Environmental Impact assessment
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Lecture 32
EIA – Air Assessment – Part II

Welcome to the course- Environmental Impact Assessment. In this session today, we are going to cover the second part of the method for environmental impact assessment considering air within the larger ambit of the EIA method. So, we have been covering EIA methods for some time. In the previous session, we covered the concept and the screening stage. And we also looked at different standards. So, today we will cover the impact prediction and evaluation stage while we look at how we assess the environmental quality with concern with air.

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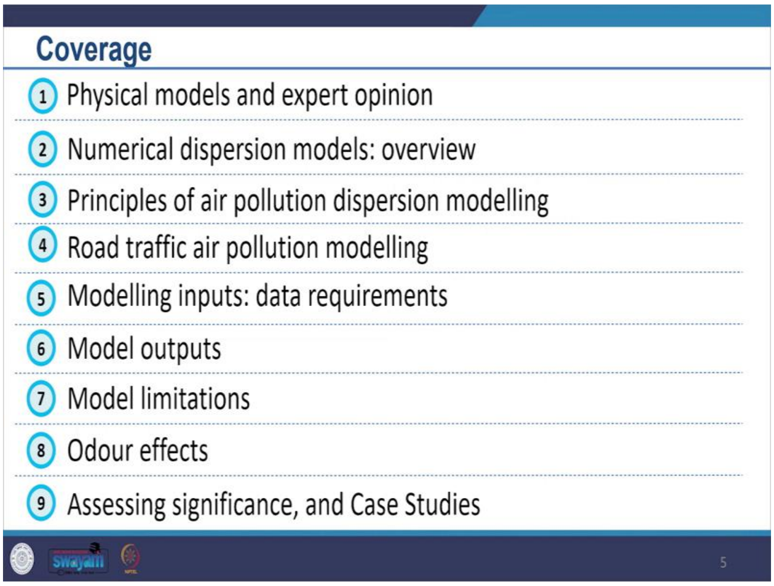

So, accordingly, the coverage and impact prediction and evaluation will include we will look into the background, we will look into the physical models, and the expert opinion I used, as well as we will look into numerical dispersion models. We will look into the principles of air pollution, dispersion modeling, what is the idea behind it, and what rules we follow. Then we look into road traffic air pollution modeling. Further, we will look into what kind of data is required for modeling purposes. So, what is the input data we are given? Then we look into the model output.

Further, we will look into the limitations of the modeling. Further, we will also look into odor effects concerning the air quality, then we will look at how we assess the significance of our results. Whatever, impact we get, how do we look at the significance of that impact? Further, we will just briefly cover one of the case studies.

So, accordingly, the expected learning outcomes are that you should be able to review the purpose and you should be able to identify and choose which method to use, such as the physical model or you need to use have an expert opinion or you need to look at numerical dispersion models. Further, you should be able to review the principles underlying principles of air pollution, and dispersion modeling, you should be able to list road traffic air pollution modeling tools, that are available to you, and you should be able to identify the modeling inputs like, what kind of data is required from where you find those data, you should be able to review the model output.

So, once you get the model outputs, you should be able to like, see what it says, and then further, you should know what to expect after you have done modelling, you should be able to state the model limitation. So, when you are using a certain kind of tool you should be able to tell about its limitations and then accordingly make judgments, you should be able to review the significance of the impact identified through different methods and you should be able to explain all of these with the help of case study and further will usually be able to also tell about the odor effects and then the method available for that. Our textbook for this purpose is terrible and the word which we have been following for this particular segment, you may read Chapter 4 for reference purposes.

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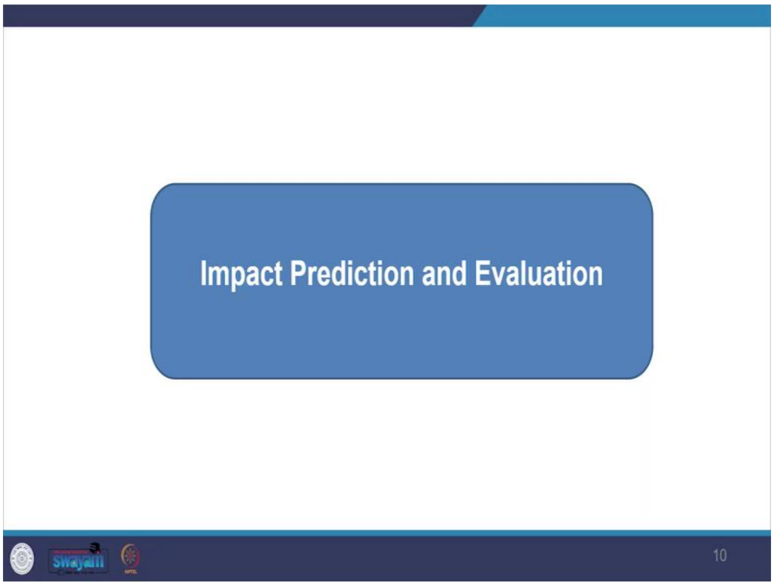

So, looking at the methods for impact prediction and evaluation first option available to us is that we see the physical models and the expert's opinion.

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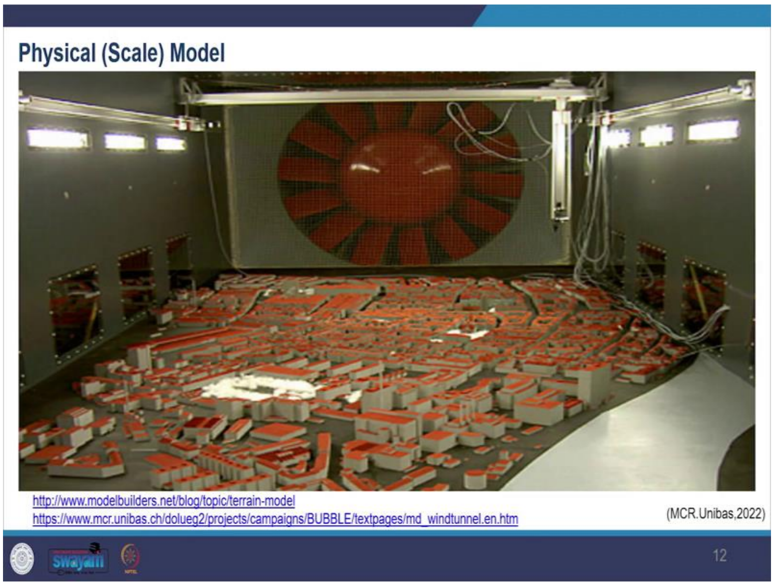

We see that, occasionally physical scale model is being used with a combination of wind tunnels and we also see the usage of computer graphics for impact prediction and evaluation. In particular, these are used in conditions where topography is complex, such as hilly terrain also when numerical models indicate uncertainty. So, whenever, you use a numerical model, it indicates a certain level of uncertainty regarding the pattern of effects due to the surrounding buildings and terrain.

So, in those conditions also, you use the physical model or the computer graphic model in the image, you can see the physical scale model and wind tunnel. The study consisted of two phases in this particular case, you can see they are estimating the turbulence and they are also looking at the pollutant dispersion experiment. So, a link to this study is provided to us if you are interested in learning more about it the link is given here.

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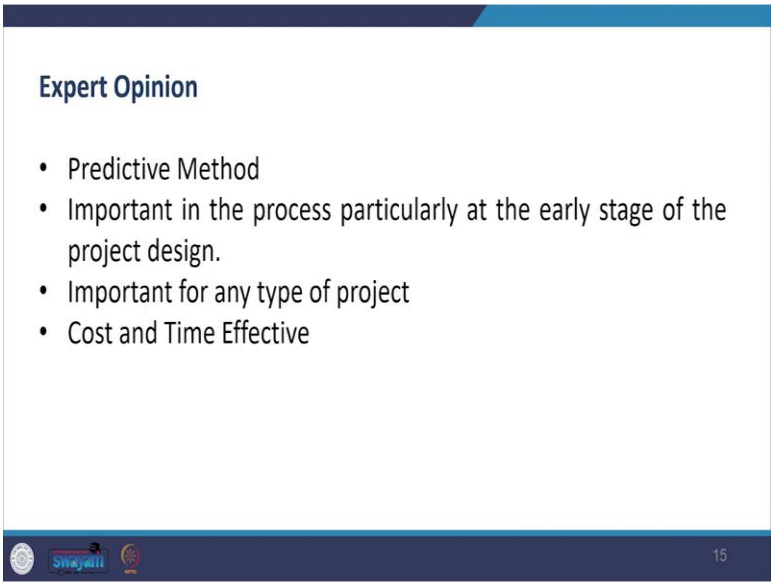

You may also use expert opinion with the justification for the opinion whatever just opinion is given you need to justify it and this can be used as a predictive method. Expert opinion is important and the process particularly, at the early stage of the project design, is important for any type of project it is also cost and time-effective when you have similar projects to learn from. You can also use the analog, this method by comparing with such similar existing developments or planned projects for which prediction has already been undertaken for estimation.

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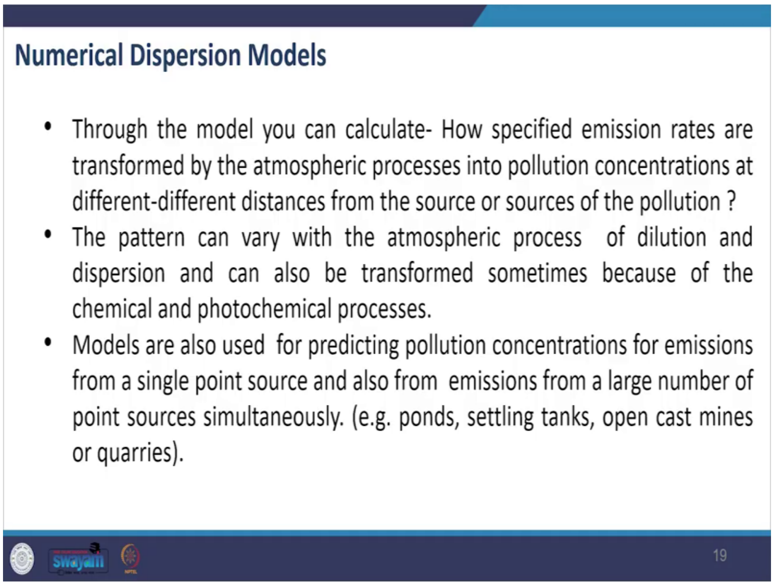

Next, we see the numerical dispersion models, numerical dispersion models are the most used for the purpose through the model you can calculate how specified emissions rates are transformed by the atmospheric process into pollution concentration at different distances from this source or sources of pollution. The baton can vary with the atmospheric process of dilution and dispersion and can also be transformed sometimes because of the chemical and photochemical processes.

We see that models are also used for predicting pollution concentration for emissions from single point sources for example, from the industrial stack, the chimney which you see, or the rent, and also from emissions from a large number of point sources simultaneously of example, pond setting times and then opencast mines or queries.

The basic model which is available while you use it can be further enhanced in accuracy. How they predict by adding site-specific complexities into the model site-specific complexities such as flat or hilly terrain, then you can also add surface roughness example urban or rural conditions, you can also, add like effects of sea breeze in the coastal area, then, even the presence of nearby buildings which may cause building vague effects can also be added to the basic model.

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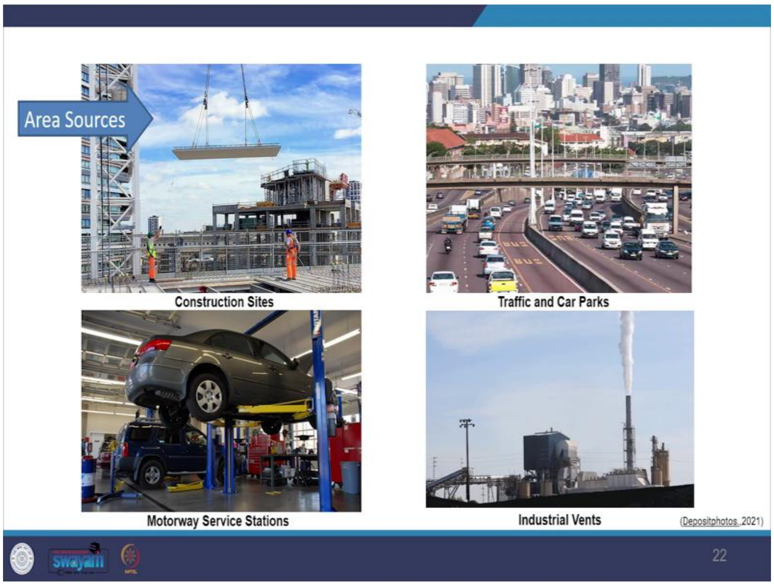

You will also find models for area sources. So, area source such as construction sites, car parks, motorway service stations industrial processes, which has numerous rents, urban areas metropolitan areas storage lagoons, and so on. So, these all are the area sources.

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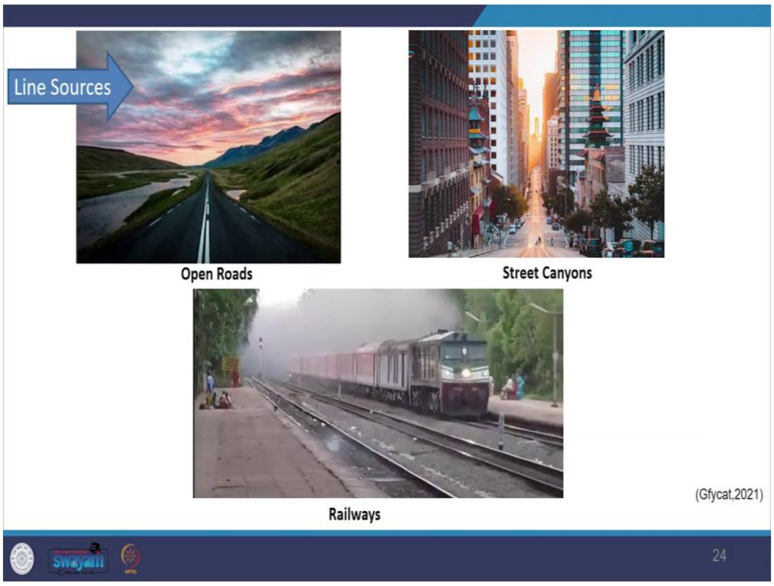

So, you would find models for this is that as well then you have line source for example, open roads you can think of the open roads where there are vehicles continuously moving vehicles, the railway tracks, and so on.

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Then, you also have volume sources such as the vertical area sources with vertical depth for example leaking gases from a group of industrial processes.

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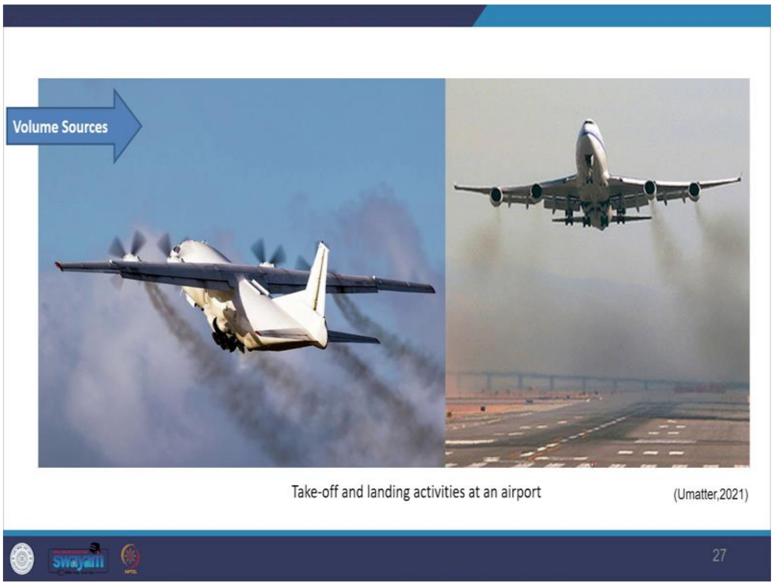

Then the takeoff and landing activities of an air from the airport for the odour.

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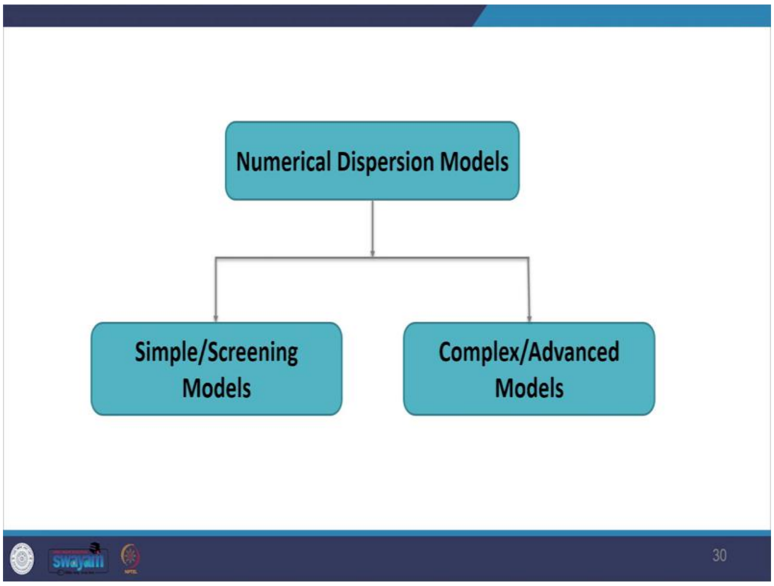

Now, we are going to look at the odor and the smell the effect can also be predicted by point source dispersion models. It can be done based on the emission of a pure substance or in terms of emissions of odor units. So, you can tell it by the units as well. We see that both simple and complex, an advanced version of the numerical dispersion model exists, so you can use it from either of them. Simple models usually known as the screening models which are used for screening purposes are designed for use as an inexpensive tool to identify whether or not air quality further investigation into the air quality is required or not.

In the screening models very, simple assumptions are taken simple assumptions about the behavior of pollutants in the atmosphere, they can be used with limited metrological input data such as minimum and maximum ambient air temperatures and minimum wind speed with which worst-case pollution concentrations can be estimated. If you see in the screening model that emissions from our proposed developments are producing air pollution concentration, the results are minimal, they are considerably below the standards, then you may not go for further detail or a more accurate investigation.

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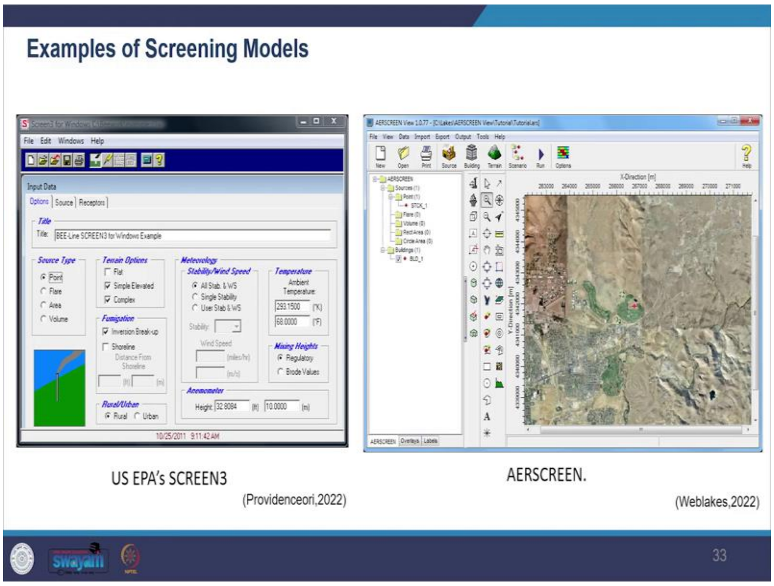

Therefore, you would not require complex models there are screening models that are available like the US EPA's SCREEN 3 and AERSCREEN. These are examples of screening models. However, it is suggested that irrespective of you saw if the result is minimal below these terms, then you might not go but it is suggested that if there is a major development, then irrespective of your results you should go for a complex model.

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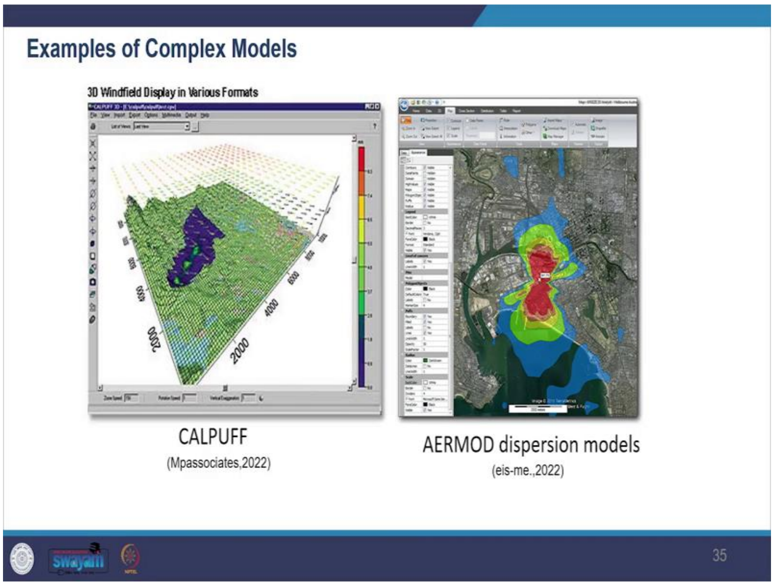

Examples of complex models include EPA's CALPUFF and AERMOD dispersion models and then you also see another model from UK ADMS dispersion modeling which is available in the image.

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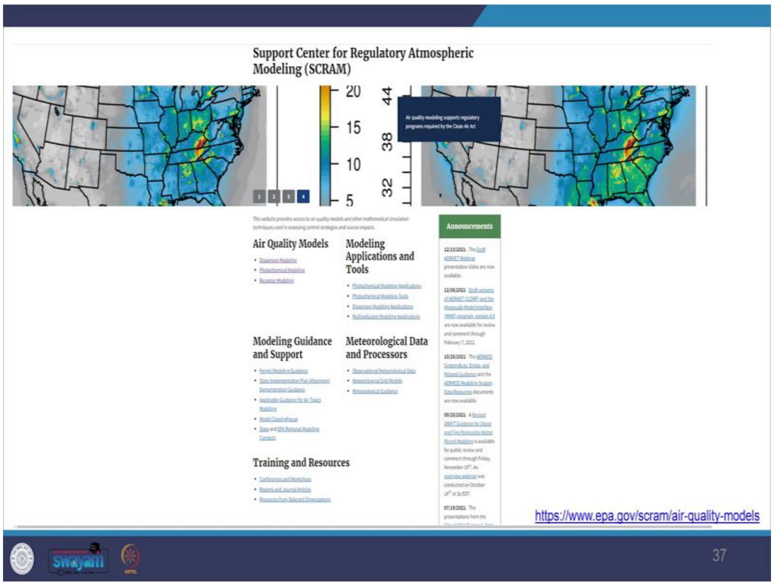

You can see the snip off Support Centre for regulatory atmospheric modeling where they provide info on air quality models modeling applications and tools guidance and support metrological data and processor, they also provide training and resource support. So, the link is provided to you and you can visit this website it is indicated that the usage of US EPA models is very widespread and you can see it is used in Australia, New

Zealand, Canada, and South Africa. Furthermore, they have usage is high because they have open access to the Source code through this particular Support Centre.

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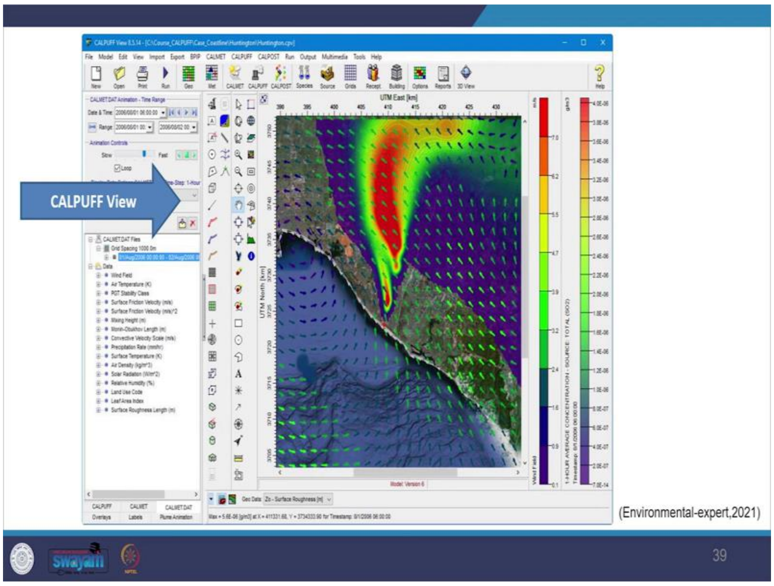

We also see that there are certain commercial versions also available for example, you have CALPUFF view which is the commercial version which uses like it is very user-friendly in terms of input and output routines that are available to them. Now, we will look at how we choose the dispersion model. Selection of a dispersion model will depend on our what are your requirements? What exact requirements are there for assessment? For example, for modeling industrial emissions you may require a permit to operate.

Also, regulatory authorities may have specific requirements regarding what type of modeling software you may use, what would be the input data and what will be the modeling procedure. So, you need to decide based on this you may also follow a very general guidance that the bigger and more complicated the installation of the project you have you would require a complex dispersion model.

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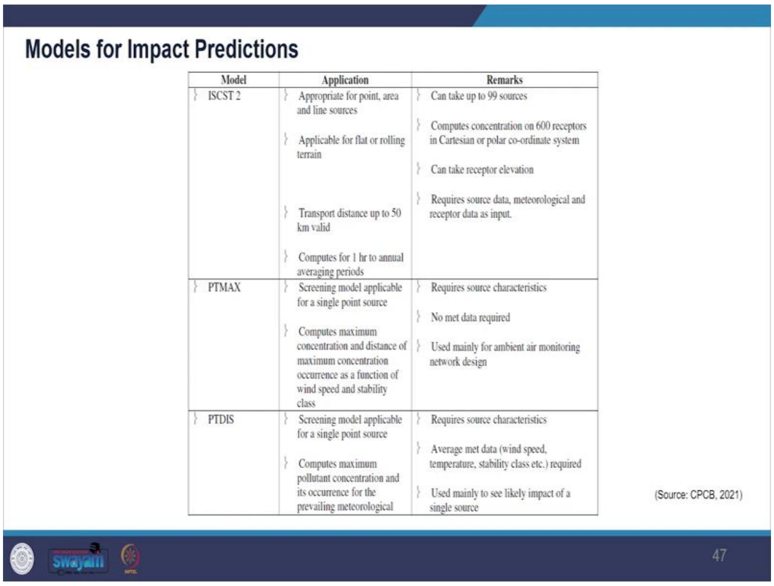

Model	Application	Remarks
ISCST 2	Appropriate for point, area and line sources Applicable for flat or rolling terrain Transport distance up to 50 km valid Computes for 1 hr to annual averaging periods	Can take up to 99 sources Computes concentration on 600 receptors in Cartesian or polar co-ordinate system Can take receptor elevation Requires source data, meteorological and receptor data as input.
PTMAX	Screening model applicable for a single point source Computes maximum concentration and distance of maximum concentration occurrence as a function of wind speed and stability class	Requires source characteristics No met data required Used mainly for ambient air monitoring network design
PTDIS	Screening model applicable for a single point source Computes maximum pollutant concentration and its occurrence for the prevailing meteorological	Requires source characteristics Average met data (wind speed, temperature, stability class etc.) required Used mainly to see likely impact of a single source

Example of models for impact prediction as suggested by the Ministry of Environment government of India like the list has been provided to you, you can just see how they are telling about all the models which are available and then how it can be applied and what kind of information can be extracted or what kind of input or output data can be taken out from here.

So, you can see you can go through the entire list I am just going to read out one of the details from here. So, you have model ISCST 2 which can be applied for 4 Point area and line source as well and it is applicable for flat or rolling terrain also. And then you have transport distance up to 50 kilometers. Then you also have it computed for one hour two annual averaging periods.

Then you will see that it can take up to 99 Sources and it computes concentration on 600 receptors like the where the impact will happen and it does it in the Cartesian or polar coordinate system. It can also take the receptor's elevation requires source data, it also needs metrological and receptor data as input. So, all these details are provided to you.

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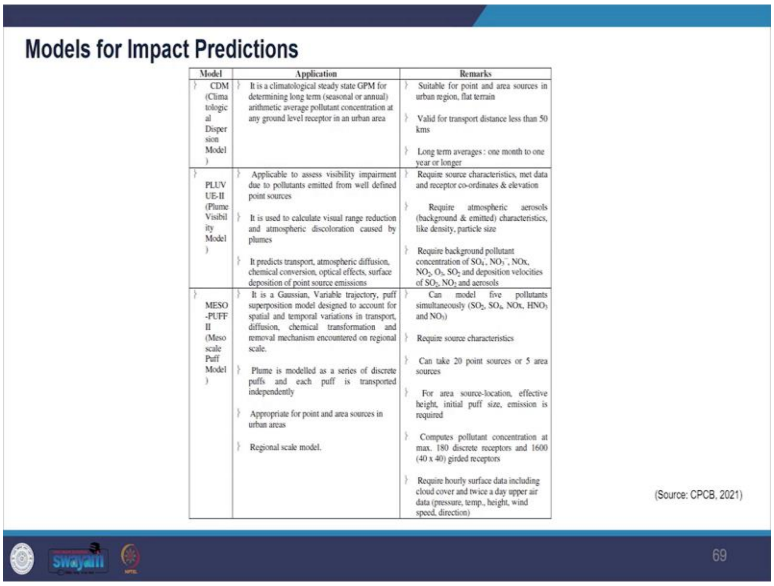

Model	Application	Remarks
CDM (Climatological Dispersion Model)	It is a climatological steady state GPM for determining long term (seasonal or annual) arithmetic average pollutant concentration at any ground level receptor in an urban area	Suitable for point and area sources in urban region, flat terrain Valid for transport distance less than 50 kms Long term averages : one month to one year or longer
PLUVUE-II (Plume Visibility Model)	Applicable to assess visibility impairment due to pollutants emitted from well defined point sources It is used to calculate visual range reduction and atmospheric discoloration caused by plumes It predicts transport, atmospheric diffusion, chemical conversion, optical effects, surface deposition of point source emissions	Require source characteristics, met data and receptor co-ordinates & elevation Require atmospheric aerosols (background & emitted) characteristics, like density, particle size Require background pollutant concentration of SO_4^-, NO_3^-, NOx, NO_2, O_3, SO_2 and deposition velocities of SO_2, NO_2 and aerosols
MESO-PUFF II (Meso scale Puff Model)	It is a Gaussian, Variable trajectory, puff superposition model designed to account for spatial and temporal variations in transport, diffusion, chemical transformation and removal mechanism encountered on regional scale. Plume is modelled as a series of discrete puffs and each puff is transported independently Appropriate for point and area sources in urban areas Regional scale model.	Can model five pollutants simultaneously (SO_2, SO_4, NOx, HNO_3 and NO_3) Require source characteristics Can take 20 point sources or 5 area sources For area source-location, effective height, initial puff size, emission is required Computes pollutant concentration at max. 180 discrete receptors and 1600 (40 x 40) girded receptors Require hourly surface data including cloud cover and twice a day upper air data (pressure, temp., height, wind speed, direction)

So, likewise, you can see all the. So, you have seen the list of models that are available to you from the Indian context as well. Now, we will look at the principles of the air pollution dispersion model. So, how on what basis are the underlying principles on which all this modeling is done? What we see is that most of the numerical prediction models are developed based on the Gaussian assumptions in the case of a point source of pollution.

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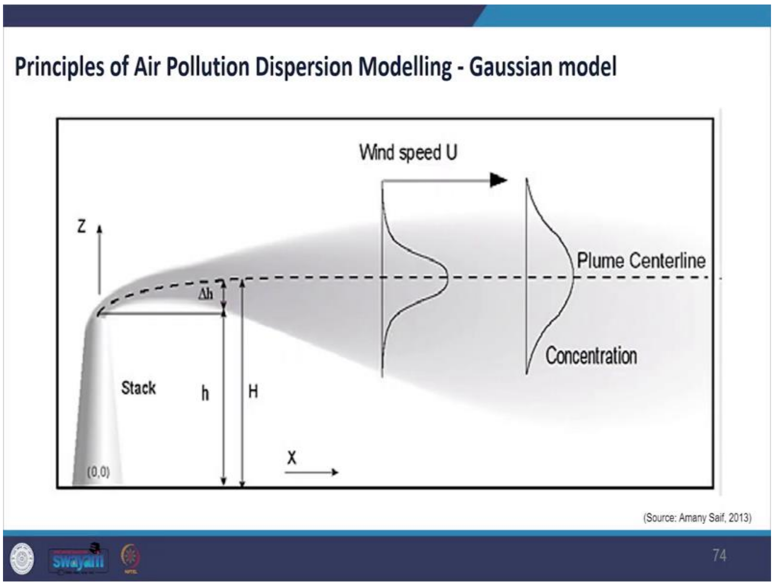

For example, in chimney stack, the basic Gaussian model considers that the pollutant emission spreads outward from a source in an expanding plume aligned to the wind direction. So, it goes in the wind direction it spreads in such a way that the distribution of pollution concentration decreases as the distance increases both in vertical distance or in horizontal distance. So, mostly the average shape of the plume is cone-shaped.

So, you might be seeing the plume changing shapes, but on average the shape is cone-shaped. Further, the rate of dispersion of the plume is a function of atmospheric turbulence what happens in the atmosphere influences the rate of dispersion atmospheric turbulence is based on simple metrological parameters involving as it would take solar radiation, cloud cover, mean wind speed and is unexpressed in form of 6 or 7 Pascual stability categories.

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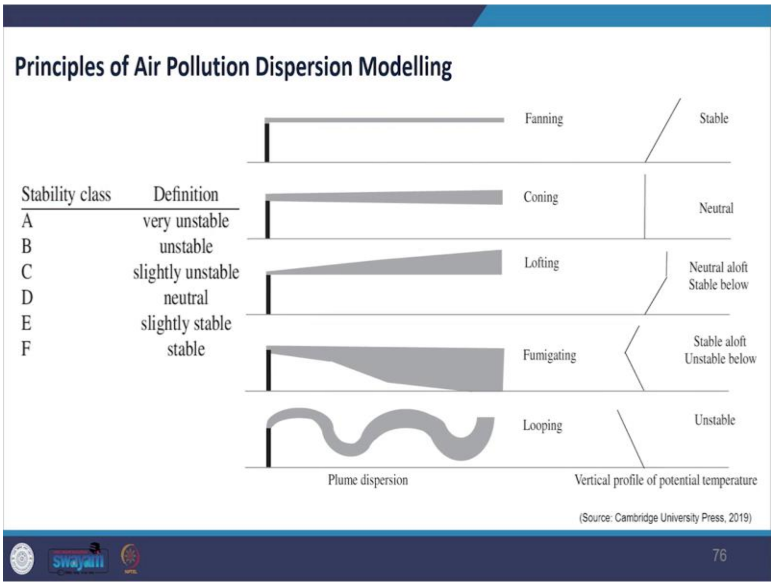

There are also stability categories, which range from Class A which is a very unstable condition that usually occurs during hot sunny conditions with light wind to you have classifications like F, and G, which indicate very stable conditions usually such stable conditions occur during cold still night with clear sky. So, you can see in the image the range of the stability class. However, new versions of Gaussian plume air dispersion models, for example, you have AERMOD or ADMS 5 our improved version of the turbulent flow in atmospheric boundary layers.

So, we have seen the principle but now newer models are coming with the improved concepts you may know that the maximum ground level concentration from a pollution plume is where the plume touches the ground. So, wherever, the plume is touching the ground that means, there is maximum ground-level concentration this can happen due to several factors. So, such high pollutant concentrations because there is pollution is very high because of the metrological conditions.

So, how the atmosphere is or because of the surroundings how is the terrain topography, the adjoining building, and soon? So, this can happen for multiple reasons. Usually, the maximum ground-level concentration stack or elevated source occurs close to the source. So, it would happen close to the Source. This happens during light wind when the atmosphere is very stable. At these times considerable vertical mixing happens.

So, it usually happens on hot summer days. It can also be seen that during light winds the peak concentration is found further from the Source during conditions of increasing atmospheric stability. You can see why it is important to take into account local metrological conditions at the site. So, depending on that your ready rate of transfer dispersion will vary. Also, whenever tall buildings are there, adjoining the facility wind can sometimes give rise to high ground-level concentration.

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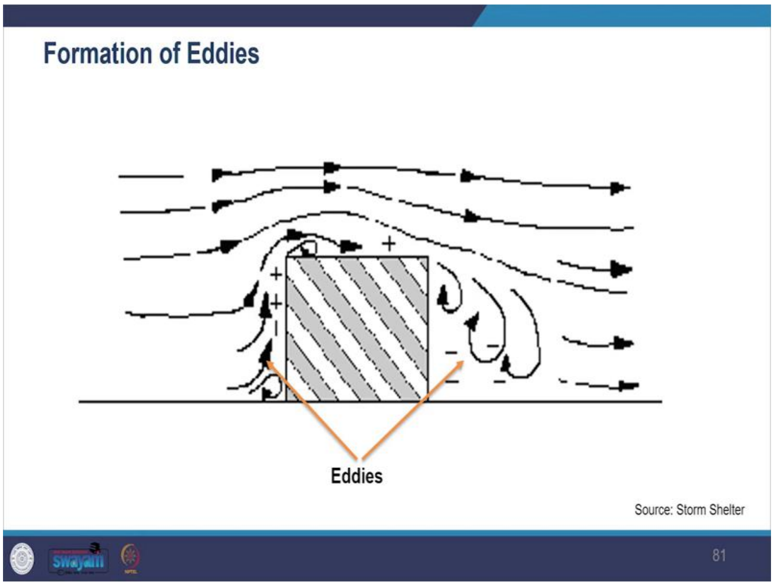

So, that can also happen such a situation arises and you will see why it situation arises due to the formation of eddies around the building that make the plume touch the ground much closer and absence of the building these plumes would have not hit the ground, it is usually understood that building downwash problems occurs if the stack height is less than 2.5 times the height of the building above which it projects.

So, you can see the impact like how the wind moves around the building, which causes the pollution to go down. Similar problems may occur if adjacent buildings or hills are within about a certain distance, for example, the five-stack height of the release point. So, that similar situation can happen in such cases the buildings can influence the stack emissions, and they can be changed in the pattern. Therefore, the local context must be considered in the modeling.

So, that is where you see how different things can change how, how the pollution travels. So, you must consider the local context other situations giving rise to high pollution concentration may be when plumes impact directly on the hillside under certain metrological conditions or when valleys trap emissions during low-level inversion. So, all these conditions can also impact.

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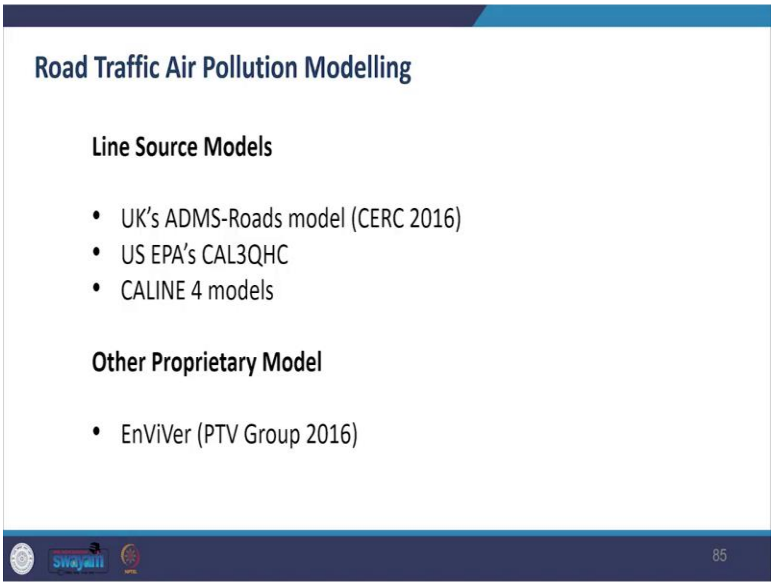

So, now, moving on to road traffic, and air pollution modeling. So, for the prediction purpose, as you can see like we are talking about road traffic, the linear Source model I used for the prediction is made at the receptor's levels. So, the receptors we make the prediction risk at the receptor level in the surrounding areas, several models are designed for road vehicles.

So, you see, the UK has developed the ADMS road model, then you can see the US has EPA's CAL3QHC, which is available and then you can see CALINE four models both of which are available as an open-source code. So, you may also find other proprietary models for traffic flow modeling and the examples include EnViVer which is also available for calculating mass emission.

Usually, when you do this modeling and when you get the output, the difference in results is taken out of the difference between, when you estimate without the project, without the development proposed development, and with the proposed development. So, with among those you take out the difference, the results indicate the predicted concentration for each scenario. So, you are building a scenario with the project without a project with alternatives, and so on.

So, you see the difference between them for this purpose also you will have to consider the local and metrological data. So, you also need to see how it goes with the context when you are comparing the results. There will be a lot of details which you may have to look into. Let us now look into modeling data requirements and what kind of data will be required.

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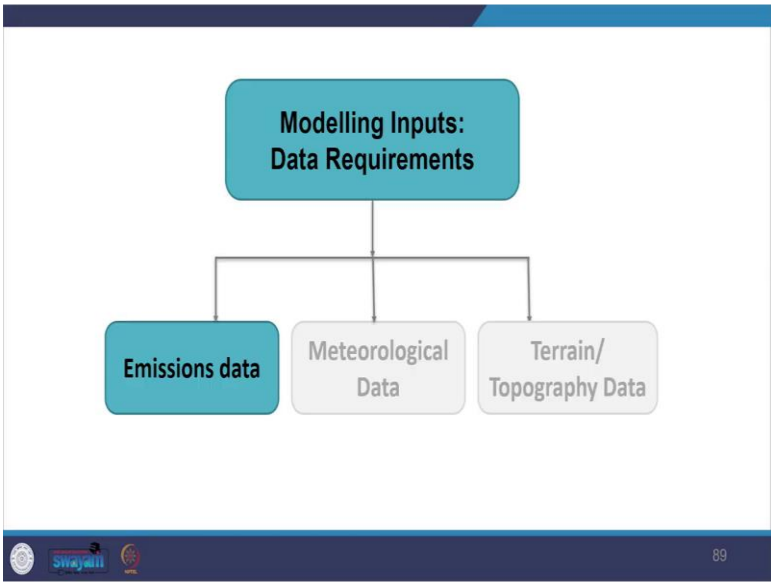

So, we see that for the modeling purpose, you will be requiring emission data all the numerical dispersion models require emission data either in the form of Spesh-certified emission rates. So, you can take from the emission rates which are specified for the sources for example, the amount of pollutant released per unit of time or you can measure or you can take the measure of the level of activity of the source for example, you can take care of the amount of fuel consumed in an accumulative manner with the corresponding emission factors, the quantity of pollutant emitted per unit of the activity and emission rates need not necessarily be exact.

So, for this purpose, you need not take the exact value as the likely impact of a planned development could be assessed by using the highest likely admission. So, you can take the highest admissions also and you can do the prediction. Using the highest values could be like maximum emission limits defined for the operational purpose. So, for those figures also you can take and do the calculations.

Models can also calculate vehicle emission rates for a specific section of road from input data such as the vehicle flow. So, which input data you have already given vehicle flow vehicle per day peak hour value? So, with that, it will also calculate for all the sections, average vehicle speed like if you have given input data vehicle makes what kind of vehicles are there and vehicle emission factors.

If you are using the model for future year predictions for prediction purposes then accordingly you have to provide the input data and you may also account for changes in the technology in the field and changes in the policy in the future time. So, when you predict the future you need to take care of those aspects also. So, you will require now moving on we see that you would also require metrological data.

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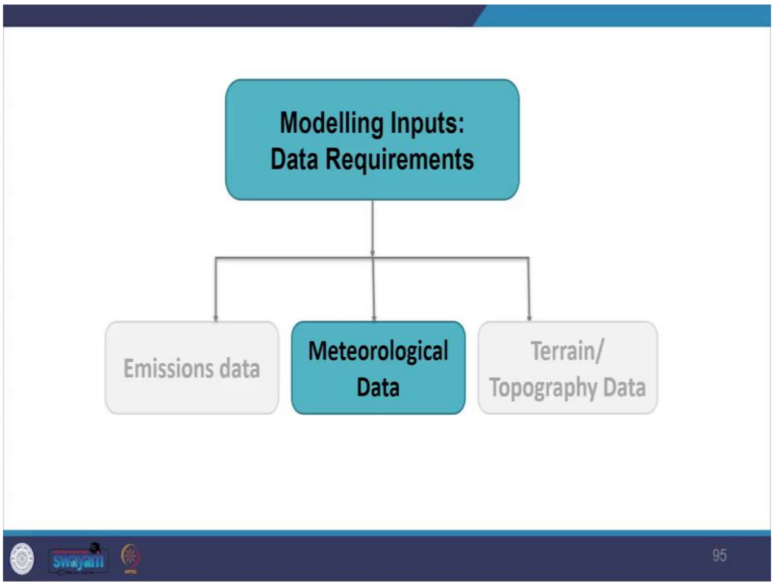

All models use metrological data, some use simple statistical data sets, for example, Pascal stability classes whereas, others use more complicated data sets such as hourly sequential data. So, rather than just classification you can have hourly data as well, you will have to use the data as per the location and the assessment you are making.

So, the assessment you have to do and to what detail you need it, it is suggested that as weather patterns vary from year to year, therefore, when map modeling is undertaken for scale industries installation, one should use 3 or 5 years' metrological data and should compare the results even CPCB gives you these guidelines he will look into that.

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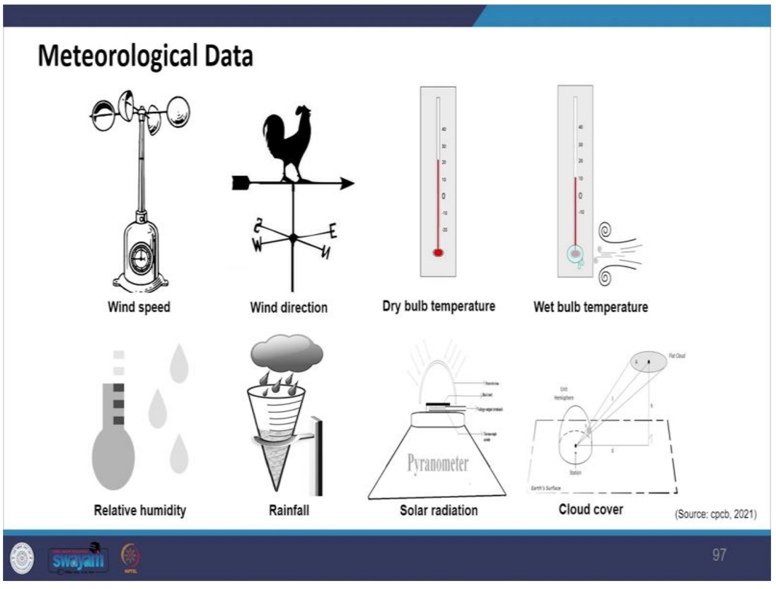

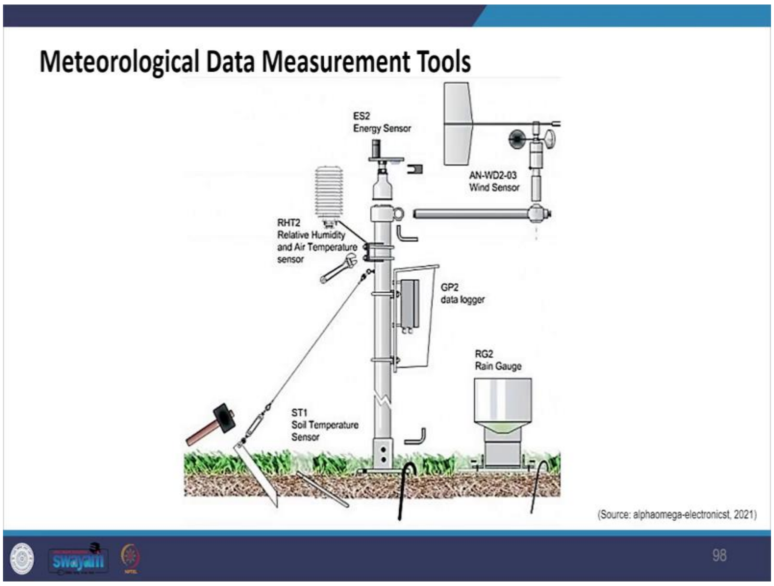

You can see, the type of meteorological data required which is wind speed, wind direction, dry bulb temperature, wet bulb temperature, and so on. You can also see, the pollution data measurement methods and tools used for measuring and collecting these metrological data.

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Pollutants Data Measurement Methods

Attributes	Sampling	Measurement Method		Remarks
Pollutants				**Monitoring Network**
SPM	10 to 15 locations in the project impact area	24 hourly twice a week (Please refer	Gravimetric (High-Volume)	Minimum 2 locations in upwind side, more sites in downwind side / impact zone
RPM		National Ambient Air Quality Standards, CPCB	Gravimetric (High-Volume with Cyclone)	All the sensitive receptors need to be covered
SO_2		Notification dated 11th April, 1994)	EPA Modified West & Gaeke method	**Measurement Methods**

(Source: cpcb, 2021)

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Pollutants Data Measurement Methods

Attributes	Sampling	Measurement Method		Remarks
NO_x			Arsenite modified Jacob & Hochheiser	As per CPCB standards for NAQM, 1994
CO		8 hourly twice a week	NDIR technique	
H_2S*		24 hourly twice a week	Methylene-blue	
$NH*_3$			Nessler�s method	
HC*			Infra Red analyser	
Fluoride*			Specific Ion meter	
Pb*				

***Project Specific**

(Source: cpcb, 2021)

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So, there is a list that CPCB provides like how the data has to be collected, how it has to be measured, and what frequency one needs to measure how many seasons one needs to take. You will be required to note other factors also while taking metrological data such as the relative height of the metrological stations. So, from where the data has been taken and then the assessment site and potential coastal effects if any, only needs to be considered.

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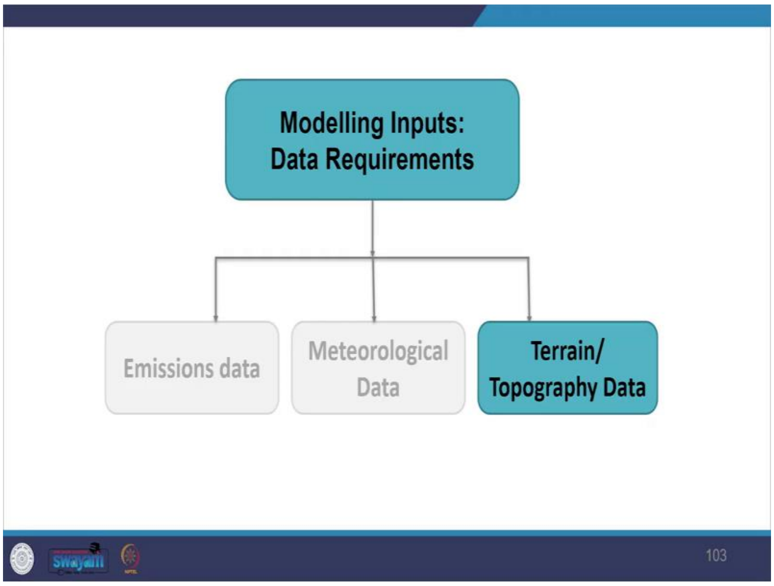

Further, as discussed before you will also be required to consider terrain topographic data as you can think of topography creating turbulence at and close to the ground level. This in turn influences the dispersion of pollutants between the source and the receptor. So, that there might be disturbances the complex model can take account of terrain and topography. So, those models can take care of it so that data can be drawn from the survey to create a three-dimensional map of the modeling area.

This allows for landscape features like for example hills, mountains, valleys, and even manmade structures such as motorway embankments and so on in the modeling algorithms. So, you can take care of these things. So, now, we look at the model output. So, now we have seen what kind of data is required.

Now, we are going to look at the model output, usually, the output is the short-term pollution impact. So, the output can you can get the output of short-term pollution impact like the highest or the worst case hourly mean concentration. You would also get long-term impact and will mean concentration, you will be required to compare the outputs with the applicable air quality standards.

So, when you get the results, you need to compare them with these Standards and Guidelines for your study area as per the local legislation given to you. So, then you make the judgment whether it is low or high, what it is. Among many benefits significant one about the modelling is that it allows the user to generate graphical outputs. So, it allows you to take care of a lot of factors at the same time, it allows you the graphical output, such as ISO line plots, which can greatly support you to do the assessment and also to communicate the results.

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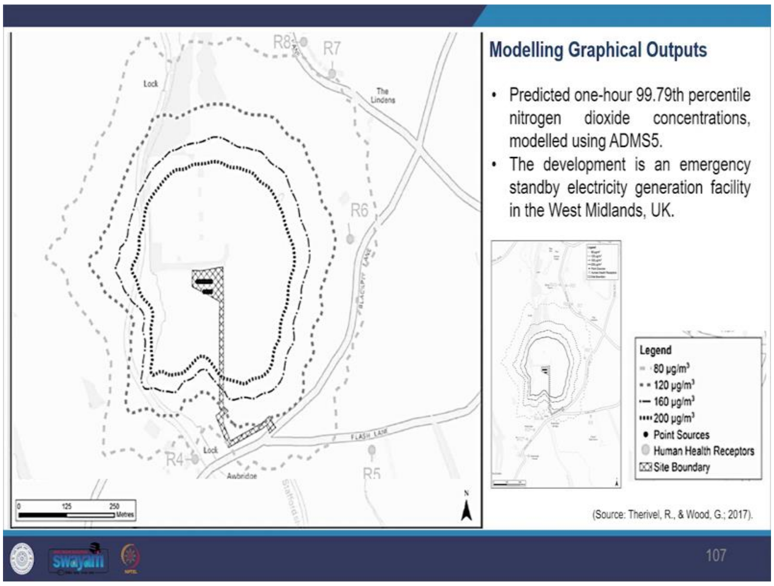

And you can see that many newer models now can integrate with GIS Geographical Information Systems. This can allow many other overlay analyses. Now looking at the model limitations, what kind of limitations are there, you may reflect that the models are simplification of reality. So, in modeling, you are simplifying the reality, you are just putting a few numbers of factors there. So, it is a simplification of the actual scenario.

So, there will be limitations. There will be concerns for accuracy and confidence in which you are giving the results or calculating the estimate, you need to clearly state the limitation of the model and assumptions whatever you have used, those things to be clearly stated. In all the prediction processes and results there are certain levels of uncertainty, you should take note of it and also communicate about it.

The accuracy of the output will depend on the quality of the input data. So, what kind of data you put in will depend on them, as well as it will also depend on the algorithm used in the model. So, there can be uncertainty. Because of this, what process you are using and then what kind of data you are giving in the real tech for this purpose to validate is to match the model results with the current baseline condition in the study areas.

So, you see the actual scenario and you match it with that, you can cross-check the results using the monitored pollution status as well. There are also guidelines, and methodologies to check the road traffic air pollution modeling results, which are developed by the UK. So, the UK has developed a framework for validation purposes, the predictions made by modeling software for point Sources are normally validated during the development of the model itself. So, when you are developing the model, when that model is developed, that time itself the validation is done. So, usually, one may not be required to compare the results.

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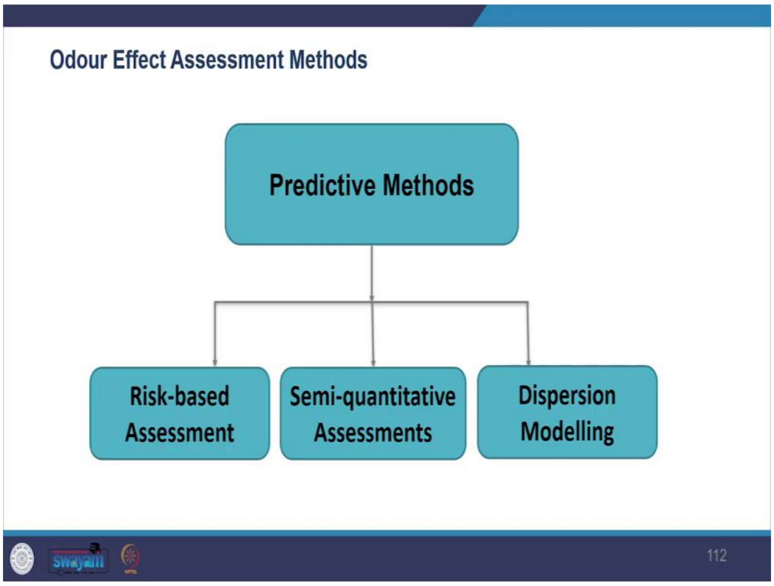

Now, looking at the odour effects, in assessing the odour effects, both predictive and observational methods can be used. So, you can predict and you can observe also. Predictive methods can involve a risk-based assessment of the source, where you look at the pathway and the receptor. And then you can conclude, you can have another semi-quantitative assessment. So, you can use these screening models or lookup tables to predict the odour concentrations. So, you might see what is the scenario here and compare it.

And then third is the dispersion modeling whereby odour concentrations are predicted and compared to the benchmark values, what are the accepted values you compare with that? So, now, coming to the significance, how do you evaluate the significance of your impact, the level of significance is assessed by comparing the predicted change in the area to the air quality standard.

So, whenever you get the results, you compare it with the air quality standards, and then look at the objectives and the guidelines values, and you see how far or ahead or lower you are, then you evaluate if these outputs are likely to be exceeded at any location. So, for any other location, the value will increase or it will go beyond the standards. After taking into account the existing and the predictive baseline pollution levels you make a judgement.

So, if the plan development is predicted to increase pollution levels in access to the close to the air quality standard, then you have to adopt the mitigation measures. So, if it is in access, then you have to come to the mitigation measures of how you are going to control that. And so, those ways, you have to take care of it. We will be looking at the mitigation measures in the later part of the lectures.

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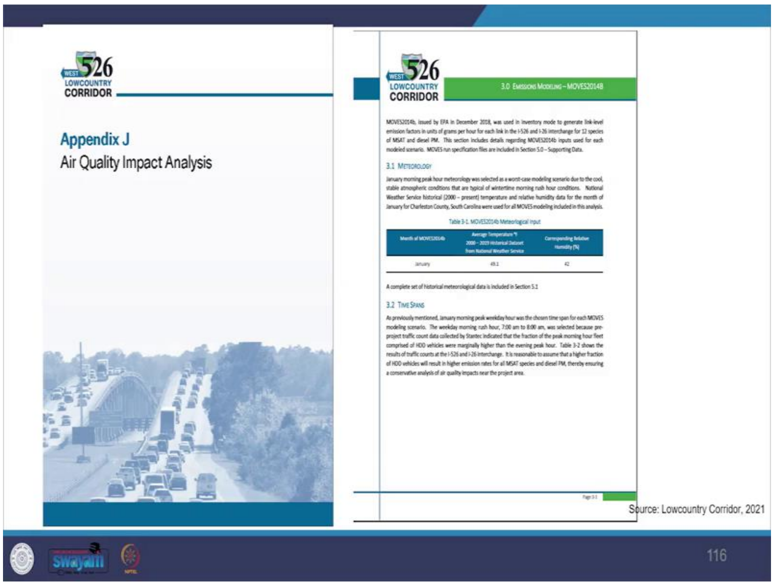

Now looking at the case study. So, this case study is being given to the link to the case studies given. So, we will briefly look into it. You are looking at the EIA of the low country corridor, the West project in Charleston, and northern Charleston, South Carolina in the US. Their quality impact analysis focuses on mobile source air toxics, which is MSAT emission, and they are looking at this emission and they are measuring the potential air quality impact on severely economically disadvantaged communities and the neighborhoods there, which are near this particular source. So, you are looking at these reports, this has been also given to you.

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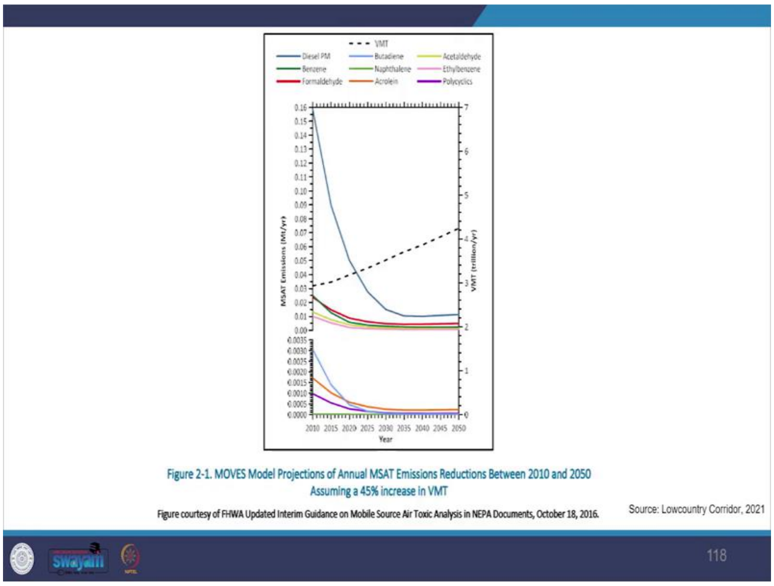

You see that look at the model output, how it looks like, and what kind of projections have been done, you look at the kind of data which has been fitted there.

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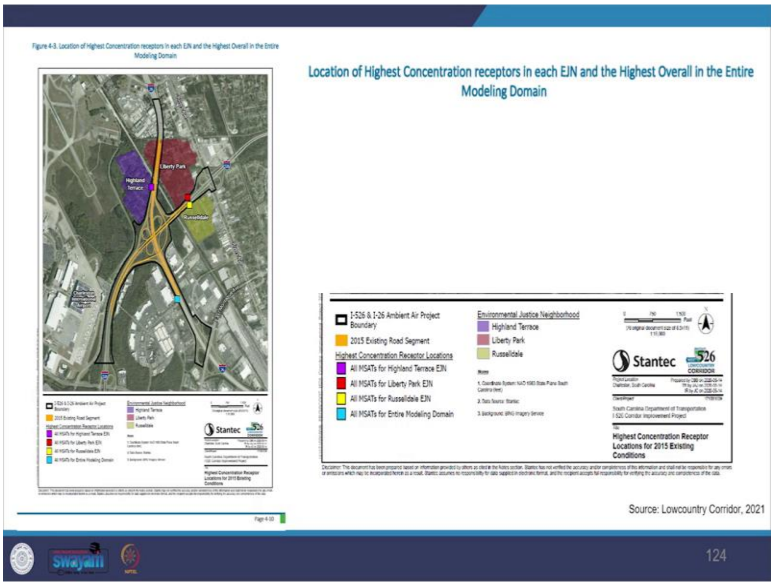

Then you see the dispersion model, they have selected the AERMOD model here, as per the EPA preferences, they have used the model and then they have also linked the context and terrain, as you can see here in this particular. So, I have just taken some of the snips from the report.

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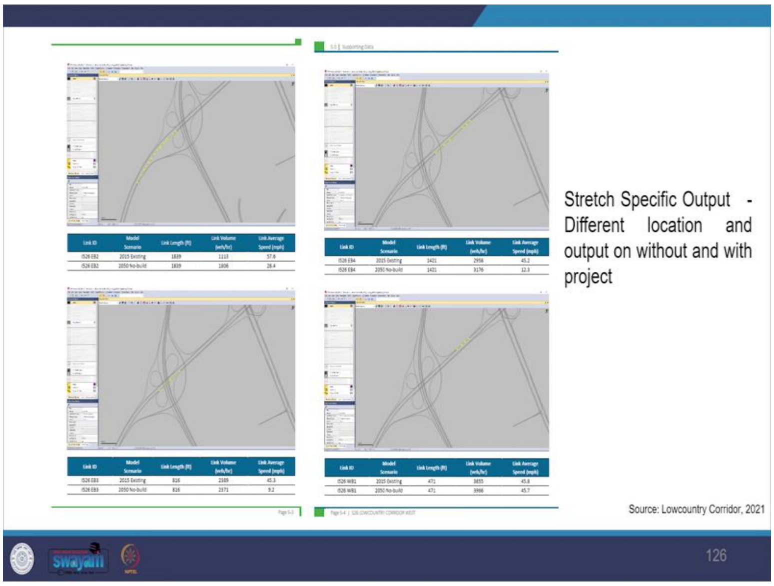

You will see that, the model is also providing stretch-specific output, you can see here different locations and output without and with the project. So, you can see here, how in the bottom rows you can see against each of the images how the output values vary, and what is the difference between them. So, you had talked about the model output. So, you can see the model output here and with the scenarios, different scenarios, and the different locations.

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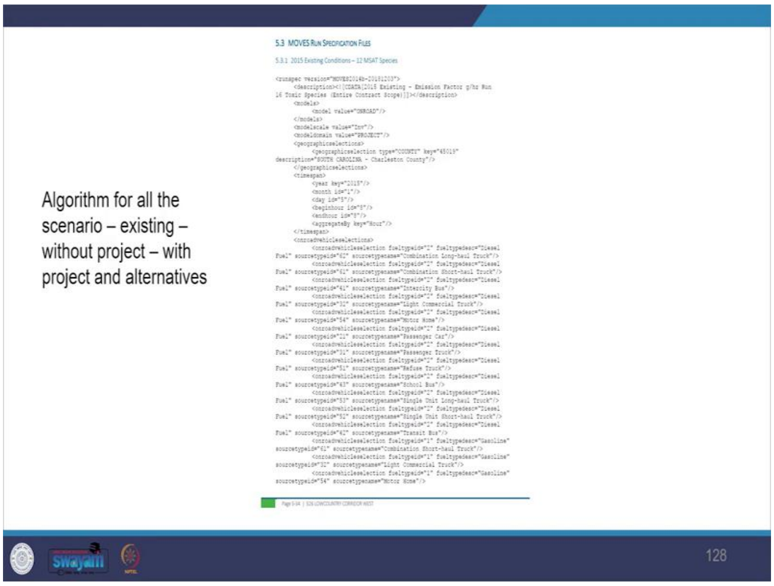

So, they have also provided the algorithm for all the scenarios. So, all the scenarios which they studied, and so you see what kind of information is given. So, the link to the case study is provided to you for further details.

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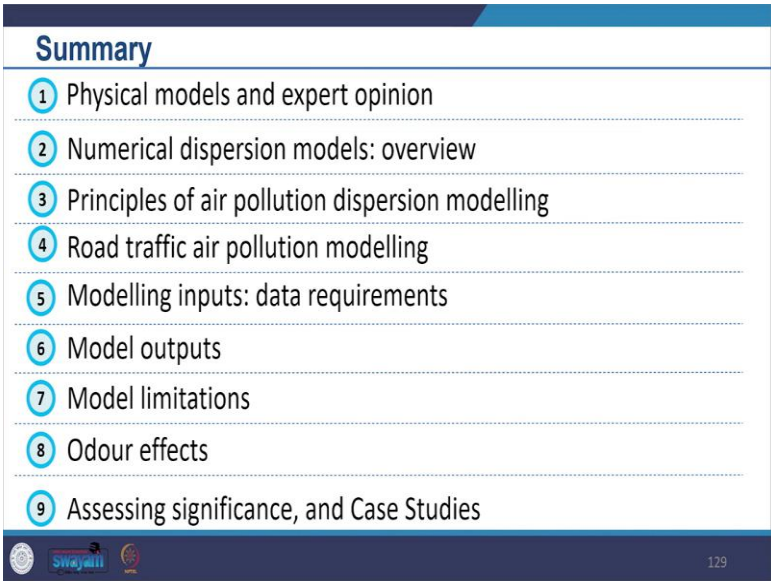

So, summarizing what we covered today, we looked at the impact prediction and the methods that are available to you in this. So, we looked at their physical model and the expert's opinion we looked at the numerical dispersion models, we looked at the principle underlying, principle of air pollution dispersion modeling, we looked at the road traffic air pollution modeling, and then we looked at the what kind of data is needed for modeling purpose, then we looked at the outputs we looked at the limitation. We also looked at the odour effects. And then we just skimmed through a case study which has been given to you for further details study.

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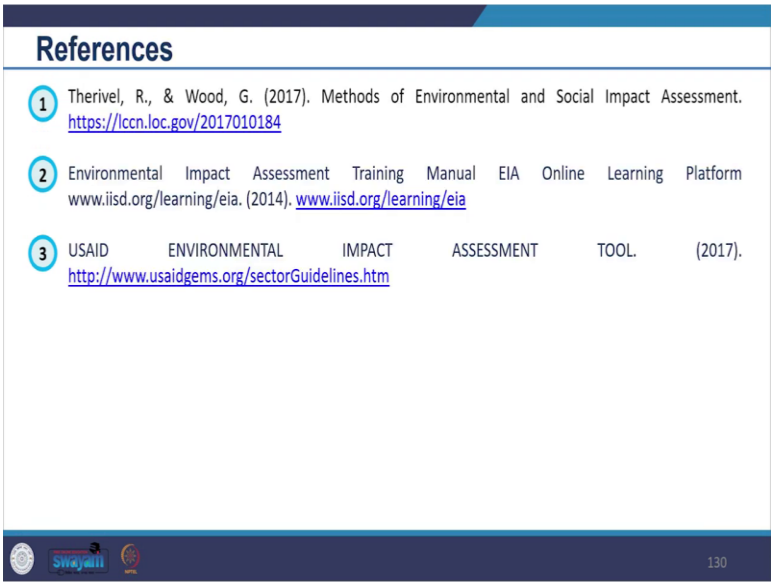

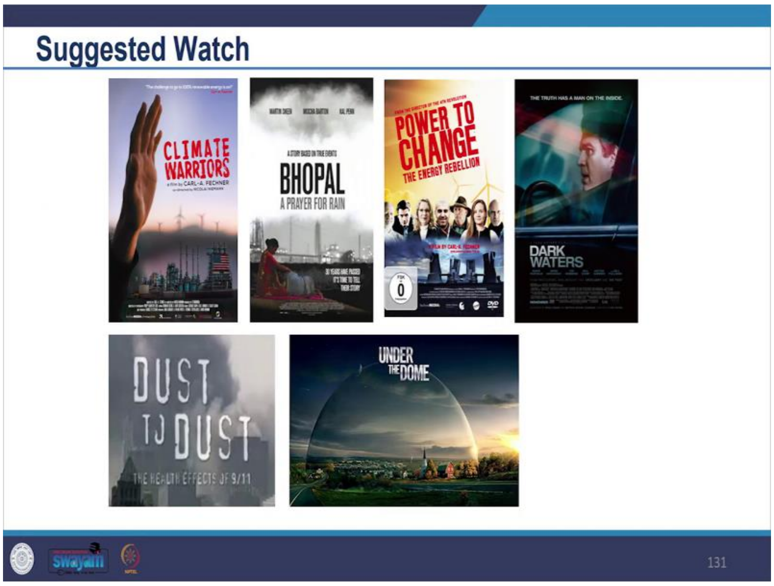

So, these were the references and these are the suggested watch and read because our coverage is very limited. So, you can read more if you are interested and explore further.

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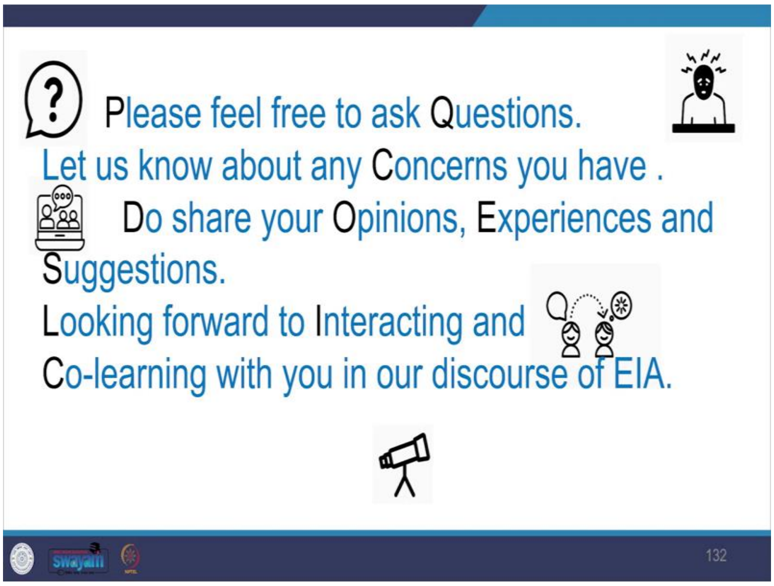

Please feel free to ask questions. Let us know about any concerns you have to share your opinions, experiences, and suggestions looking forward to interacting and co-learning with you while exploring AI. Thank you.