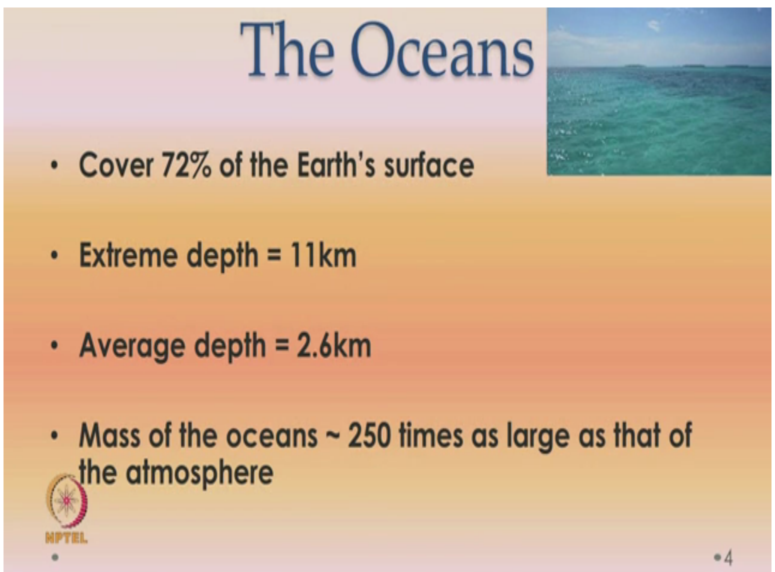
Introduction to Atmospheric Science
Prof. C. Balaji
Department of Mechanical Engineering
Indian Institute of Technology-Madras

Lecture-05
The Earth system – Oceans Contd... And Marine biosphere

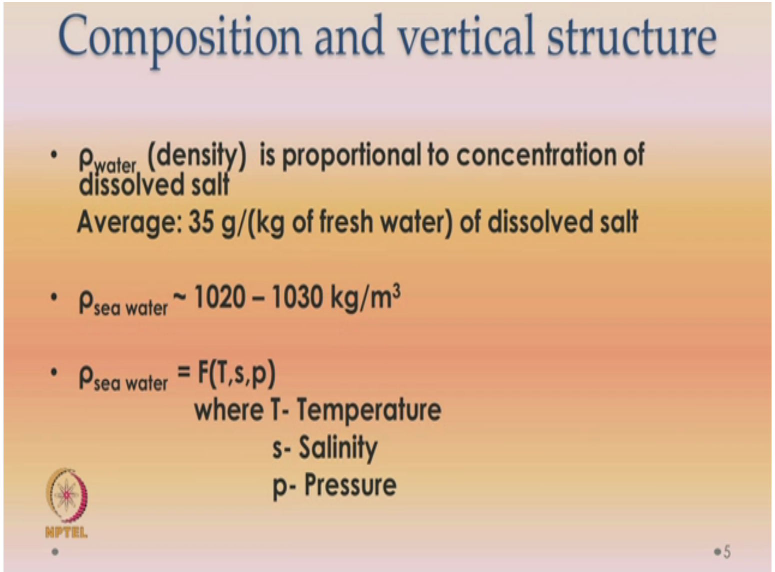
Okay. So, Good afternoon! So, we will continue with our discussion on the various components of the earth system. In the last class we saw that the atmosphere, the properties of the atmosphere or the behavior of the atmosphere is controlled, not only with the atmosphere but other components basically, cryosphere, terrestial biosphere, oceans and so on. So, we started our discussion on the oceans. The oceans cover 72% of the Earth's surface.

(Refer Slide Time: 00:38)



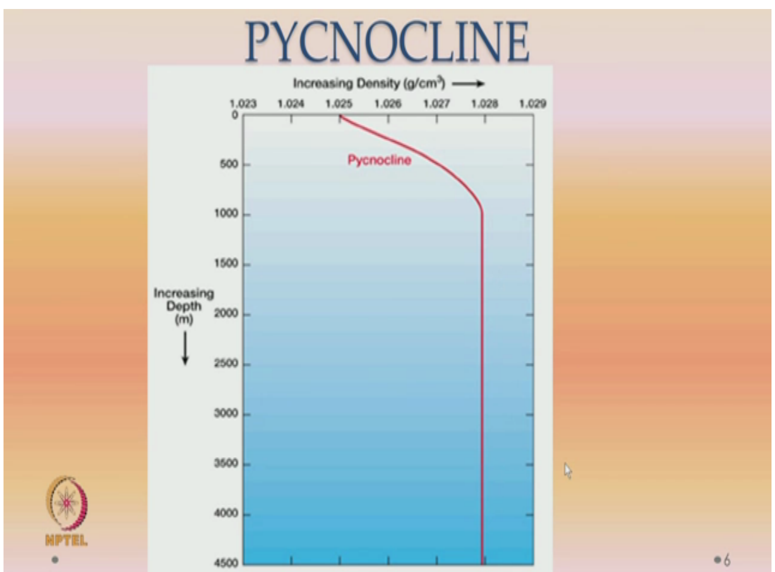
The extreme depth is the Mariana Trench which is what 11 kilometres deep. Then, the average depth is about 2.6 kilometers so the mass of the oceans is about 250 times as large as there are the atmosphere and the atmosphere mass is 5.11 into 10 to the power of 18 kilogram, that we figured out in one of the earlier classes.

(Refer Slide Time: 00:57)



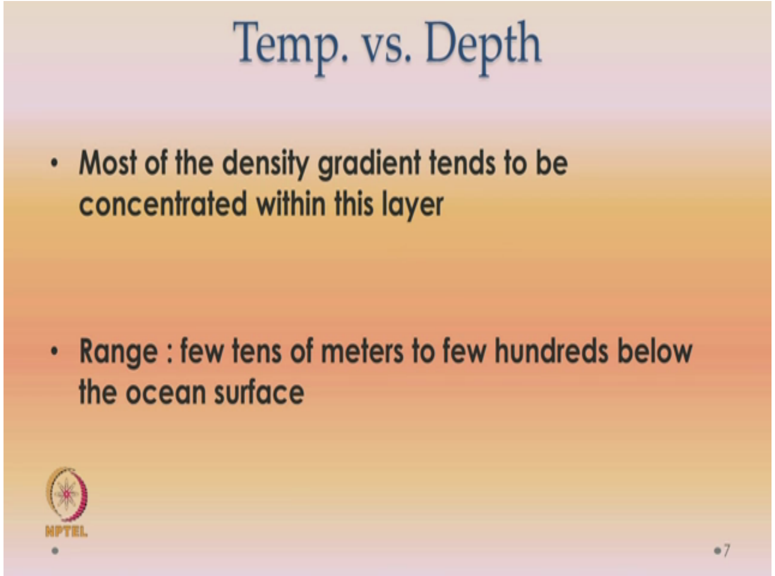
So, the density of sea water is about 1020 to 1030 kilogram per meter cube it is not 1000 kilogram per meter give it a little more because of the presence of water presence of salt. Salt is like 35 grams per kg, right. That is the salinity of seawater which I have said 35 grams per kilogram of fresh water which is about 3 and a half %, correct. It is about 3 and a half %. So, this density of the sea water is a function of the temperature salinity as well as the pressure boundary.

(Refer Slide Time: 01:28)



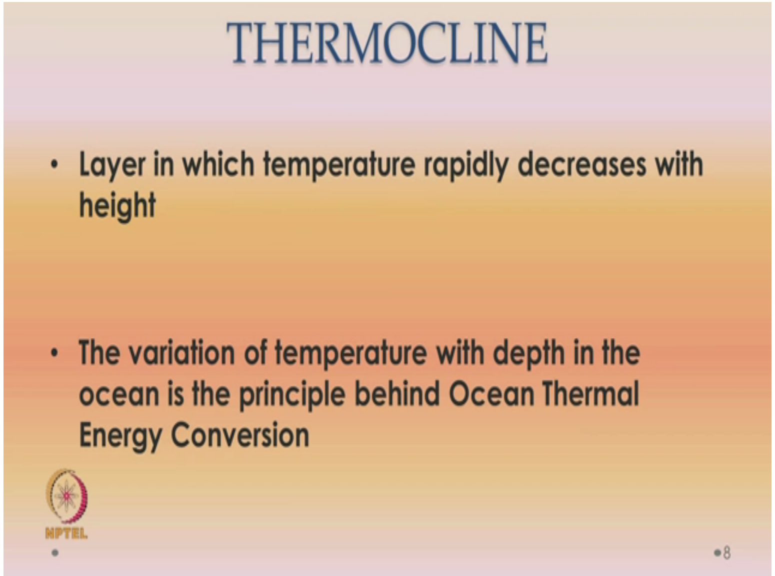
So, the density of the sea water changes with depth like this. So, there is a region where it is rapidly increases that is called the pycnocline, okay after that. So, that is only a few 100 meters maybe 500 1000 meters after that it remains constant throughout, okay.

(Refer Slide Time: 01:48)

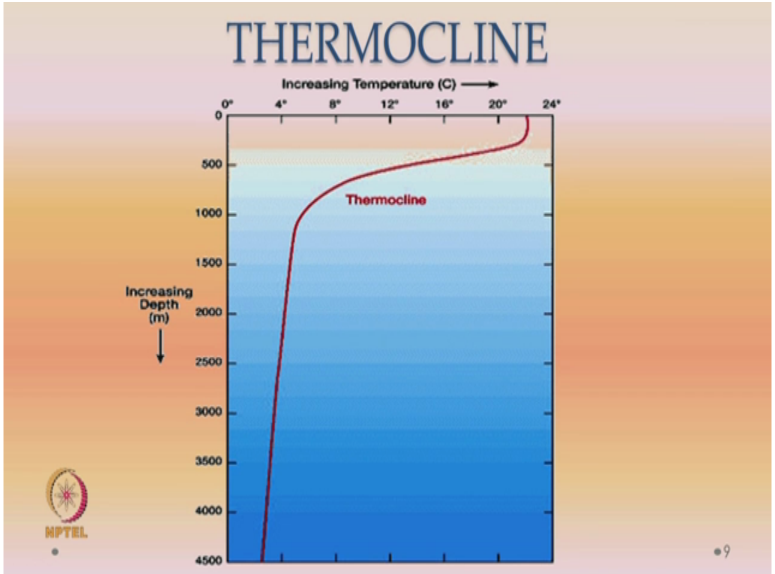


So, With reference to the earlier view graph most of the density gradient tends to be concentrated within this pycnocline. So, it can range from a few 10's of meters to a few 100 meters below the ocean surface.

(Refer Slide Time: 01: 58)



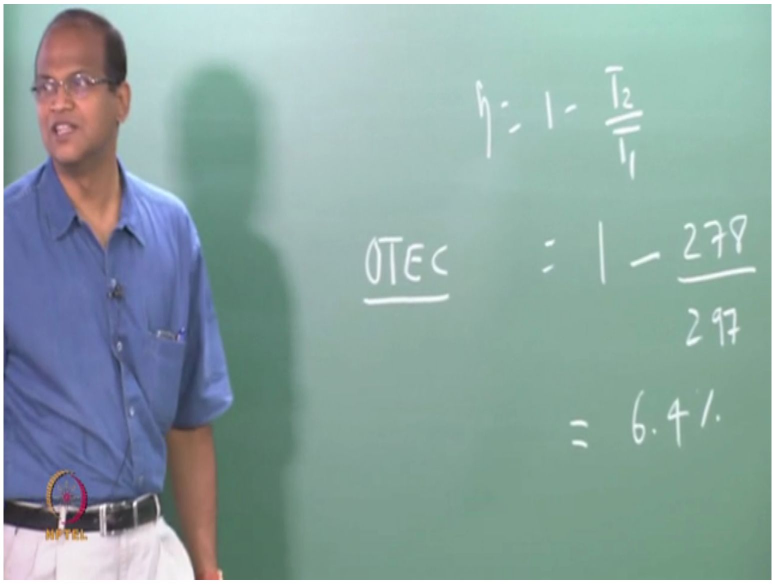
(Refer Slide Time: 02:03)



What about thermocline? So, the thermocline is a region where temperature rapidly decreases with temperature rapidly decreases with height. So, the surface typically is about 22 degree centigrade, it is not corresponding to Chennai for example. In Chennai, it will be about 30 degree centigrade, right. So, it changes rapidly it goes down to 8 degree centigrade about 7 and half or 8 meters.

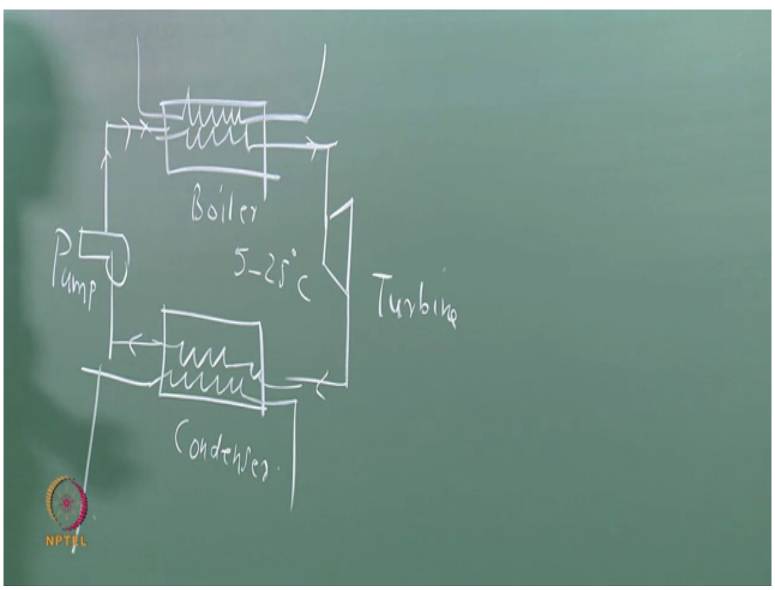
So, what about 1 kilometer you have water at a temperature of 4 degree centigrade. So, as mechanical engineers, some of you at least are mechanically, mechanical engineers it rings a bell. There is a source available at 20, 25 degree centigrade, there is a single available at 5 degree centigrade so, I want to run a heat engine, okay. Go ahead, please run a heat engine but the problem is the heat engine will be:

(Refer Slide Time: 02:43)



Let us take T2 to be 5 degree centigrade which is like 278. T1 will be let us take 24 degrees 273 + 24, 297 all right. What is its efficiency? It will be a very low value what is this just pull out a calculator. 5, 6, 7, 8, 9 how much is it, it? 6.4%, okay. So, the theoretical maximum efficiency of a heat engine running between the hot water available at the surface and the cold water available at 4 degrees is 6.2% only. So, this heat engine which explores each is called the this technology is called OTEC, the ocean thermal energy conversion okay. Now, we cannot harness this fully because what you have to do is basically,

(Refer Slide Time: 03:58)



Pump, condenser, boiler, turbine do this. So, so you are having a high pressure liquid, okay coming into the boiler. The hot water at 25 degree centigrade is used to heat this fluid which will boil at a temperature less than 25 degrees such fluids are available. So, you can have organic fluids. So, it will become a high pressure height, high pressure high temperature, high temperature within quotes, 25 degrees then it will run a turbine.

Then it will come out then for condensing it will use a cold water from below, okay. So, this will be a cycle which will be working between 5 and 25 degrees centigrade. But the funda is in order for this heat exchanger to work you should allow some temperature difference. If the temperature difference is very, very small then, the area of the heat exchanger will be very high. Then, the cost will be very high.

So, you lose some delta T like 2 to 3 degrees here you lose some other delta T 2 to 3 degrees here, because you want the condensation to take place. So, 1 - 278 by 297 will be 1 - 278 + 4 or 5 divided by 1 - 297 - 4 or 5. Already this fellow 6.4 then, if you take off these temperature differences, it will come to an efficiency of 4 or 5% only. Every day it gets hurt, okay. It willl come to only 4 or 5% and then our agonies do not stop there.

This condenser cooling water you have to get from a depth of 1000 meters, 1000 meters you have to lay a high density polyethylene pipe, okay. You need underwater divers and this thing it will be on a ship you have to put this 1000 meter long. And 1000 meter long pipe use your Darcy Weisbach equation FLV square by 2 GD and do all this and finally you have 1 K 1 megawatt plant and the pumping power of cold water itself is 400 or 500 kilowatts then you will have an excellent power plant which produces negative power after everything, ok.

So, these are the issues involved. Then somebody would say sir I have a tick I have a concept to capture the energy of lightning very nice but we have to wait endlessly or divide when lightning will take place and where lightning will take place and so on. So, many are very intuitively appealing concepts when it has to become a technology then it has to be afforded by many people. Just like the cell phone originally it was 60 rupees one call.

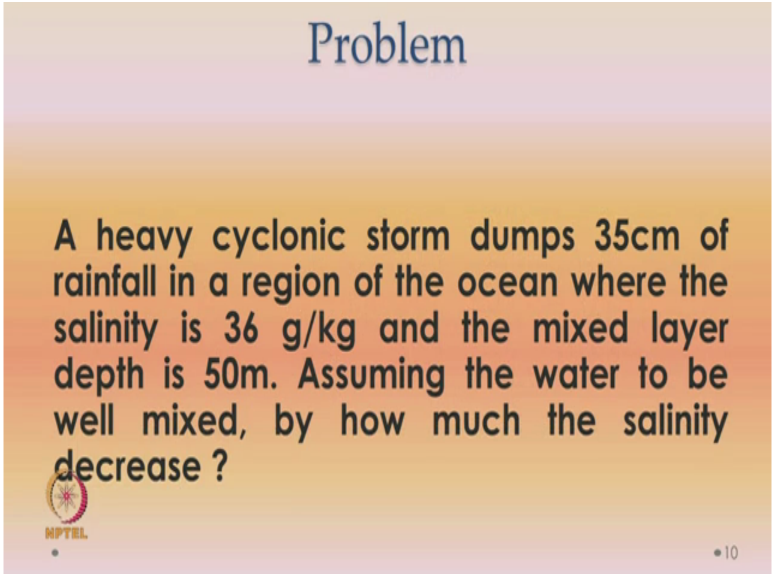
Right now it has come to like 35, 50 paise or whatever because more people has become affordable, okay. So now, right now, what that case it is very good, it is a very good technology on paper we can demonstrate we can show in lab experiments how would OTEC will work we can also have small demonstration plants 100 kilowatt 50 kilowatt we can have such plants in Andaman and Nicobar Lakshadweep, if it has been done by Government of India.

But to get to the next level it is going to take a, it is going to be very difficult. The other option is to just use this cold water and they use it for have a research lab and use it for air conditioning the lab or use this technology for desalination. There are several technologies available for desalination. For example, there is a desalination plant in Emily in Chennai that works on multi flash evaporation distillation and so on, right.

There also reverse osmosis plants and so on. So, this is what they can also be used for getting fresh potable water from brackish water or salt water for air-conditioning laboratories and you can consume the power on board. For example, bauxite can be converted to aluminium and all that. So, you can take the bauxite into a plant ship so they will have a big ship where there will be a floating aluminium factory.

The bauxite will be converted into aluminium and the power will be produced Vortec for example. Or it is possible to combine OTEC, you will have windmills on the board ship itself. so you have a combined the solar wind, may OTEC plant whatever you can just keep on working on that, alright. So, this one slide can lead to a 40 hour course on ocean to ocean thermal energy conversion, okay. Now, let us solve a problem.

(Refer Slide Time: 08:53)



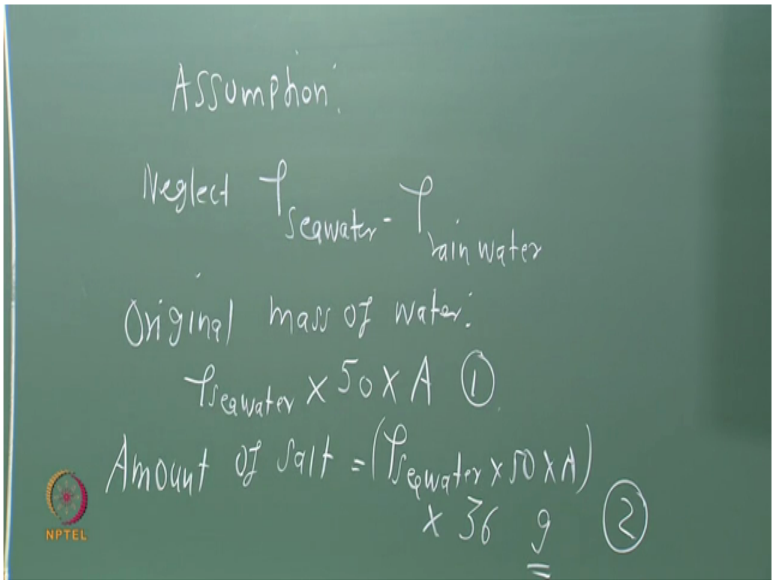
Problem number: 6. A heavy cyclonic storm, please take down the problem. A heavy cyclonic storm it is available there so I do not have to do that is good. That is a prompter which I can read from there, okay. A heavy cyclonic storm dumps 35 centimeters of rainfall in the region of the ocean where the salinity is 36 grams per kilogram and the mixed layer depth is 50 meters assuming the water to be well mixed by how much will the salinity decrease, is the question clear?

I have not told you what the area is so that means you assume a area a and this area a we come in both the Part A and Part B of the when you work out the problem there is a area a and we know that if the rainfall dumping is 35 centimeters so compared to the original volume what is a new volume. On the original volume, the salt concentration is so much, on the new volume but the salt is the same. Is the funda clear?

The amount of salt is the same but the amount of water is not the same because the rainfall after the rainfall the amount of water in the ocean in that region. Do not ask me questions Sir, this water will diffuse and you go all that is fine, okay. Let us consider a particular area a and then let us see how additional rainfall will increase the salinity or decreases the salinity, very good. So, conceptually you know that it has to it will decrease the salinity, okay.

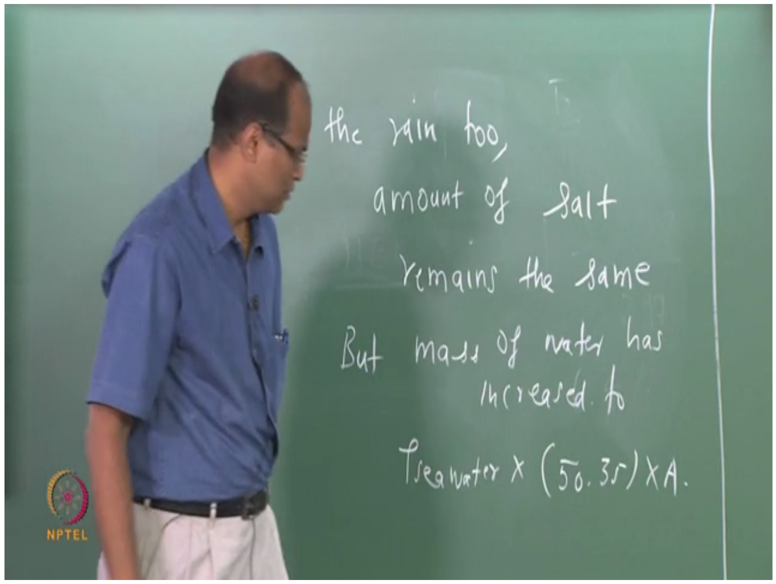
I want a number solve it and get the solution but some I have to we have to make some assumption. What is the primary assumption? Say it again. Density of seawater and the density of rainwater we do not consider the difference. Otherwise that will agonize this thing further. So we assume that the Rho of the seawater and the Rho of the rain, rain water is the same, okay. So, let us start working out.

(Refer Slide Time: 11:23)



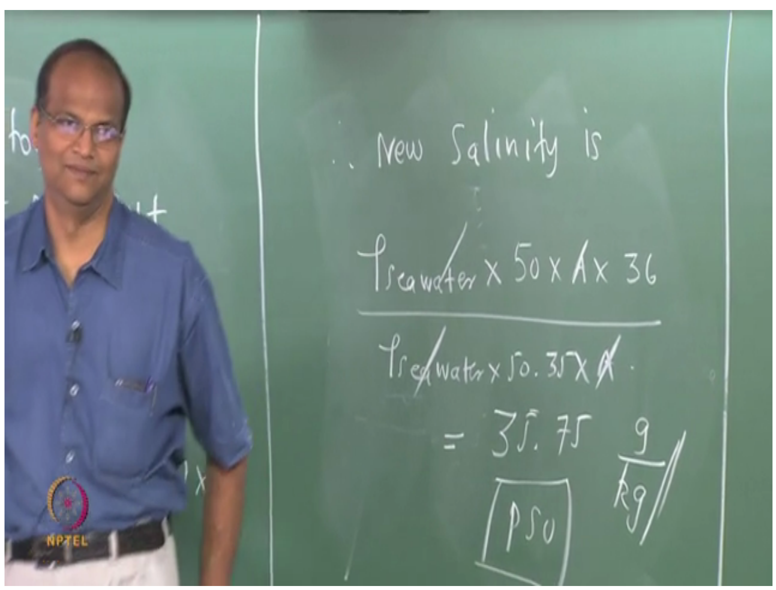
So, problem number six. Assumption: original mass of, original mass or original mass of water, row of seawater into volume into some A, orbit A, okay. What is the amount of salt, so what is the amount of salt contained in this mass of water, okay. Amount of salt is Rho 36 by 36 you want 36, this will be in kg know, if you make it, this will 36 grams, okay. Or says you can just say as 10 to the power of 3 and make it kg. This is okay, all right. Now, any doubt? What is in okay?

(Refer Slide Time: 13:39)



After the rain also, after the rain too, the amount of salt remains the same. Photo shoot is over, ah. So, it means have to become oh very good let this also come. No problem, okay. So, now I am more relaxed. So, the amount of after the rain into, the amount of salt remains the same, okay. But mass of water has increased, has increased to Rho sea water in 250 point. What did I say? 35 centimeters, 50.35 into A, this is correct okay.

(Refer Slide Time: 15:03)



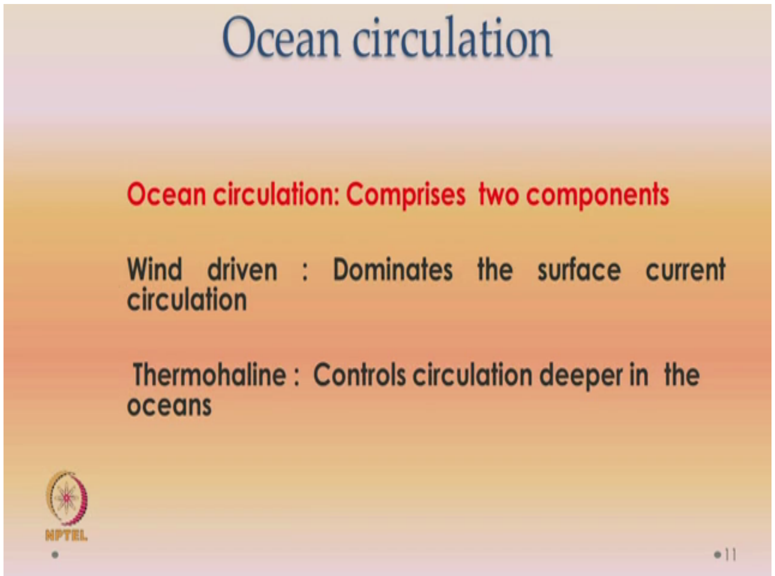
Now, therefore new salinity is new salinity Rho sea water into 50 into A, okay. 35.79 grams per kg, okay. Please check under, 35.75. What is this? It is a simple elementary problem. But it just gives you reinforces the basic concept of salinity. You will not forget the concept of salinity by now, right. So, if it is fresh water rain, rain happens in the salinity will go down. Is it okay? Now, shall we proceed?

So, the salinity is basically, how is the salinity measured? Concept, you take 1 kg of 1 liter of water and dry it, you will get solid. What is this Sir? Take a sample of water get the electrical conductivity, you take a sample of salt water get the electrically conductivity, calibrate the electrical conductivity directly. There is a stud, a most IIT way of okay right. So, this is, so you can measure it using the change in electrical conductivity of water within the presence of salt.

And then, this can be directly calculated to practical it is put as usually denoted as not public sector undertaking. Practical salinity units, okay 35 that means 35 grams per kilogram, okay. So, the next, the next player within this ocean, is basically this ocean circulation. Ocean circulation is very, very important you must have heard somebody must have told you about Gulf Stream and this thing and okay the remains, okay which keeps the Europe cool and all that, right.

You heard about Gulf Stream and all that, all right okay. So, the ocean circulation basically comprises two components. One is the wind-driven so the wind-driven is basically because of the effect of winds, there is a circulation.

(Refer Slide Time: 18:18)



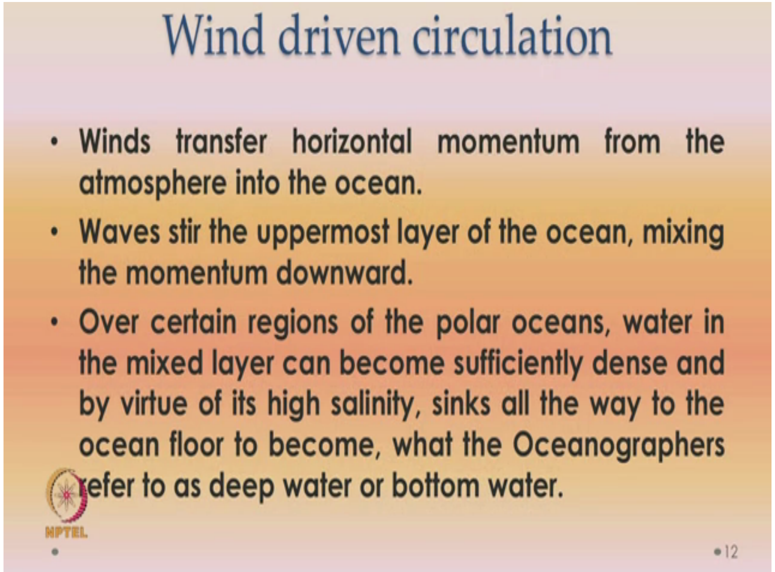
But as I have already indicated on the blackboard, the wind-driven convection wind driven circulation will dominate only the top layers because the wind cannot penetrate the bottom layers of the earth. So, it is restricted to the top layers of the ocean only. But for deeper circulation it is basically the thermohaline convection. Thermohaline means, there are two effects: thermo and haline.

That is temperature differences within the water as the depth increases we already seen the temperature changes and also the salinity changes because of this thermohaline effects, there is a deep circulation which can take place from the equator to the pole. And if you just mark if it is RFID or one parcel of water it may take hundreds of years to come back to the same position. It is a slow circulation but it is a steady circulation.

We are looking but we are looking at timescales corresponding to our life 80 or 100 days for the earth is basically 1000s of years or million or more, right. So, this circulation is very slow. Now, let us see the wind-driven circulation I will make this notes available to you, okay. So, the winds transfer horizontal momentum from the atmosphere into the ocean. So, the winds are responsible for the so called ocean atmosphere coupling.

If you want to solve the accurately this problem, you have to solve with the governing equations of the atmosphere, the governing equations of the ocean and then, this heat. Then, this interfacial flux also has to be taken into account.

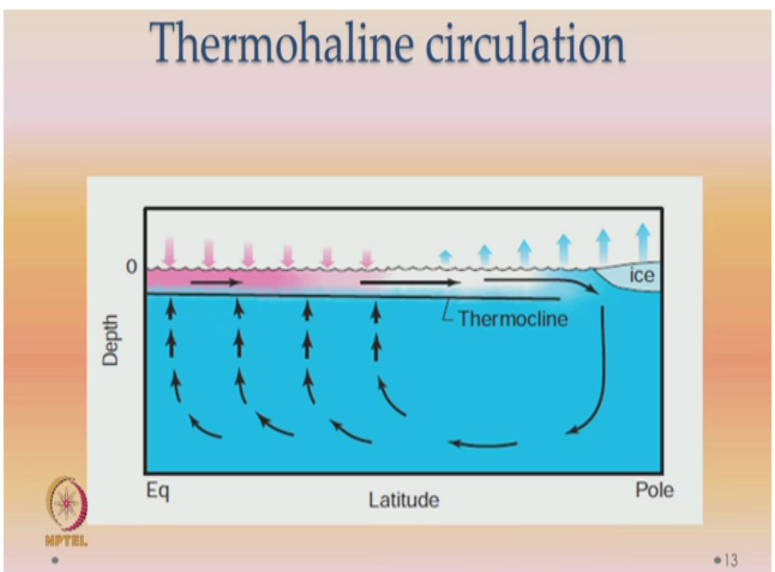
(Refer Slide Time: 19:41)



So, this winds transfer horizontal momentum and then, the wave stir up the uppermost layer of the ocean mixing the momentum downward. So, there so the surface effect leads to some subsurface effect also. Over certain regions of the polar ocean's water in the mix layer can become sufficiently dense and because of the high salinity, they sink all the way to the ocean floor.

This dense water and these oceanographers refer to this Rho oceanographers refer to this as the deep water or bottom water, okay. So, this if you want, you can take down this picture.

(Refer Slide Time: 20:17)

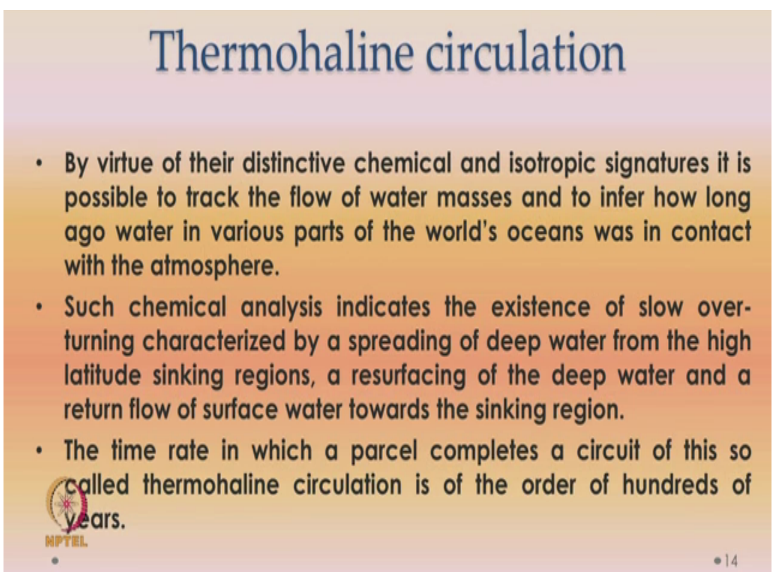


This is basically the thermohaline, thermohaline convection, which is taking place. Now, this is from basically from the equator. This is from the equator to the pole, here in the low latitude region there is lot of there is lot of incoming solar radiation that is dominating whereas when you go here the incoming solar radiation is less because of ice and snow ice and other things, the reflectivity is very high.

So, what happens is, as it comes like this then it becomes denser and denser and there is also more salt it and then icebergs, ice and salt later nice is there, that it sinks all the way up to the bottom. Then what happens is here, the salt is rejected then, it sinks down then, the circulation continues then, it goes to lower latitude then water becomes warm and water becomes warm again becomes lighter then it goes up it comes here.

Its heat from the solar radiation it goes and so there is a natural convection loop, which is setting which is the effect of so, the basic things are the radiation at the surface and then, the thermohaline convection which is taking place because of the density differences as well as the temperature differences within the ocean. So, this is called the thermohaline convection the thermocline is indicated in the figure, all right okay.

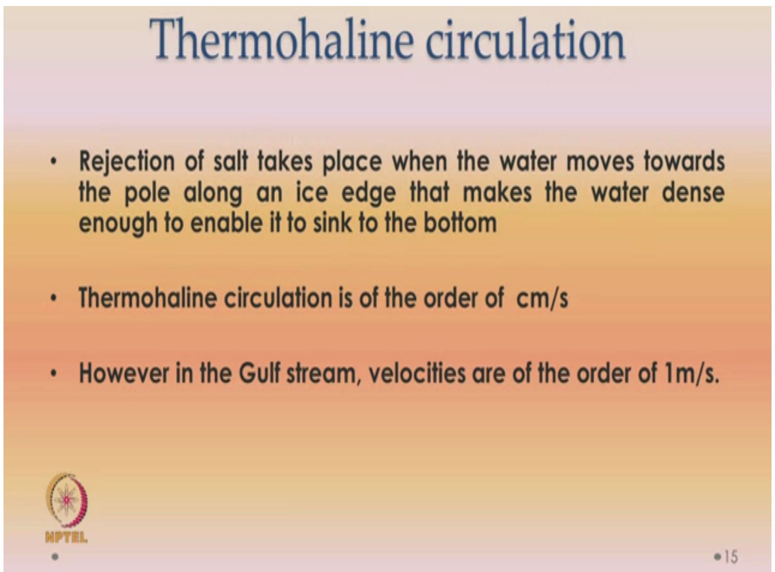
(Refer Slide Time: 21:32)



So, I have already explained this let us run through this by virtue of the distinctive chemical and isotopic signatures it is possible to track the flow of water masses and we can actually infer how long it has taken for various parts of the oceans was in contact with the atmosphere. We can actually date them. So, such chemical analysis indicates the existence of slow overturning characterized by spreading of deep water from high latitude regions researching resurfacing of the deep water and the return of the surface water towards the sinking region.

The time rate in which a parcel completes a circuit in this so called thermohaline convection is of the order of 100 of years. One particle to complete it takes 100 of years, okay. That is your time constant.

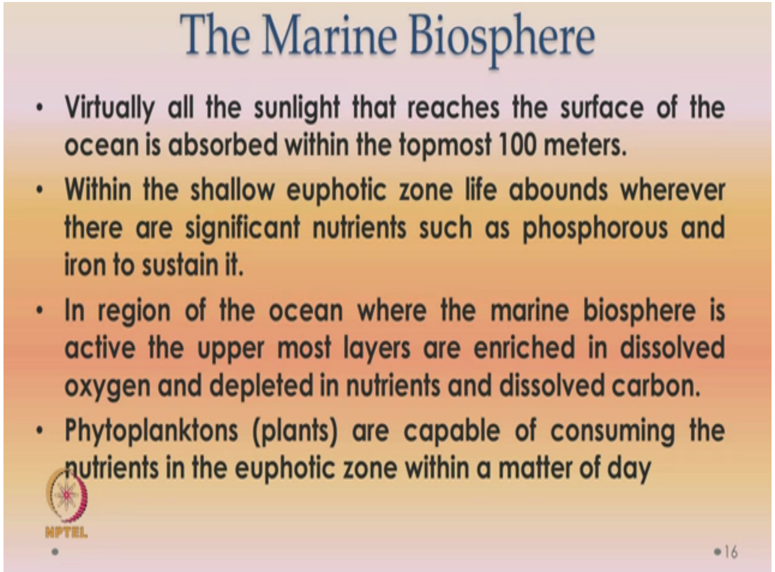
(Refer Slide Time: 22:20)



As I already explained rejection of salt takes place when the water moves towards the pole, along a ice edge that makes the water dense, okay. And then, when it becomes dense the water sinks down, okay. So, thermohaline circulation is the order of centimeters per second. However, in the Gulf Stream, velocities of the order is of one meter per second. The Gulf Stream is responsible for making, the making Europe highly habitable.

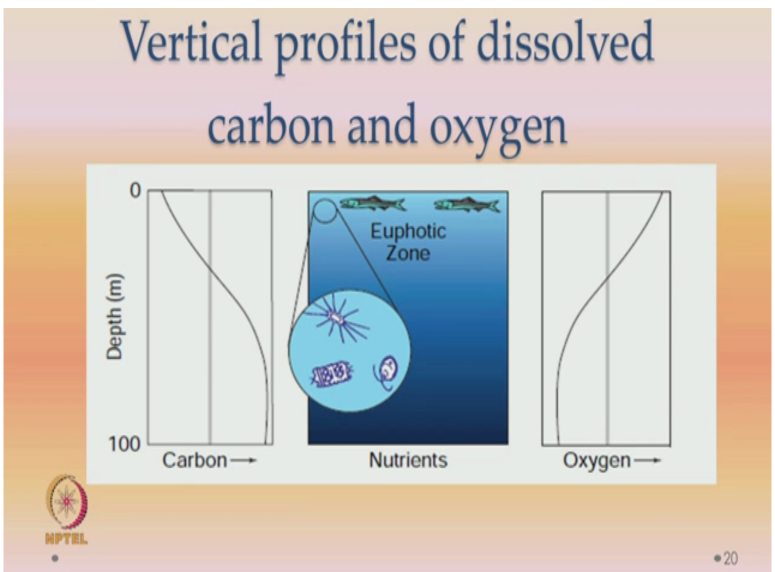
In fact civilization started in Eurasia you know that right because Europe even though it is 40, 50 degrees latitude, the Gulf Stream is responsible for maintaining equitable climate, okay. So, we can discuss why everybody's looking, giving perplexed faces. You know you have not discussed in any of the other courses, right. So, Gulf Stream is a major player. We can discuss this later, all right.

(Refer Slide Time: 23:08)



What about the marine biosphere, ok? The marine biosphere, ok, so, first I will show you the picture.

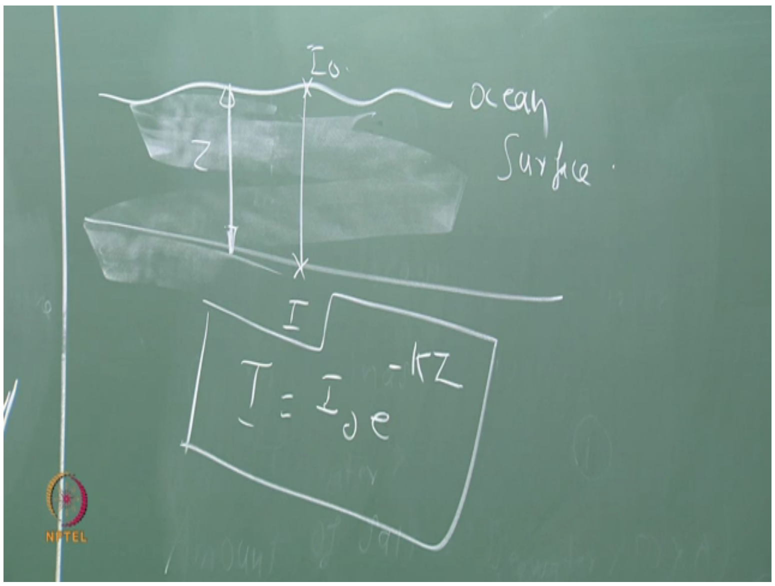
(Refer Slide Time: 23:17)



And then you can figure out. So, this is basically the depth versus carbon content in the ocean waters. Left side left panel, left panel gives you the depth versus carbon content the carbon content is very low in the first few meters then, it become it increases in the lower half. Why? Many phytoplankton and they die and come down and then, that carbon accumulation is there. And then, oxygen, obviously oxygen is very any near the surface, oxygen is very high near the surface.

And then, as you go down, the oxygen concentration decreases. There is no photosynthesis at deep layers, all right. Now, there is something called the euphotic zone, okay which is the first hundred meters. We will discuss about this. This is picture clear? Vertical profiles off you can just qualitatively take this. This will help you to understand the discussion better, okay. Virtually, all the sunlight that reaches the surface of the ocean is absorbed within the top 100 meters okay because this follows.

(Refer Slide Time: 24:39)



So, this is the intensity at any Z, you want the intensity I, so, the intensity I is given by this called the Beer Lambert's law of radiation. But Kappa is the absorptivity of the sea water, okay. So, this called the Beer's law, Beer Lambert's law or whatever. The Beer's law as applicable students who have taken my radiative heat transfer, you already know this. The Beer Lambert's law is a asymptotic version of the general radiation heat transfer law where it is highly absorbing and weakly emitting, okay.

It is highly absorbing and a weakly emitting medium, all right. Now, because it is like this the absorption is more in the top layers, the absorption is less in the bottom layers this is one of the principal reasons why temperature decreases with height in the oceans. If temperature decreases with height in the ocean the top layers are less dense. They are available at the top the dense layers are available at the bottom. This leads to some stable conditions stable stratification in the oceans is responsible for maintaining stable conditions in the oceans, okay.

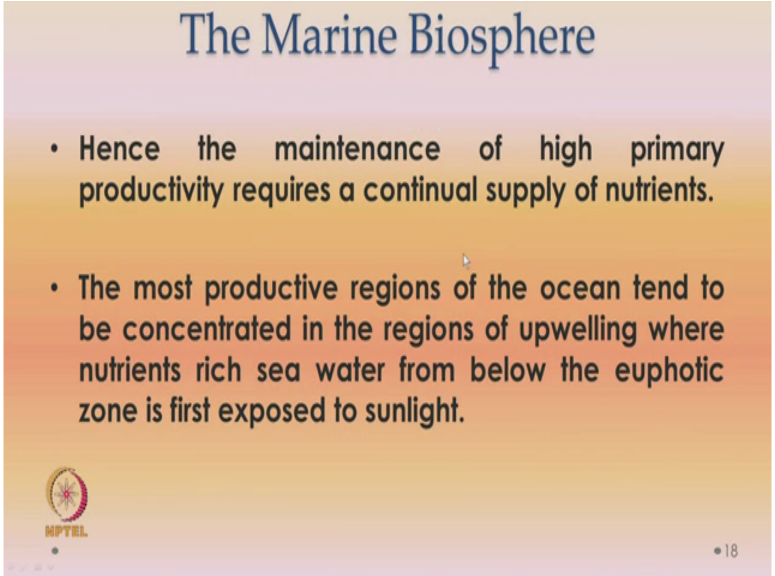
This is also responsible for the maintenance of aquatic life, okay but the point is I is =I naught e to the power of - K is at a depth of 3 kilometer 4 kilometer hardly any radiation will reach. So, there is no photosynthesis possible at this lower level, lower levels. How do these marine organisms, how will they survive? Is my question clear? So, how are these fellows surviving?

Nutrients fall down are there, okay. So, or these phytoplanktons are dying and they are going down and these fellows will, these fellows will take them, there are regions where the upwelling takes place suddenly from bottom there is an upwelling and then upwelling and downwelling where just like some Springs are created, within the ocean. There are some currents locally there will be some recirculation of these nutrients.

Otherwise what you are saying is correct. All the fellows the phytoplankton which are involved in photos in this and all that which are very active in the first hundred meters after all that they will decay and die when they sink to the ocean floor these fellows will lead them and for the fishes and other things they can swim and get it. And there is no problem, okay. For the plants, it is a problem, okay.

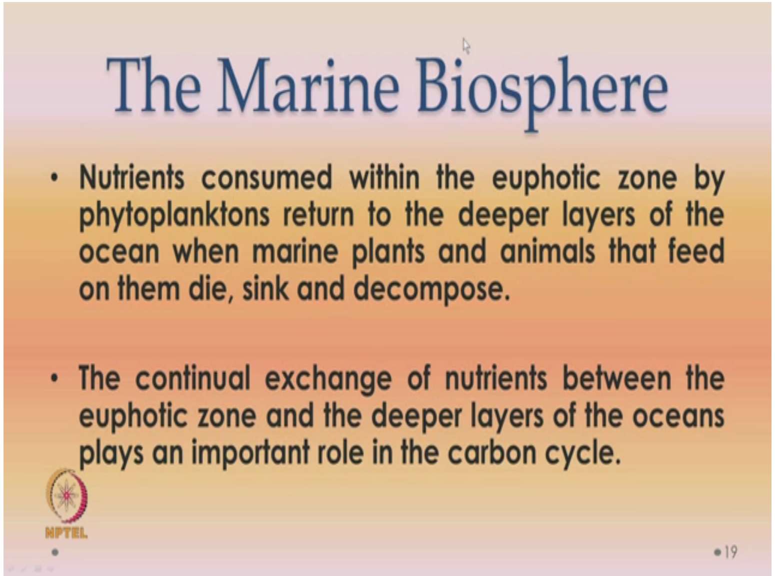
In the region where the marine biosphere is active the uppermost layers are enriched in dissolved oxygen and they are depleted in nutrients and dissolved carbon, okay. So, phytoplanktons are capable of consuming the nutrients within a matter of a day predominant, predominantly this phytoplankton which are single celled. So, there is not much complexity with regard to marine organisms right, in order with regard to marine life. But there is a lot of diversity in our terrestrial, right okay.

(Refer Slide Time: 28:23)



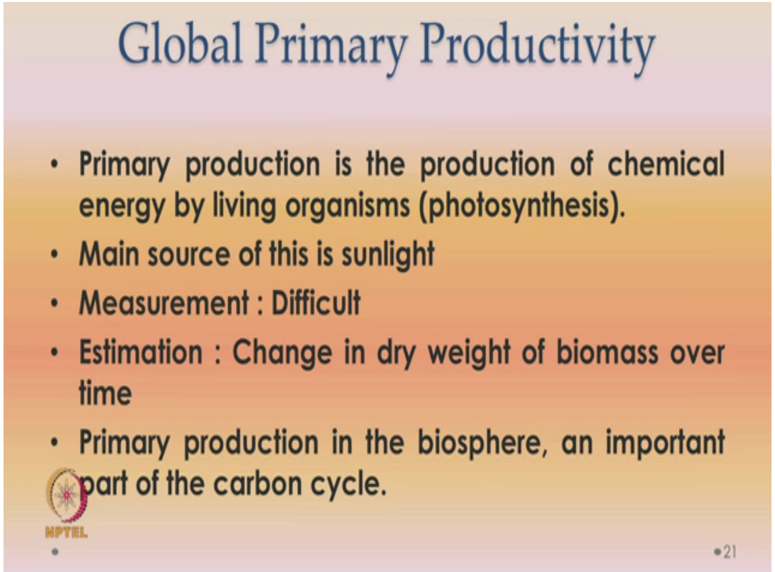
Hence the maintenance of high primary productivity requires a continuous supply of nutrients. How does this continuous supply of nutrients take place? So, as somebody said so, there is a there are regions of upwelling, where suddenly nutrient rich seawater will just flesh out from bottom to top and then it gets dispersed and this is taking place regularly, right.

(Refer Slide Time: 28:42)



Nutrients consumed within the euphotic zone by phytoplankton returned to the deeper layers where marine plants and animals that feed on them die, sink and decompose. The continually exchange of nutrients between the euphotic zone and the deeper layers plays a very important part in the carbon cycle which we will see in a later class. This we have already seen all right.

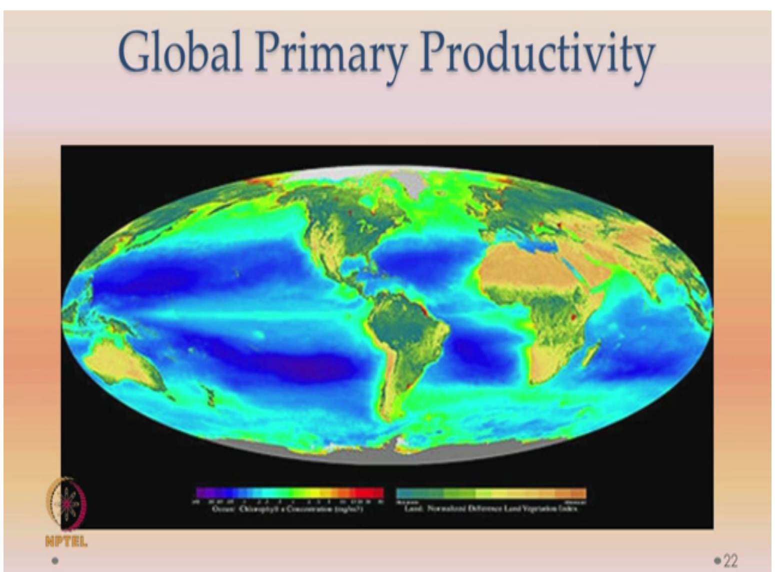
(Refer Slide Time: 29:02)



There is something called GPP global primary productivity. Primary production is the production of chemical energy by living organism. How much energy we produce by photosynthesis? So, the main source of this is sunlight. So, we cannot measure this directly the measurement of this is very difficult. So, estimation is basically done by change in dry weight of biomass over time. And how is it done? It is done with the help of satellites, okay.

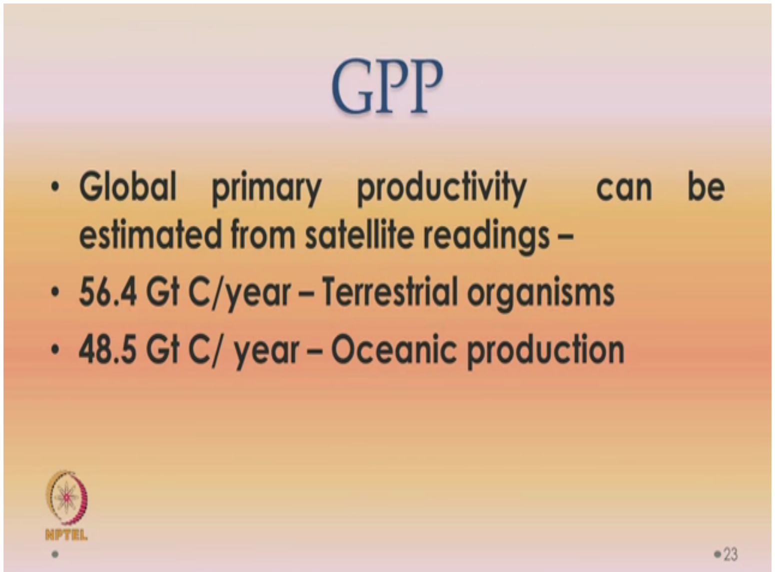
You have a satellite derived estimate. So, the primary production of the biosphere is an important part of the carbon cycle, okay. So, this some satellite derived picture. You can show that you can see the color pattern.

(Refer Slide Time: 29:42)



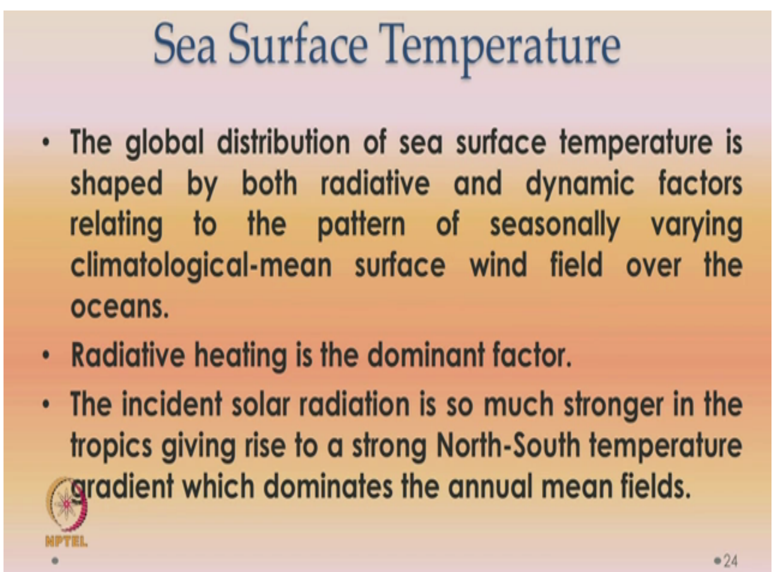
So, some places it is less, some place it is more. So, you can see that this is the distribution of, I am sorry about this, you are not able to see read this, is it not, okay. But anyway this is a distribution of global primal global primary productivity or GPP, okay.

(Refer Slide Time: 30:01)



So, it is 56.4 Geiger tons of carbon per year in the case of terrestrial organisms and 48.5 Giga tons of carbon per year in the case of oceanic production. Total exceeds 100 Giga tons of carbon per year. This is the amount of carbon exchange which is taking place, okay. So, just have an idea of these numbers.

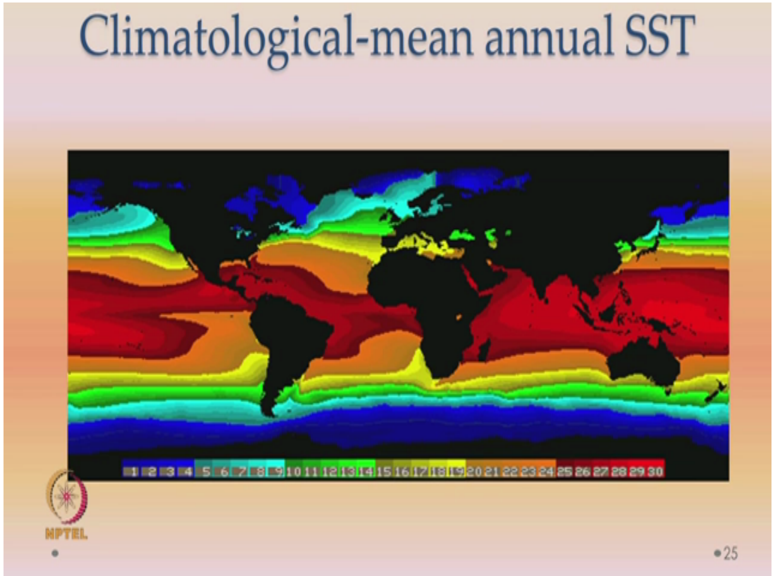
(Refer Slide Time: 30:23)



Sea surface temperature, how is the sea surface temperature distributed in the ocean? The global distribution of sea surface temperature is predominantly shaped by radiative heat transfer and dynamic factors like winds and other things which lead to the pattern of seasonally varying climatological mean, surface wind field. I mean related to the climatological mean surface wind field, okay the wind field will also determine the temperature.

But the radiative heating is a dominant factor the incident radiation is much smaller is much greater in the equatorial region. Therefore, you get a big north south divide in the temperature. Please take a look at this plot.

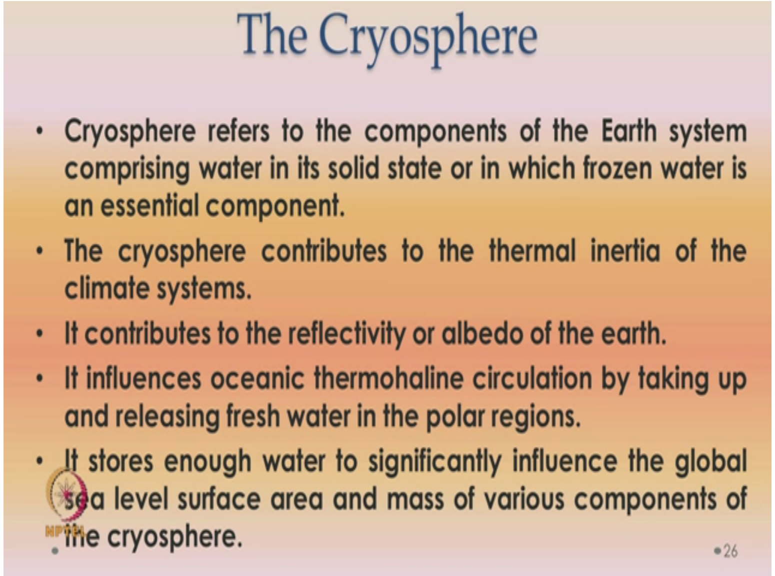
(Refer Slide Time: 31:00)



The color code is given here, okay. So, the blue is very cold and then the red is the hot regions. You can see in the equatorial regions the sea surface temperature which is called as SST. The sea surface temperature is very high. And then, slowly decreases and therefore you can see near the a Greenland and all that. It is very less, okay. And generally, the sea surface temperature remains constant for example around Chennai it will be about 29 or 30 degrees throughout the year, okay.

So, this is the Climatological Mean Annual. That means January to December you measure and take the average. And then, when you do it or many years it is called the climatological mean, okay. Cryosphere.

(Refer Slide Time: 31:43)



The next thing we are going to consider is the cryosphere. The cry since it is descriptive I put it in the form of PowerPoint. It will be very boring to write it on the board, right. So we will quickly finish this and in another two classes. And then, we will get to the earth thermodynamics, right. But in hydrological cycle and all that we solve some problems also, right. But the quizzes and exams are only problems, okay with the neat sketch explain the cryosphere, okay.

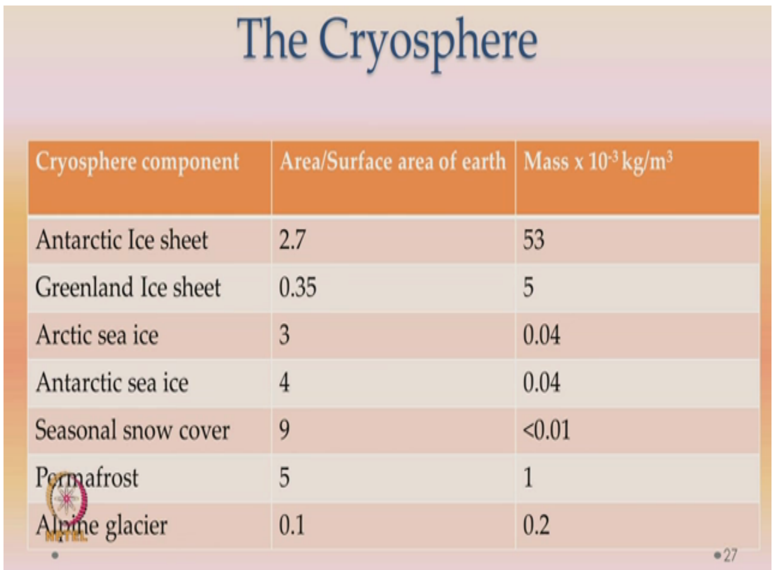
So, cryosphere refers to the components of the Earth's system in the solid form where water is in its solid form or in which frozen water is an essential component. So, what do you think? Antarctic ice sheets, okay Greenland, ice sheet, Siberia. So, these are the regions where you ought to consider this. So, that is also a player in the climate. If it melts it will add to the ocean this thing and then if it melts then the reflectivity changes and so in climate change studies cryosphere is also important.

The cryosphere also contribute to the thermal inertia otherwise the earth's temperature will change much faster. It contributes with thermal inertia because first it has to melt with a lot of heat is required for melting okay and then it once it melts and then specific heat change specific heat will change. It also contributes what is called the reflectivity or albedo, the amount of radiation reflect, if incident radiation is one, how much is reflected back is called the albedo.

For the earth as a whole we call it as what is called a planetary albedo. There is a planetary albedo because of all these climate changes albedo changes. When the albedo changes then, it will lead to severe consequences, right. When the albedo changes, you can see, you can find you can actually will solve problems too, at the end of the course where we change the albedo perturb the albedo and see what happens to the mean temperature of the earth, okay.

It influences oceanic thermohaline circulation by taking up and releasing freshwater in the polar region. It shows enough water to significantly influence a global sea level surface area and mass of various components of the cryosphere, okay.

(Refer Slide Time: 33:45)



The Cryosphere

Cryosphere component	Area/Surface area of earth	Mass x 10^{-3} kg/m^3
Antarctic Ice sheet	2.7	53
Greenland Ice sheet	0.35	5
Arctic sea ice	3	0.04
Antarctic sea ice	4	0.04
Seasonal snow cover	9	<0.01
Permafrost	5	1
Alpine glacier	0.1	0.2

You can take this down this table. So, you can see the major items here are, components are major contributors of this cryophere component of Antarctic Ice Sheet, Greenland ice sheet, Arctic sea ice, Antarctic sea ice, seasonal snow cover, permafrost where it is something is frosted for more than two years continuously frosted for more than two years, it never melts, that is a permanent frost of permafrost. Siberia is there, okay.

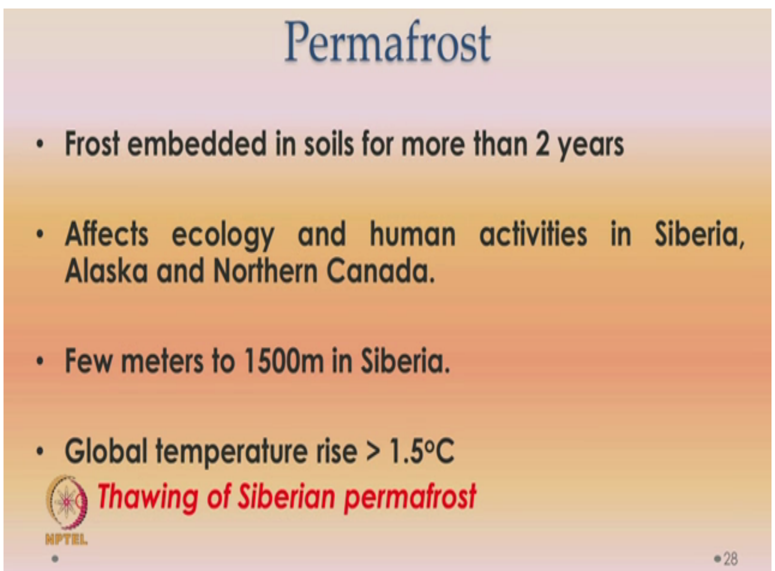
Then, alpine glaciers Alps, the glaciers, right area at the surface area of the earth it is like this so what is the total it should know if it exceeds under then it is blacki, okay. So, 2.7, 5.7, 918, 23% cryosphere contributes about 23%. The major player there is the seasonal snow cover, okay.

Now, mass into ten to the power of - 3 kilogram per meter square is given in the in the panel on the right side column number 3.

You can see that the Antarctic ice sheet has got 53 into 10 to the power of three, mass into ten to the power of - three is 53 therefore, Antarctic sheet is 53 into 10 to the power of 3, correct it is 53 into 10 to the power of 3 kg per meter cube. Very huge Greenland sea ice and Antarctic sea ice and all this, right. So, this gives you an idea we can solve problems in this suppose the whole of, I can give the next problem.

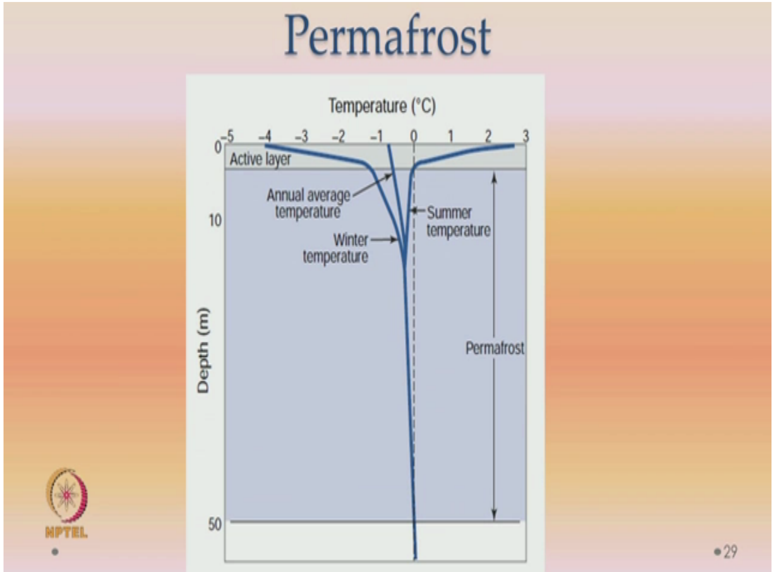
If the whole of Antarctic ice sheet melts, the whole of the Antarctic ice sheet melts, how much will the ocean, ocean rise? Just like the cyclonic storm dumping 35 centimeters you can assume a radius of the earth and all that and I will give you some depth that could be a possible good quiz question. I can consider it any of this, right. Greenland ice sheet melts what happens? And that Antarctic ice melts whatever okay.

(Refer Slide Time: 35:40)



Permafrost, what is this permafrost? Permafrost is something which is always frosted this permanent Frost, okay.

(Refer Slide Time: 35:44)



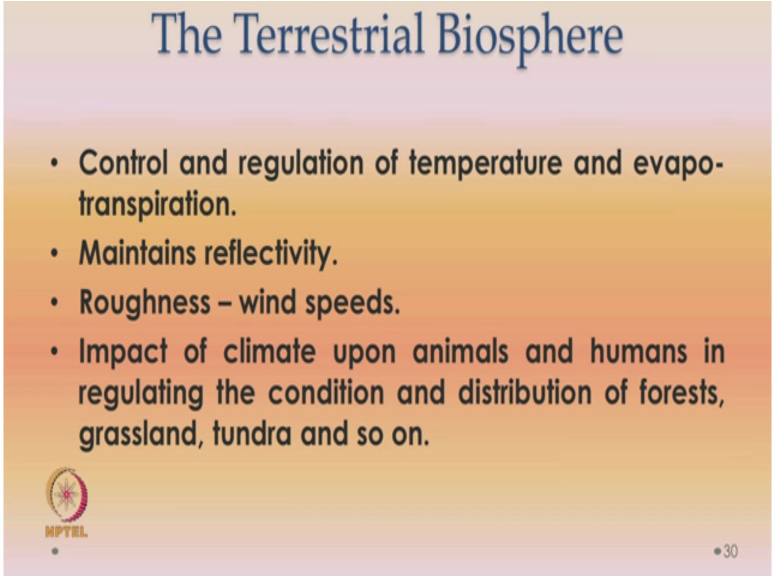
The first top layer first few meters is basically an active layer. The active layer means it will not be permanent first. During summer it will, it will melt. During winter, it will be frost. Then, below this is called the permanent permafrost, okay. So, you can take down this figure. So, depth was not so the winter temperature is lower. So, the winter temperature will vary like this, okay. And the summer temperature will vary like this and what is this fellow?

This is the annual average temperature and please notes that it has to be less than 0 degree centigrade. Otherwise there is no question of frost permafrost, okay. So, the average must be less than 0, is it okay? So, this permafrost is getting hit by climate change. Actually it has got economic consequences also. The permafrost once it melts lot of people has got access to Siberia. There is lot of, lot of oil present within Siberia now.

Let us see what this what permafrost is? Frost embedded in soils for more than 2 years is called permafrost. It affects ecology in human activities in Siberia, Alaska, northern Canada, few meters to 1500 meters in Siberia. The global, a global temperature rise is greater than 1.5 degree centigrade if the global temperature increases by more than 1.5 degree centigrade, it will lead to Thawing. You know what is thawing, right.

So, it will lead to thawing of the Siberian permafrost, so that is a danger. What is the danger level? 1.5 degrees increase in temperature, okay.

(Refer Slide Time: 37:31)



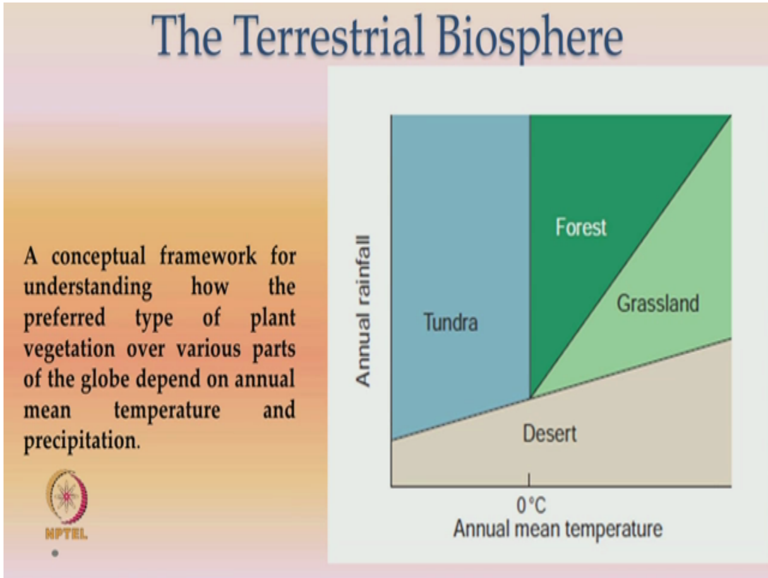
The terrestrial biosphere, okay, so, those people who are restless as to when will all this end so I will tell you the various compressed okay. So, we finished the ocean, we finished the cryosphere, now a terrestrial biosphere and then the Earth's crust and mantle, okay. Today's class we will finish the terrestrial biosphere. Next class will do the Earth's crust and mantle then, the hydrological cycle, carbon cycle and oxygen in the earth system.

Little bit of PowerPoint and then chalk and talk, afterwards, it will go to chalk and talk is that okay? Wait there is no other way of teaching this. I mean, so we have to go through this. Terrestrial biosphere is what the biosphere, the vegetation which is available not on the ocean but in the land that is the terrestrial biosphere. So, they are very important they control and regulation of temperature and evapotranspiration ok.

Evapotranspiration is transpiration and evaporation is taking place from the trees and plants. So, it maintains the reflectivity. So, if they say that if in a forest you will get more rain when you enter the campus it is little bit cooler compared to the outside is it not because of the presence of so many trees and the vegetation also increases the roughness and there is an influence on the wind speeds, okay.

So, the impact of climate upon animals and humans in regulating the condition and distribution of forests and all this, these are some of the things by which the terrestrial biosphere influences the Earth's system, ok.

(Refer Slide Time: 39:09)



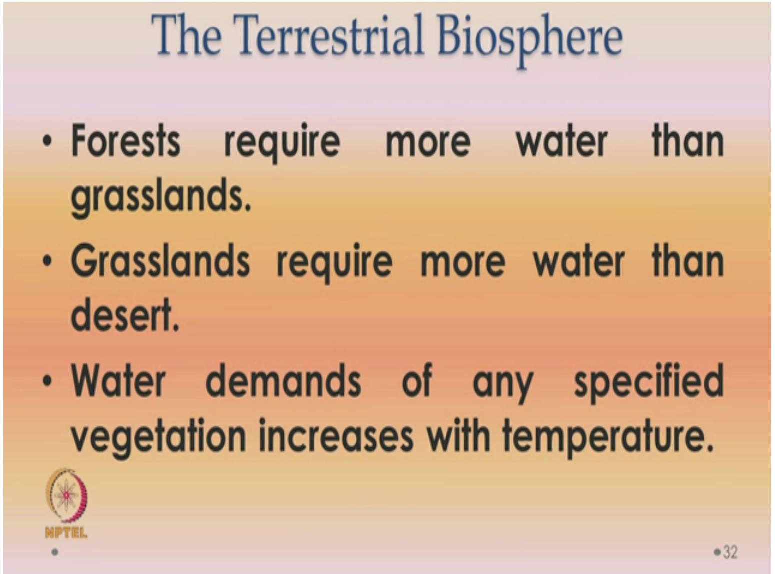
This is a very important figure you have to take down. So, this is a picture, this is a graph which shows y-axis, which shows annual rainfall on the y-axis and the annual mean temperature on the x-axis, ok. So, no rain and increasing temperatures, basically the desert region, ok, so then, there is a tundra region there is a forest tundra region, the forest on the grassland, ok.

So this is basically conceptual framework for understanding how the preferred type of plant vegetation over various parts of the globe depends on annual mean precipitation and temperature okay. So, can you argue now? What do you understand from this? For the same temperature, a desert requires much lower rainfall than a grassland and forest request very high rainfall, correct.

That is one way of understanding. That is I put a vertical then there and then, say for a given temperature, the maintenance of the desert, there is no maintenance, 0 maintenance. So, the maintenance, the maintenance of the desert requests many minimum rates. Grasslands some rainfall is required. The forest requires high rainfall to maintain, okay. Likewise, you can cut the horizontal, you can draw horizontal and say, well as the, for a given rainfall with the increasing temperature what happens, okay?

With low temperature you have the tundra then the forest and the grassland, okay. Now, if the rainfall is very less, you will not have any of this, you will only desert. So, regardless of the temperature, if the rainfall is very less, you will have a desert. That is what is shown in there, correct. This is a conceptual framework of understanding you do not ask me what are the limits of this? This is just for you to understand, okay.

(Refer Slide Time: 41:17)



Forest require, so forest requires more water than grassland. Grasslands require more water than the desert. Water demands of any specified vegetation increases with temperature. So, these are inferences from this.

(Refer Slide Time: 41:30)

We will stop here. So, any questions; Earth crust and mantle, some somewhat boring portions will be there we will finish that and then we will get a hydrological cycle where I will work out some interesting problems on precipitation and lake. There is a lot of rain, how will the lake respond to change in brain and so on. Any questions;