**Environmental Air Pollution**

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**Lecture No. 25**

**Stability, Mixing Height and Plume Behavior – 1**

We will begin from the point where we left yesterday. What we did yesterday was to arrive at the temperature profile under the conditions of dry adiabatic lapse rate.

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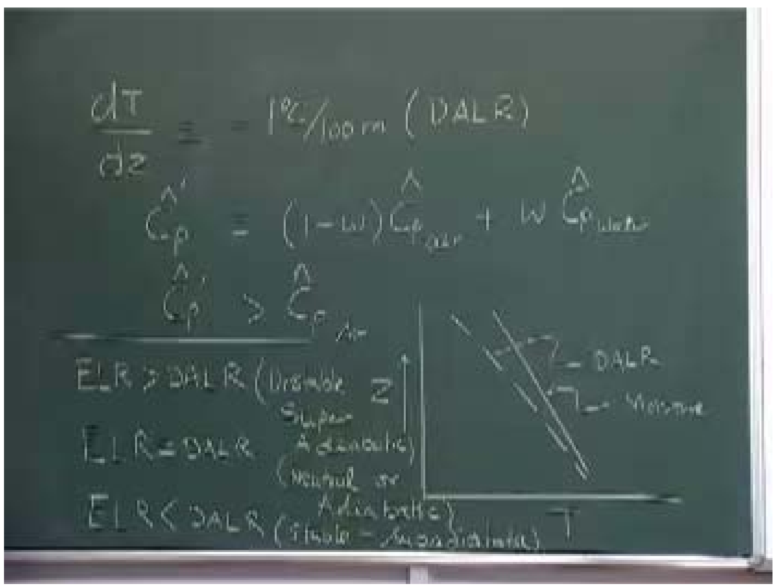


Then, the important relation that came up was…. Then we also saw what it really means in terms of the stability of the atmosphere and how the pollutants will disperse or the atmosphere could be unstable or stable, depending on what is DALR – we call this as DALR. But then, we had also done a little graph here to show what will be the effect of moisture. I will once again write that. Suppose your air is not dry but it has moisture, so let us call the $C_P$ hat dash that we were describing yesterday with the moisture is… let us say the moisture content fraction is w, so 1 minus w is your air component and that is $C_{Pair}$ and we put the hat plus w (that is the fraction of water content in the atmosphere) times $C_{Pwater}$ hat or basically water vapor. You will see here that $C_P$ dash or $C_P$ hat dash is greater than $C_{Pair}$ hat or dry air.

Therefore, if you recall, in the graph that we showed yesterday, Z was on this side, T was on this side and then this was our reference. The atmospheric conditions having some moisture will be somewhere here (Refer Slide Time: 02:50). After considering the moisture, the graph between Z and T will be like this. This is your normal DALR and this is the condition when there is moisture in the air – this will depend on the local conditions.

This is what I wanted to do make clear to you, because we really rushed through this graph yesterday. The other important thing that we came up with was if ELR is greater than DALR, what did we say the atmosphere was? If ELR, the environmental lapse rate, is greater than DALR, what did we call that as? Unstable. Unstable. So this is unstable. There is another name given to the same condition – we call this as superadiabatic. We call this situation as neutral or adiabatic. We call the third situation where ELR is less than DALR as stable or subadiabatic. This is what we did and I have just summarized what we did yesterday.

We will stay with the same concept but we will see how these things vary with the different hours of the day. This is a typical situation we have talked about, but let us see what happens to my ELR with respect to the various hours of the day – that is what I am interested in; let us see what happens in the morning. You recall I made a statement yesterday that the environmental lapse rate is not always the same as DALR. In fact, the ELR will very seldom be equal to DALR – very rare situation or very few times. Let us see what happens in the afternoon, let us say 2 to 3 PM.

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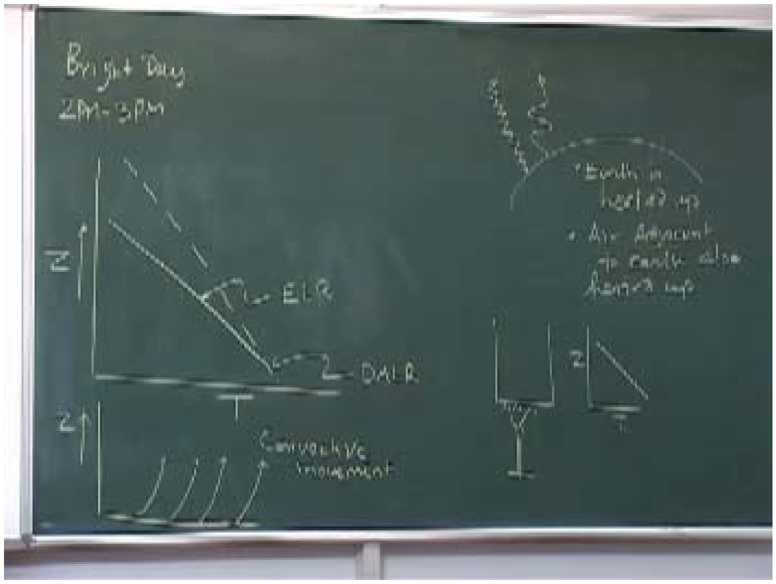


I say the situation is a bright day and the time we are really looking at is, let us say, 2 PM to 3 PM. We plot the same kind of graph again – we have Z here, we have temperature here and my standard lapse rate DALR is like this. At this particular time of the day, we will try to at least say qualitatively how our environmental lapse rate will be. To draw that, let us consider that on the surface of the earth, in the daytime, shortwave radiations are coming and then long-wave radiations go out. What happens in this situation: bright day, lot of heat coming in?

The first thing that happens is that the earth is heated up. The second thing that will happen is the air adjacent to the earth also gets heated up – air adjacent to earth also heated up. As a result, you will see the gradient of the temperature – temperature will be higher here and as you go up, temperature will be lower and lower. If you agree with me, in the daytime – 2 PM to 3 PM on a bright sunny day, my situation in general is likely to be something like this, because at the ground, the temperature is higher and as I go up, the temperature will be less and less and will reduce much faster than what it will reduce in the situation of DALR, so this is what will be my ELR.

It is similar to what we said yesterday – the beaker, you are heating it up from the bottom and that will give you a temperature profile that will be like this, this is my height Z and this is my temperature T; this situation has a few meanings for us. If this is the situation, if I want to look at the vertical movement of the air, how will this be? There will be strong convections going from the ground to up because you have higher temperature here (Refer Slide Time: 09:32) and lower temperature here. If I look at the wind profile, you will see the air moving up because of convection – convective movement. Do not forget that whenever I am drawing the graph, Z is always here; this is not Z but this is Z here but not showing the temperature but the [10:13].

What you see during the daytime, especially bright sunshine, is all the birds flying and soaring very nicely in the air – that happens in the afternoon, bright sunshine; because of this convective movement, the birds can really support themselves and they can just soar around without really flapping their wings – this happens because of this situation. The second thing, another example just for the sake of physical understanding, is this: people who go for hand gliding cannot go everyday – they have to really wait for bright days and bright sunshine; they normally like to go in the afternoon – about 12 o'clock or so; they cannot go very early in the morning because even those who go for hand gliding are to a large extent supported by these convective currents.

Suppose you want to plan for a picnic or hand gliding and you find the day was not very bright and there were clouds; once clouds are there, this thing is cut off, so the earth is not heated up, air is not heated up, there are no convective currents and then you will probably put off your plans of hand gliding – you cannot do hand gliding on that day. The point is this: when even the birds and your picnic plans can change, the pollutants will also depend a great deal… how they will disperse, where they will go will depend on the time of the day that we are talking about.

Also, do not forget the important word that I am writing – bright day; it is a somewhat nontechnical term and we will probably talk about this at some other point; it will also depend on the amount of the solar radiation that is reaching the earth. What you see here is that there is a lot of meaning in terms of the time of day that we are talking about. What we can say is that the condition shall be unstable. If I can draw a chimney, you will see the chimney really dancing and looping and going up and down (we will talk a little bit about it later). This is the emission that you are talking about.

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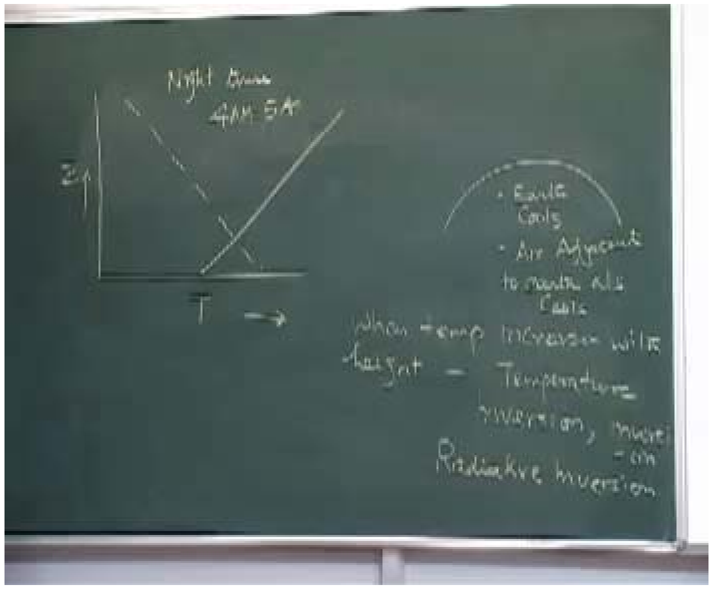


Now I take another reverse picture of this. Let see what happens in the nighttime. We will draw another picture and talk about what happens in the nighttime. You will never see birds soaring in the nighttime – cannot happen. If I draw a very similar picture T here, Z here and this is my standard conditions. Go back to the earth, no solar radiation. What would happen? The situation we are talking about is nighttime, let us say we are talking between 4 AM and 5 AM.

There is no solar radiation coming in, earth cools, so is the air adjacent to the earth – air adjacent to earth also cools. Then, what happens once the earth is cool, the temperature here is low and what is the temperature up? The temperature is higher because adjacent to the earth, the temperature has cooled down but the temperature over the earth, over the higher altitude is still high. This happens because of one fundamental reason – always remember this: earth cools off very quickly and heats off very quickly, whereas the atmosphere will show some kind of distance in the change in the temperature. So what do you find? The earth has cooled down but the temperature is still high here – this temperature is reduced, whereas the upper temperatures are still higher.

What do you get here? The picture might look something like this – complete reversal of the temperature gradient. This is nighttime (Refer Slide Time: 14:59) and this is daytime. We call this where instead of decreasing, the temperature starts increasing as temperature inversion; we call this situation when temperature increases with height as temperature inversion – some people will simply call it inversion and the more technical name for such a situation when the earth is subjected to cooling and heating is called radiative inversion.

What I did with these two things you see here is I have talked about very extreme conditions – daytime, bright sunshine, rather nighttime in the morning 4 AM to 5 AM. Let see what would happen on other days.

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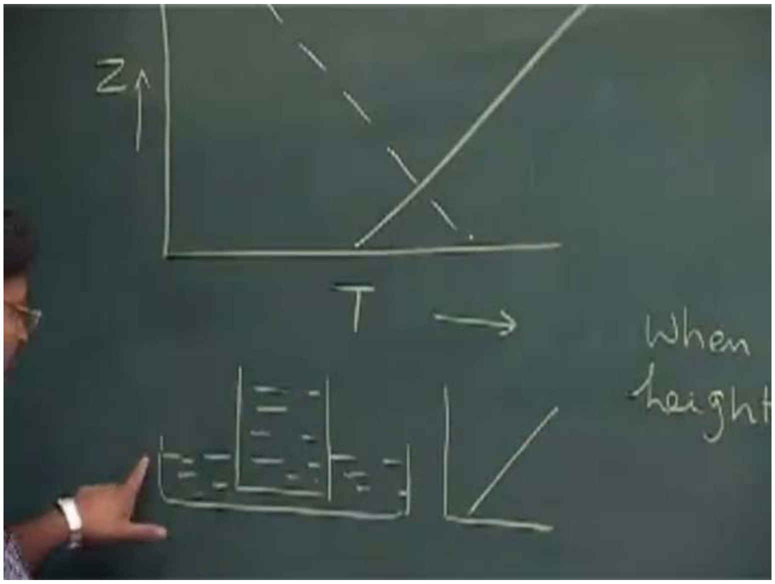


The situation is something like this. You had a beaker with hot water in it. I brought another container with cold water. You see that this water will immediately become cool and this water will stay hot. The temperature profile that you will get in this situation is exactly like this. This is hot water to start with and this is another container with cold water. The idea here is to show you how things can change from day to night. We will try to draw an overall picture based on this, because things are not as discrete as you see – things are continuously changing

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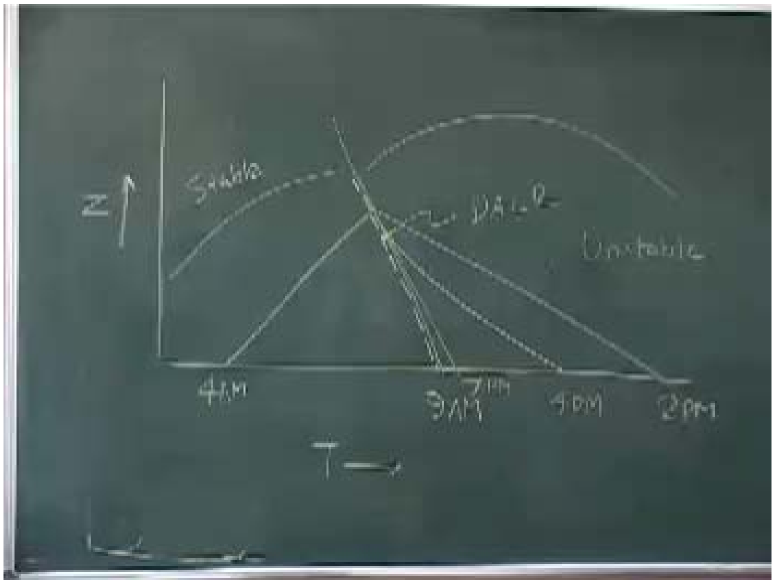


This is important from the air pollution point of view because all the air pollution will depend on the dispersion of the vertical movement. Always remember that these this lectures are focused on the vertical movement of the pollutants – we are not talking about the horizontal movement. Here again, we have Z here and T here. Suppose I say 4 AM, you see the picture is like this. Let us write temperature here. By 9 o'clock in the morning, there is a little change, the earth gets heated up and the temperature starts becoming like this – things will change. From inversion, we will go this side. By the time you are around 2 o'clock – the situation we saw a little while ago, now if I have to draw the temperature profile at 4 o'clock, where do I draw the line? 2 PM, 4 o'clock, do you think I will be coming this side or will I be going this side?

[Conversation between student and professor - Not Audible (18:52 min)]

Here, do I move to the left or move to the right? Move to the left because the heating is somewhat reduced and so I am getting reverse phenomenon at 2 PM or 3 PM. Things had peaked in terms of instability, things had peaked in terms of the superadiabatic conditions and now the sunshine is reducing and as a result, the temperature is reducing. Slowly, I will start a reverse trend and then if I say I am at 4 o'clock, the situation will be like this. I am still going with respect to time. Why we are discussing this is that we all will use this somehow or the other because you want to find out the concentration, you want to find out the vertical movement of the pollutant at different times of the day. Now when you are close to around 7 o'clock or so, you will be again very close to what 9 AM is and this is your 7 PM. Then, from 7 PM onwards, you will get to a situation that is 4 AM.

This window that you see (Refer Slide Time: 20:06) at around 9 o'clock in the morning to around 7 o'clock in the evening, this is where you are very very close to the dry adiabatic lapse rate, our standard rates – somewhat close. On a typical day, on a particular day, things may change but this is what will be the situation on typical days. This is what your [20:30]. You see here how things can change and again, this change is largely because of heating of the earth, cooling of the earth and the corresponding change in the atmospheric temperature or the air temperature, which may not change as rapidly as the temperature of the earth changes.

There is a question for you. Suppose you want to see the dispersion of the pollutants not on the surface of the earth but you want to see the dispersion of the pollutants from a chimney or ship. You have all seen Titanic and huge chimneys – they burn a great deal of fuel. They are moving not on the surface of the earth but on the surface of the ocean. Then, obviously, the same kind of stability that we are talking about here, same kind of temperature profile that we are talking about – it will be different because the earth surface behaves differently and the water body will behave differently.

Then again, the problem or the good thing or bad thing about the water body in terms of temperature is that it also resists change in the temperature – it does not get cooled off so easily and so there will be a delay. Suppose you are getting 4 PM like this (Refer Slide Time: 21:48), this profile may be still be close to 2 PM for the ocean. That change is very slow and so that kind of a stability will be very different from what you get on the earth surface. This picture is very important for us.

We have still talked about in some sense the qualitative way but you can appreciate that our pollutants will behave very differently based on where we are. In the morning, they may behave differently, they will behave differently at 9 o'clock, 2 o'clock different, 4 o'clock different and at 7 PM and it is a continuous scale. We need to know about the information and the stability part. If you like, I can write this part as unstable and this part as stable – the atmosphere is stable during this time and unstable during this time.

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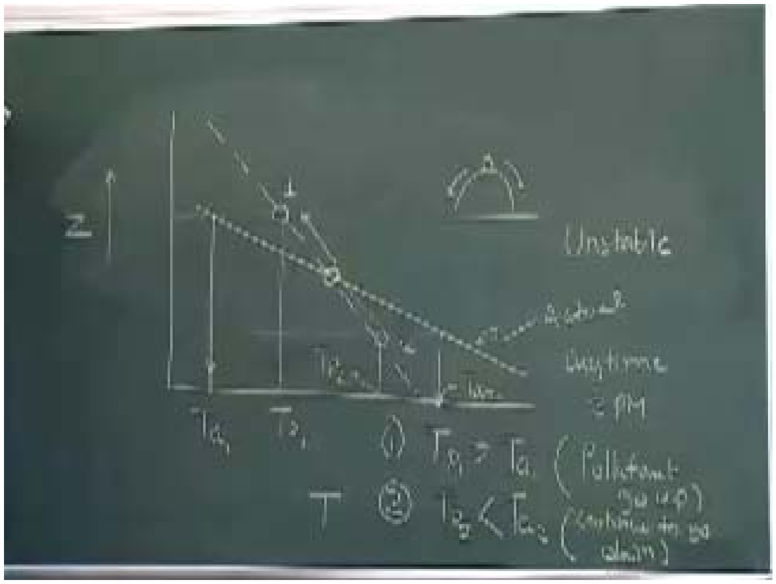


Let us talk about something more, which will decide.… I want to come down to the specific pollutants. Let us forget about the atmosphere for a while and let us talk about pollutants and how pollutants will behave – will it go up or down, what will happen to the pollutant. I draw a picture again with Z versus T. Z is here, this is my reference DALR. Suppose I am talking about what happens in the daytime to the pollutant. We have talked about the temperature, but now I want to see what will happen to the pollutant. Let us say the situation is like this (Refer Slide Time: 24:04).

We are already talking about the daytime situation – let us say 2 PM and we will talk about the pollutant. Suppose I have the pollutant here, which is a small pollutant. What I did was I somehow gave a little push to the pollutant. What did we do? Through the chimney, you are sending out a puff. The puff went up. Let us examine what will happen to the temperature of the pollutant and the temperature of the air surrounding this after a certain distance that it has travelled – that is what we want to examine. When the pollutant goes up, you can assume that the pollutant will travel or the temperature profile of the pollutant will be adiabatic because we are neither supplying the air to the pollutant when it came out nor taking the air out for a short duration for which we are considering [25:17]. This is something similar to the expression we derived yesterday.

What will happen? This is your actual, if I can use the word actual. Although traveling vertically, the temperature profile of the pollutant will be following the dry adiabatic lapse rate – this is important because if you miss this point, then there could be confusion. After certain time when I push it up, what temperature will it acquire? Suppose it has gone up to this point, it will acquire this temperature because it will follow the adiabatic path. My atmosphere is like this, that is fine, but the pollutant will follow the adiabatic path. Let us say after some situation, the pollutant is here. We pushed it up and it acquired this position – I call that as situation 1.

Corresponding to this, the temperature of the pollutant – let us call that as $T_P$ at situation 1 (this is the temperature of the pollutant). What is the temperature of the air surrounding the pollutant? Do you agree that this will be the temperature of the air because this is my actual air? Let us call this as $T_{air}$ and at position number 1. What can you say? What will happen to the pollutant? Now, you have to answer the question whether the pollutant will stop here or it will go up or it will come down. It will continue to go up because what it finds is that the surrounding air is cooler and the pollutant temperature is higher. This is my situation number 1. What we have concluded is $T_{P1}$ is greater than $T_{a1}$ and the resultant or answer is that the pollutant goes up.

You made just a little push and then it continues to go up. No matter what height I go, it will still continue to go up. What is the situation if I push it down? When I push it down, it should follow the adiabatic lapse rate. It comes to the situation that is situation number 2 – that is situation number 2. Then, the corresponding temperature of the pollutant is, let us say, T of the pollutant for situation 2. What is the corresponding temperature of the surrounding air? This is T of air at point 2.

Suppose we have pushed down the pollutant – situation 2, what I can say is T of pollutant at situation 2, T of the air at situation 2, temperature of the pollutant is less, so we make it like this. What will happen to the pollutant? It will continue to go down. What you see here under this situation is that the pollutant either continues to go up or continues to go down and you see a lot of turbulence in the atmosphere. You cannot make the particle sit at one place – it will move, it is on the move. It is something like this. I tried, I have not done a good job here, but it is something like this – it is an inverted bowl and if there is a ball kept here, it will not be stable, it falls off –

with a little tilt, it will fall off this way and it may go up or it may tilt a little this way and it will fall off this way.

What you see is that the pollutant will either continue to go up or continue to go down – it is highly unstable, the pollutant is highly unstable and this is what the situation is. If you like, I can put it like this just for clarity: the ball is sitting here, it is unstable, it is willing to fall or going to fall quickly this way or that way and will continue to move – the situation is unstable. In an unstable situation, you see that the pollutants will be travelling, mixing and jumping. That is the thing that I wanted to tell you.

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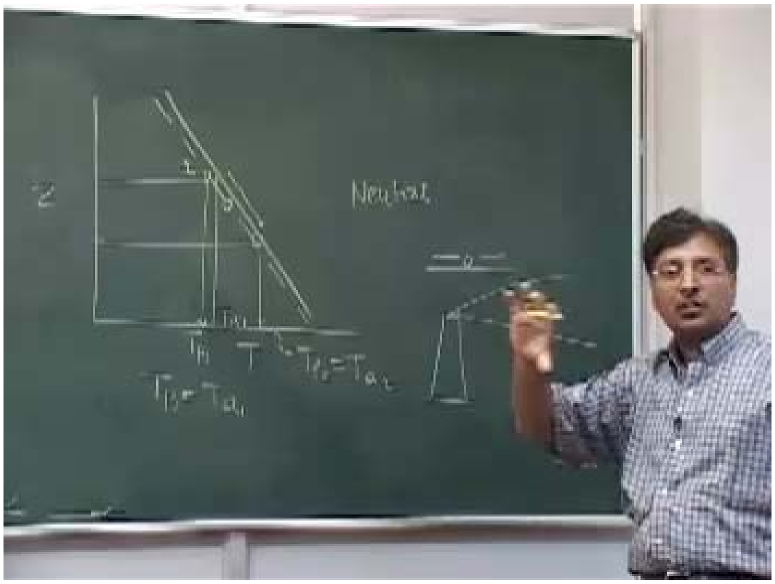


Let us talk about situation 2. We have a situation that is something like this. This is Z, this is T, my atmosphere is the same as adiabatic atmosphere. I left a particle here, which is again an air particle and I pushed it up to the situation 1. I try to look at the temperature $T_{P1}$ and I try to look at the temperature of air, which is $T_{a1}$. You see that $T_{P1}$ is almost equal to $T_{a1}$. Similarly, if I push it down to situation number 2 here, you will again agree with me that even for situation 2, $T_{P2}$ is equal to $T_{a2}$. When you push the pollutant under the neutral conditions, it will get pushed, acquire a new position and stop there.

It is not a highly vertical movement, but if you give some movement, it is going to sustain that movement up to a certain distance and probably acquire a new position where it will be quietly sitting – this is the neutral situation we know. It is something like this: suppose this is a flat plate and there is a ball here; when you slightly push the ball this way, it acquires a new position and if you push the ball this way, it acquires a new position.

It is like having the same ball and rolling it over the duster or rolling it over the surface. I push it and it gets a new position, I push it this way and it gets another position. This is the neutral situation. Typically, you see chimneys that are dispersing a little bit on both sides and stopping it there – you will realize this situation also but the plume is not dancing up and down as we have seen earlier but you see here that it is travelling as a… conical shape of the dispersion takes place.

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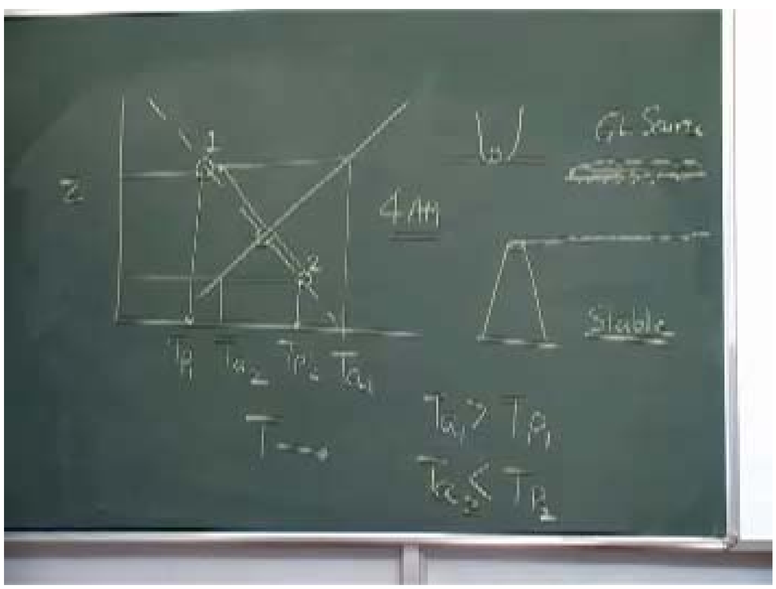


Now let us talk about the situation number 3 when things are very stable. This is Z, this is T and this is my reference rate – dry adiabatic lapse rate. Let me take this situation – something like this. This is nighttime, unstable condition. Now, let us see what happens to the pollutants when the atmosphere is stable. What you see here is the particle. I push the particle through a puff at position number 1 and this position number one is here. As we have been doing, at this height, the temperature of the pollutant will be $T_{P1}$.

What will be the temperature of the air at this height? Temperature of air, situation 1. What do you say? What will happen to the pollutant? It will come down. What level will it come down to? To its…?

[Conversation between student and professor - Not Audible (35:00 min)]

Original position, wherever it was. Even if you had somehow pushed up the pollutant, it will come down. Why? It is because $T_{a1}$ is greater than $T_{P1}$ – the pollutant will come back and stay back here; it comes back to wherever it started. Suppose we have situation number 2 where we have pushed the pollutant down – let us say this is the situation 2. Then, let us find out what is the temperature for the particle. It is $T_{P2}$. What is the temperature for the atmosphere or air? It is $T_{a2}$.

In the position 2, $T_{a2}$ and $T_{P2}$. What is the relation? Are we getting same or different? We are getting the same relation that $T_{a2}$ still continues to be higher than the temperature of the pollutant.

[Conversation between student and professor - Not Audible (36:14 min)]

Or did I say the reverse? All right, the situation is $T_{P2}$ is higher than $T_{a2}$. What happens to the pollutant? It will go back and stay, come back and stay here. No matter what you do – you are shaking and you want to move this, but the pollutant, if I can use the word, refuses to move and it says, 'I am not going anywhere. I will just stay where I am, no matter how much you try.' We try to push this pollutant from here to here, but it came back and said, 'Sorry, I do not want to go up.' You push it down, it says, 'Sorry, I do not want to be down, I want to maintain my original position.'

This situation is something like this where you have a bowl and in the bowl, you put a ball and shake it but this is not coming out – it just stays wherever it is. For demonstration purpose, I can make a bowl like this and in the bowl, I make a ball and then shake it. However much energy I try to give this, it is not moving. Things are stable, pollutants do not disperse vertically and they refuse – that situation is really very bad. In what time of the day will this happen? Nighttime. Do you remember we drew this picture – something at 4 AM, something like this? That is what exactly occurred in the Bhopal gas tragedy episode, because it happened in the nighttime. The situation was something like this – there was no vertical dispersion of the pollutants. As a result, the concentration will go up and more and more people will suffer.

If you see how the chimney will disperse, we will talk a little bit more in detail about these things but you see here as the pollutant refuses to move, the chimney will simply… you can almost draw a straight line – there is no dispersion, no vertical movement, the chimney will just be like this; it can travel hundreds of kilometers until the day breaks and the situation changes. This is what is highly stable. The advantage here is that the people at the ground level are not so much affected. In a way, you are saying stable conditions are bad but if the source is an elevated source, the problem faced by the people is not so bad.

But just imagine if the source was a ground-level source, this will not disperse and as a result, the entire population will be affected. This is the ground-level source. That is seen in the nighttime, in the winter, in the evening – there is some source that will cause some kind of layer and that is not dispersing and you see the pollution level really going up. If there are vehicles, they create a lot of problems. Interestingly, sometimes people do not recognize this in the winter and in the nighttime, the problem from the tall stack may not be so great because the pollutants are not dispersing, they are not coming to the ground level and if they are not coming to the ground level, it is not affecting the receptor.

There are other issues with this and we will see them. The other issue with this when it is not coming out, then it will be subject to long-range transportation. Once long-range transportation happens, there is the problem of acid rain and problem of places being affected from very far and distant locations. The Norwegians would shout that the emission is from Germany or there is emission from England, the Canadians will shout that the emission is from this thing – they have the situation like this, this kind of dispersion.

What we have done in this lecture is that we started with atmospheric stability and said that the stability varies depending on the time of the day. We took that concept of stability from the atmospheric stability to what impact it will have on the particles or the pollutants and then how pollutants can behave. That is what we have tried to deal so far. These are important things and somehow or the other we will utilize these. Since time permits, we will also do something else.

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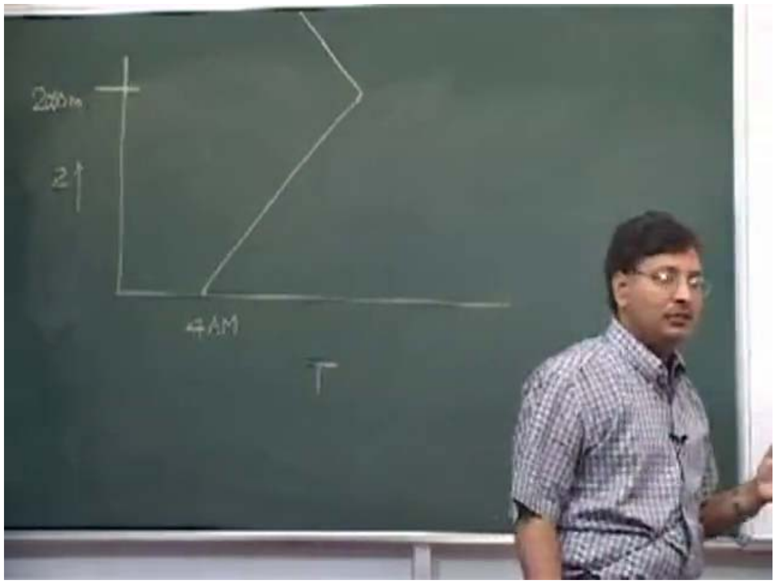


Now, I want to see the temperature profile of the entire atmosphere or the entire vertical atmosphere with respect to various times of the day. We had talked about very limited thing but let us see how it will be if you are talking about the whole thing – let us say something like 2000 meters or so. These were very little local things we were talking about. Now if we talk about bigger things, Z here and let us say approximately I put this as 2000 meters and this is the temperature. How will the profile be? Now, with your knowledge, you can tell me. Let us say I start in the morning at 4 o'clock. What will be the profile? Increasing temperature with height and generally, you do that through the entire region and you get something like this. Can you comment or at least make a guess what will be the profile after a certain height let us say 2000 or 2500 meters? Will it continue to be like this? Or will it have some change or shift?

[Conversation between student and professor - Not Audible (42:52 min)]

It will change because the influence of the earth will diminish as you go up. You are getting this particular profile. Why are you getting this particular profile in the nighttime? It is because there is the influence of the earth – cooling of the earth has resulted in the decrease in the temperature and that influence will be up to a certain extent and the influence will diminish as you go vertically up. So generally, it has been found that when you go up to that particular height or so (we will define what is that height) so if the impact or the influence of the earth is diminished, what kind of profile do you expect? Ordinary, normal profile with temperature decreasing with respect to height. We all know the temperature at Simla will be lower than the temperature in Delhi. This is what we have seen and what we have – you know the conclusion drawn is that of the influence of the earth.

So as you are going up, the influence of the earth is diminishing and you might get a situation that is again something like this. Even in the nighttime, you will see the.… Well, the thing will not be so sharp as I have drawn here but something like this. Do you agree with this kind of profile or you think this cannot be so? The influence of the earth will diminish, right? The normal behavior of the atmosphere is this (Refer Slide Time: 44:20), but since it is getting influenced by the earth, there are changes at the local level. But at higher altitudes.… I just put 2000 but do not take this number as very sacrosanct and that 2000 means something like this may happen. It may happen at 2500 or it can happen at 1500 – depending on the year or depending of the day of the year, winter, summer, these things change. I just want to give you a feel that things can change.

Typically, if I start measuring the temperature at different heights and go beyond 2000, I would get a picture like this. I have drawn at 4 o'clock but normally at 5.30, IMD…. What is IMD? Indian Meteorological Department. Indian Meteorological Department, yeah, that is correct. In fact, it is India Meteorological Department, not Indian – interesting. Every day in the morning, I have written 4 AM, but they normally send a radio sound [45:35] which they send a balloon up and then with the balloon, they can remotely look at the… with the computer, they get the temperature at various heights.

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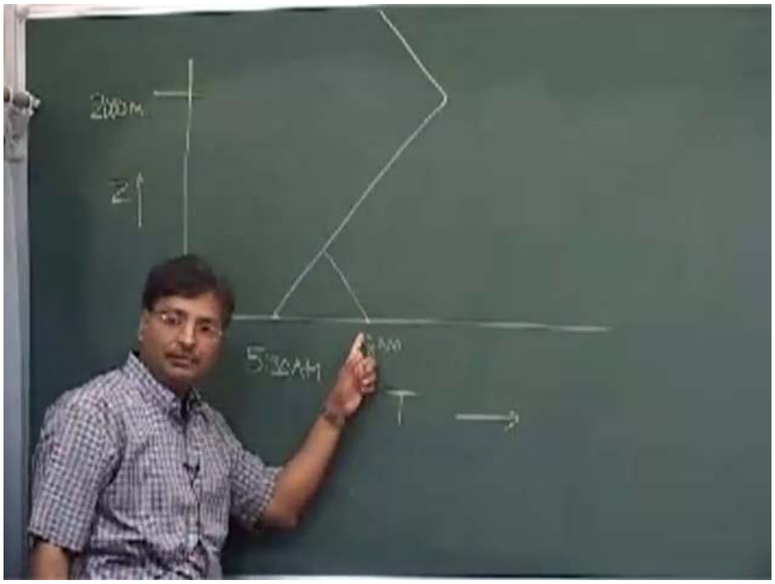

The standard thing to do is… I wrote here 4 o'clock, but the standard thing that IMD does is probably send it at 5.30 AM and they do get some profile like this. For IMD now of course, things are very easy to do, but it is still difficult to get the temperature profile for every hour to hour and minute to minute. Pay some attention. Let say now I am in the morning 7 o'clock or let us say 8 o'clock if you like, I am here, 8 o'clock. What will happen? Will my temperature increase or decrease? Compared to 5.30 AM, temperature will go up.

Let us say I am somewhere here, at 8 AM. Do you think this profile of the temperature…? The temperature has gone up – that is for sure, we all know that. What do you expect this profile to be? Like this or will the profile slightly change? The profile will slightly change and then you may get the profile to be something like this, because the earth has got heated up, the surrounding air also got heated up and you see here the profile at 8 AM becomes like this. Probably you can write it differently at different time.

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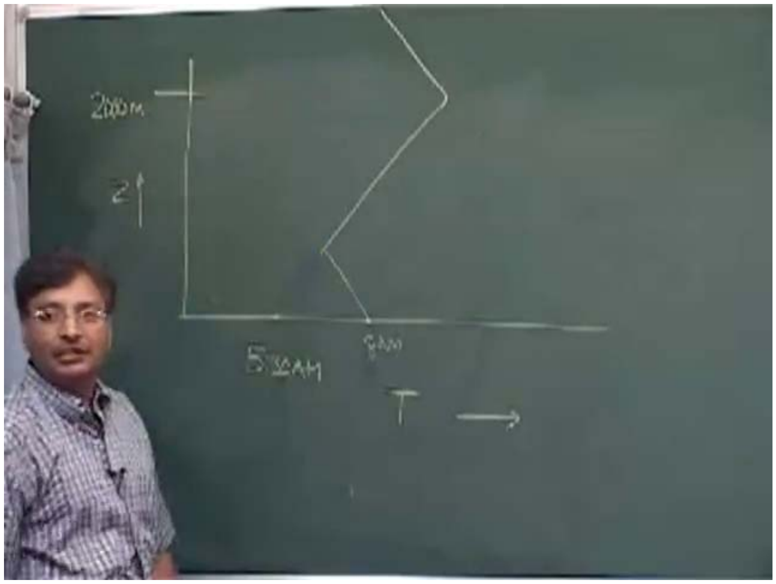


If I go and measure the temperature at 8 o'clock – the vertical temperature, this might look like this. Do you agree or disagree? I think you will agree with this that if I go and take the profile in the morning at 8 o'clock, things will change.

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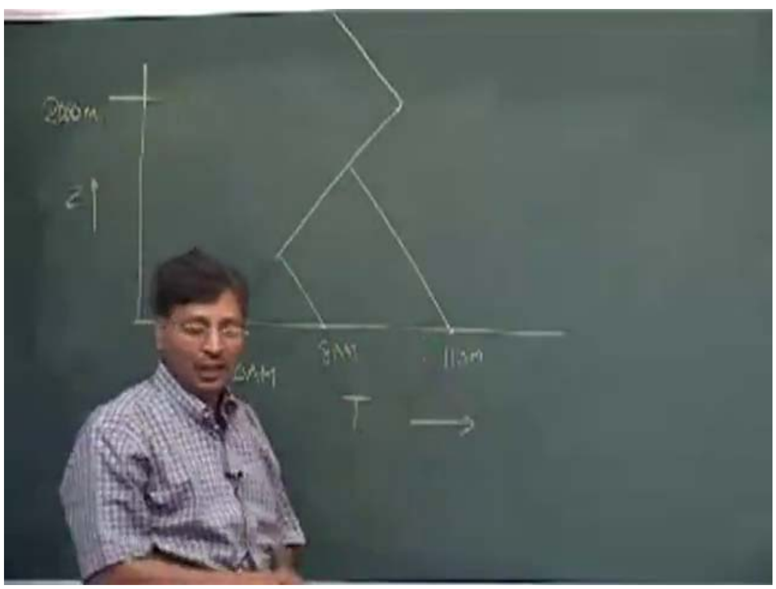


Then, let us say I went at 11 AM. Then, things will change, there will be some slight this thing but the shape will be something like this because the temperature is even higher by 11 o'clock.

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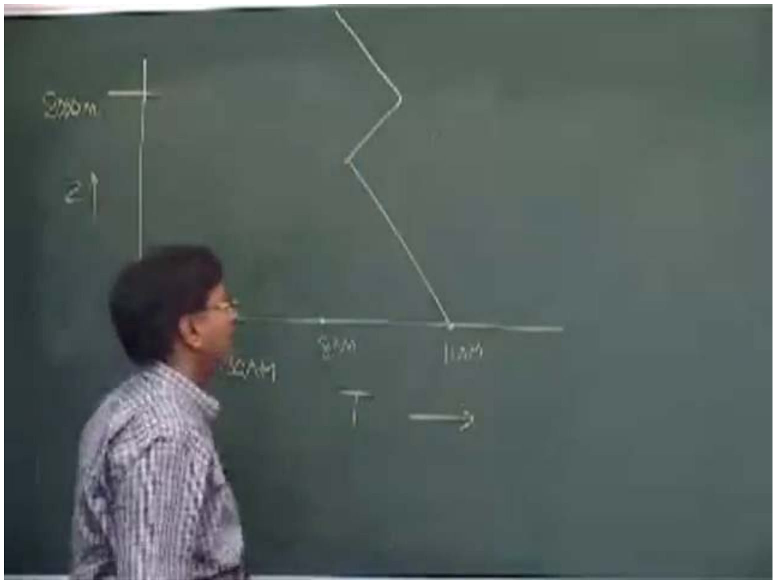

Then, at 11 o'clock, the picture will look like this. So you see at the elevated levels, inversion is there but at the ground level, inversion is broken. You see this – what an interesting thing.

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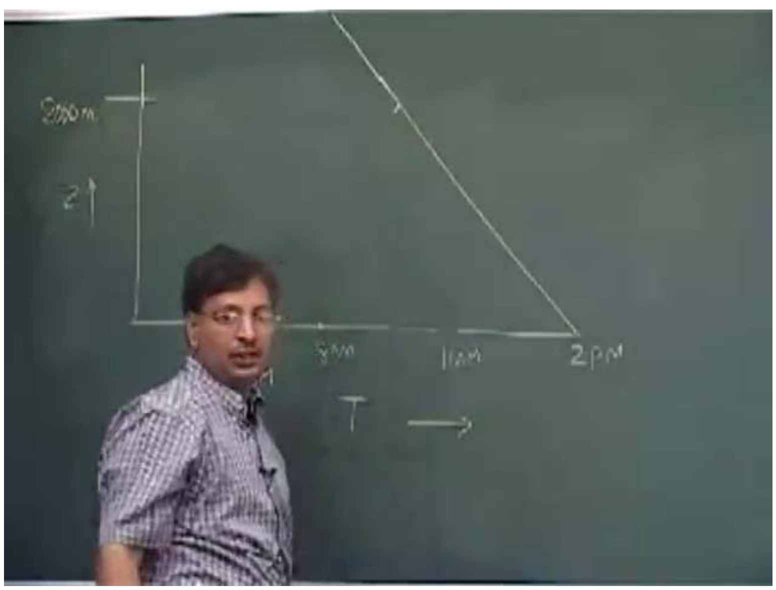


By the time you are at 2 PM or so, the temperature is even higher and so you may get a situation that is complete disappearance of the inversion. The inversion is completely gone. This is what you see at various times of the day. What will happen? There will be a reversal trend as the sun sets. You will get back to your changes here. From 2 PM, you will get 4 PM, 4 PM, 6 PM, 7 PM, 9 PM, 10, 12, 5, 5.30. You will see here that things are changing and how the behavior will change. I am trying to see if we can reconstruct that thing.

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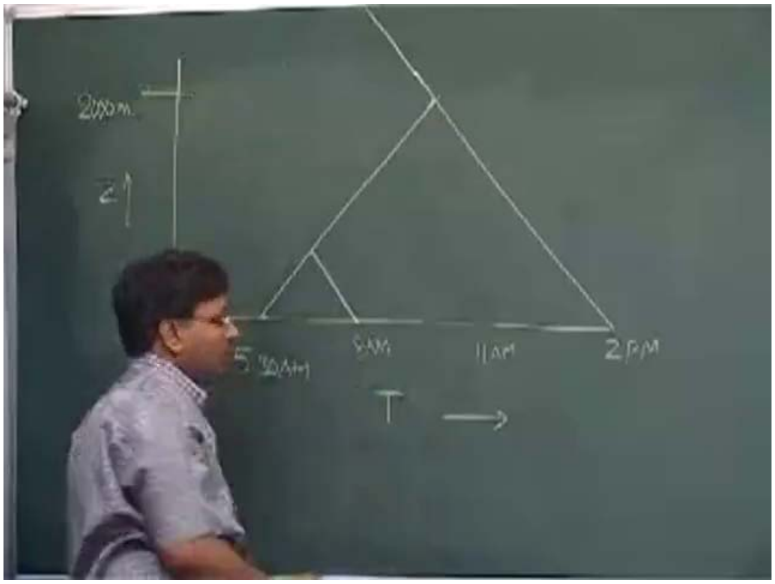


At 5 o'clock, it was like this and at 6 o'clock, it was like this. Why do we not do one thing?

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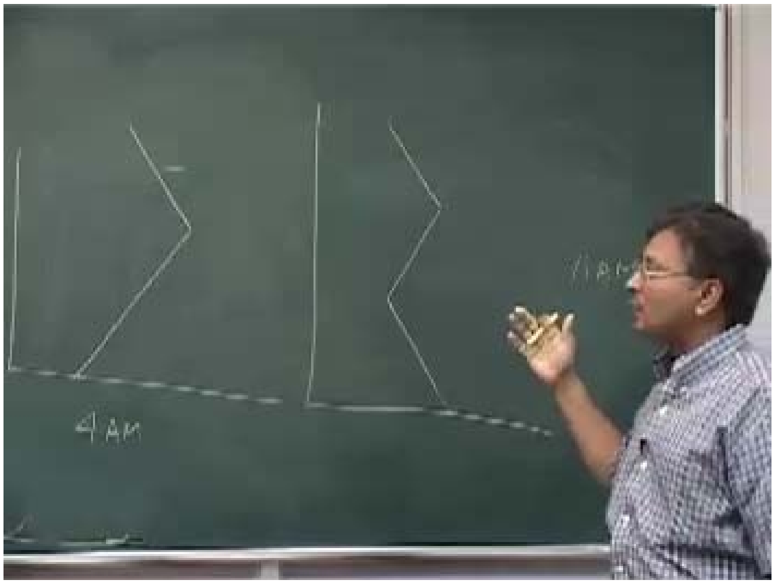

I will finish in a moment. This is the picture at 4 AM and this is the picture at 11 AM. I have occupied the whole space.

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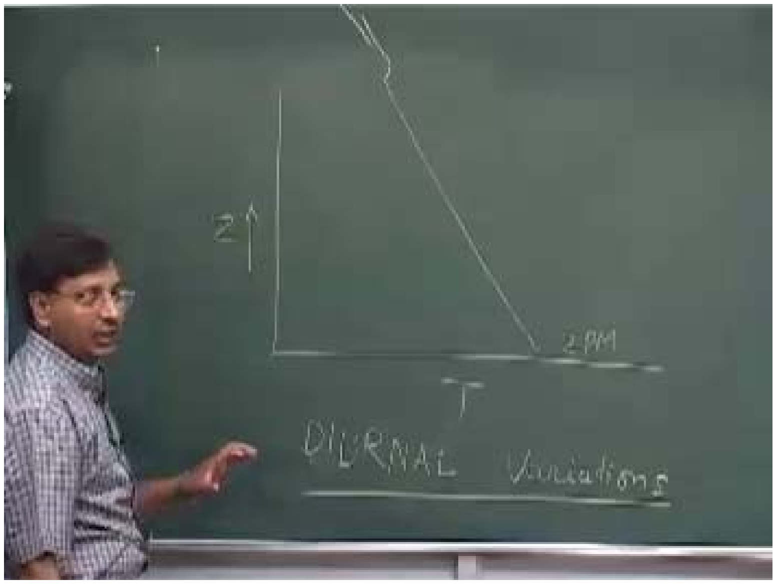


This is the picture, but do not forget we are talking about Z and T. This is the picture we will get – something like this at 2 PM. What I want to point out to you is depending on where your source is, if your source is here (Refer Slide Time: 50:43), the dispersion will be different; if your source, a chimney, is here, the dispersion will be something else; if your source is here, things will be different and depending on this layer going up and down, the dispersion of the chimney will vary or will change. We want to somehow model that and see how this variation will be.

Sometimes, your chimney may not disperse because your chimney is here. You will say that this is a bright day with sunshine and we see the chimney is not dispersing, because the chimney or your stack is trapped in this and here, the dispersion will be very very poor. So what you have seen is this variability in the temperature profile with respect to day or stability and in meteorology, we call this as diurnal (that is daily) variations.

We are not talking about mathematics as yet, but you can appreciate what these things would mean when it comes to dispersion of the pollutants because ultimately, what we want to do is to look at the source and what is the impact on the people – how much it is dispersing. We will stop here. If there are questions, we talk about those; otherwise, we stop here. You should have a good feel of things now – how the atmosphere behaves, how possibly pollutants can travel and what could possibly happen to them at least in a qualitative sense if not in a quantitative sense. We will stop here. Thank you very much.