**Introduction to Flight**
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**Other Standard Atmospheres**
**Lecture 01.4**

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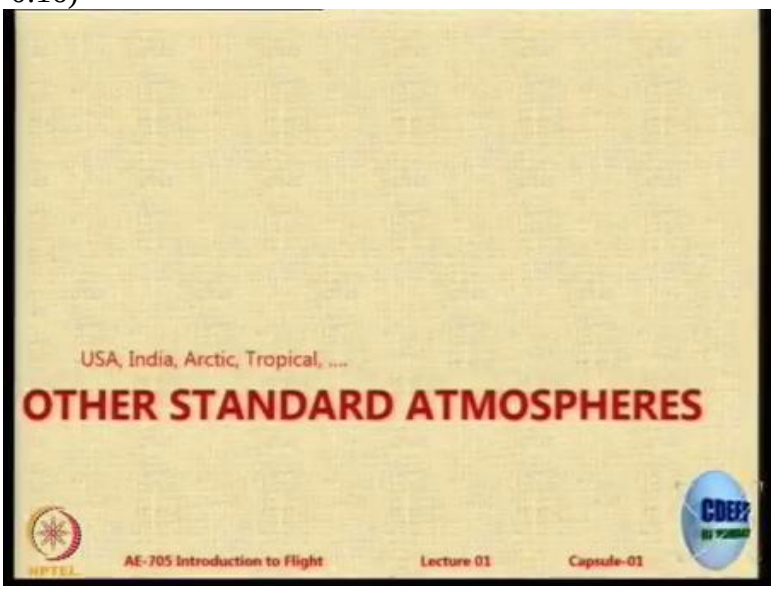


Now ISA is not the only atmosphere, so let us see, let us see some other atmospheres.

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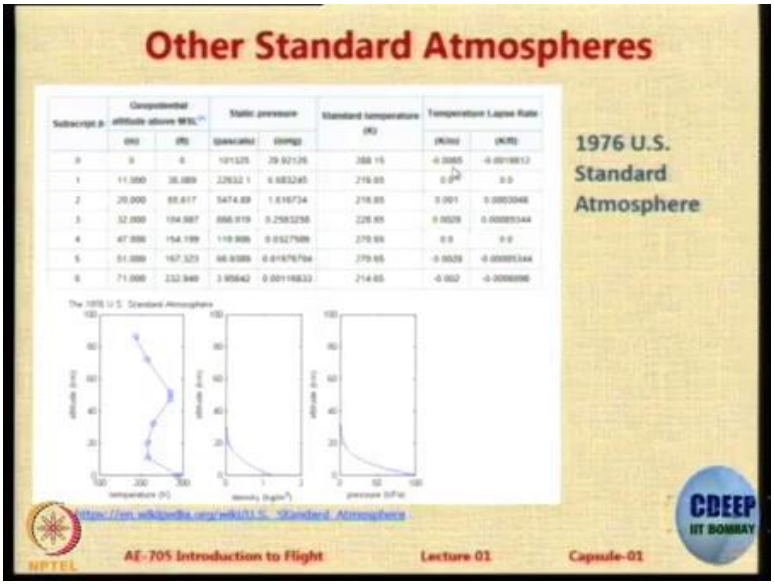

First of all let us look at the atmosphere that is applicable in the US. So, you have 288.16 or .15 at sea level and their lapse rate is 6.5 which is what we know and then there is 0 lapse rate between 11 to 36 thousand feet or you know 20 to 20 thousand meters but in ISA this is constant to 25. In US, it is up to 20. So, you can see there are minor differences. The sea level temperature in the US atmosphere could be the same but there are subtle variations.

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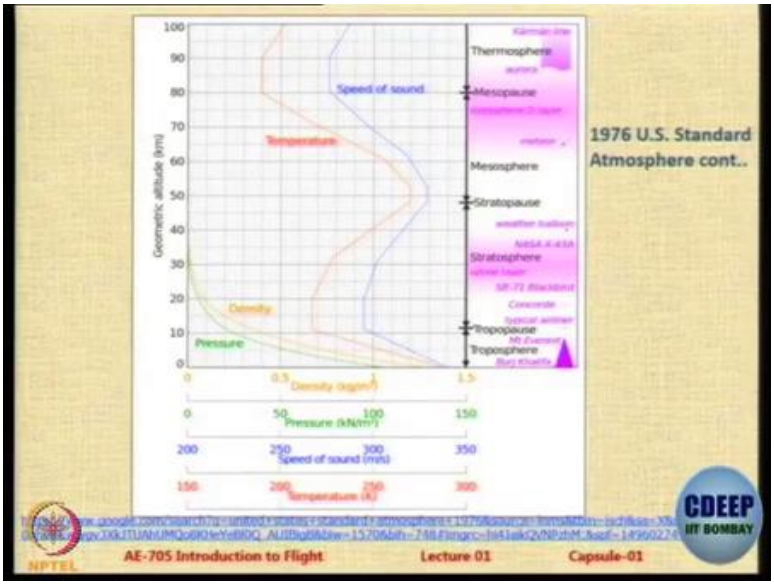


Let us look at the chart again. So, this is the variation of pressure, density and temperature for the US atmosphere or the US standard atmosphere. Now, tell me at which place in USA is this weather recorded? Because if we say atmosphere there must be a place. So, what is the location and what is the season, which month of the year and which day of the month on which this particular atmosphere is recorded in USA, can you guess? Is there a need for something like this nahin, because like ISA you need not have that anywhere, similarly you need not have this at one place, this is the standard followed in the US, it does not mean it is there at Denver or at some place.

So why is it done, so that aircraft which are operating in the US, designed by the US people when they talk to each other and if they say we do not follow ISA we follow IUSA whatever, this is what they refer to. Normally they do not, normally people only talk about ISA but there can be; what about India? So, we also have done some studies about atmosphere prevalent in our country. So, we have defined something called as a IRA.

So, when we buy an aircraft from somewhere, we say tell us the performance under IRA then only it is useful to us, you may fly at Mach 1.7 in ISA, I do not care I do not have ISA, I have IRA, so tell me in IRA, so what is IRA, IRA is atmosphere which is standard, considered to be a standard in India which is valid in the Indian Equatorial zone up to only 80 kilometers, above that it goes into space and they have their own way of calculating which I do not really know.

This data was recorded way back in '85 and after that there has been no plans to do any upgrade or change. It is a standard where it remains like that. So, what is basically IRA?

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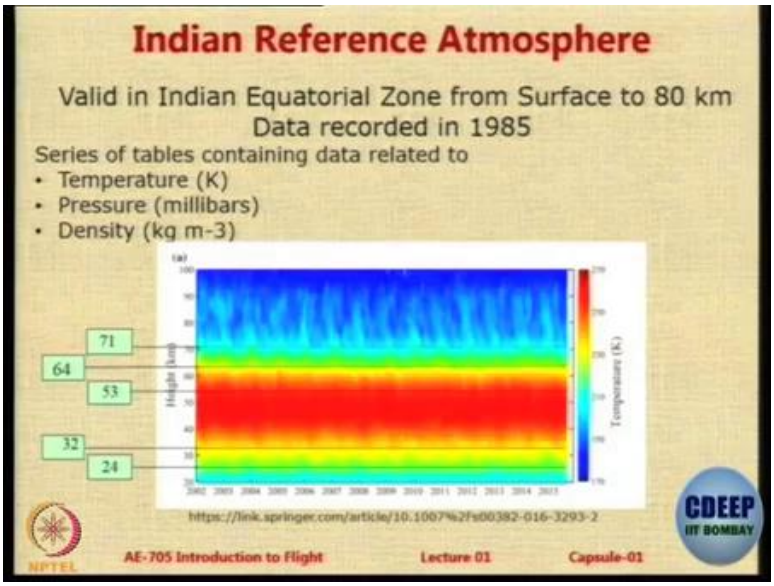


IRA is a series of tables it contains the values of temperature in kelvin, pressure in millibars and density in kg per meter cube and this is just an information for you that in IRA conditions, between let us say, the temperature you can see, you can see this a variation over the years recorded in India. So, it is not constant, you can see it goes in cycles right, so that is why what we have done is we have drawn a mean line. So, it varies from 53 to 71, ok we draw a mean line and similarly we draw a mean line here and we just keep it like that.

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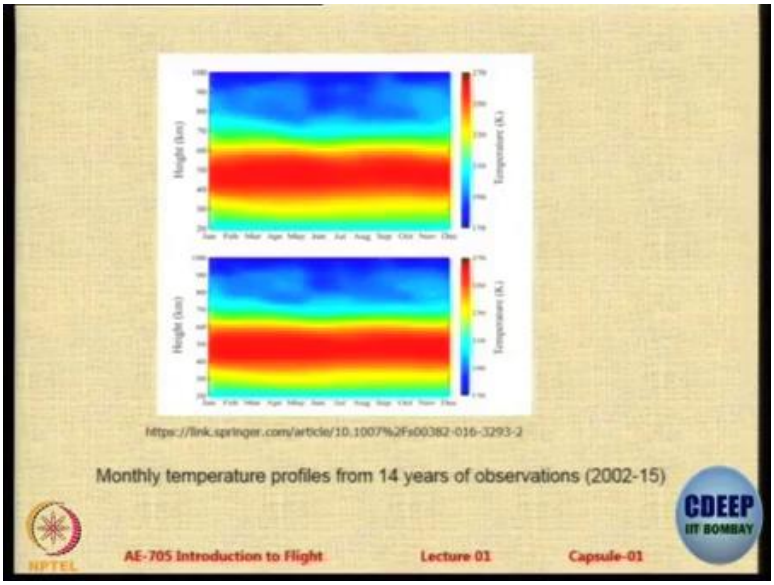


This is only for information and these are the values recorded on a particular day also, a particular year. So, this is the average of so many years recorded in the country, so you notice that the temperatures are not remaining constant throughout the year, there are seasonal variations also, so such charts are used (more) mostly by the airlines, to plan out. You will notice if you look at the, if you look at the timetable of an airline you will not find the same time for a flight on all days of the year. There are there is a summer time table, there is a winter timetable and there is a changes, yeah ok.

So, this is a question that I would like you to answer, I do not know, you have to search on the links. See for everything I quote here, I am going to give a link so you should go to the link check out yourself and put on the Moodle that the question in the class was which, to the answer is this. It is nice, that is what I would like to do.

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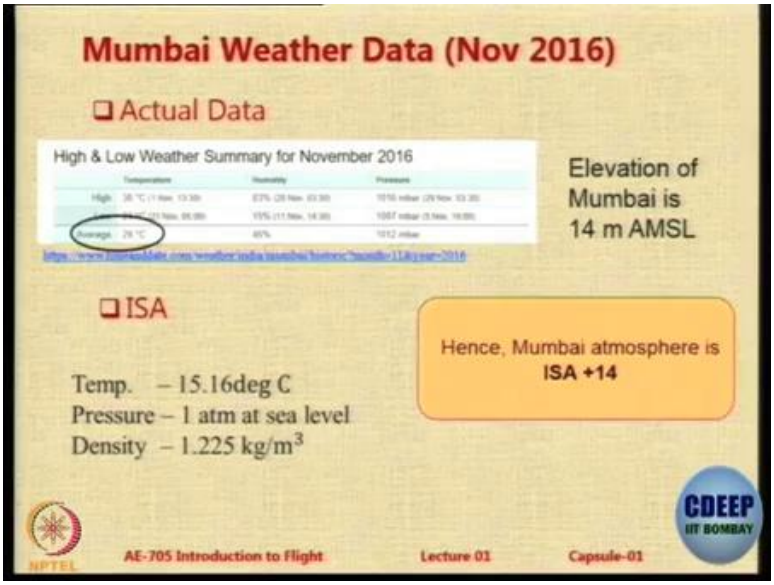


Okay, so we are in Mumbai so let us have look at Mumbai data, you will be here for some time now, it is better you know when to carry a chhatri and when not to carry a chhatri. So, November 2016, this is the actual recorded data at Mumbai the highest was 36 degrees, the lowest was 21 degrees and then you have humidity and pressure also ok and a the average was 29 degrees centigrade.

So, that is the average temperature in Mumbai in November for the temperature. Now, Mumbai location is 14 meters above mean sea level, so therefore from 288.16 it will reduce at the rate, the temperature will change slightly at 14 meters very slightly, so calculation may, under ISA condition Mumbai should have a temperature of 15.16 degree, pressure of 1 atmosphere and density of 1.225 roughly under ISA condition, assuming almost sea level ok, but the temperature actually is 29 degree centigrade, under ISA it would have been 15 degree centigrade. Therefore we say that Mumbai is ISA plus 14. So, Mumbai is ISA plus 14 or ISA plus 15.

So, when it is ISA plus 15, one very interesting assumption is made, we assume that the temperature profiled at Mumbai from sea level to say 55 km, etcetera. It is a parallel line to the ISA line by 14 degrees by 14, so the temperature line only, so the temperature variation at Mumbai will be 288.16 plus 14 minus 6.5 degree per kilometer up to 11 kilometers it will remain that till 25, it will become plus 3 degrees till 47, it will remain that till 53, above that I do not care, got it.

I really do not care because we are not going in spacecraft design in this course. What you need to know is, now how do you calculate density of air at 2 kilometers in Mumbai?

So, you calculate, pressure at sea level will be same as 101 because pressure is not changing. We assume that the pressure remains 1 atmosphere, you can see it is 1016 bar so it is roughly the value of sea level. If you are very particular you can say no, the average pressure is 1012. So, p1 by p2 equal to no, t1 by t2 to the power g by LR correct. So, this t will be t plus 14 and at 2 kilometers it will be t plus 14 minus 6.5 degrees by whatever into 2 because it is 2 kilometers. So, by that you can get the value. So, assume that the pressure at sea level remains same as the sea level under ISA even in ISA plus 14 but temperature changes. So, the only thing changes is the temperature, hence density changes, this is how we do the calculations.

So, in the tutorial that we do, we will do some practice so that you can get a feel for this, this is very important, this you need to know, right.

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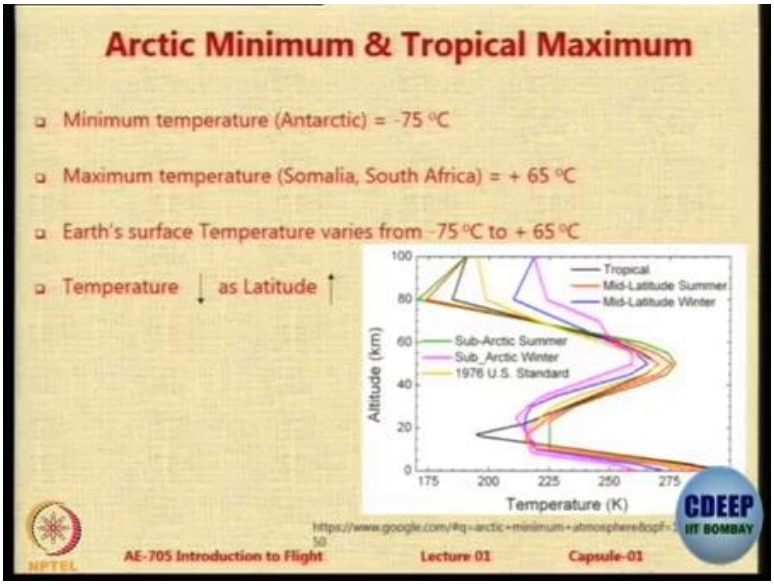


Yes, yes, no no no, if an aircraft is coming as a passenger aircraft we do not say fly in IRA or something, I am just saying when we buy an aircraft and we want to know its performance, we say give us the performance in IRA, give us the performance table in IRA. So, when you want, when you want to talk about a reference value you say under ISA so much. So, this guy under ISA so much this guy under ISA so much I can compare, but normally when we procure something we

say we do not want to worry about ISA, it may be very good in ISA apneko IRA main chahiye, give us the values in IRA. So if I compare the values in IRA, I will get the answers of the parameter that I will normally see in the country.

Ok, yes what is ideal gas equation? Haa, so do you know the pressure at a higher altitude at sea level yes, p equal to rho RT, that is how you get value of rho, but at a higher altitude pressure is changing, temperature is changing, density is changing, what do you do? That is why we need to go for the Adiabatic equation you get dp by p and p is equal to rho RT good, good questions. Any other question, yes, how do you answer this question? Kashmir se Kanyakumari Bharat ek hai that we say but it is not as far as temperature is concerned so let me put a counter question, the same is true for ISA also. I told you that nowhere in the world have a temperature like ISA, then we take a reference, so similarly in India also we have taken a reference.

There is no particular place in India where we say Allahabad, the temperature here is ISA, IRA, no. There is one nominal value assumed to be valid in the country and that is called as the reference for my country. It does not mean that it has to be present anywhere but it is a rough information. So, basically IRA is equal to ISA plus 15 generally. Sometimes we say ISA plus 20. But the IRA is defined, there is a document, our library has a document, I think professor Ojha also has done calculations in fact, before professor Ojha there was one more professor who came from HAL he has done the calculations and there is a small write up available in our departmental library. IRA tables are available.

Let us look at some other temperatures Arctic minimum and Tropical maximum, ok. Recorded minimum temperature all over the world is in Antarctica at some place, I do not know, it is minus 75 degrees centigrade and the recorded maximum value is in Somalia in South Africa which is plus 65, so we know that the variation is so large at Earth. So, therefore some two more temperature, two more SAs have been defined, one is called as a Arctic minimum atmosphere and the other is called as a Tropical maximum atmosphere for very cold countries and very hot countries and these graphs are defining, as you notice that as the latitude increases, as you go away from the equator temperature falls, we know that.

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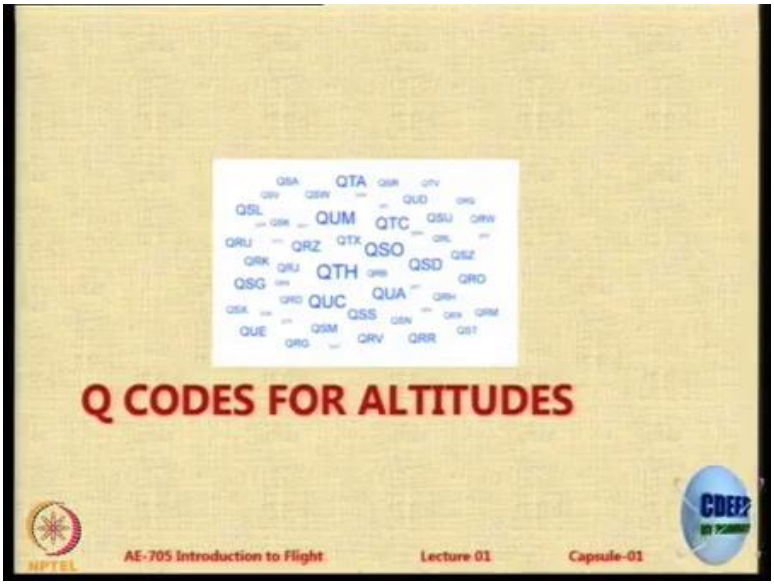


Now we come to the questions about these various altitudes and how are they reconciled, so we call them as Q altitudes or Q codes. There are many of them let us see one by one.

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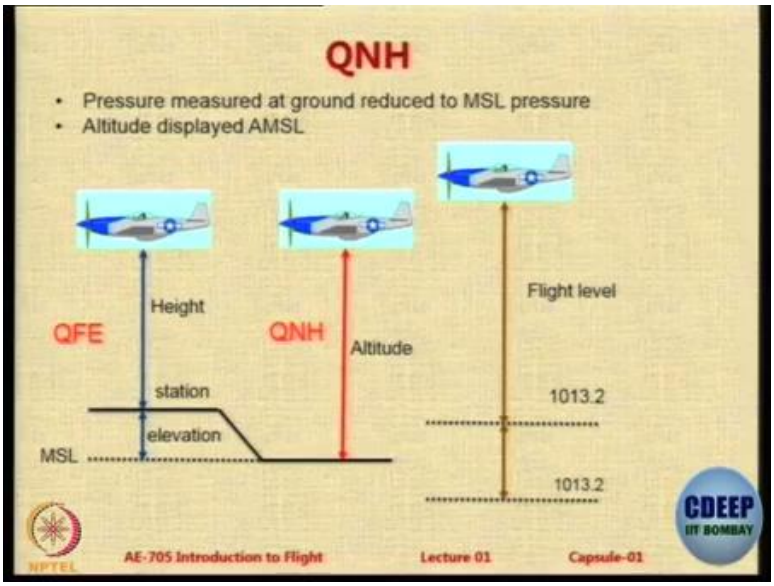


The first one is called QNH, what is QNH? First of all there is something called as QFE, QFE is the height from the current location below, this you measure by a radio altimeter. Because, you asked the question about how do you measure? The answer is if I want to measure the height from

a particular location I can use a radio altimeter, I will send a beam and take it back and find out the delta h, that height is called as a QFE.

But there is something called as a QNH, which is the altitude from the location plus the height of the location above mean sea level. So, the mean sea level in Mumbai is 14 meters and let us say I am at Khandala which has got some height, so the QFE over Khandala will be measured directly above Khandala and the QNH will be from the mean sea level, remember the mean sea level also changes from place to place, so this is the location specific. QNH at Mumbai, QNH at Pune can be different because sea level there may be slight variations.

Then you have something else also, we assume that 1013.2 is the pressure right, so the pressure measured at the ground reduce to the mean sea level pressure that is called as the QNH and the altitude is displayed above mean sea level. Now, there are others also, now you can see there is a airport located in some beautiful hill there it has got some elevation from the ground. The dark line is so the runway is location at that point so QFE will be above that right, then you have QNH which is sea level datum as you can see it is not same everywhere. But we also have the third one which is corrected not to the sea level, but to the mercury value corresponding to a standard sea level which can be different from place to place.

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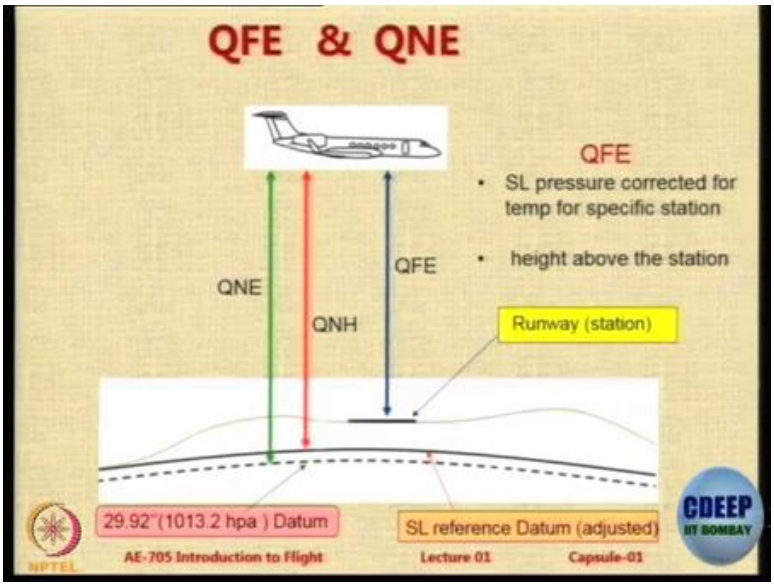

So, to be very sure because we use it using instruments, right. Ultimately, the pilot is using instruments. So, we say if the reference is sea level then it is QNH, if the reference is some theoretical place where the pressure is equal to 29.92 inches of mercury, that theoretical value reference is QNE, so QNH QNE there can be a slight difference it could be positive it could be negative also, correct. So, what are you concerned about? You are concerned about QFE above the earth, but QNH, so basically when you take off from some airport like Mumbai and when you come to land in say, Delhi the pilot has to adjust the altimeter to take care of the elevation at Mumbai, at Delhi.

So the pilot will ask the ATCO or there are charts available. The ATCO will say so when you, I will just show communication between ATCO and pilots, you will see where they talk about this ok right.

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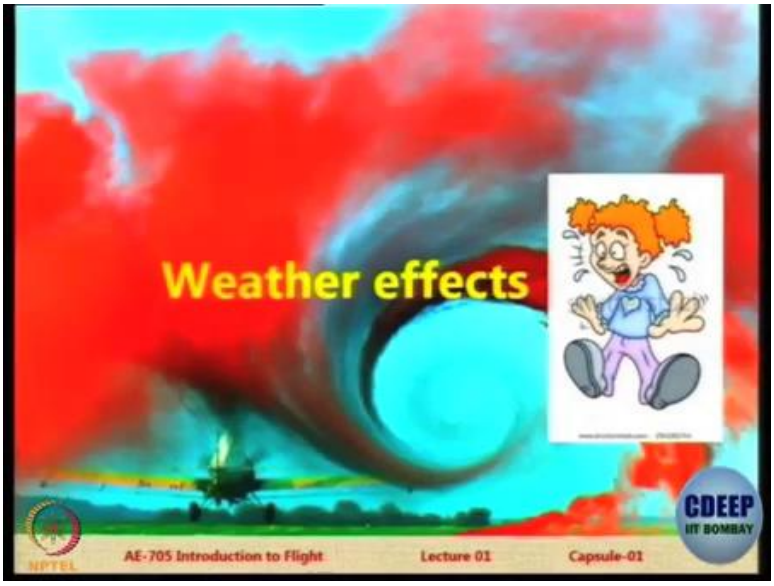

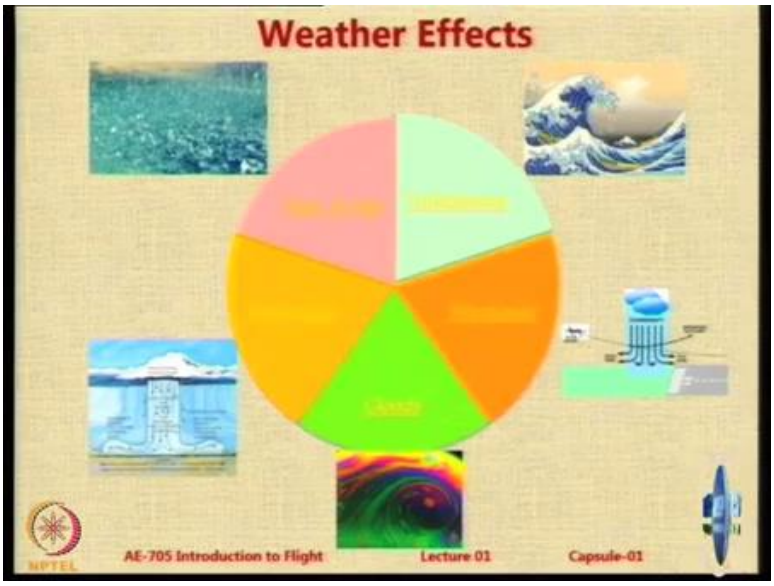


Now, the last thing that we have are some very very interesting videos about the effect of weather. I do not think I will be able to show all of you, all of them to you, but I will try to show some of them. So, the thing that affect our flying is turbulence, wind shear, clouds, rains and microburst. So, in the interest of time I think I will show you first turbulence, no no not turbulence, rain because there is a pilot communication about the QNH and QFE.

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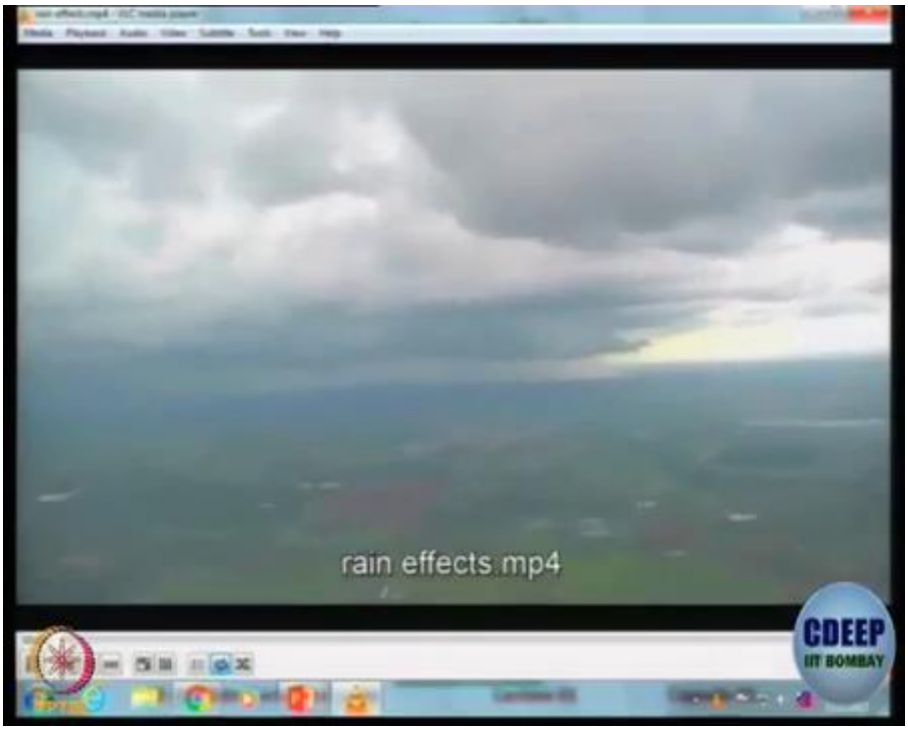
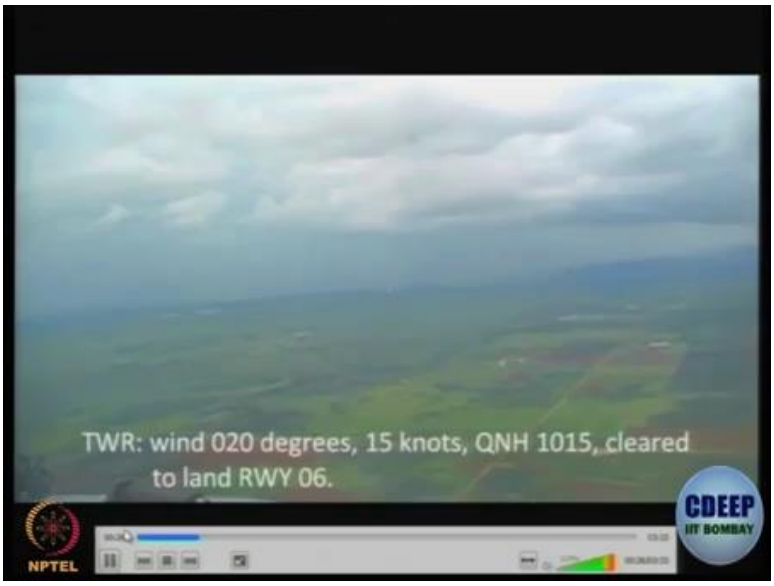
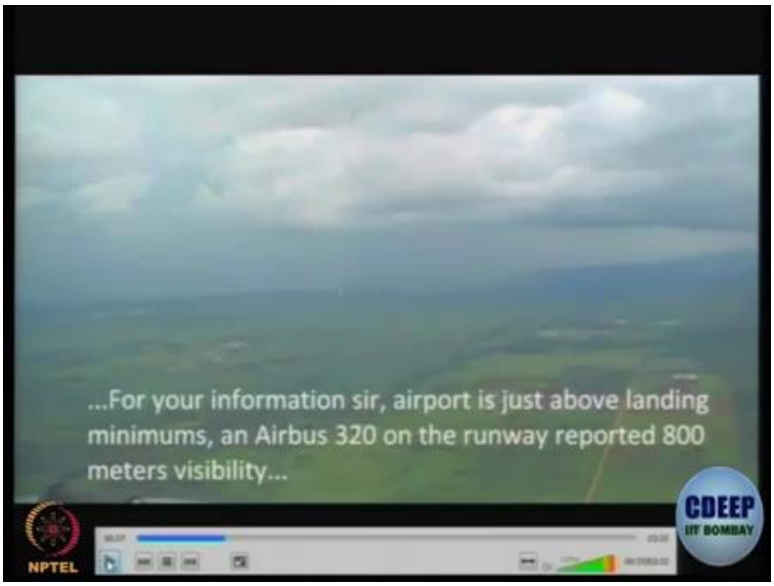
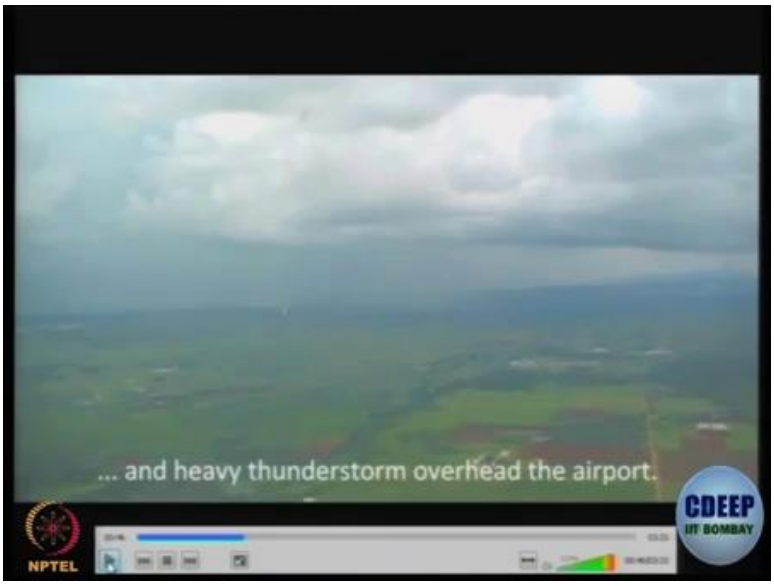



rain effects mp4

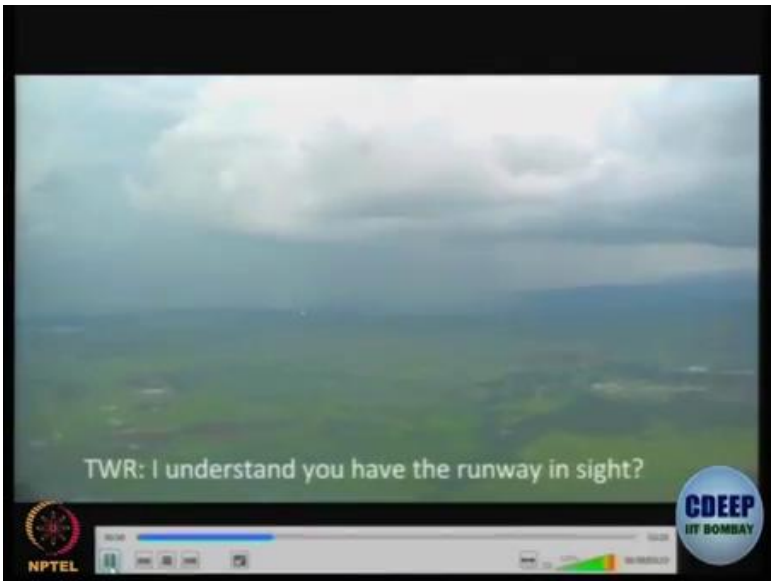

NPTEL
CDEEP
IIT BOMBAY


TWR: wind 020 degrees, 15 knots, QNH 1015, cleared to land RWY 06.
NPTEL
CDEEP
IIT BOMBAY


...For your information sir, airport is just above landing minimums, an Airbus 320 on the runway reported 800 meters visibility...
NPTEL
CDEEP
IIT BOMBAY


... and heavy thunderstorm overhead the airport.
NPTEL
CDEEP
IIT BOMBAY


F/O: Copy weather conditions, now 6.5 miles with the approach light system in sight.
NPTEL
CDEEP
IIT BOMBAY


TWR: I understand you have the runway in sight?
NPTEL
CDEEP
IIT BOMBAY


F/O: Affirmative
NPTEL
CDEEP
IIT BOMBAY


F/O: Two miles on short final...
NPTEL
CDEEP
IIT BOMBAY


TWR: Roger, still runway in sight?
NPTEL
CDEEP
IIT BOMBAY



So this is a weather radar which shows the presence of heavy rain to the pilot, the pilot is approaching to land. You can just increase the volume please, slightly. Now, so this is the tower, control tower, the ATCO speaking to the pilot saying wind 020 degrees that means the wind is coming from 20 degrees north onwards at 15 knots speed, so you have to beware that I may I may have some crosswinds or headwinds or tailwinds. QNH 1015, so he is saying the airport where I am located the ATCO is saying has a QNH of 1015 so adjust karo.

Because your instrument should also have a QNH of 1015 then we are in same page, otherwise you will follow the instruments and you will hit the ground. Clear to land runway 06, now runway

06, I will explain you in another video when I come to landing I am going to explain to you what is meant by runway 06, I stopped here because I wanted you to understand what it is. Now see what the pilot says, ok, so for your information sir airport is just above landing minima, so there are certain landing minimas that means you cannot land unless you have these things so we are just above the minima.

An airbus 320 on the runway reported 800 meters visibility, one of the basic problem on an airport during bad weather is visibility. So, every airport and actually every aircraft has got systems which can help, so there are some minimum values you are not supposed to operate below the minima from safety point of view. So the ATCO is cautioning the pilot that please understand, we are undergoing a weather condition at which we are just above the landing minima and the visibility told by someone who just went recently is 800 meter that means the pilot can see only upto 800 meters, beyond that it is hazy.

So, he is cautioning the pilot and one more thing you notice this is the place where you should focus, because you will see the runway landing lights there, that is what the pilot going to report now. Right, it is a caution, weather information, there is a heavy thunderstorm. So, the first officer says copy weather condition, that means I confirm that I know that there is a 800 meters visibility reported and we have thunderstorms. Now, 6.5 miles with the approach lighting system in sight, so he says according to my instrumentation I am 6.5 miles away and I can see the approach lights which is correct you can also see, ok.

Now, see what happens after that. Very important, the ATCO is confirming that you can see the runway lights because if you do not see the lights, then you may be below the minimum you have to abort, so he says affirmative. Remember all the conversations are recorded in the cockpit voice recorder therefore the pilots have to say yes. They do not say yes, no they talk of negative affirmative this is the language that they use. Thunderstorms, not visible now.

So, the pilot will continue to fly till the aircraft reaches the prescribed minima and at the minima, if the, that means suppose the minima is 400 meters when you are, when you are at that place and you cannot see you have to abort. One second after that you might be able to see, sorry. So this is a situation where there is now a  there is a slight issue, because there is a weather front approaching it is not visible. Visible. So, the moment it is visible the pilot communicates again and says 2 miles

on short final  that means, now I am 2 miles away,  I am on my final. There is also a short final, long final those are details.

But the moment the pilot sees again it confirms that, yes I am on the final. So, ATCO is saying roger, I understand, are you still able to see the lights? Because the rule is if you are not able to see at the final you are supposed to abort. Affirmative, yes I can see on the final. So, now you will hear a inner marker sound, rain has come now. That is it, touch down, after this it is touch down.

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