Introduction to Atmosphere and Space Science
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Lecture – 07
Vertical Structure of the Atmosphere

Hello, dear students. So, in continuation with our earlier discussions today, we will try to understand the Vertical Structure of the Atmosphere, which means we will try to understand various layers of atmosphere; how the temperature varies in this different layers in the atmosphere, what is the reason for the observed variation of temperature with respect to the height and many other aspects related to the atmospheric structure.

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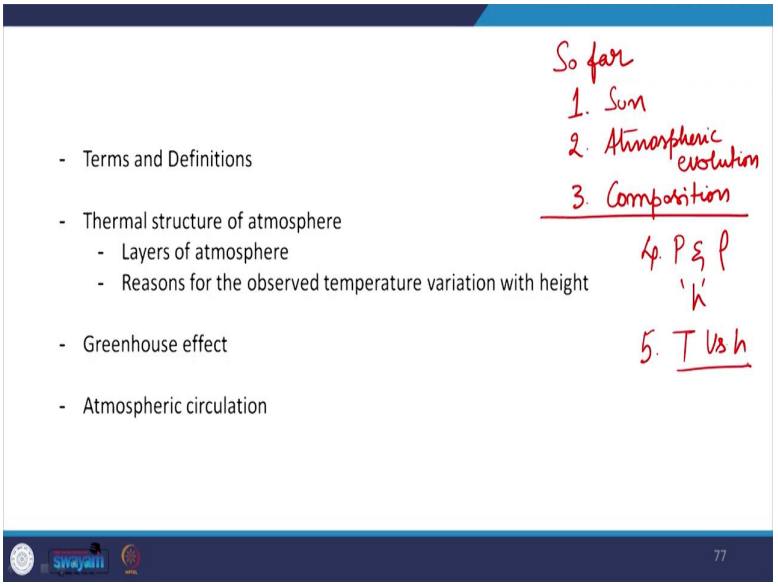

So, if you recall in our discussions so far, we have seen the aspects related to the sun, then we have seen aspects related to the atmospheric evolution. Then we have seen details about the composition of atmosphere, right. So, in continuation to this, we have seen how does the pressure and density vary with respect to height right.

So now, we will see the most important aspect which is the temperature variation with respect to the height. Why is this important? This aspect is important, because it helps us define various layers of atmosphere. The atmospheric layers are very much familiar to all of you. I mean you must have at some point of time; you must have come across various terms like

troposphere, stratosphere, mesosphere things like that. What I mean to say is these various terms represent different heights in the atmosphere, in the earth's atmosphere. They are named because of a certain reason. Each of them have a different reason for the variation of temperature with respect to height in these particular regions, ok.

Now, we will try to see how the classification is done and what is the input, what is the what are the salient features of each of these layers and physically speaking where do we come across these different layers or different phenomena; we will try to understand.

So, to begin with we will try to see various terms and definitions which are very basic in the sense and which are very much relevant for the discussions that we will have in this lecture. Then we will try to see the thermal structure of atmosphere, ok. The thermal structure atmosphere generally means the variation of temperature with respect to the height, ok.

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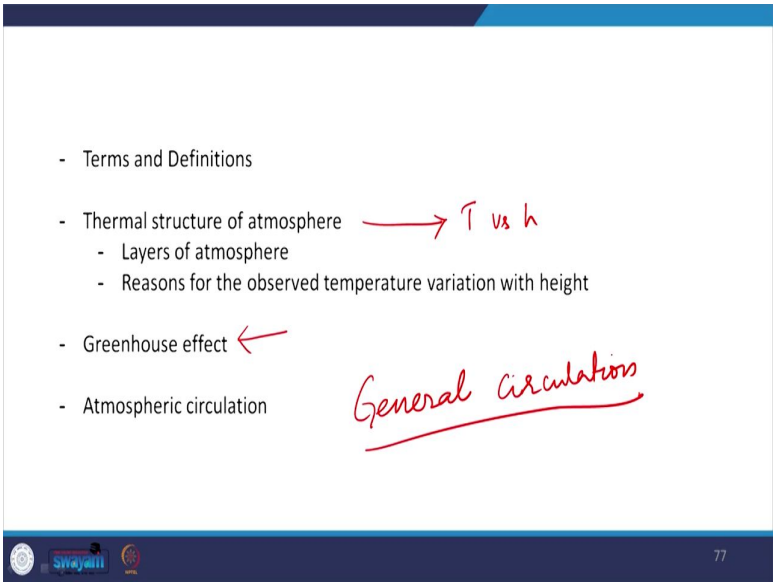

The layers of atmosphere which is a follow up to the variation of temperature with respect to the height and we will try to see why the temperature varies in a particular way; in each of the different layers that we are in define, what is the reason for that. Then we will try to understand few very important aspects about the greenhouse effect. What is greenhouse effect and how is it active in this atmospheric system and what are the physical processes or what are the chemical species which are responsible for the greenhouse gas effect to be existing in the atmosphere ok. Then we will try to understand the atmospheric circulation; the

circulation of atmosphere, the general circulation of atmosphere, the general circulation of atmosphere.

Now, circulation of atmosphere is a very famous or very familiar word that you must have come across in your earlier science lessons, right. Now, we will circulation of atmosphere at the same time is a very elaborate topic in itself. So, we will not discuss the entire scope of the general circulation; rather we will try to understand the fundamental physical principle which is behind driving the atmospheric circulation, ok. So, we will give a very brief overview of the atmospheric circulation, right.

Now, moving on for the terms and definitions. So, atmosphere by definition is the mixture of gases, droplets, water droplets and solid particles which are suspended above the earth's surface. So, this gaseous envelope which also has some moisture in it and which also allows tiny particles of mass be suspended in its; is generally referred to as atmosphere.

Weather is a short term atmospheric phenomena lasting from few hours up to a week, ok. So, weather generally refers to short term phenomena; that means, you talk about weather, let us say today is weather or weather of this particular week or things like that. So, weather is the climatic conditions or is the weather is the particular set of physical parameters which span over a very short period of time, ok. Then on the contrary, you also define climate. Climate is the long term atmospheric conditions lasting from few weeks to several years.

So, we do not talk about climate of a day, you do not talk about climate of a week rather you talk about climate over the past year, over the past several years, over the past decades; things like that. So, when you refer to the conditions of atmosphere over a period of time which is longer than few weeks, you call it as climate. When you refer to atmospheric parameters or their variation over a period of week or day or hours, you call it as weather.

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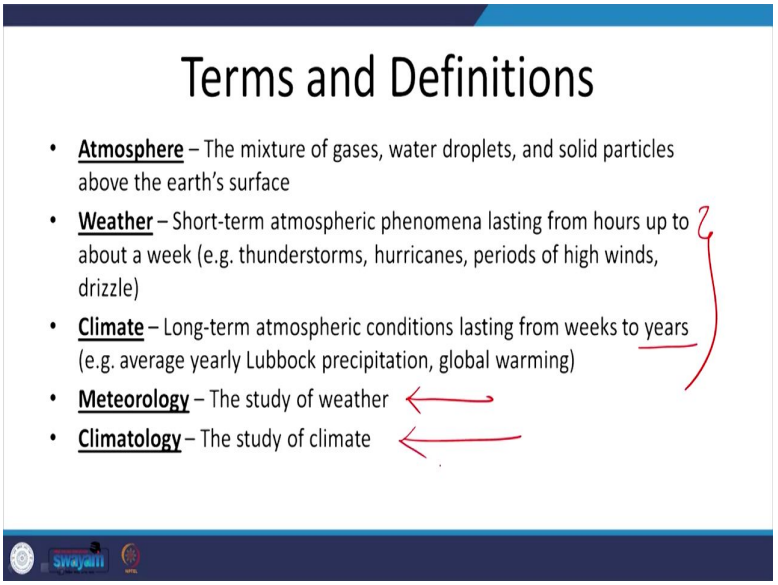

So, this is the basic definition that you should you should incorporate in your capabilities so, that when you are referring to few things in a week, you use weather and when you are referring to very large amount of time or longer amount of time, you will say the world climate. You should not say that today is climate is like this, no; today is weather is like this. So, that is the appropriate way of doing it.

Meteorology is the study of weather, right. This is a very important thing and climatology is the study of climate as simple as that, ok.

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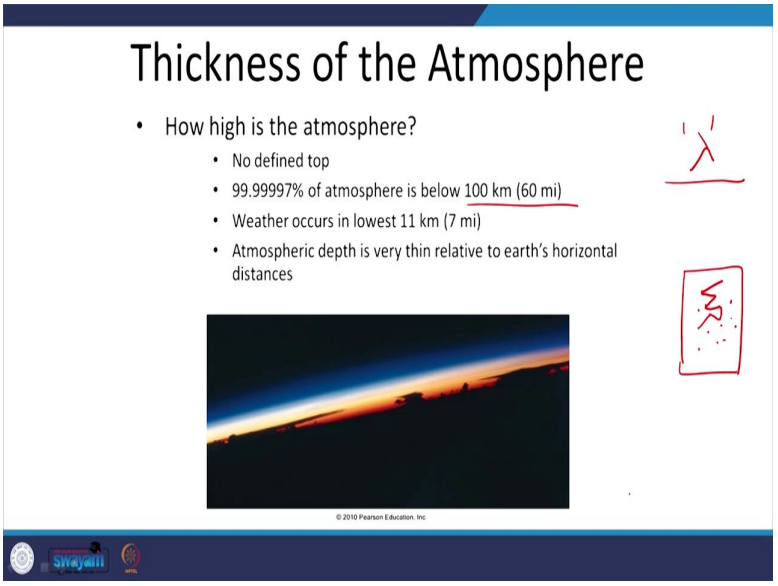

Now, in continuation, let us say some more definitions or some more physical dimensions or quantities. Thickness of the atmosphere so, we have already seen 99.999 percent of the atmosphere exist below 50 kilometres starting from the surface, right. Now, how high is that atmosphere? So, there is no such thing as a definite top, I mean this is the top of the atmosphere; that means, that about this height. There is no such thing as atmosphere, you should not say that.

Atmosphere exists from the ground to infinity. I mean infinity is a infinity should not be treated as let us say 10,000 or 50,000 kilometres in this way, in this context, rather there is no such thing as a defined limit above which you cannot find atmosphere. So, atmosphere the density of atmosphere decays exponentially; that means, it decays very fast to begin with and it decays slowly as you go ahead, ok. So, 99.99997 percent of the atmosphere is below 100 kilometres.

So, this is the I mean after which there are only few molecules or few atoms. I mean the most scientific way to say that atmosphere is sparsely populated is that generally when you talk about ideal gas, you always talk about a physical parameter which is called as lambda. Lambda is defined as the mean free path. So, what does it mean?

So, if you have a mixture of gas or if you have a gas contained in a chamber, these gas molecules will collide with themselves, I mean among themselves and each molecule in the course of its collision will travel will not travel in a straight line, it will travel in a way like this right. So, now, what it means is that the mean free path is defined as the average distance that the molecule travels between two successive collisions.

So, before it collides, you can say that before the molecule collides with another molecule, you can say that the molecule is moving freely from one collision to another collision.

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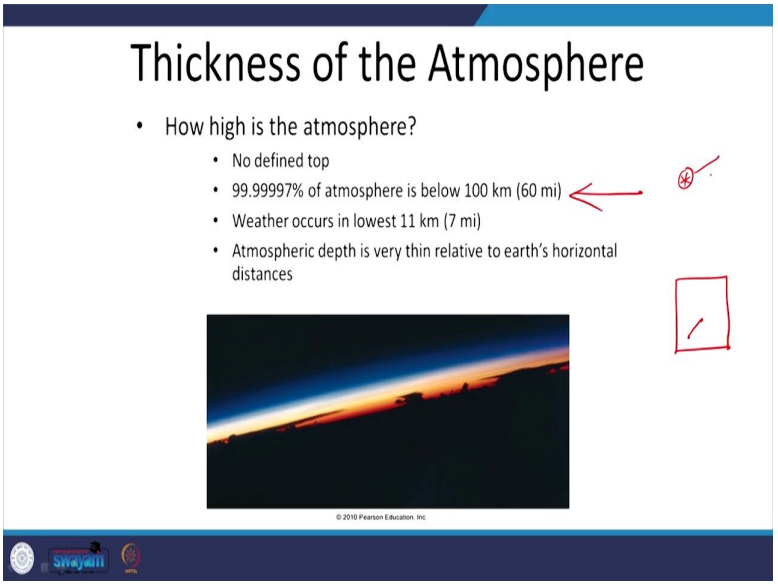

Now, in the lower atmosphere the mean free path is very very small; that means, it is very densely populated when you go to these heights. There is no such thing as collisions, molecule each molecule travels for several 100s of kilometres before it encounters another collision with a molecule. So, that is how rare the medium is. Though so, we should not say that the atmosphere ends at a particular limit, rather it is more appropriate to say that the atmosphere, it is very diffused beyond let us say 60 miles or 100 kilometres. And the most important thing like; we have seen already is that atmosphere of course, is from 0 to let us say 800 or 900 kilometres. All the weather that we see today all the weather effects everything, everything that we encounter or everything that we experience in our day to day lives happens below the 10 kilometres envelop.

I mean, 10 kilometres is the bottom most or the topmost layer. So, 10 kilometres is nearly the place or 11 kilometres like, what I have written here; 10 kilometres is the height up to which all the weather happens, ok. And, atmospheric depth is very thin relative to earth's horizontal distances. So, generally so, any movement or any weather system always moves from a point to another point; that means, the movement is horizontal in nature. So, you take the earth the systems are moving like this let us say.

So, when you take these distances, these distances are several 100s of kilometres in scale; that means, you consider a weather system to be developing at a point this weather system

will develop and travel several 100s of kilometres horizontally. But so, if you compare this distance with respect to the atmospheric depth, it is very very large, right.

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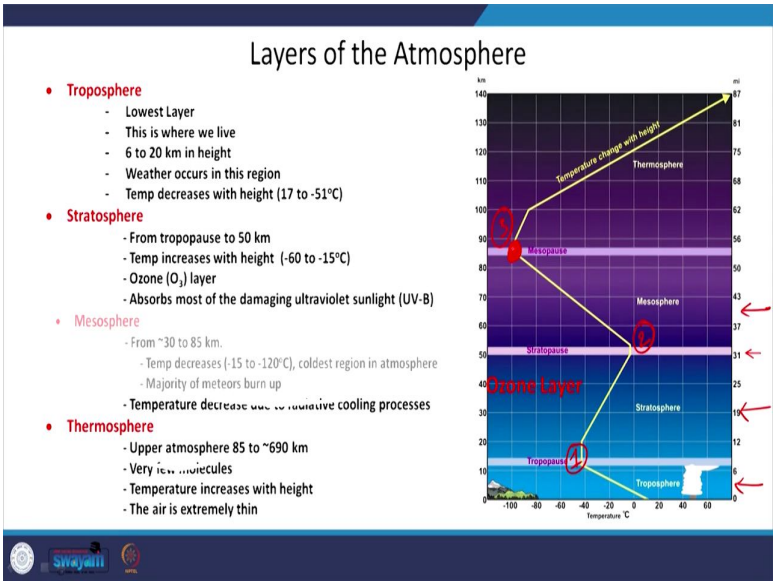

So, now, talking about the various layers of the atmosphere, what you see? The figure that you see on your right is the variation of temperature with respect to height in the atmosphere. Now, we have seen that the pressure; that means, generally let us say we can have a simple contradiction here itself. What we have seen in the last class is that, the variation of pressure with respect to height which is exponential in nature; that means, pressure decreases exponentially as we start from the ground and reach higher altitudes or let us say the log of the pressure decreases linearly; as we travel upwards right that means, there is no increase and decrease its always a decrease, right.

So, that means, that lets say if you put an ideal gas and at the surface then what happens? If you put an ideal gas in an adiabatic enclosure and take it at various heights in the atmosphere, vertically upwards. The system will have a temperature to itself to begin with and as you go up generally, what happens? As you go up the density decreases so, when the density is decreasing and if the system is adiabatic in nature; that means, the decrease in the density or decrease in the pressure has to be at the expense of the internal energy of the system. Rather than complicating it so much let us say if the pressure is decreasing if the density is decreasing, according to the simple ideal gas equation you can say that the temperature will also decrease.

So, but what you see here is that the temperature will not decrease as you go up. Temperature decreases up to a particular point then it increases, then it decreases, then again it will increase. So, this zigzag structure is a very particular or very unique feature, that you see in the only in the case of atmosphere of the earth, ok.

Now, our job is to identify what are the reasons for this variation that you see like this, ok. So, now, I will go step by step. I will tell you, what are the important features of each of these layers and why, then I will tell you, why this kind of variation is seen or why should a variation like this be existing in the atmosphere. Now, you see the turning point. The turning points are the ones where the slope of the curve changes from positive to negative or negative to positive, right.

As you see here you have how many turning points? You have like one turning point here, where the temperature goes keeps on decreasing and then suddenly it starts increasing with respect to the height, then you see the second turning point here, where the temperature was decreasing up till this point then sorry the temperature was increasing up till this point then it waist starts to decrease. Then again you see a turning point here; where you see the temperature starting to increase with height, right.

Now, what has been done is, these are these points, are at these turning points the we have defined the layers. So, every time it changes; it crosses a turning point you have a different layer in the atmosphere. So, to begin with the bottommost layer is called as a troposphere. So, uniquely this troposphere has a behaviour, wherein the temperature will decrease with respect to the height. Then you have starting from the top of the troposphere which is called as the tropopause; the layer that is above the tropopause is called as the stratosphere.

Stratosphere has temperature increasing with respect to the height, then at the end of the stratosphere you have a region or the topmost part of the stratosphere is called as the stratopause. Above this stratopause where the temperature decreases with respect to the height is called as a mesosphere. Then it reaches a minimum value which is nearly like minus 100 degree cells Celsius at nearly 85 kilometres, this path is the coldest point in the atmosphere of the earth, this is the coldest point, ok. Then above which you have the thermosphere.

So, we have four different layers in the atmosphere of the earth. These four different layers are called as the troposphere, stratosphere, mesosphere and thermosphere, ok. So, the

troposphere is the lowest layer in the earth's atmosphere, we have four different layers now, which are troposphere, stratosphere, mesosphere and thermosphere. The boundaries of these layers are called as tropopause, stratopause, mesopause; there is no boundary for the thermosphere, thermosphere extends into deep space, ok.

Troposphere is the lowest layer of earth's atmosphere, this is the layer where we live, I mean this is where all the weather happens and this is the where we live and travel, ok. This is generally 6 to 20 kilometres in height that means, the tropospheric height varies with respect to latitude generally, ok. So, let us see why it varies, we will discuss that.

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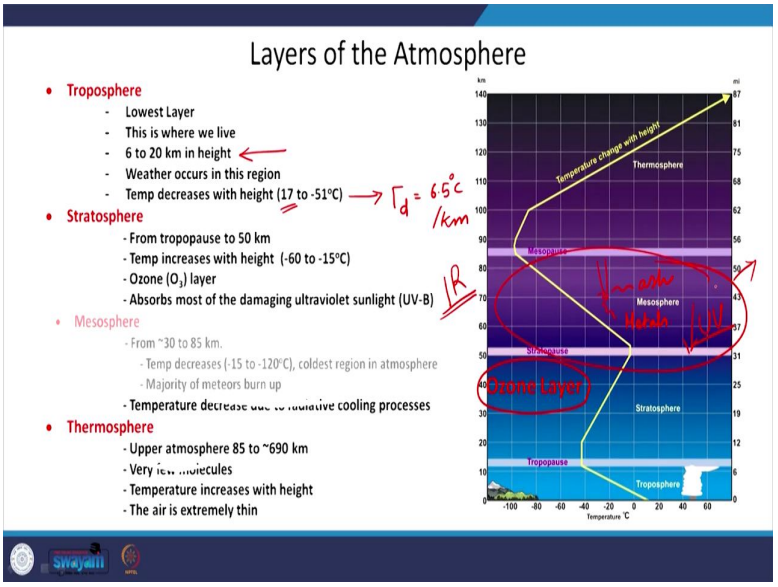

So, the tropospheric layer the height of the tropopause or the depth of the troposphere varies as a function of latitude, which can be as low as 6 kilometres at some points and which can be as high as 20 kilometres. So, what is this? This is the height of the tropopause or the depth of the troposphere; like we have mentioned several number of times, the weather occurs in this region this is where all the weather will occur. So, here in this region the temperature decreases with respect to the height so, the average surface temperature is taken as 17 degree Celsius, which is a known number I mean this is the average surface temperature for all the all the practical purposes or all the calculations that we use. It goes to as high as minus 51 degrees Celsius.

So, here what you see what you define here itself maybe; this the right point that we mentioned this parameter. So, the rate at which the temperature changes with respect to

height is generally called as the adiabatic lapse rate; which is approximately 6.5 degrees Celsius per kilometre. That means that, you travel one kilometre into the atmosphere or into this into the in the vertical direction, the temperature will decrease by a magnitude 6.5 degrees Celsius, ok.

So, these are few details about the troposphere, ok. Now, when you are about to cross the troposphere, you will encounter a region which is called as a tropopause, generally in this region the temperature is assumed to be constant with respect to the height. Then you have the immediate layer that you have above this tropopause is the stratosphere. And, stratosphere extends almost from the tropopause to up be a height of 50 kilometres. So, 50 kilometres is the height of the stratopause.

So, in this region stratosphere which is called a stratosphere; the temperature increases with height. So, as you go up you the thermometer will start showing you larger value of temperature. So, this is the region where all the ozone will be existing so, this is the ozone layer that we know very well exists in the stratosphere, ok.

So, generally what happens is so, the oxygen molecule has the capacity to take up the ultraviolet radiation, which is coming from the top. So, this ultraviolet radiation is taken by the oxygen and it gets heated up; that means, you have a source or you have you have some species which is trapping the heat. So, that is why the temperature increases with respect to the height, in this particular region which is called as the stratosphere, ok.

So, stratosphere by the virtue of oxygen and as well as the ozone, because of the complicated chemistry we will not go there, but we can say that it is because of the production of ozone and its ability to take up the ultraviolet, U UV ultraviolet radiation. The temperature in this region increases with respect to the height. So; that means, that that is there is one particular region where there is a lot of ozone, there is a lot of oxygen, ok. Immediately above the stratopause the region or the layer of atmosphere that is existing is called as a mesosphere. Mesosphere generally extends from almost from the stratopause up till a height of 85 kilometres and temperature decreases very sharply in this region.

So, this region is actually the coldest region in the atmosphere, which whose temperature goes always almost up to minus 100 degree Celsius, ok. So, temperature decreases from minus 15 degree Celsius to minus 120 degree Celsius also the coldest region in the

atmosphere and most importantly all the meteors, which come from the outside burn up in this region.

So, it is I mean we know that there is there are not much of the gas molecules in this region. So, material comes and it burns here. So, it burns that means, it is leaving two possibilities. The meteor burns here, because of whatever the friction that could be offered by the existing molecular densities in this height of course, that is why it burns if there is no friction; there is no reason for it to burn itself, I mean it does not burn in deep space, right. So, why should it burn here? Those are there are number there are molecules which will offer friction to it and eventually it will burn. So, it will release a lot of ash and it will also release lot of metals. So, all the metals which burn are released and are stored in this mesospheric region.

So, this is a very interesting study that people have taken up where they will they will try to understand, this metal species that are deposited by the meteors or the burning of meteors from the from the outside, ok. And, most importantly like we have seen, the temperature decrease in this region is mainly, because of the radiative processes. That means that, there are few chemical species which are existing in the mesosphere and these chemical species what they do is they will radiate infrared radiation; that means, they are converting the temperature into radiation, let us say energy into radiation and they are radiating this energy out into the space. So, this energy is lost. So, once this energy is lost let us say, once this energy is lost so, because of the conservation of energy the temperature will decrease, that is as simple as that, ok.

And, most importantly so, after the mesosphere once you cross the mesopause; that means, you once you cross the coldest point in the earth's atmosphere the layer that is above mesopause is called as the thermosphere. Thermosphere is mainly the region where the temperature increases or temperature increases with respect to height. So, thermosphere of course, I mean it extends almost up to 690 or 840 kilometres. It is very rarely populated, the entire thermosphere; you have not much gas molecules or atoms and temperature increases with respect to height the air is extremely thin here.

So, what happens is thermosphere of course, I mean it reaches several 1,000s of Kelvin I mean this figure does not permit you to see more temperatures, but generally the thermospheric structure is like this. So, you have the troposphere, you have this stratosphere

and you have the mesosphere, then the temperature will increase just like anything. I mean, it can increase in two different ways.

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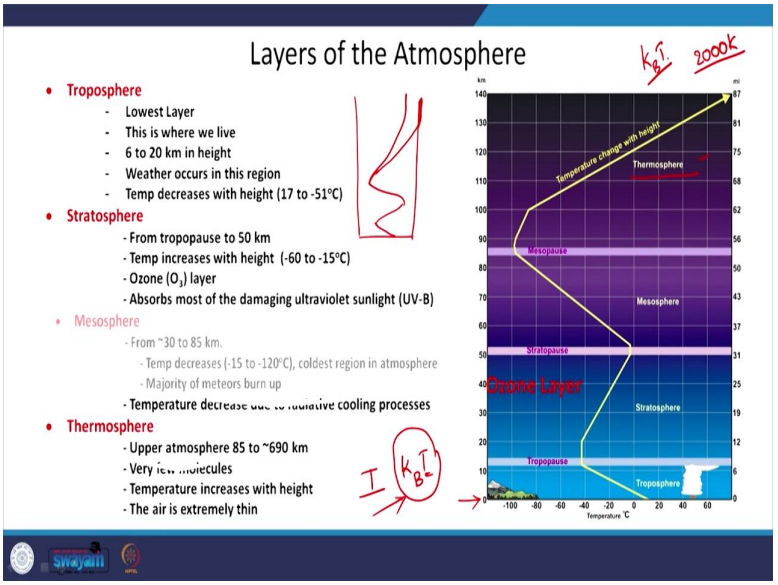

So, temperatures will increase will by several orders of magnitude I mean, they will go almost up to 2,500 or 3,000 Kelvin. But, so, coming to the perception let us say, but what is perception, human perception? If you here at the 0 physically you can perceive, how much is the temperature? Let us say if it is cold or if it is hot or if it is very hot or if it is burning, things like that I mean, this is this is the perceptions, right.

So, on the let us say in on at the ground; you do not have to touch something you can just be in the ambient the air itself and then you can realize, how cold or how hot it is. Because at any given point of time any measurement that you take up or even your own skin, senses gas or air around itself, right. That you have temperature you have a gas, you have a temperature then the mean energy that the gas molecule will possess is this.

Now, the skin or any measurement equipment reaches thermal equilibrium at this temperature; that means, the measurement measuring equipment will show you this temperature; that means, the measuring equipment has arrived itself into an equilibrium condition with the ambience, right.

Now, what happens in thermosphere is that, although the temperatures are 2,000 Kelvin, it is extremely hot for the extremely it is extremely cold for the perception; that means, that there

are not many molecules or there are not many atoms, which can make you feel how hot it is out there, ok.

So, that is just an idea just to just to give you an idea that despite the temperatures of intensely hot here; it is not really hot. If somebody if you go the let us say you do not have a user there that is a different thing, but for the point of perception it is generally not very hot in there, it is only the temperature the; this temperature that it is a 2,000 Kelvin. If I say 2,000 Kelvin is just a measure of the one gas molecule which has this energy that is it. This molecule has this energy that is it, but will a single molecule be enough for you to perceive heat no, absolutely not. So, that is what idea is, ok.

So, this was some discussion about various layers of atmosphere. Now, one very crucial or very very important aspect is that, here you come across one very important term which is called as gamma. Let us say we will not define several variants of it, we will just say gamma; this gamma is the lapse rate.

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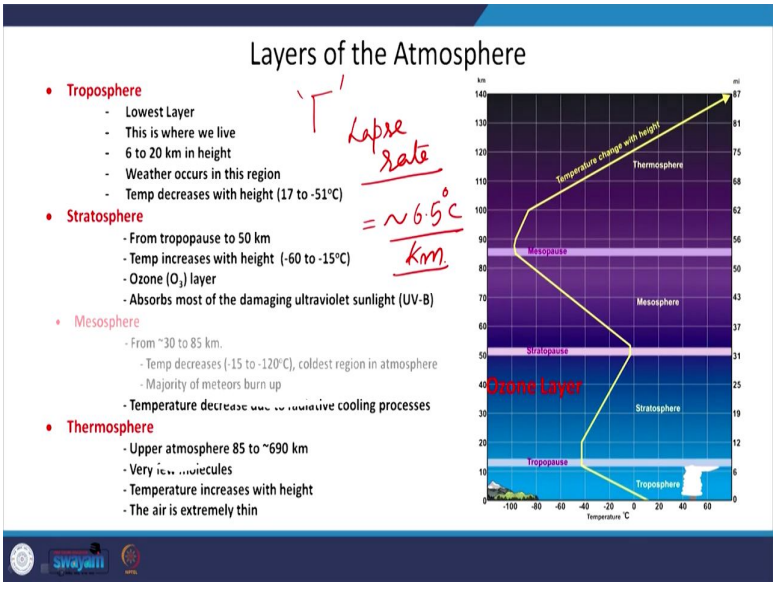

What is lapse rate? Lapse rate is the is the rate at which the temperature changes with respect to height which is generally or of the order of 6.5 degree Celsius per kilometre, ok. Now, now let us see so; this is the general overview of the variation of temperature with respect to the height. What we will do now is; we will look into each of these layers, what does what are other features other important features or salient features about each of these layers, what are

other interesting physical or chemical processes which are existing in these regions we will see, ok. Now, let us say the troposphere one by one.

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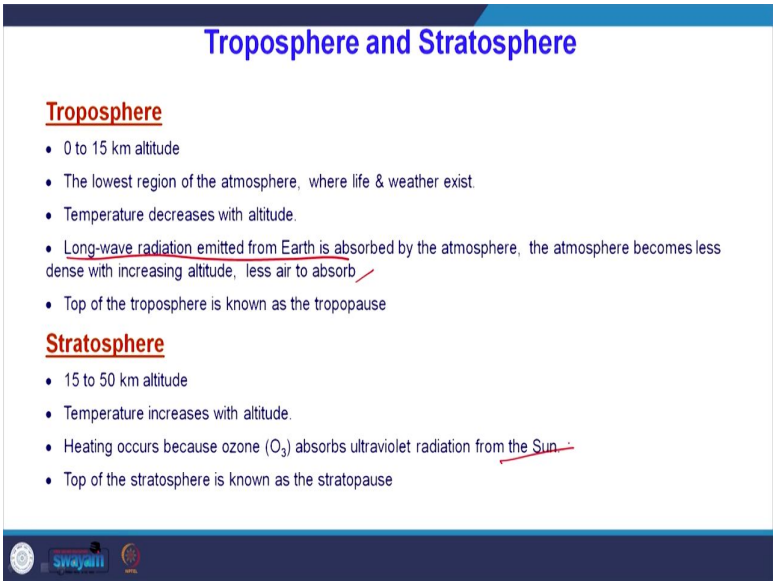

Troposphere is the bottom most layer; like we see where all the life and weather exist. So, most importantly apart from what we have seen in the last slide, long wave radiation which is emitted by the earth is absorbed by the atmosphere in this region. So, now, you remembered long wave radiation emitted by the earth and the atmosphere becomes less dense with increasing altitude, we know that and let us say to absorb. Yes, on the top of the troposphere is known as the tropopause.

The stratosphere is the layer about is 15 to 50 kilometres altitude, temperature increases with the altitude, heating occurs because Ozone absorbs ultraviolet radiation that is coming from the sun. And, the top of this stratopause stratosphere is called as the stratopause.

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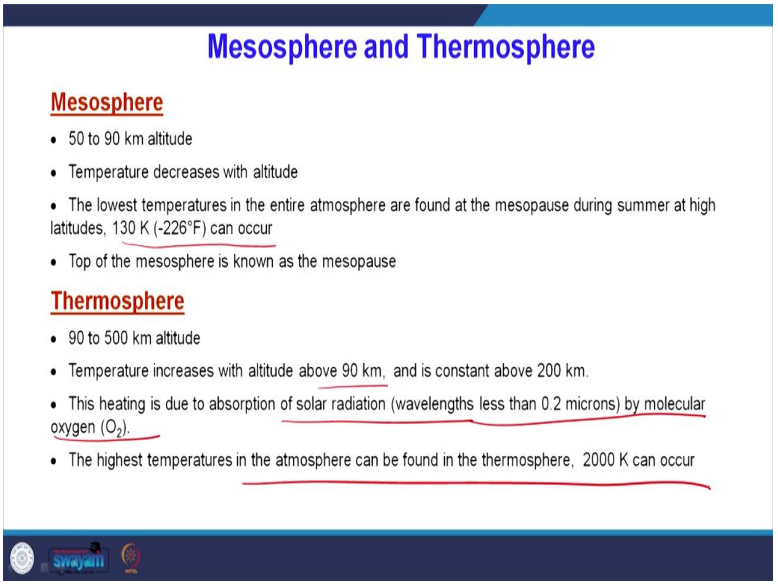

Mesosphere is the layer above the stratosphere, which is the coldest region. So, the lowest temperatures in the entire atmosphere are found in the mesopause during the summer, at high latitudes almost reaching minus 226 degree Fahrenheit. Thermosphere is the region of all or the topmost layer, temperature increases with altitudes above 90 kilometres and it is constant above 200 kilometres. The heating is due to the absorption so, ultraviolet radiation by molecular oxygen, yeah.

So, now, I forgot to mention why is it that the thermosphere is very hot is that, because thermosphere is the region which is the first that is to be encountered for solar radiation, when it is traveling into the earth's atmosphere so, the radiation is abundant in nature so, it has a lot of energy, the radiation has a lot of energy all the ultraviolet is intact, ultraviolet is not lost ultraviolet radiation c say a single atom, it is ionized or dissociated whatever it is; so, this atom takes up this energy so, this atom is at a very higher excited state. So, then you hold the atom then you measure its thermal energy and you convert this thermal energy into temperature; you have a large value of temperature that is it.

So, the highest temperatures in the thermosphere can be found in the sorry, in the atmosphere can be found only in the thermosphere and, temperatures as high as 2,000 Kelvin can occur in this region, ok. So, now, let us go for few more interesting aspects.

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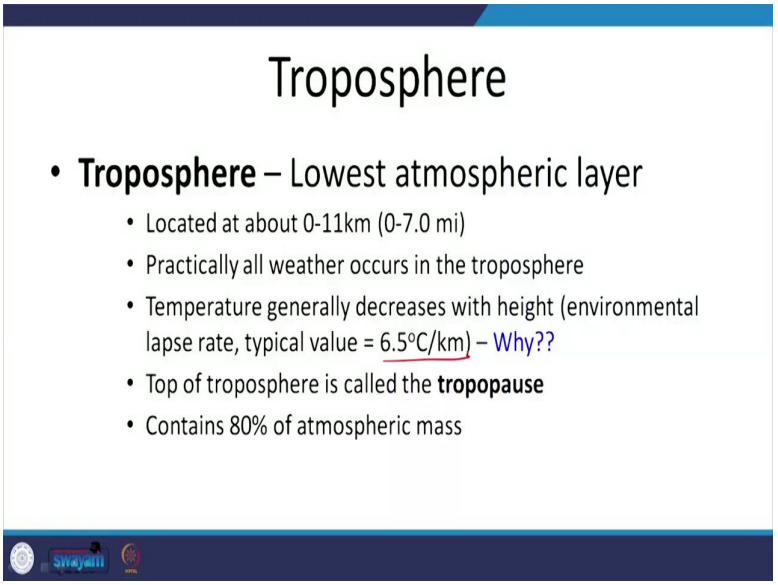

So, troposphere is the region with a lapse rate which is negative; that means, temperature decreases with respect to the height.

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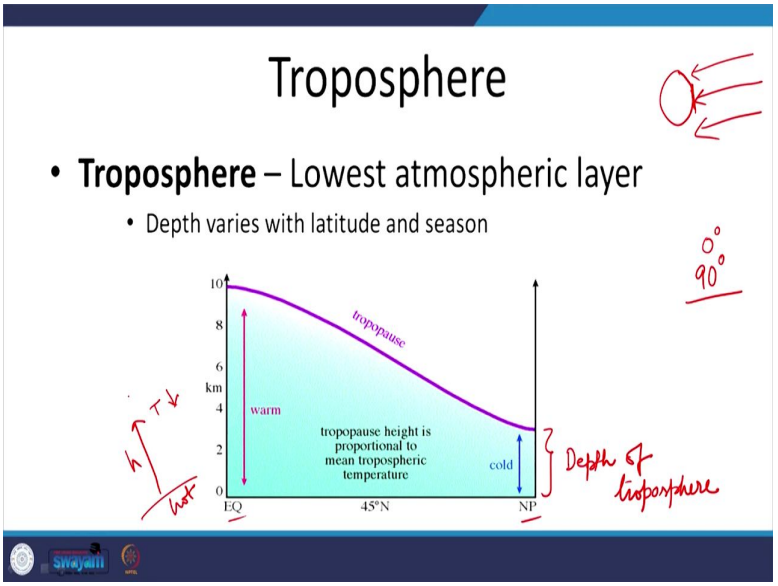

And, yeah, most important aspect about the troposphere is that; troposphere the height of the tropopause or the depth of the troposphere, this is the depth of troposphere varies from the equator to the North Pole NP is the North Pole. What this is (Refer Time: 29:35) latitude. So, the equator is at 0 degree latitude and the North Pole is at a latitude of 90 degree, ok. Now, equator has the highest depth of troposphere that is, because if you look at the geometry in

which the sun and earth system exist. So, this is how the radiation is received on the earth, let us say Sun is to the right, ok.

Now, equator receives the maximum amount of energy that is why, because of the larger temperatures at the equator the air expands and as a result; you have more depth of the troposphere. Now, most importantly why does the temperature decrease from the troposphere from the ground? It is simply, because let us say you have an object which is hot; as you go as you go away from the hot object the temperature will decrease that is it, this is as simple as that.

So, you have height as you go far from the hotter object the temperature will decrease, ok. So, the point is temperature decreases in the troposphere as you go up the height of the tropopause is maximum at the equator, because of the more heating that happens due to the solar radiation and the height of the tropopause is less at the poles. So, the height of the tropopause is nearly 17 kilometres at the equator and like, 6 kilometres at the poles, ok.

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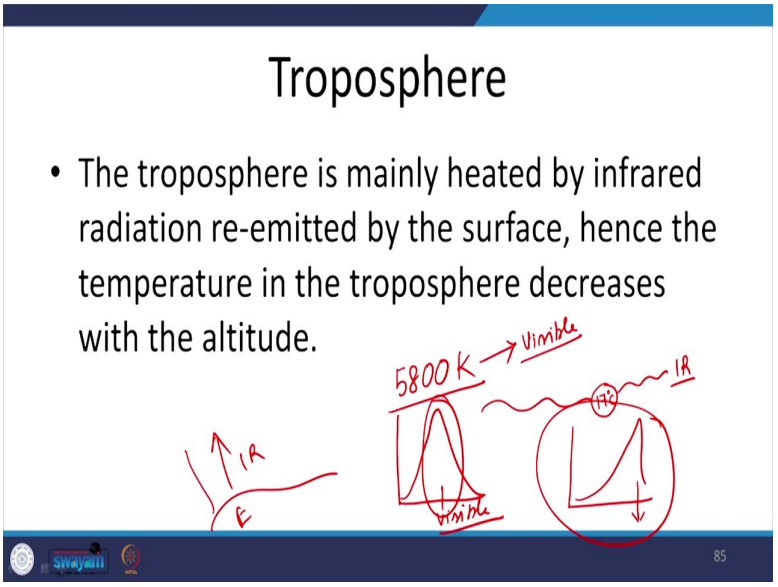

So, the troposphere is mainly heated by infrared radiation that is re emitted by the surface hence the temperature in the troposphere decreases with altitude. Now, here we should say one important thing. So, it is so, we have seen that Sun average temperature of the sun. So, the solar surface to be precise is 5,800 Kelvin. What does it mean? The altitude is that you see is at 5,800 Kelvin. So, this is the so 5800 Kelvin is the object which is emitting radiation,

right. Now, this radiation comes, this radiation heats up the earth its, it heats up to an average temperature of 617 degree Celsius, whatever in Kelvin whatever it is.

Now, most importantly if you draw a blackbody spectrum for 5800 Kelvin you can do that by using the Planck's law. You can say that the blackbody spectrum will look something like this; with its peak in the visible region. What does it mean? It means that maximum amount of energy is concentrated here. Now, if you also draw a blackbody spectrum for 17 degree Celsius; you will see its peak in the infrared region that means, this blackbody is radiating in the infrared part and this blackbody is mainly radiating in the visible part, ok. So, this is the basic difference. Now, the earth by whatever the mechanism is getting heated to this temperature. So, earth is also a blackbody now, which is emitting at 17 degree Celsius.

So, now, the radiation that is originating from the earth, this is the earth, this is the infrared radiation. So, this radiation that is originating from the earth is heating the troposphere. So, the troposphere is mainly heated by the infrared radiation re emitted by the surface, hence the temperature in the troposphere decreases as a function of altitude.

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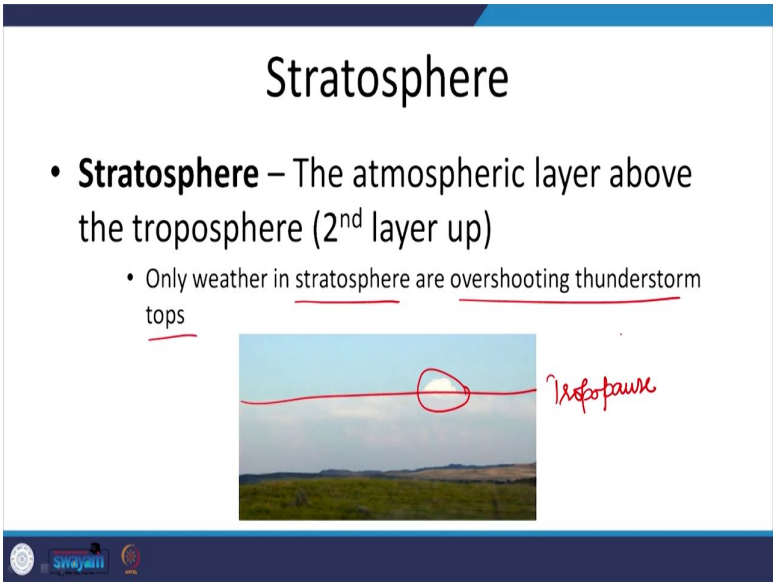

So, similarly, stratosphere is the second layer from the bottom, the atmospheric layer above the troposphere or the second layer. So, what you see is I mean nothing much happens here. All the weather happens in the troposphere and nothing much really happens in the stratosphere. The only weather sometimes you may encounter some weather in the stratosphere, the only weather that you that you may encounter in stratosphere are the

overshooting thunderstorm tops. I mean, there may be some times when the thunderstorm develops above the troposphere. So, this the cloud top that you see is the tropo tropopause.

Everything that is above the tropopause is just the stratosphere. So, in that way the only weather system that could develop into the stratosphere is the overshooting thunderstorm tops, ok. It may happen.

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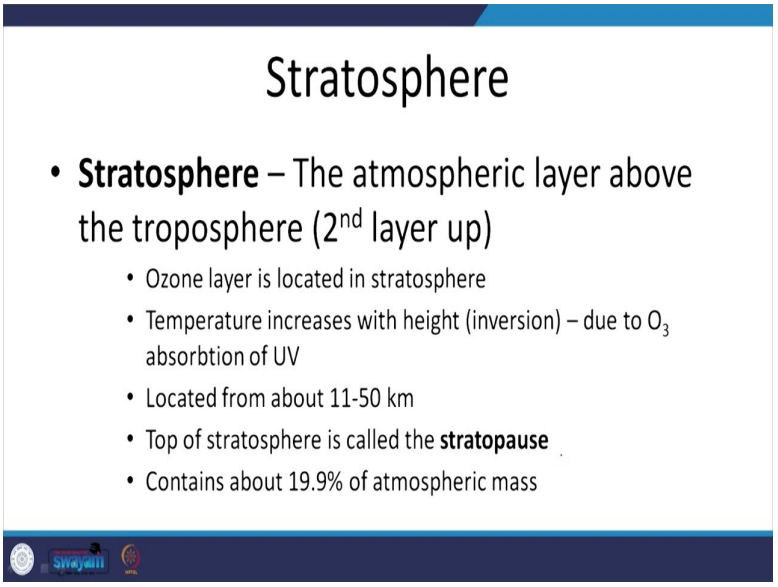

On ozone is located in the stratosphere; the temperature increases with height. So, this is an inversion I mean if the temperature decrease is assumed to be normal then this phenomenon is inversion to this. So, the temperature increases with respect to height due to the absorption of ultraviolet by the ozone molecule and this is located 11 to 50 kilometres and the top of the stratosphere is called the stratopause. The stratosphere contains nearly 19.9 percent of the atmospheric mass, ok.

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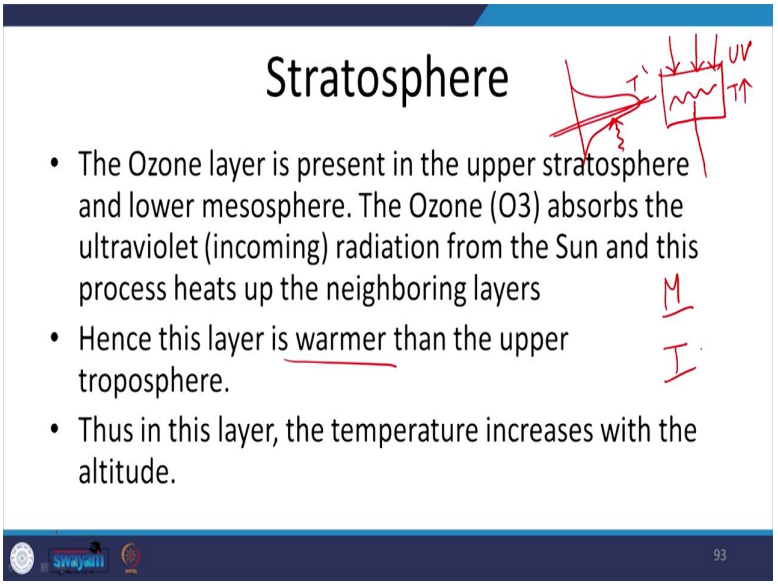

The Ozone layer is present in the upper stratosphere it and lower mesospheric region, ok. The Ozone absorbs the ultraviolet incoming ultraviolet radiation, which is incoming solar radiation from the sun and this process heats up the neighbouring layers. So, you have Ozone layer which is existing at let us say 45 or 55 kilometres. It absorbs all the incoming ultraviolet radiation UVA, UVB whatever.

So, as a result this gets heated up, this temperature will increase. Now, if you are travelling from the bottom let us say what do you see? You see that the temperature, see the density also density is maximum at a particular point, right. The heating is maximum at this point where the density is maximum so, as you travel from the below what happens? Your temperature with height will keep increasing, that is why; you see the stratospheric temperature increasing with respect to the height that is it.

So, as a result this layer is warmer in comparison to its neighbours and it is if this layer is warmer in comparison to the troposphere or in comparison to the mesosphere, ok. So, thus in this layer the temperature increases with altitude.

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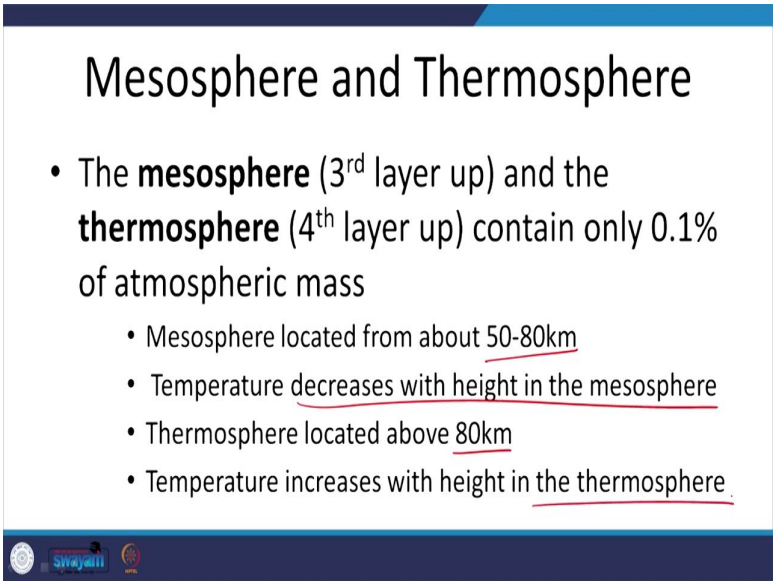

So, the mesosphere, the 3rd layer up and the thermosphere, the 4th layer up contain only 0.1 percent of the atmospheric mass. So, mesospheric and mesosphere and thermosphere so, generally for the point of weather or for the point of for the discussions about the weather or anything that, generally matters for the Sun-Earth system, these two layers are relevant. I mean nothing that happens here is relevant to us, ok. So, mesosphere is located about 50 to 80 kilometres and temperature decreases with height as is a in the mesosphere, thermosphere is located above 80 kilometres and temperature increases with height in the thermosphere, ok.

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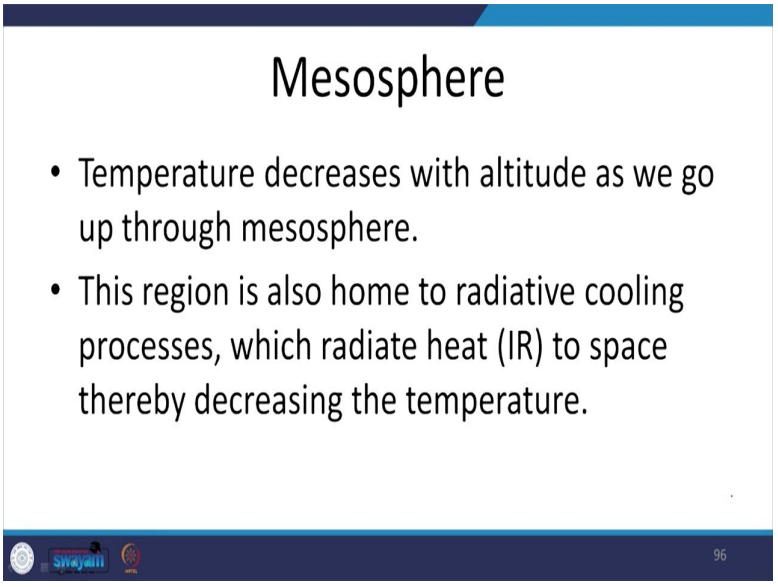

Now, why does the temp so, now, so because of the ozone the temperature increases as you are departing away from and from a hot object the temperature decreases in the troposphere fine. But, why does the temperature decrease with respect to height, right? So, why does it? I mean decrease it mainly decreases due to radiative cooling processes, which are active in this particular region. So, so they radiate heat to the space thereby decreasing the temperature, ok.

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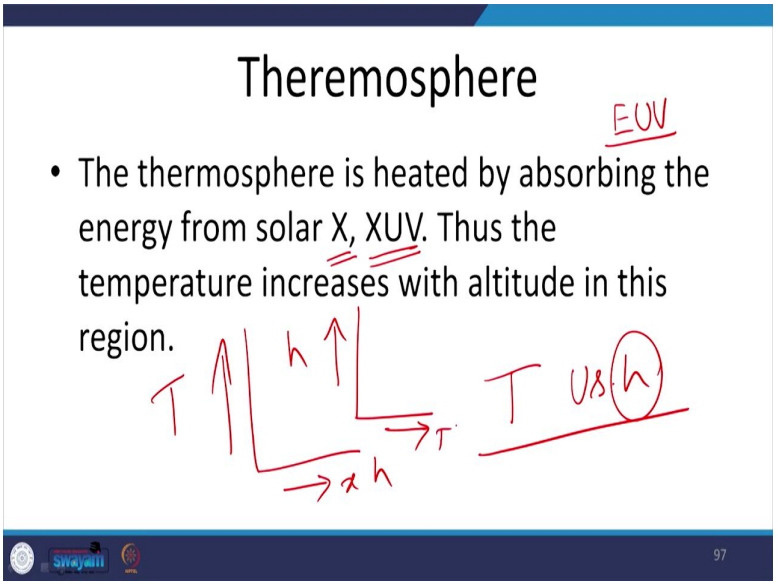

And, the thermosphere that thermosphere is heated by absorbing the energy from solar X, X-rays, extreme ultraviolet, X ultraviolet then again EUV, several small wavelength ranges you call this X extreme ultraviolet, X ultraviolet things like that.

So, thus temperature in this thermosphere increases with respect to altitude in this region, ok. So, this was yeah, so, this was some characterization of the atmosphere based on the variation of temperature with respect to height.

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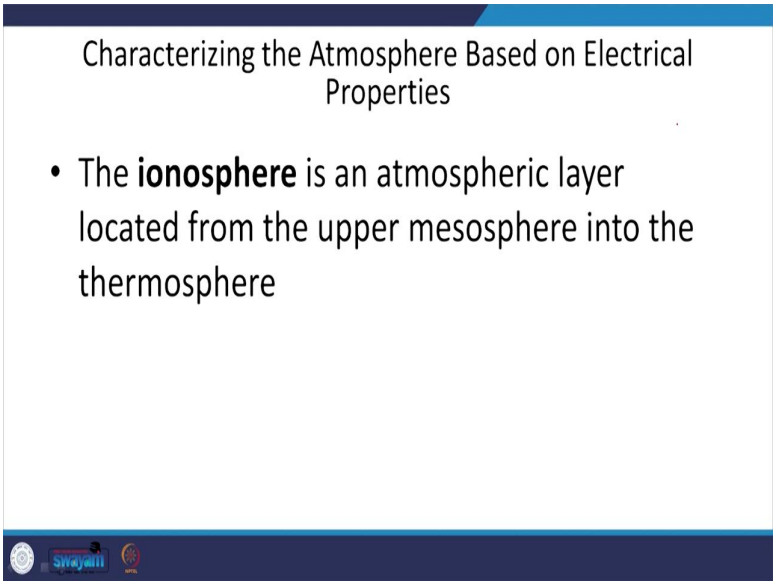

Now, one very important thing is so, so here the height should actually be represented on the x axis, on the x axis and the temperature should have been expressed on the y axis. But for the physical perception to be easy we always express height to be on the y axis and the temperature on the x axis, that is it, ok. So, next in the next lecture; we will see the classification or of the atmosphere based on electrical properties not the neutral properties or not the thermal properties, we will see how it can be classified using the electrical properties yeah.