Geomorphic Processes: Landforms and Landscapes

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Lecture - 4
Earth Energy Budget
(Part – I)

Welcome back. So, in last lecture we discussed about the negative and positive loops or feedback. So, how the one system is affecting the another one. Similarly, as I was talking in one of the previous lectures that humans will also influence the earth system.

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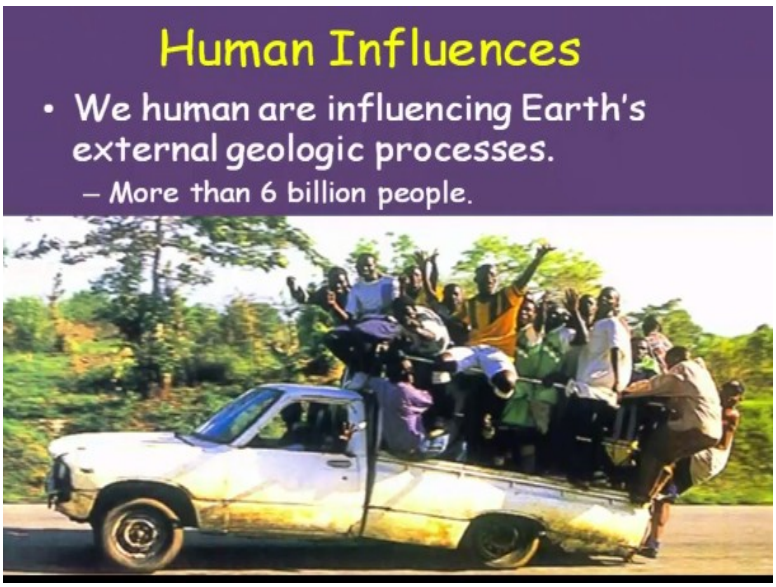

One of the reasons for influencing the earth system is the humans are influencing earth's external geological processes and that is because of the increase in population. So, what has happened is that we have the tremendous in population and we are altering some extent the environmental conditions that are prevailing surrounding us. So, this picture shows the overload in a car and this is what similarly happening in the present day world, population is tremendously increasing.

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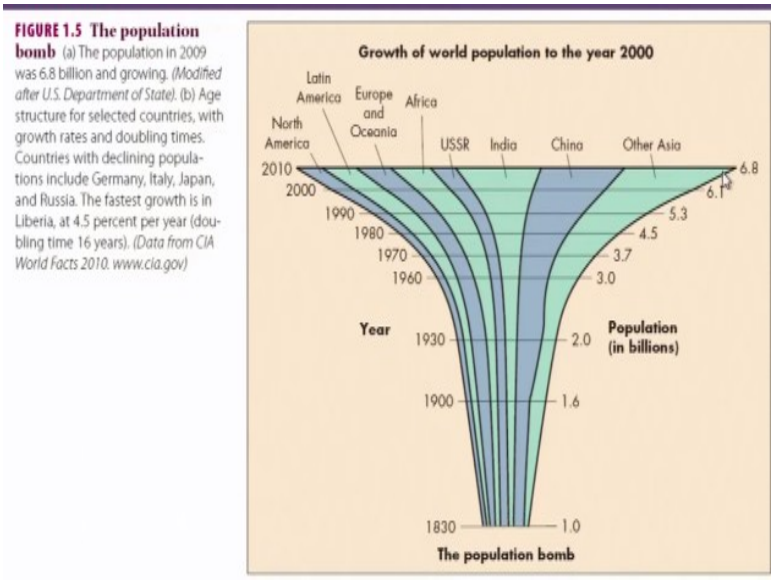

FIGURE 1.5 The population bomb (a) The population in 2009 was 6.8 billion and growing. *(Modified after U.S. Department of State).* (b) Age structure for selected countries, with growth rates and doubling times. Countries with declining populations include Germany, Italy, Japan, and Russia. The fastest growth is in Liberia, at 4.5 percent per year (doubling time 16 years). *(Data from CIA World Facts 2010. www.cia.gov)*

Now this chart it shows the increase in population over the time from 1830 till 2010, but more must have increased definitely for sure. So, the increase in population even for India if you can see is going very high and this is the world population total.

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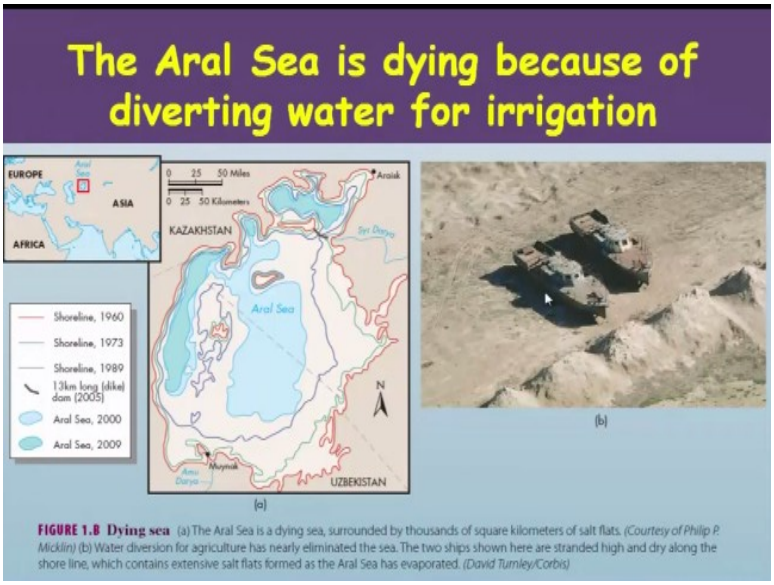

FIGURE 1.8 Dying sea (a) The Aral Sea is a dying sea, surrounded by thousands of square kilometers of salt flats. *(Courtesy of Philip P. Micklin)* (b) Water diversion for agriculture has nearly eliminated the sea. The two ships shown here are stranded high and dry along the shore line, which contains extensive salt flats formed as the Aral Sea has evaporated. *(David Turnley/Corbis)*

Now, this is one of the example, which I was talking about that could tell us and there is a lesson to learn from this example, which shows that if we alter the overall environment for our needs or benefits at present, but in long run, it can result into devastation. So, this is the Aral Sea is dying because of diverting water for irrigation. So, this is diverting water for irrigation.

So, Aral Sea has been fed by some major rivers and the dams have been constructed on that and the water has been diverted for litigation purpose and that resulted into depletion of the

water level in Aral Sea and you can see the condition that the ships are lying on the sand floor.

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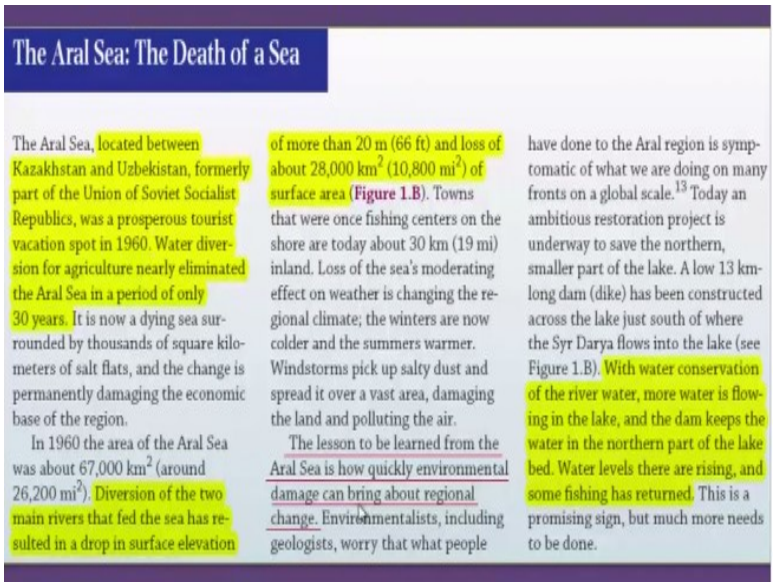

So the Aral Sea which is located between Uzbekistan and Kazakhstan, formerly the part of the Union of Soviet Socialist Republic, was prosperous tourist vacation spot in 1960. Water diversion for agriculture nearly eliminated the Aral Sea in a period of only 30 years. Just in 30 years, this area was subjected to a dry bed. Further diversion of two main rivers that fed the sea, that is Aral Sea, has resulted in drop in surface elevation of more than 20 meters and loss of about 28,000 square kilometer of surface area.

So, the lesson to be learned from the Aral Sea is how quickly environmental damage can bring about regional change. So, this has brought like changing the landscape completely. So, sea which existed is now seen as a dry bed. Now some attempts have been made with water conservation of the river water, more water is flowing in the lake. So this Aral Sea is a big lake, very huge lake actually, so they have started flowing the water into the lake and the dams keep the water in northern part of the lake bed.

Water levels there are rising, and some fishing has written. So, this has not only affected the fishing industry, but the habitat or the people who are staying close to the cost of this Aral Sea, they also were forced to shift. So, overall, it has affected the environment. So, this is important lesson to be learned from Aral Sea is how quickly environmental damage can bring about regional change.

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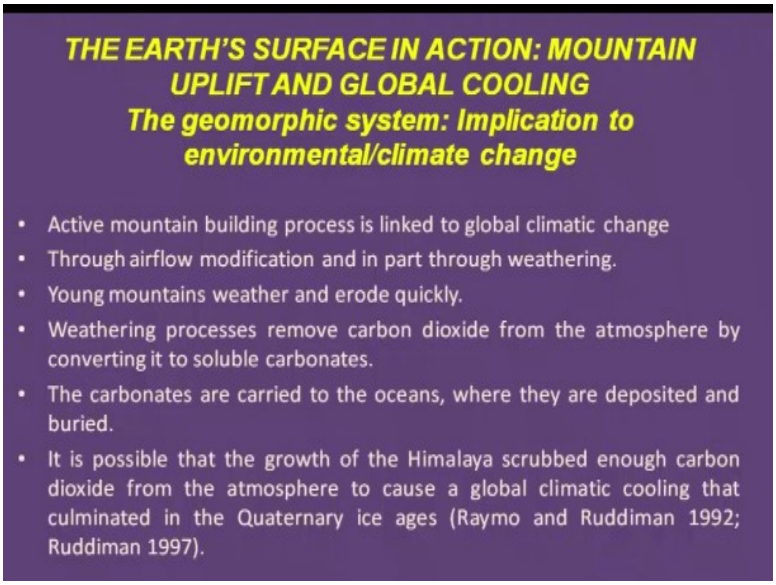

Now, another example is the geomorphic system implication to climate change. So, the earth's surface in action, mountain uplift and global cooling, how this is connected, let us see that the mountain building activity can also bring change in the climate. Of course, we all know that the Himalayas which was formed, so before the formation of Himalayas, we were not having the monsoon season, but after formation of Himalaya, towering height of the Himalaya which was achieved, we started getting the monsoon.

So, of course, this can or have brought the changes in the environment and climate also. Now, coming to this point that the uplift. So, active mountain building process is linked to global climate change through airflow modification and in part through weathering. Young mountains weather and erode very quickly and this erosion removes or weathering processes removes carbon dioxide from the atmosphere by converting into soluble climate. The carbonates are then carried to the oceans, where they are deposited and buried.

So, in one way, because if you keep on increasing the height of any mountain, the erosion will be faster and that erosion will result into the removal of carbon dioxide from atmosphere and convert it to the soluble carbonates, which will be further deposited to oceans and buried. It is possible that the growth of Himalaya scrubbed enough carbon dioxide from the atmosphere to cause a global climate cooling that culminate in Quaternary ice ages. So, this has already happened and this will happen in future because the mountain building activities continue, it has not stopped, the growth of the mountain is continuing.

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Our daily activities are having measurable effects on rainfall, climate, air, water quality, erosion.

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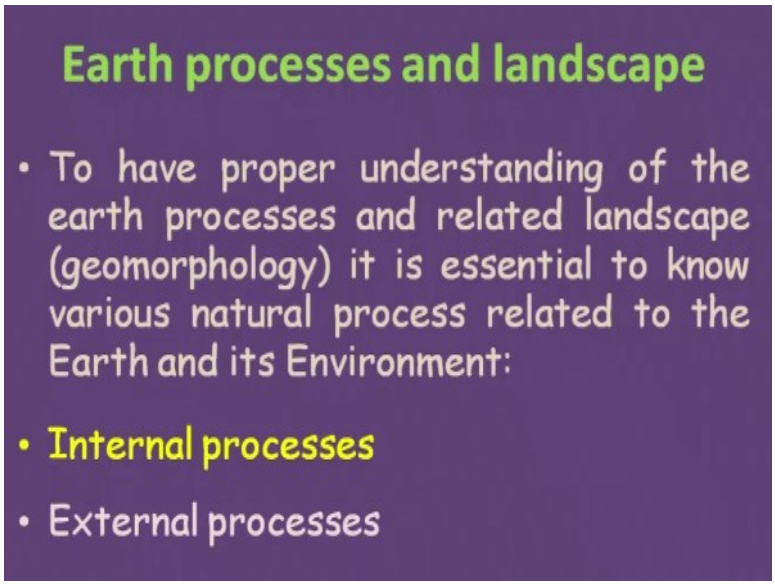

Earth processes and landscapes. So, this is the point which we have discussed that to have a proper understanding of earth processes which are operating surrounding us and related landscape that is your geomorphology, it is essential to know various natural processes related to earth and its environment. Those are internal processes and external processes.

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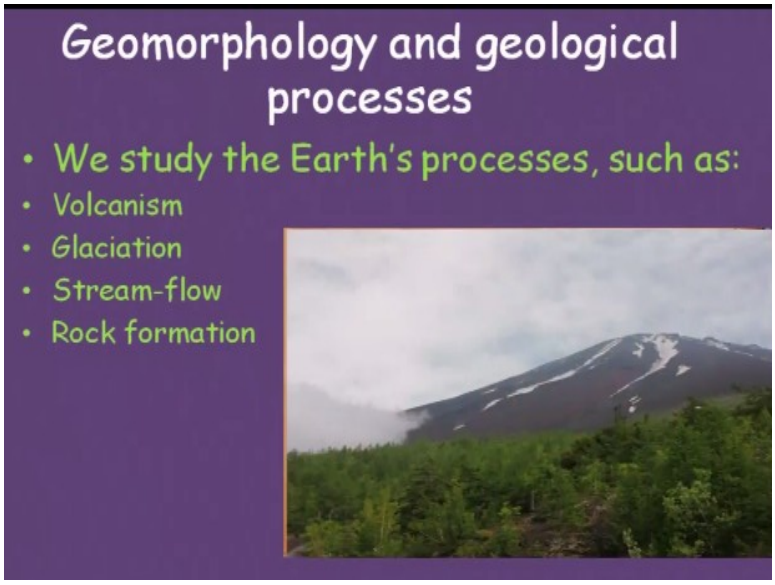

Further, we study earth processes such as volcanism, glaciation, stream flows, rock formation, etc.

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We also study to understand the minerals, how they were formed, dissolved minerals, mineral resources, rock formation and groundwater.

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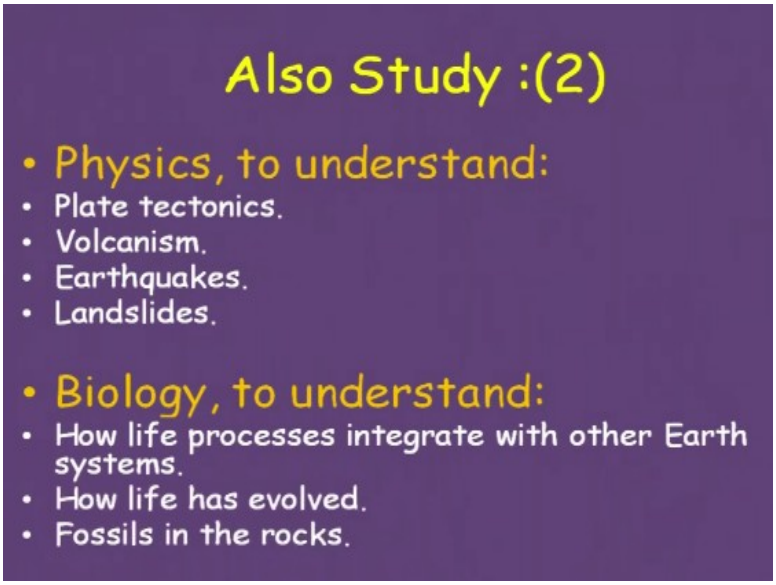

Physics to understand plate tectonics, volcanism, So now, we are towards the end of the introduction part. So, we are just trying to see the overall view of the talks which we did for the introduction part that we need to study all this to have the proper understanding of the geomorphological landscape, so earthquakes, landslides. Biology to understand how life process integrate with other earth systems, how life has evolved, fossils in rocks.

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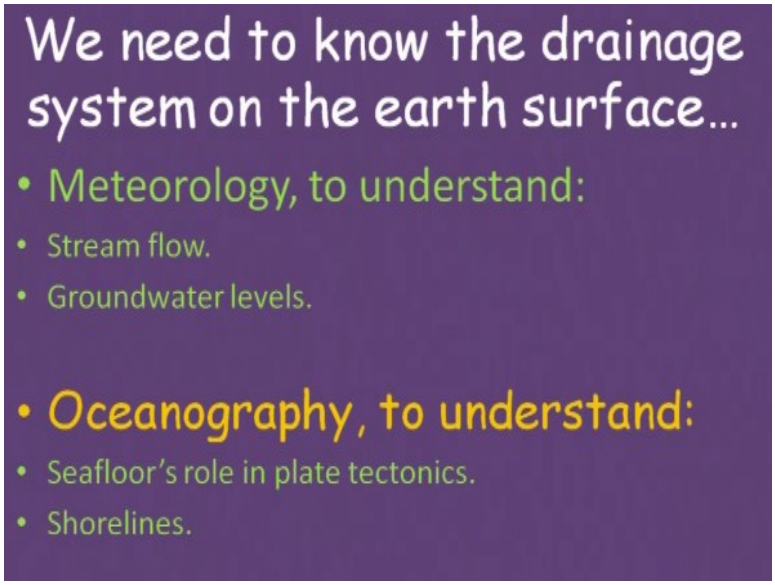

We need to know the drainage system on the earth's surface. So meteorology to understand stream flows, groundwater levels and this is connected with the floods and all that. Oceanography to understand sea floor role is plate tectonics, shoreline changes, but some of the aspects we are not going to talk in this course, but yes of course, most of them we will be covering as I told in the beginning as per the course content.

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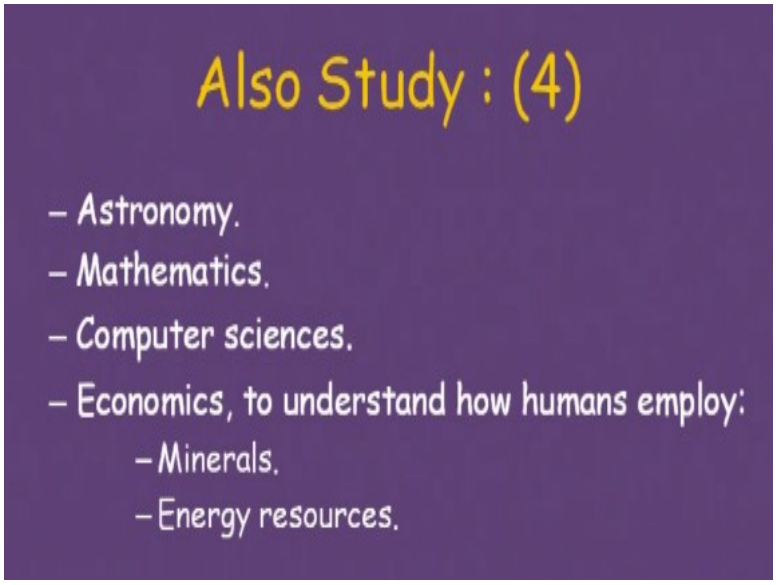

So, these are a few more which are involved astronomy, mathematics, computer sciences, economics, minerals, energy resources and all that and mainly the mineral and energy resources has been involved or to understand to know because the human wants to be involved in these resources.

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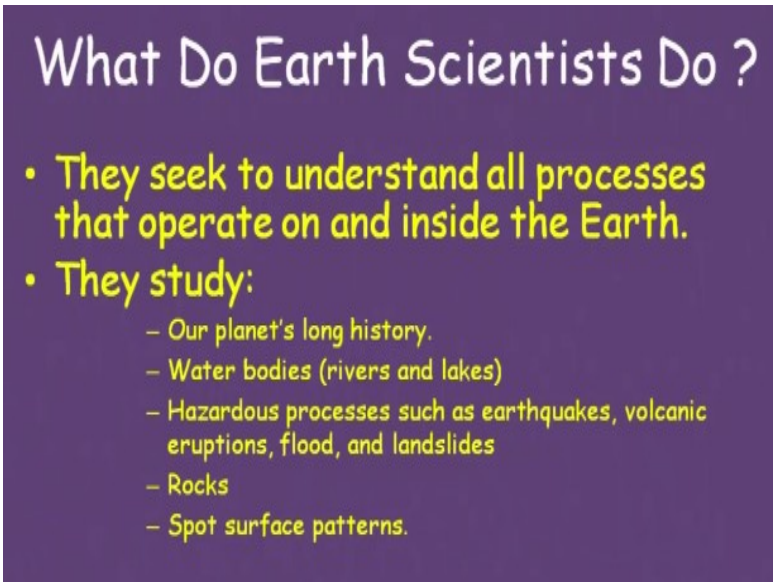

What do our scientists do, mainly they seek understanding of all processes that operates on and inside the earth. They study our planet's long history that what we call historical geomorphology, water bodies they study, the study the hazardous processes, they study rocks, spot surface pattern to understand the landscape change.

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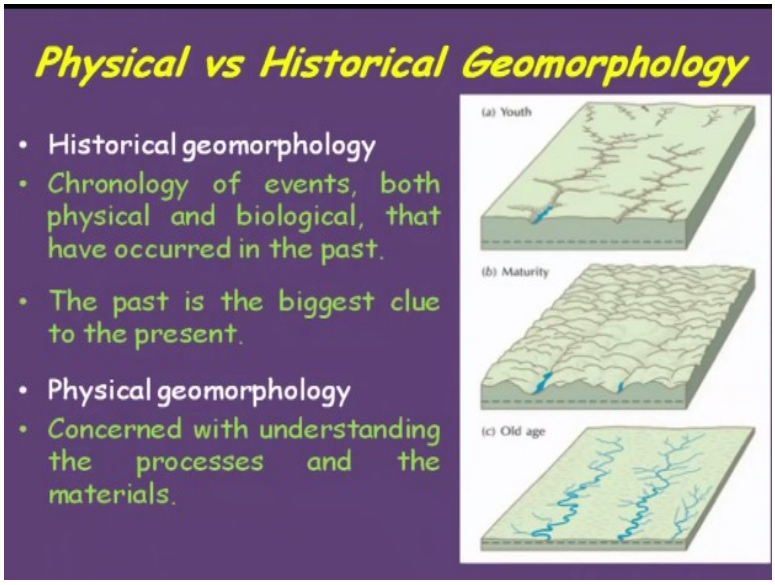

Now, this is an example of physical and historical geomorphology. So, historical geomorphology mainly is the chronology of events, both physical and biological, that have occurred in the past. The figure on the right hand side shows the evolution of the drainage over the time, where it shows youth, maturity, and old age drainage. So, this is the chronology. So timescale of how the drainage was evolved over the time. The past is the biggest clue to the present, that is what we have been talking since beginning, and present is the key to the past.

So, past also can give us a clue about the present condition and future also. So physical geography, so that is the part of the historical geography and then physical geography, what we see it is concerned with understanding the process and the materials.

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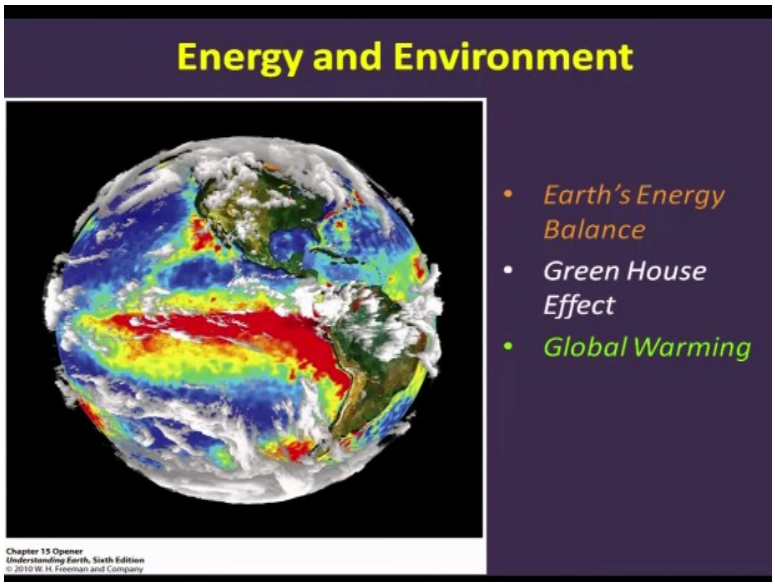

Now, let us see what is there in the energy and environment topic. So, earth energy balance, we talk about green house effect, and global warming, and of course, in brief, if possible, we have been discussing about the greenhouse effect and we have talked in couple of slides in the previous lecture also. Let us see earth energy balance.

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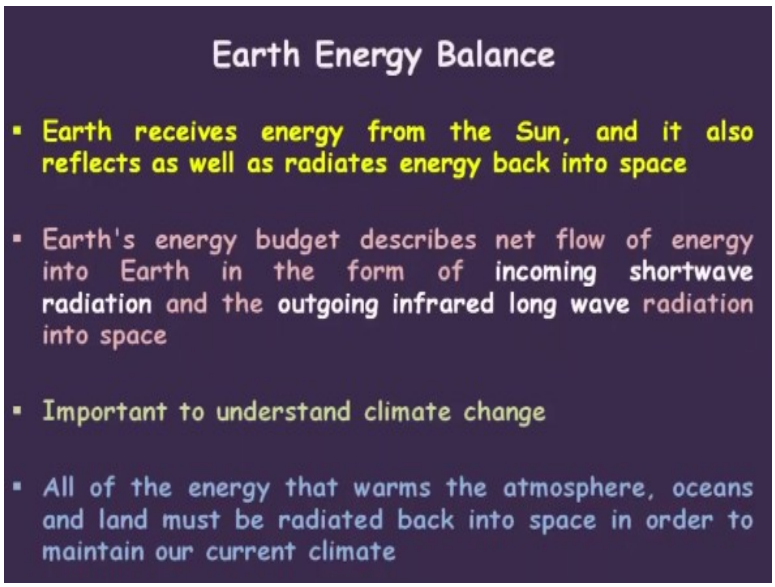

So, earth energy balance, earth receives energy from sun and it also reflects as well as radiate energy back into the space. So, not all energy which has been coming from sun has been taken away by the earth's surface or the earth. Some is reflected back, some is absorbed and transmitted back into the atmosphere and some of the energy which is transmitted to the atmosphere is also reflected back and that is how we are experiencing the greenhouse effect. So earth's energy budget describes net flow of energy into earth in the form of incoming short waves, and outgoing infrared long wave radiation into the space.

It is important to understand climate change because this will help us in understanding the landscape change also. All the energy that warms the atmosphere, oceans and land must be radiated back into the space in order to maintain our current climate, and if it is not done so, then we would not be able to support life on earth. So, this is important part that all energy which has been received or which warms the atmosphere, ocean and land must be radiated back.

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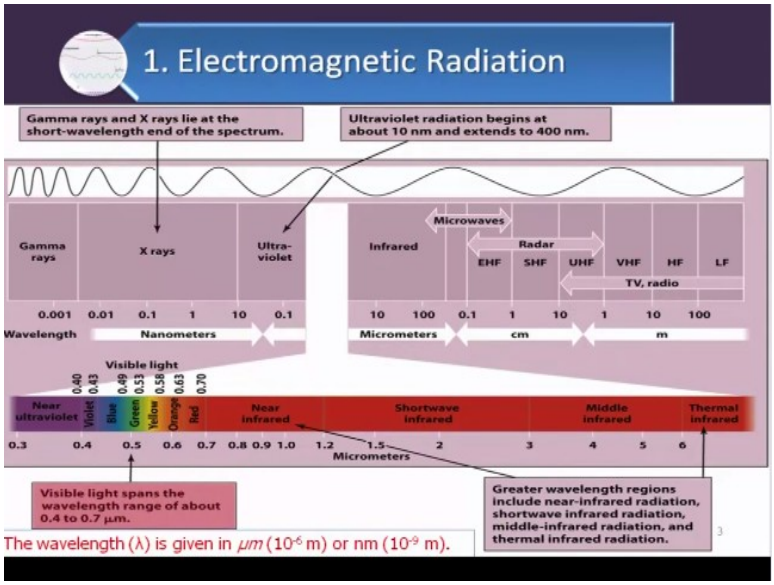

So, we have different frequencies of electromagnetic waves of the radiation. We have short waves which are coming in and the long waves which has been moved out from the earth's surface into the atmosphere. Shortwave radiation incoming and outgoing long wave radiation.

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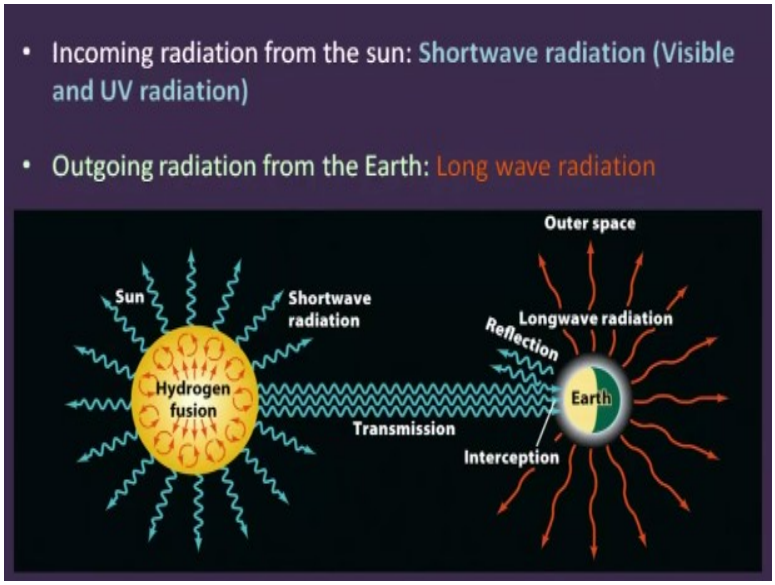

So, incoming radiation from sun, shortwave radiation that occupies the frequency range of visible and ultraviolet radiation, outgoing radiation from the earth is long term radiation, just keep this in mind.

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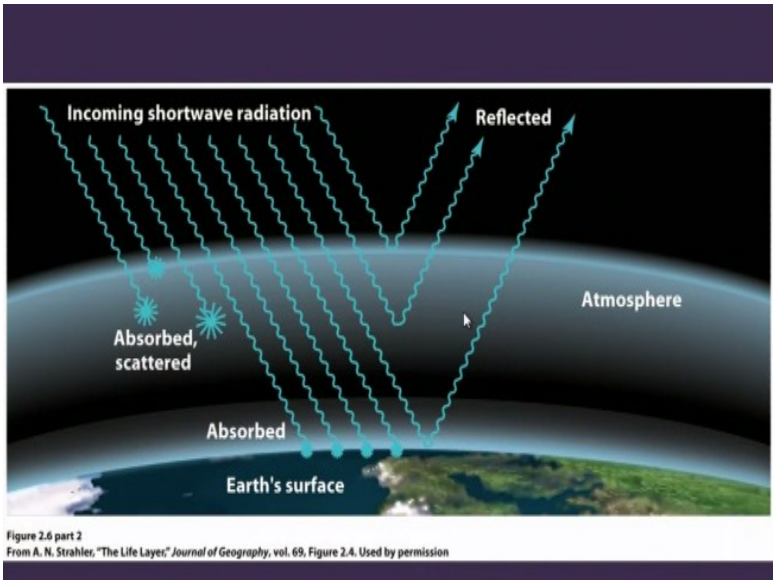

Figure 2.6 part 2
From A. N. Strahler, "The Life Layer," *Journal of Geography*, vol. 69, Figure 2.4. Used by permission

Now, here as I was talking about that not all shortwave which is coming in through the atmospheres is passed through and through to the earth's surface, some gets absorbed within the atmosphere, some is reflected back from the atmosphere, it never reaches the earth's surface, and some which reaches the earth's surface absorbed and radiated back to the atmosphere.

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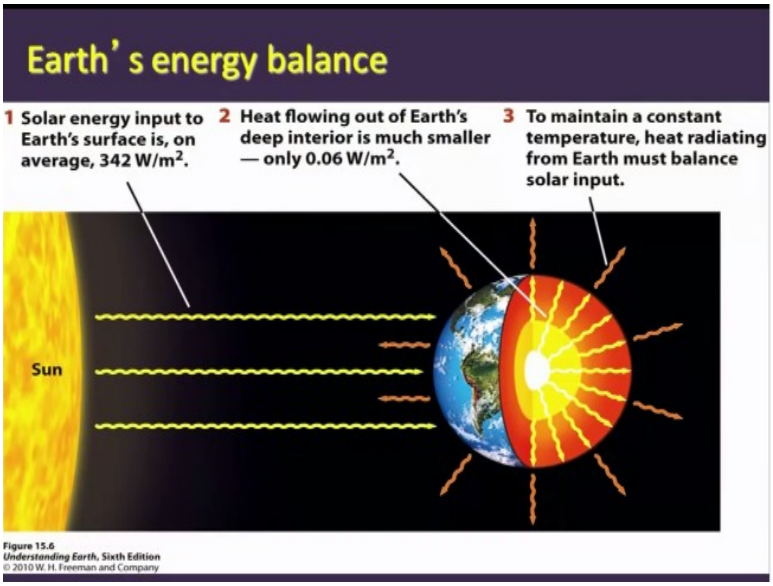

Figure 15.6
Understanding Earth, Sixth Edition

So, earth energy balance if you take solar energy input towards surface is on average 342 watt per square meter. Heat flowing out of earth's deep interior, because there is another source of heat which flows out towards the surface and this heat flow has been transmitted to the atmosphere in terms of the long radiation. So, heat flow from the deep interior is much smaller as compared to what we are receiving from the sun.

Third is to maintain a constant temperature, heat radiating from earth must balance the solar input. So, the radiation which is going out should balance the input radiation and that is how the energy balance will take place. Let us see how it is happen.

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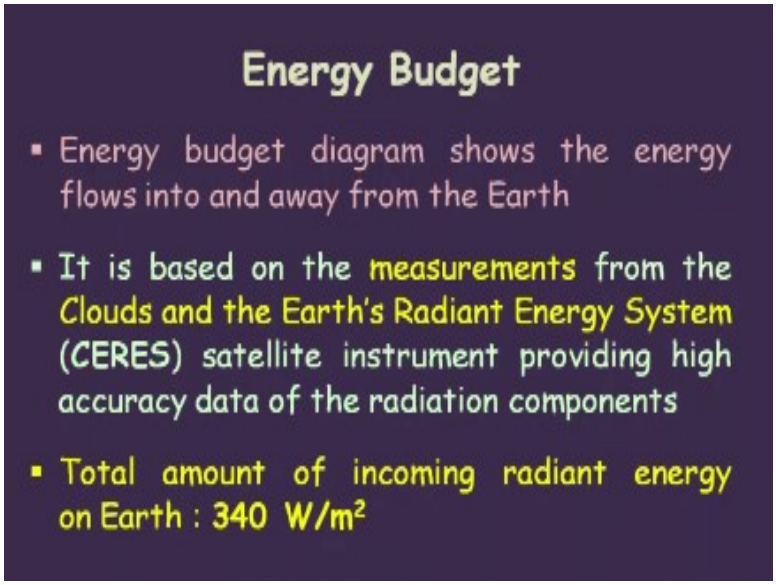

Energy budget. Energy budget diagram shows the energy flow into and away from the earth. It is based on the measurement from the cloud and radiant earth's energy system. So, it is cloud and earth's radiant energy system, CERES. So, this has been measured through a satellite instrument providing high accuracy of the radiating components. Total amount of incoming radiation is 340 watt per meter square.

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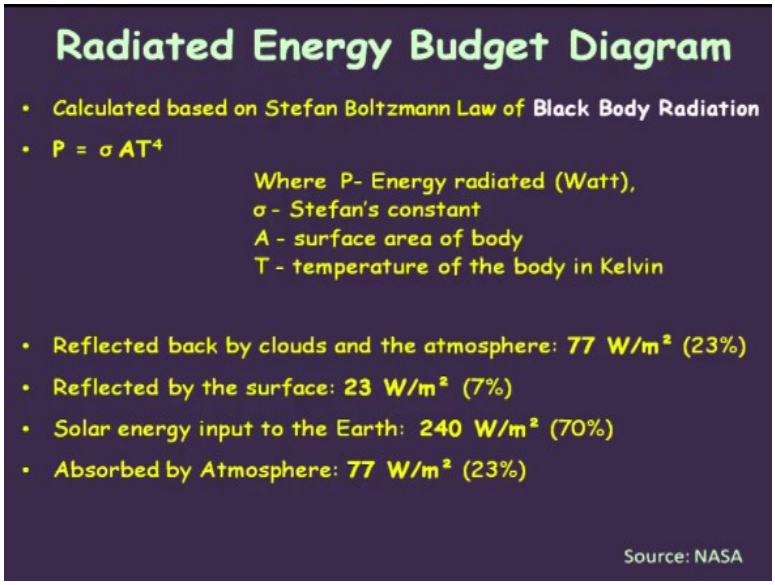

So radiated energy budget diagram, the calculation has been done based on the Stefan Boltzmann law of black body radiation. So P = sigma AT to the power 4 where P is the

energy radiated in watts, sigma is Stefan's constant, A is the surface area of the body, T is the temperature of the body in Kelvin. So, reflected back by cloud that is the energy which has been coming that is from 340, 77 watt per meter squared is reflected back by clouds and the atmosphere, 23 watts per meter square, around 7% of the total is reflected by the surface, 70% that is about to 240 watt per meter square solar energy input to the earth. Absorbed by atmosphere 77, almost of 23%.

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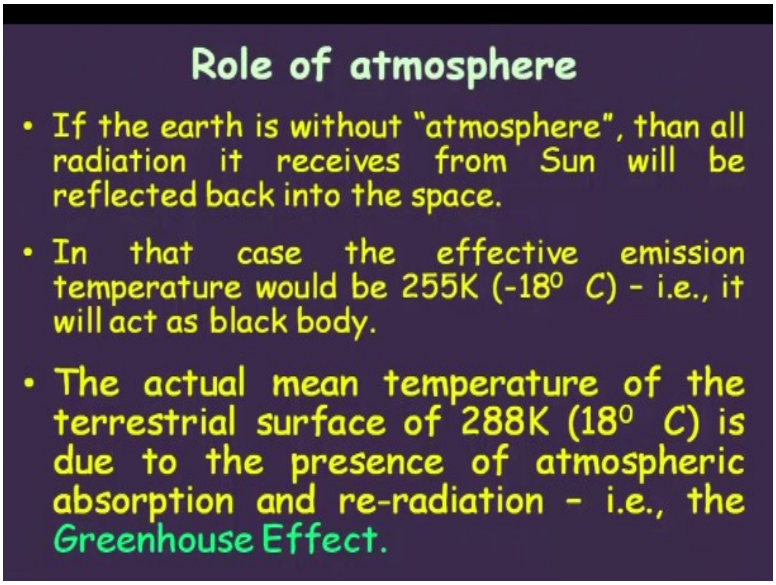

Role of atmosphere. If the earth is without atmosphere, suppose we consider that the earth is without atmosphere, then all radiation it receives from sun will be reflected back into the atmosphere or into the space. and In that case, the effective emission temperature would be 255 Kelvin, which is -18 degrees centigrade and this is the temperature which act as a black body.

So, actual mean temperature of the terrestrial surface that is our surface of 288 Kelvin that is 18 degrees centigrade is due to the presence of atmospheric absorption and re-radiation, that is the greenhouse effect, because of that, we are having the 18 degrees centigrade temperatures which supports the life on the surface, otherwise everything will act as a black body.

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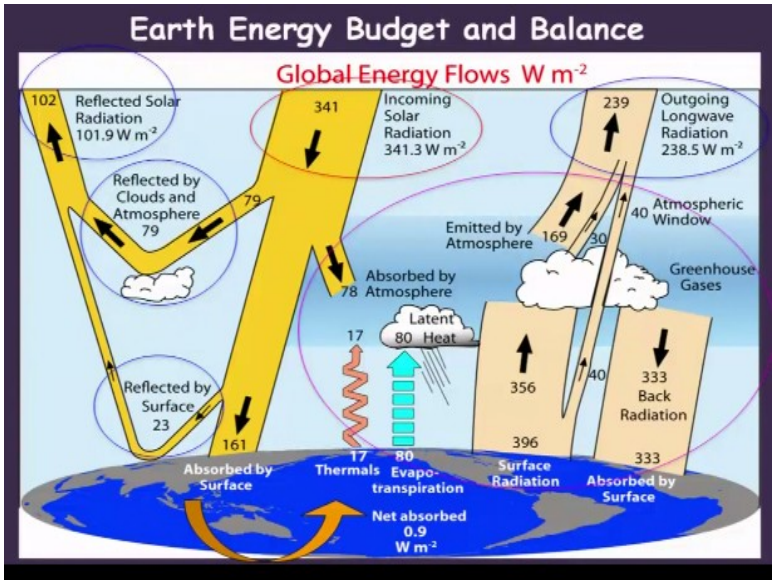

Now, if you see the energy budget here and balance. So, in total 340 or 341 watt per meter square is the incoming solar radiation. Now, out of that, 79 watt per meters square has been reflected by cloud and atmosphere and 23 is reflected back to the atmosphere from the surface of the earth. So, it takes away total 202, and on the other part, 161 is absorbed by the surface and again the absorption along with the greenhouse effect the total is reflected back is 239. So, if you add 239 and 102, which is reflected back, all which has been reradiated back to the atmosphere, then it is equal to 340 or 341.

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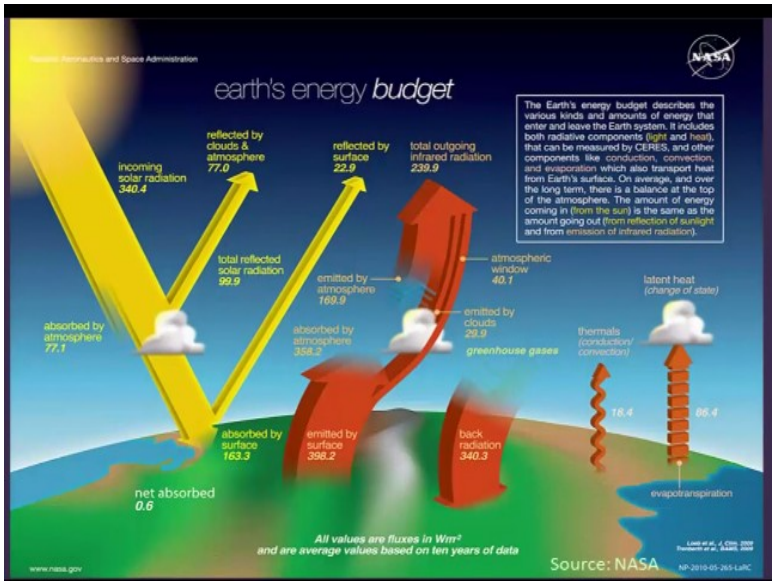

This is another example, which is similar to the previous one.

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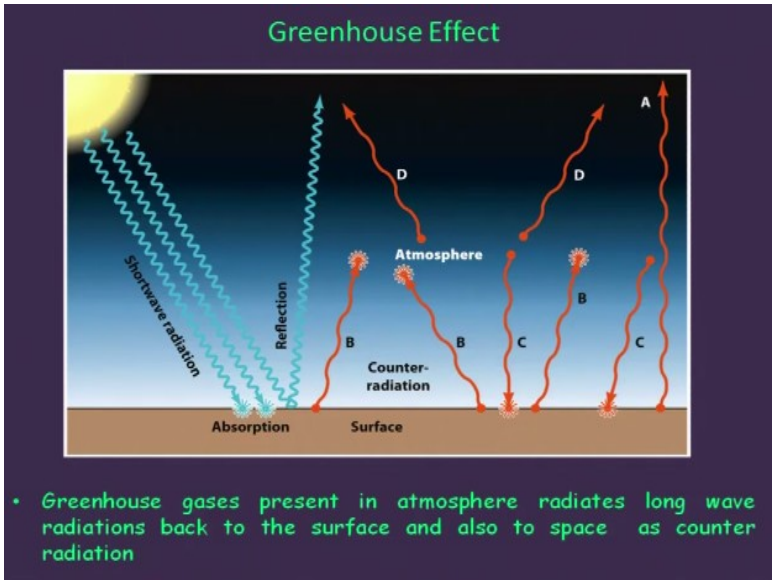

So, greenhouse effect, mainly what we were talking about that nothing has been so secured, not all waves or the electromagnetic waves or radiation which has been received is radiated back to the atmosphere, some is reflected back from the atmosphere to the earth's surface and some is directly or is reflected or irradiated to the atmosphere.

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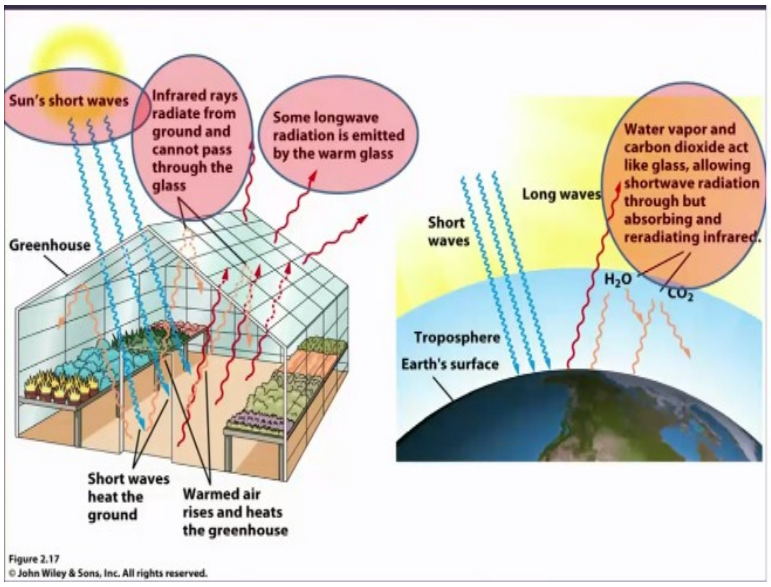

This part we have discussed. So, I will quickly move. Mainly the shortwave radiation coming from the sun and this is the glass surface which is covering the earth acts as atmosphere. So, shortwave radiation has been received through the glass and some which is radiated back that is infrared to the atmosphere, but cannot go through is again reradiated back to the earth's surface and this makes the warming that is the greenhouse effect.

Some long wave radiation which goes through the glass and glass is very much similar to what has been we can compare to the atmosphere. So in total, this is the process which results into the greenhouse effect and warming of the earth's surface.

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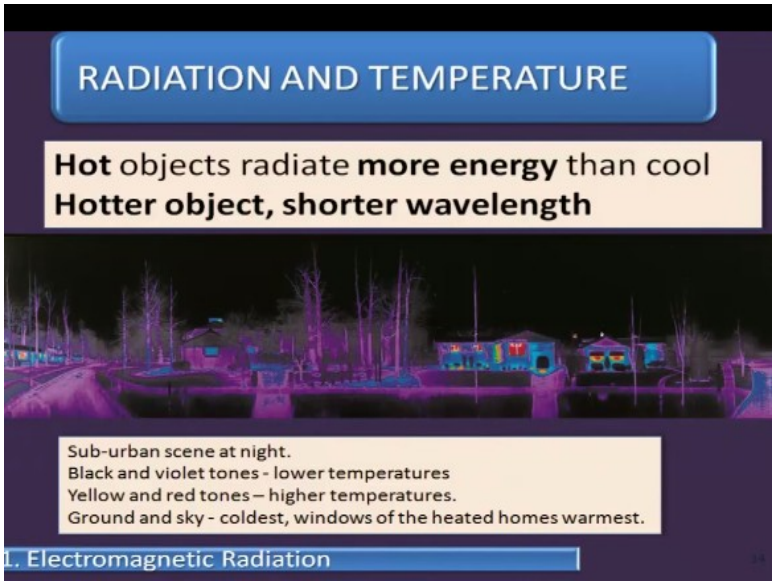

Radiation and temperature. So this is an example of hot objects which radiate more energy than cool hotter objects with shorter wavelengths. So basically, the blue portion which you see here is your low temperatures and black is also of low temperature, so blue or either you say violet. Then red is your high temperature areas and the yellow one. So, we will stop here and we will continue in the next lecture. Thank you so much.