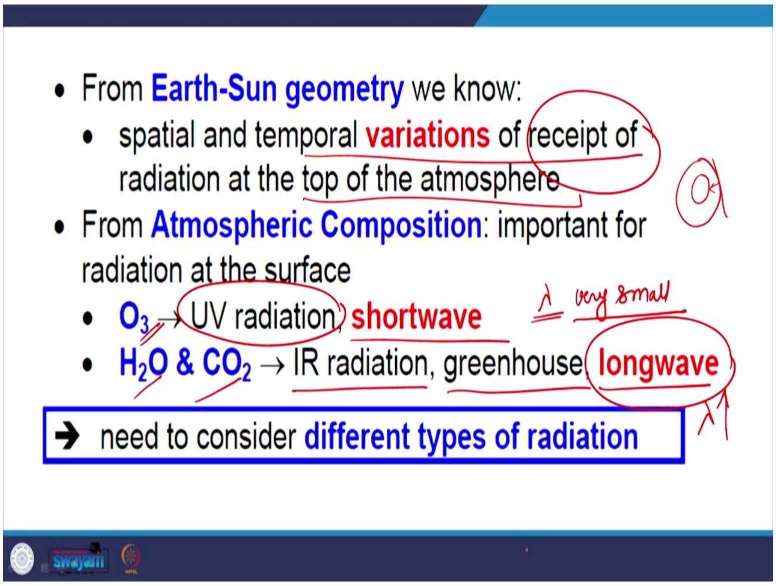

Now, what we know is that from the sun and Earth geometry we know that there are spatial and temporal variations of always there are spatial and temporal variations; that means, depending on the position of Earth with respect to the sun. Sun is rotating there is a different thing, but with respect to Sun treating Sun as a stationary object we treat Earth to be revolving around the sun and this revolution takes generally one year for the completion right.

Now, so, depending on the position of Earth at different times so, we have variation in the position and variation in the time in the temporal domain. So, depending on spatial and temporal the positions it is always possible that Earth receives different amounts of energy at different points in space and time ok. So, that means, that the received of energy is different at different times. So, at the top of atmosphere so, we always take it at the top of atmosphere so, we take that the Earth is receiving energy at the top of atmosphere and this energy travels down towards the Earth's surface and it creates all the effects. It creates ionosphere, it creates it creates several ions or electrons things like that.

And, we know that from the atmospheric composition itself; from the basic atmospheric composition itself, it is very important to study the amount of radiation at the surface ok. Now, what you see; what we have seen is that ozone, O3 molecule is requires the ultraviolet radiation; the ultraviolet radiation is short wave. Why it is shortwave because the lambda is very small; the ultraviolet radiation's lambda is very very small. The other molecules let us say water vapor and carbon dioxide; these molecules, they generally are they generally are excited by the infrared radiation.

So, what the most important thing is ultraviolet radiation dissociates ozone that is what we have seen and infrared radiation. So, these two molecules have the vibrational bands in the infrared spectrum. So, since infrared spectrum has long longer wavelengths, I mean several orders of let us say up to meters. So, we call this as long wave radiation. So, these now the radiation is now categorized in two basic categories such as short wave and long wave; long wave radiation are of importance for water vapor or water molecule and carbon dioxide molecule.

So, now, we need to consider different types of radiation. So, let us see how many different types of radiation can we get from the standard solar spectrum ok.

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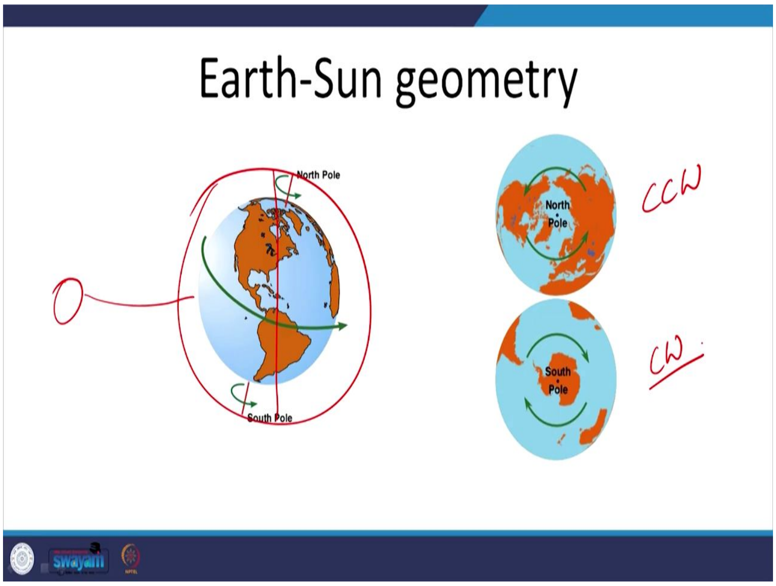

Now, you see Earth-Sun geometry if you see how the Earth is aligned or kept in position with respect to the sun we know that sun is holding Earth by gravity and is it is like, it is revolving around itself and it is also revolving around the sun. Now, you have an axial tilt I mean the north south axis is not, but completely perpendicular to the sun. So, it is it has an axial tilt ok. In addition to that let us say you have Sun here unequal areas of surface receives equal amounts of energy ok.

So, any given point now you break it to the point any given point on the Earth receives different amounts of energy as a function of time ok. Now, the Earth is revolving around itself from west to east right. So, as a result what you see is if you are standing on the north pole you will see that the Earth is revolving in counterclockwise direction and if you are standing on the south pole, you will see that the Earth is revolving around itself in the clockwise direction. These things are will be essential for understanding how the seasons come into picture things like that ok.

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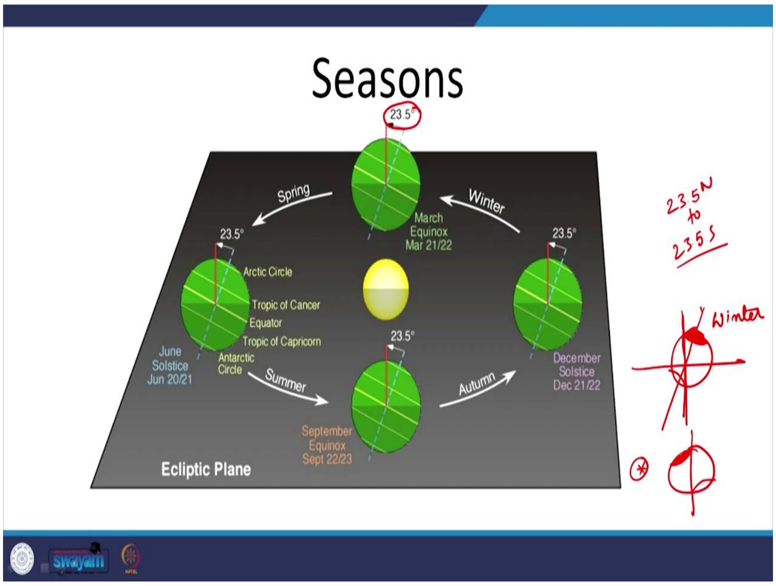

Now, you see seasons; I mean if you imagine an ecliptic orbit what you will realize is that, this axial tilt that I was telling is about 23.5 degrees ok. So, that is why you have the tropics between plus 23.5 and minus 23.5 or 23.5 north to 23.5 south ok.

Now, so, as the Earth revolves around the sun, we have different seasons. Let us say we have seasons in terms of spring, winter, summer and autumn and there are times in which the Earth is in such a position that the amount of the duration of day and the duration of night are exactly equal there are some times like that. And, those times are generally called as the equinoxes equinoctial times now.

So, it is basically the different the rotation of the Earth combined with the axial tilt gives you the seasons. What happens is, so, if you put the; if you imagine the Earth which is kind of say, this is the pole the circle. So, this is the north south axis and this is the perpendicular axis with respect to the ecliptic plane. You will you will realize that at some points in the time this then entire north pole will be in a position and it as if it is facing away this away from the sun.

So, this period of time is winter and when it is exactly in the opposite direction due to the axial tilt you will see you will see the Earth to be in this way where if this is the position of the sun this is the summer for the north pole. So, due to this combined relation we can say that seasons do originate for the different positions on the sun on the Earth.

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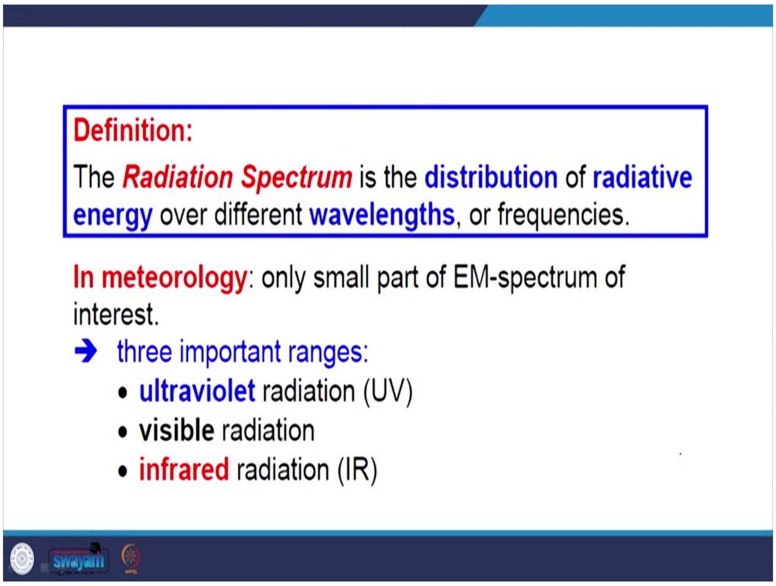

Now, in let us say the basic definition of radiation; the radiation spectrum is the distribution of radiative energy over different wavelengths or over the complete wave length spectrum or frequencies. In meteorology, you know or in the atmospheric or in this area of study not the entire part of the electromagnetic spectrum is of interest. It is only a small part of it is of is of interest for us ok.

Now, there are three important ranges in this electromagnetic spectrum – one the ultraviolet radiation; that means, the lowest wavelength part; the visible radiation let us say 3500 to 7000 nanometers 7000 angstroms and the infrared radiation which is the highest wavelength part.

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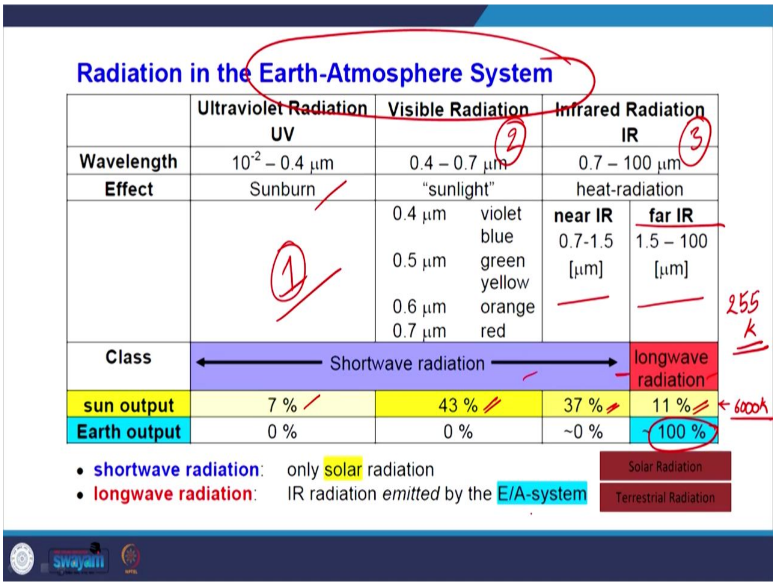

Now, if you see the radiation in the Earth atmospheric system let us say you have ultra violet radiation, visible radiation, infrared radiation ok. Now, the wavelengths are typically for the ultraviolet radiation it is 10 to the power of minus 2 to 0.4 micrometers. So, this is the ultraviolet radiation, you have the extreme ultraviolet radiation this and you have also you also have the ultraviolet radiation which is going to be touching the boundary of the visible spectrum. Then you have the visible radiation which is 0.4 to 0.7 micrometers and the infrared radiation extends very far and the infrared radiation is 0.7 to 100 micrometers.

So, what is the physical effect that you see of this radiation? I mean, if you see the white light that is coming from the sun it contains almost it contains the entire, all the three different ranges of wavelengths in it and the effect that you see of this different parts of very radiation is the sunburn if you experience ultraviolet radiation which you may have never you will realize it is it will cause you sunburn.

Visible radiation is the sunlight that you see with your naked eye and visible radiation has again different colors which you know already. And, infrared radiation like I always say infrared radiation is the heat radiation, the feeling that you have that the hotness that you have is the; is basically caused by the infrared radiation. And, infrared radiation is again categorized into near infrared and far infrared. So, by all means these ranges are defined for the purposes of discussion in the Earths atmospheric system ok.

Now, if you categorize them into classes let us say the entire range up till 1.5 micrometers is the; is called as a shortwave radiation and long wave radiation is anything which is above 1.5 micrometers. So, this is shortwave radiation this is the longer radiation ok. Now, if you put the if you consider the entire energy that is emitted from the sun let us say you take entire solar spectrum, you integrate, then you will get what is the total energy and then you calculate percentages of these spectral windows let us say.

How many windows you have? We have three windows let us say the ultraviolet window is the one, the visible radiation window is the second one, and the third one is the infrared radiation. So, you calculate the weighted weights for these three windows in the entire solar spectrum you will realize that the ultraviolet radiation is nearly 7 percent of the entire energy that is emitted from the sun. And, the visible radiation is nearly 43 percent of the entire energy which is almost like 50 percent of the energy that is emitted from the sun or the yellow disk that you see is visible 50 percent of it is visible. And, the infrared radiation in the new is infrared is nearly 37 percent and in the far infrared it is 11 percent right.

And, now, what is important is let us say this is the sun output is taken at let us say 6000 Kelvin right 6000 Kelvin whatever that you get because in between you have vacuum cells, so, there is no there is no such thing as which can absorb the radiation and can attenuate the incoming radiation right. Now, like I say Earth is also it is also to be considered as a blackbody; blackbody as such it is a blackbody at let us say 255 Kelvin. So, if you take the Earth to be a blackbody the amount of radiation that comes out of Earth is entirely in the long wave radiation that is 100 percent in the long wave radiation that to in the in the far infrared spectrum; that means, what are the amount of radiation that Earth radiates is above 1.5 micrometers.

So, now, now you have defined two rare two types of radiation – one shortwave radiation and one long wave radiation. When it when you are talking about the sun both the windows what the limits are equally important – shortwave radiation is important and long wave radiation is also important. Shortwave radiation some of the shortwave radiation is absorbed in the atmosphere like ultraviolet for causing many chemical effects let us say and some of the radiation let us say the visible radiation which is nearly 43 percent it does not have does not contribute to any effects I mean this is not energetic so, it will not dissociate or ionize anything, it will be directly reaching the surface of the Earth.

And, the third part is the long wave radiation right. Now, when you take the same example for the Earth what will happen is Earth will completely radiate or give its energy only in the form of infrared radiation ok. So, this is the short wave and long wave radiation. So, solar radiation is shortwave radiation, incoming radiation; terrestrial radiation that is the radiation emitted by the Earth is completely long wave radiation.

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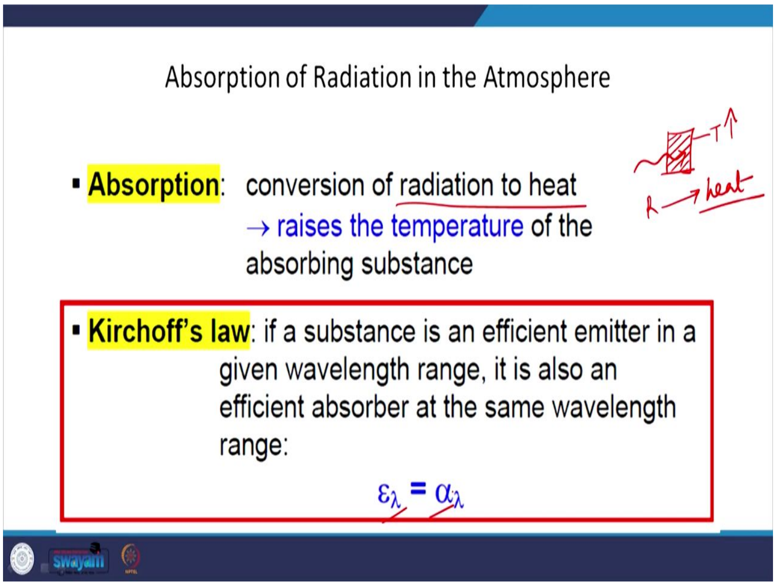

Now, absorption; how does this radiation gets absorbed? Absorption is basically the concept of conversion of radiation to heat when something when you keep some object in the place in the in the path of the radiation, this radiation will be absorbed by the by this object.

Now, what will be the effect of absorbing this radiation this object's temperature will go up ok. So, raise the temperature of the absorbing substance that is it this is the effect. So, what is happening? The energy transfer or energy conversion is from radiation; that means, there are two magnetic waves to heat right, this is the effect. Now, from the very known Kirchhoff law, we can say that if a substance is an efficient emitter in a given wavelength range. It is also an efficient absorber at the same wavelength range.

So, it is like the concept of blackbody. Blackbody radiates the entire spectrum all the wavelengths are emitted by the blackbody. If you heat it to a particular temperature and at the same time; if there if the blackbody is capable of emitting some radiation it is equally capable of absorbing the same radiation if it is incident on it ok. So, the absorption and emission will happen at the same wavelength range. If a body is capable of emitting certain m wavelength range it is also capable of absorbing the same wavelength.

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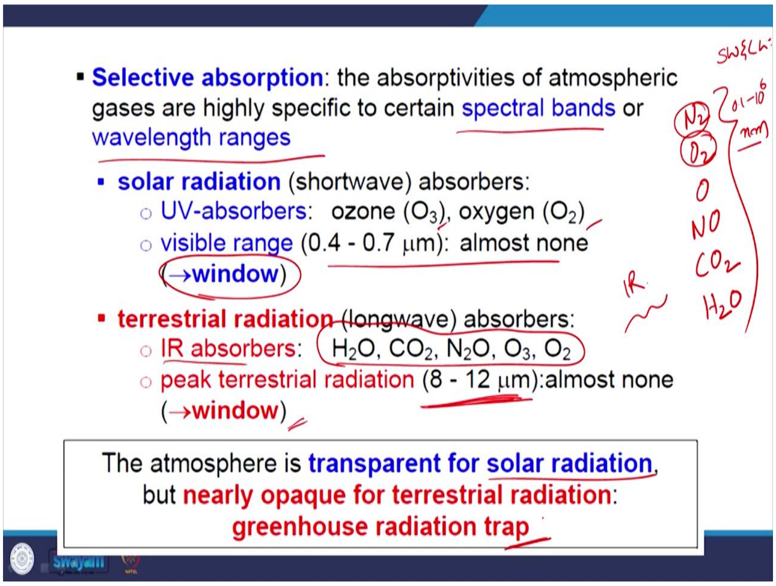

Now, we talk about what is called a little selective absorption. So, the absorptivity of atmospheric gases are highly specific to certain spectral bands or wavelength ranges; that means, you consider N2, you consider O2, you consider O, you consider nitric oxide, you consider CO2, you consider H2O; these are the different species which can which are present in the atmosphere. I mean to different concentrations of course.

But, if you allow radiation to fall on these gases so, the radiation has let us say a limit of 0.1 to 10 to the power of 6 nanometers; the incident radiation window is from 0.1 to 10 to power 6 nanometers. What selective absorption means is that each molecule or each species will absorb in a particular, very narrow wavelength range, this is called as the selective absorption ok.

Now, solar radiation; let us say, the Earth is emitting the infrared radiation into the atmosphere, the sun is emitting both the shortwave and longwave radiation into the atmosphere right. So, the both of them have effects; I mean the infrared radiation emitted from the Earth has some effects and the entire wavelength range that is emitted by the sun also has some effects.

So, solar radiation, shortwave radiation let us say UV absorbers are ozone and oxygen. So, ozone and oxygen have the ability to absorb UV a, UV b. Visible range nothing absorbs; so, that means, it is a window where visible radiation is not absorbed by any gas. So, why I mean it is a very spectroscope very easy is the answer because visible radiation does not have the amount of energy to excite electronic vibrational states right.

Now, terrestrial radiation the radiation that is emitted by the Earth is longwaves, long wave radiation. So, IR absorbers so, these molecules have the ability to absorb the infrared radiation. These molecules are generally called as the greenhouse gases. And, the peak terrestrial radiation that we have seen in the last slide 8 to 12 micrometers almost none; I mean this wavelength range is not absorbed by any gas and this is again a window. What I am a calling is a particular value of lambda a particular range of lambda for which the atmosphere is transparent.

So, if I shine visible radiation in the atmosphere nothing is absorbing literally the entire atmosphere is like it is like a transparent glass which is not absorbing anything totally and it is also the same thing for let us say this peak total radiation 8 to 12 micrometers is there is a wavelength range which is not absorbed by any greenhouse gasses the least ok. So, what you can say see is the atmosphere is transparent for solar radiation over a particular wavelength range. You call these wavelength ranges as windows ok.

Now, the atmosphere is transparent for solar radiation only over a particular wavelength range, but nearly opaque for terrestrial radiation, greenhouse gases radiation. So, this is what we have already talked about right. So, atmosphere is transparent for solar radiation, but it is nearly opaque for terrestrial radiation. So, longwave radiation is even though if it is trying to go away into the space, the atmosphere is a trap, the atmosphere is opaque. So, atmosphere will not allow it ok.

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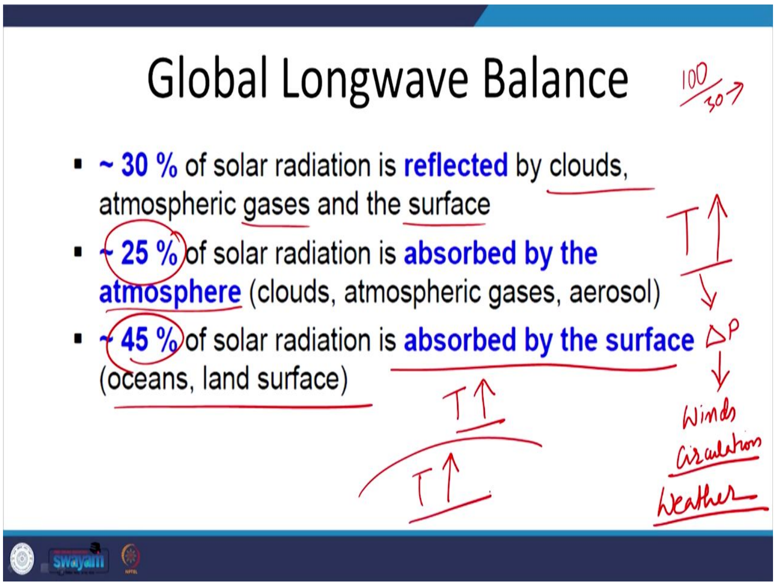

Now, if you see the global long wave balance how many how much amount of energy is emitted, how much is refracted, how much is transmitted things like that. So, what you see is thirty percent of the solar radiation is reflected by the clouds. We have already seen that clouds have a very high albedo and they reflect more; they reflect much radiation that falls on it. So, to put a number 30 percent of this solar radiation is reflected by clouds and atmospheric gases and the surface. So, if you have 100 photons coming onto the Earth, 30 of them are reflected by the clouds by the gases and by the surface.

25 percent of the solar radiation is absorbed by the atmosphere. So, see this; what is being absorbed so, naturally, if the radiation is absorbed by the atmosphere the atmospheric temperature will increase and this temperature increase will create a pressure gradient and this pressure gradient will create winds, patterns of winds and circulation and so many things. So, it is basically this temperature change that is that that is caused by absorbing radiation is what drives the weather. We already kind of seen this right.

Now, the remaining 45 percent of solar radiation is absorbed by the surface by the surface, oceans and the land surface; surface oceans or ocean cover, ice cover whatever it is. So, now, just look at it I mean what I really want to emphasize here is that so, off the radiation that is entering the that is incident on the top of the atmosphere 30 percent is lost then and there itself 25 percent of the 25 percent of solar radiation heats up the atmosphere; that means, it will increase the temperature of the atmosphere ok.

Now, the remaining 45 percent of the solar radiation is absorbed by the surface. So, surface also gets heated up right surface, anything that absorbs radiation will get heated up. So, surface temperature increase is caused by this 45 percent; atmospheric temperature increase is caused by this 25 percent as simple.

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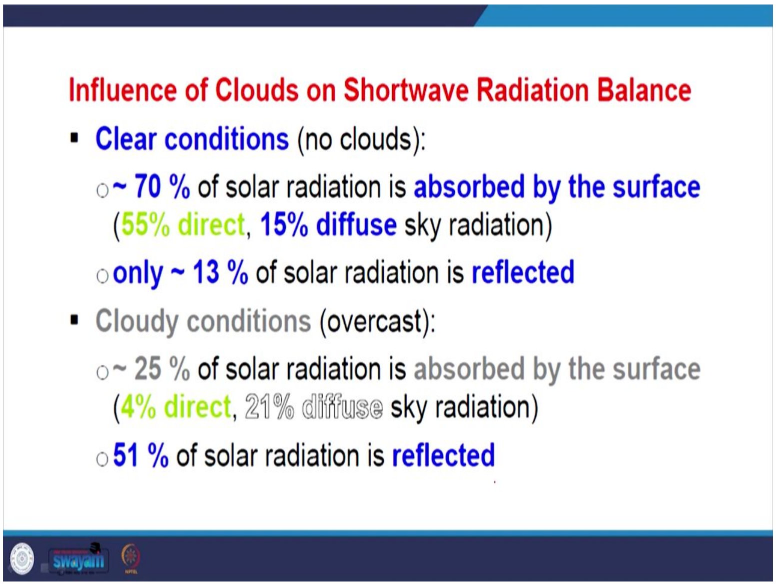

Now, there are several small systems in the global atmospheric system, let us say influence of clouds on shortwave radiation balance. Now, see I am saying that shortwave radiation is very important for atmosphere because it is what creates the electrons and ions ok. But, what happens is clouds on things like that will change this equilibrium let us say, if you have no clouds clear conditions if you have do not have any clouds of whatever the percentage that we have seen before 70 percent of the solar radiation is absorbed by the surface directly; 55 percent direct and 15 percent diffused by sky radiation if there are no clouds. So, whatever is coming is directly incident and only 13 percent of the solar radiation is reflected a very small percentage which is getting reflected.

And, if there are clouds if there is a over caste and 25 per; that means, that these percentages change 25 percent of solar radiation is absorbed by the surface because clouds are refracting much and of which 4 percent is direct and 20 of 21 percent diffuse sky radiation ok. Now, 51 percent of the solar radiation is getting reflected; now, this reflecting percentages these percentages are changing. Why because so, so the here you see that 13 percent of solar radiation is refraction and 51 percent of solar radiation is reflected.

So, this increase between 13 to 51 percent is only because of the clouds and the high albedo that the clouds possess or the cloud tops possess.

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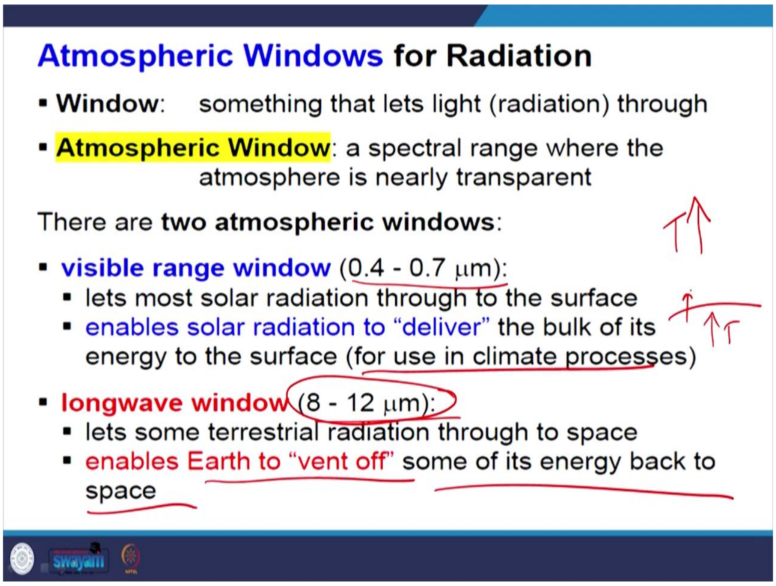

So, in let us say in totality what you can say is so, you define a window as something that let us light or the radiation to pass through just like windows what we have in our room. So, windows are the ones which will allow light to pass through into the room right. Atmospheric window is a spectral range where the atmosphere is nearly transparent that the atmosphere window is simply defined as a spectral range over which the atmospheric is nearly transparent. So, atmosphere is allowing the radiation to reach the surface ok.

There are two atmospheric windows; visible range window which lets most of the solar radiation to the surface at 43 percent. Enable solar radiation to deliver the bulk of its energy to the surface for use in climate processes yes. Then the long wave window is between 8 to 12 micrometers. Again, we have seen that the greenhouse gases also do not utilize this energy the 8 to 12 micrometers wavelength energy; that means, the gas is of course, the other gases do not have any business with the with this very low energy spectral band. And, this radiation passes right through the through the atmosphere and enables to Earth to vent off some of it is energy back to the space.

Now, had the greenhouse gases if they had the ability to take this energy also what would happen? The average temperature of the Earth will rise incredibly and had the let us say so, that is why so, this window the long wave window is helpful for losing some temperature some energy away from the Earth. So, what where do this radiation go? This is just simply escapes to the space. So, if you have a filter somewhere in the in the distant let us say galaxy and if you see Earth in this particular window you will see a very clear image because much of it is escaping the Earth right.

So, the terrestrial radiation has a window in this range and the visible range window is in this range. So, this allows the sun to deliver energy onto the surface which with this radiation heats up the surface and this radiation kind of allows the allows the surface to lose some temperature ok. So, these two windows are very important now. So, this was something about the atmospheric windows, what is the purpose of these windows, how do these windows contribute to the formation of weather or climate things like that ok.

Now, now we talk about another very important aspect of the atmosphere or we do not talk about it very in a very detailed way we will cover it or with everything with a small introduction ok.

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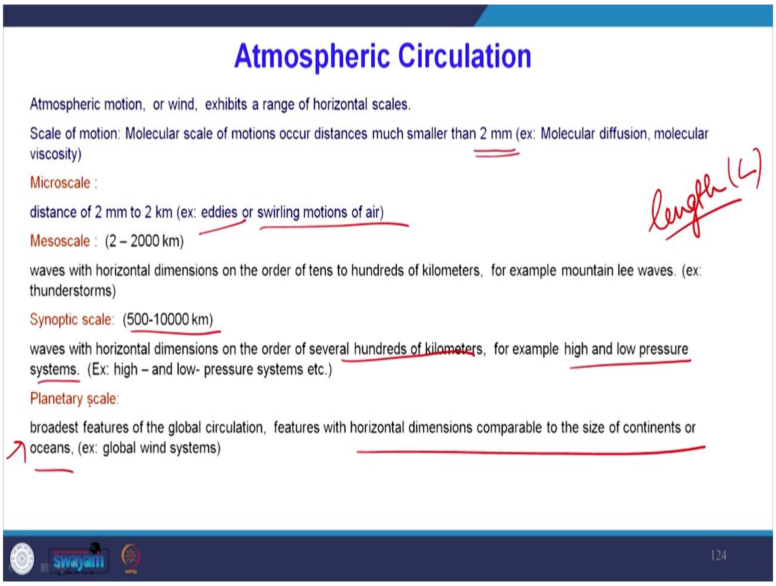

Now, we call it as atmospheric circulation. So, what is circulation? Circulation is it is just a cyclic process in which things will come back to its origin and it will go on again and again right.

Atmospheric motion or wind exhibits a range of horizontal scale. So, before we talk about circulation we talk about scales. So, what is a scale let us say? How do you define a scale? A scale of motion in this context let us say scale of motion. So, let us say if you consider a typical human being and if I ask you what is the mac what is the horizontal scale which a human being can cover in a particular day? You would say let us say a few kilometers let us at 20 kilometers – 30 kilometers.

So, the human being has the ability. So, this is the, it will not go beyond few kilometers few tens of kilometers. So, let us say if we extend this exam what you can realize is that molecular scale motions let us say if you consider gas and if you consider molecules in it to be moving from one point other point how much distance do you think they will move? How much distance they will travel? This is defined as the scale of a motion. So, it can be very large, it can be very small.

So, since the molecules are very small, but the typical scale of molecular motion will be much less than will never be greater than two millimeters.

So, all the molecular motions and all the mean free paths that you define are always below this two millimeter limit right. So, now, the scale can go as low as nano meters or even lower than that, but the scale on the other side will go into a very larger number.

Now, in the atmospheric science the most important thing is we generally talk about systems or we generally talk about things or stuff that we see with our naked eye; that means, we were generally not bothered what happens at the molecular level, what happens at the micro level. We see things in a macroscopic description; that means, we see winds to be moving from one point on the point; I mean we see what the wind what the effects that wind will do when it moves from one point to other point, we see clouds to be moving from one point to another point; that means, the physical description that is needed is macroscopic in nature.

It is not we do not we do not see what is going on inside. We will see how does the system exhibit itself from the outside for the perception of a naked eye. Now, the system here is beyond the naked eye, I mean the systems are far to be able to comprehend by a human being right. Now, even in itself we have different scales of motion. So, the scale motion is the is the dimension is the length dimension over which a physical phenomena or atmospheric phenomena can exist or can occur ok.

Now, you define these scales into four different types. Micro scale are the systems which span over the distances of few millimeters to at least 2 kilometers. So, what are the examples for eddy currents? Swirling motions of air; that means, you see small swirling motions of air which will not be very large, they will not be more than 2 kilometers in if you measure. So, the microscale motions are the ones which are very very small in size in horizontal scale I mean you say you say the length scale that is a very easy way to understand. So, you always it is just the unit of length ok.

Meso scale is anything which spans from 2 kilometers to 2000 kilometers it is it has a very large scale. So, for example, waves with horizontal dimensions on the of the order of tens to hundreds of kilometers there are global atmospheric waves which exist over several hundreds of kilometers; that means, the length scale of wave; the wavelength of these of this particular wave of will be of the order of several hundreds of kilometers, but it is the wave which is traveling from one point to other point. So, for example, mountain lee waves, thunderstorms things like that. So, these the motions which are from the order of 2 kilometers to 2000 km are categorized into meso scale meso scale motions.

The synoptic scale is a is a more important or more familiar scale of motion with which many of the atmospheric processes happen and also many of the many of the people many of the scientists, many of the much of the science is going on. So, synoptic scale is the is the motion in which covers almost like a wide range of scales 500 to 10000 kilometers. So, waves with horizontal dimensions on the of the order of several hundreds of kilometers.

So, for example – high pressure, low pressure system; so, if you see any weather system or any weather map even in your news broadcast you will be able to realize that yeah entire let us say sometimes an entire country can be a high pressure system and it will be it will be surrounded by a low pressure system. That means, these systems are spanning over several hundreds of kilometers.

So, and the last scale of motion is planetary scale. So, which is which is the broadest feature of the of the all and this the planetary scale system like the name itself suggests planetary scale system is of this scale of the planet itself ok. So, features with horizontal dimensions comparable to the size of continents or oceans or to the planet itself are covered in this particular scale.

So, it is micro scale which is kind of small, meso scale, synoptic scale and planetary scale. So, these scales of motions are very important whenever you pick up a system it is very important for you to categorize the this particular system into one of these scales and then use the techniques accordingly.

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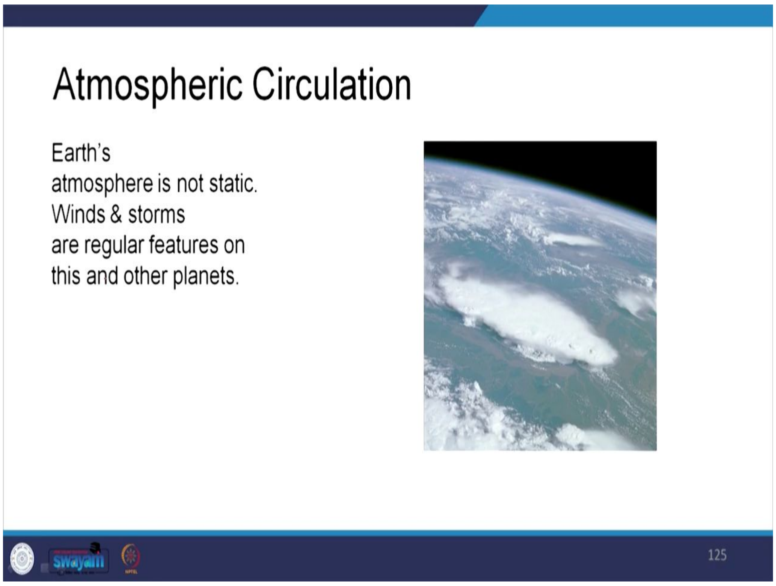

Now, atmospheric circulation: so, what is atmospheric circulation? Earths atmospheric circulation Earth's atmosphere is not static, it is a dynamic thing; I mean it is it does not stay still. So, winds and storms are regular features on this and other planets. So, its atmospheric circulation an example that atmospheric atmosphere is not static is that there are winds and storms which are regular features that you see in the atmosphere ok.

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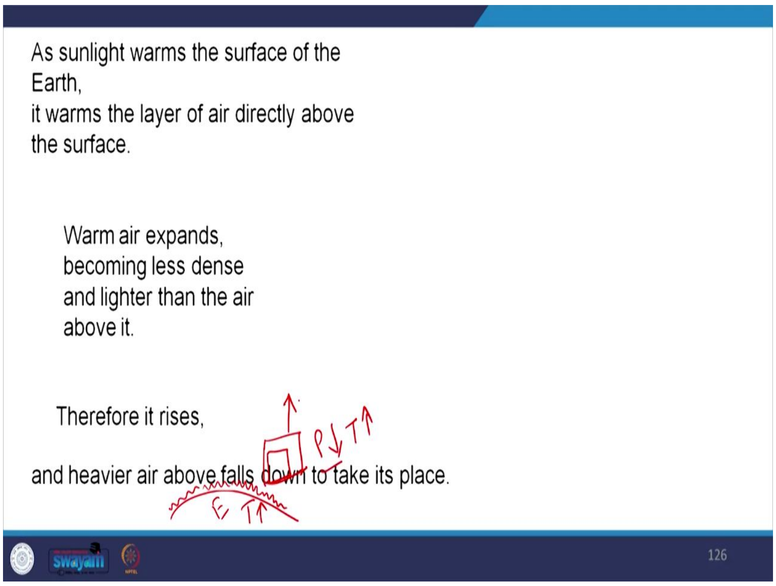

So, what is the reason for the circulation of the atmosphere? Why should the Earth Earth's atmosphere moves from one point to another point? It is a fluid system nobody nothing can stop a fluid system from moving from one point to other point. Anyway, as the sun warms the surface on the Earth it warms the layer of the air that is directly above the surface. Now, we specifically know what is the radiation, which part of the radiation is the one which it reaches the Earth's surface and it increases its temperature right.

Now, what I am trying to say here is as the temperature of the Earth's surface is increased it that the layer of air that is immediately above this surface is naturally getting heated right it is it naturally gets warm. Now, what happens warm air has a tendency if you take warm air in a parcel, this will expand right; this will expand and as a result of expansion the density will go down if the temperature is going up; that means, it will go down and if the density is low anything which is less denser is we will try to move up due to the buoyancy. So, therefore, it rises here yeah.

So, we have learned something about atmospheric scales of motion and various types of weather systems or atmospheric systems which will be categorized as these scales. Now, in tomorrow's lecture we will try to understand the atmospheric circulation and various aspects of atmospheric circulation, yeah.

Thank you.