Sustainable Transportation Systems
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Lecture No. 42
Dispersion Models for Transport Emissions

Hello friends, so, after the emission modelling now, we would like to know about dispersion models because when emission modelling has been done and we know how much emissions are coming out of transportation sector or transport related activities, then what is the fate of those emissions where do they go?

So, we need to know about dispersion models because ultimately emissions are converted into some concentrations; emissions are basically mass of the pollutants which is being emitted by tailpipe emissions or re-suspension of dust or other sources related to vehicular movement and transportation infrastructure.

But what happens when it comes to the atmosphere it gets transported in the atmosphere, because of wind direction, wind movement, and then it gets diluted because of like diffusion and dispersion phenomena. So, that is why we want to know what happens through dispersion models, how do we estimate concentrations at a particular point because of certain emissions?

So that we can get to know what is the exposure assessment and whether the concentrations are being exceeded the prescribed guideline concentrations or not, because of certain activity. Because these dispersion models help us to calculate those concentrations of air pollutants in the atmosphere at whatever point you want to know x, y, z you can decide and this is the beauty of modelling because in monitoring you can go and monitor certain pollutants, but every nook and corner you cannot monitor because it requires a lot of resources, manpower, etc.

So, the modelling is the tool which helps us to get pollutant concentrations at whatever point we want to know. So, in today's lecture, we will discuss first of all what is atmospheric dispersion and its modelling and the types of models which are used and we will focus more on like vehicular emissions related modelling efforts for dispersion.

Because there are several models like point source, model area, source model or line source model. So, our emphasis will be more on line source model kind of things, so, that our focus is more on emissions from road transportation sector and then what happens when it disperses in the air. Then, the source types like point source as I said or area source, but again our focus will be on line source like road transportation, vehicle is moving so, it is a kind of line source.

Then, the dispersion procedures of the modelling efforts, how do we go for modelling of these lines source or any other source of dimensions, then dispersion models of various kinds like box models or Gaussian models or Lagrangian or Eulerian models or different techniques like computational fluid dynamics, CFD models, those kind of model techniques, we will in understand very basics of that.

So that you know the differences between different kinds of modelling approaches and what kind of model is more useful or more applicable in case of transportation sector. So, after attending this lecture, you will be able to know the differences between available models and their strengths limitations and how do they work, when we want to calculate concentrations out of these emissions and then we will conclude this lecture.

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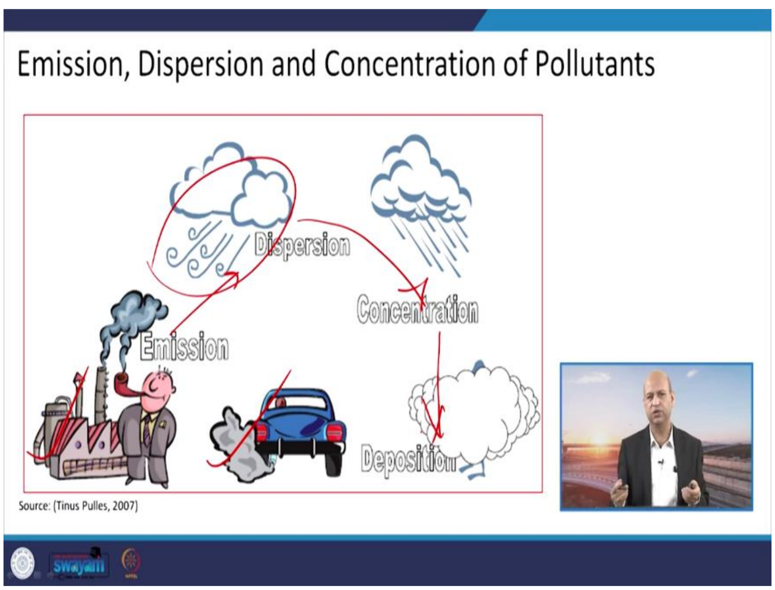

So, emissions and dispersion and concentration is this pictorial representation can easily describe like emissions can be from various activities like industries or transportation or human activities, then it disperses and like particulate matters, it can contribute into like, some kind of even these cloud formation or those kinds of things, which may be because of particulate matters nucleation and those processes maybe, but gaseous dispersion may also be there and which is not visible, but it is there means some concentration will increase because of dispersion and then it can get deposited through wet deposition with the precipitation or this raining, or dry deposition can also happen.

So, it can come to the ground or surfaces of buildings or trees and all those when you see the dust particles et cetera that is basically the phenomena of deposition. So, something goes into the atmosphere then by gravity it settles down. So, the particulate pollutants quickly settle down but gaseous pollutants can travel even in small particles can travel several kilometres from the source in downwind directs and basically.

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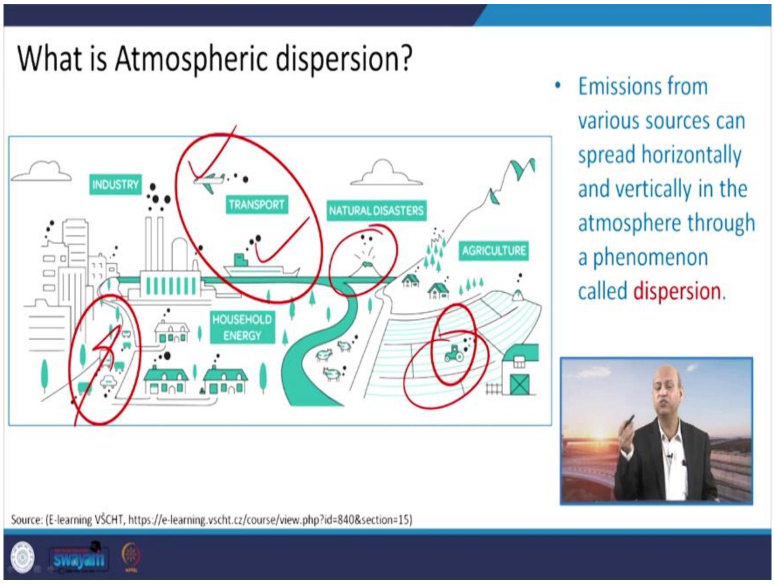

So, the what is the atmospheric dispersion if you want to understand So, this is kind different kinds of sources maybe there including aircraft or this movement of vehicles here also like street canyon emissions may be there then within the buildings household energy related emission sources maybe they are ships maybe there even natural emission sources can be there like volcanoes or forest fires are those from trees also like from trees also like VOC volatile organic compounds can get emitted from agriculture practices, we get different kinds of emissions.

So, there are so many sources including industrial sectors or transportation power plants. So all those emissions come to the atmosphere and it has its own impacts because of dispersion then their concentration increases in the atmosphere and whosoever receptor is there or like human beings or animals or buildings or trees et cetera or vegetation whatever get exposed, then there will be some chemical reactions and that can have its implications or negative impacts because our health can be damaged like respiratory related problems or buildings soiling happens it is discolours the buildings or right if ozone is there, then it cracks the tiers it can harm the yield of the crops. So, every kind of impact is there. So, for estimating those impacts we should know the concentration and that is why the dispersion models are important in that case.

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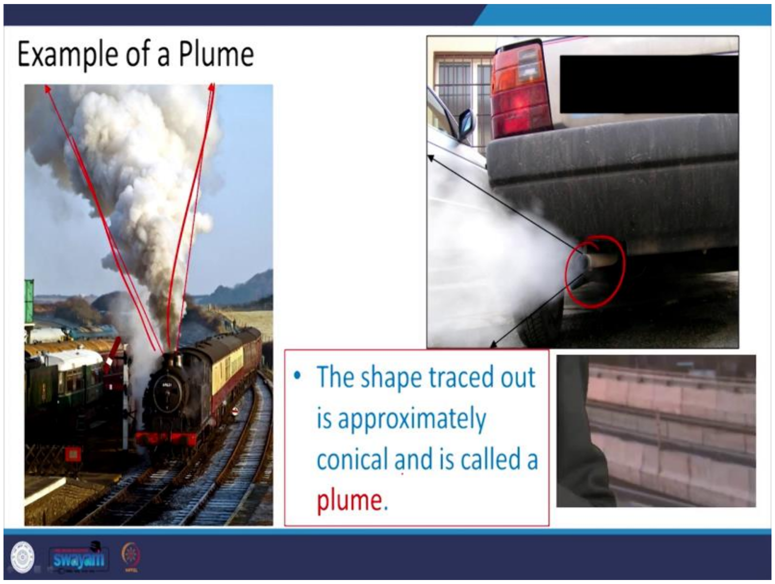

Then the example of plumes because emissions can be in the form of plumes continuous plume or puffs also like when somebody smokes those puffs comes out of those emission sources so puffs maybe there or plumes maybe there like this is the plume you can see and this disperses like a cone.

So, we assume that this is kind of Gaussian dispersion model normal distribution you can see that concentration higher at the central level then concentration decreases when we go beyond the central line left or right or above or below that central line that dispersion will happen and dilution will also occur.

Similarly, this tailpipe emission can be there it also disperses. So, with the wind with the turbulence of the wind, with the movement of the wind, so mechanical turbulence can be there thermal turbulence can be there, all these parts paid, diffusion can also occur then some atmospheric reactions can occur all those physical chemical reactions, they help in dilution also of the pollutants.

So, these plumes can be in the form of conical shape and they can travel distances depending upon what is the wind velocity and turbulence is there. Then, if we talk about like correlation between the spatial or temporal scale of modelling, because within the space from the source if you go away from the source, from the central line, then this dispersion occurs and concentration decreases. Similarly, time also means, at a particular time if something is emitted, so, after a certain time it will be diluted because of those physical chemical reactions you can see.

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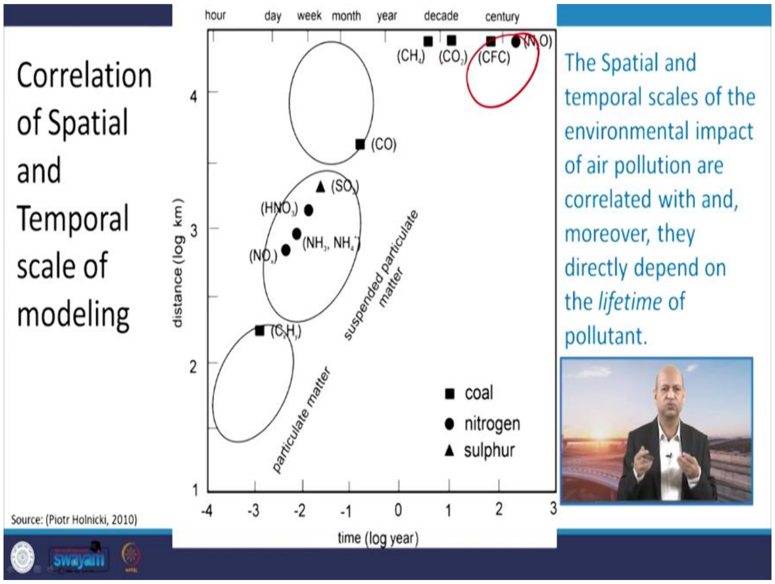

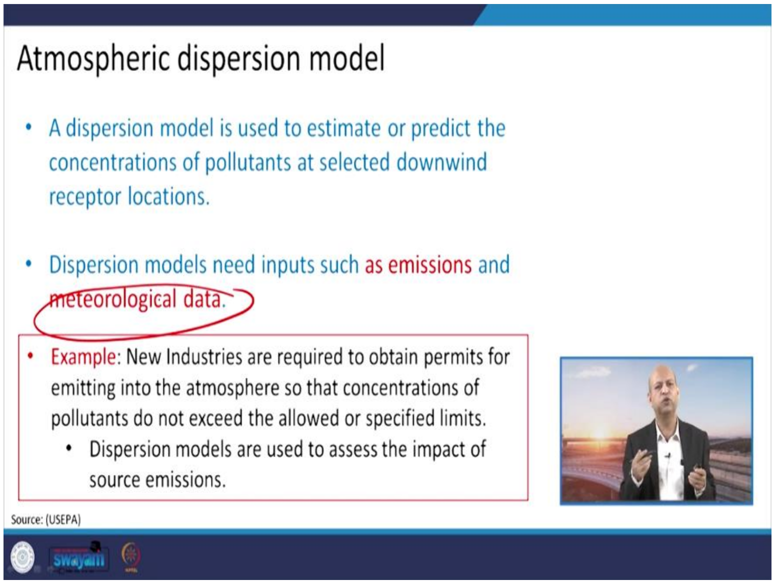

So, different kinds of pollutants have their lifespan, those pollutants which have higher lifespan they will remain in the in the atmosphere for decades or even centuries like CFC et cetera and to they can remain in the atmosphere for centuries, CO_2 is also like for several decades, it can be in the atmosphere, but other pollutants like particulate pollutants they settle down or they get reaction. So, they are removed from the atmosphere or CO like CO get converted into CO_2 or methane also. So, all pollutants have different lifespans.

So accordingly, especial and temporal distribution can be seen when we talk about dispersion model. So, like emission modelling we have already seen. So, those emission models output is basically the emission rate how much quantity of some pollutant is coming out of a resource per unit of time.

So, that is the input parameter and dispersion models and beyond that are in addition to the emission rates, the metrological data like temperature gradient and then the wind velocity or other physical parameters like if we are trying to simulate point source model then height of the stack. Similarly, like line source model, then it can be emission rates as well as distance travelled per unit of time those kind of thing and then the stability criteria all those things are input parameters for these dispersion models then we calculate the concentration.

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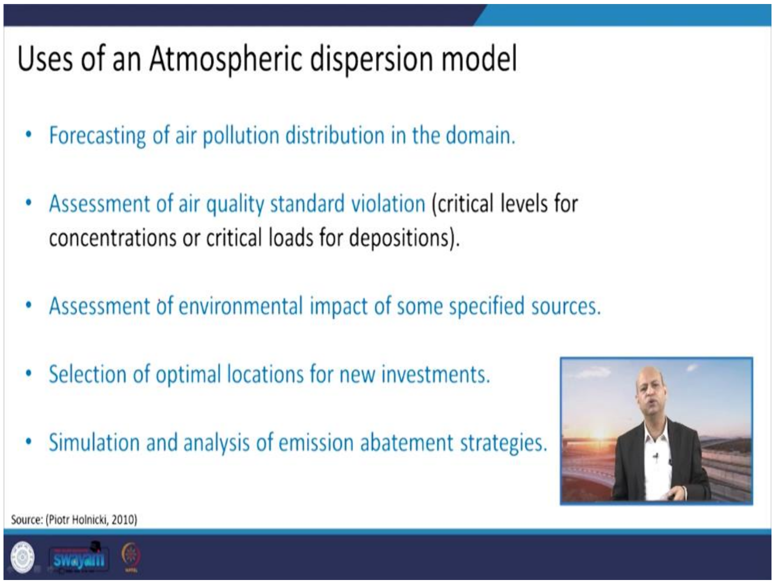

So, the usage of that atmosphere dispersion model is varied kind of uses as you can apply in several situations. Forecasting for example, if you want to predict or forecast or estimate air pollution distribution in a domain like temporal or special. So, you can know how much concentrations may be there after a certain time or after a certain distance and air quality standards comparison like some source you are adding because of some industry or some highway and you want to see that what will be its impact.

So, background concentration if you know, then if you run the model and you calculate certain quantity. So, that adds into the background concentration then you can know whether the sum of the total like the estimated concentration plus the background concentration if it is exceeding the prescribed guideline concentration then we have to do something to reduce the concentration otherwise it will be unacceptable.

So, that way also it is helpful then we also assess like environmental impacts whether in like some eco a sensitive areas or something like that, then if you want to select some particular location for new investment, so, again as I said you have to compare with the guideline concentration or standards national ambient air quality standards.

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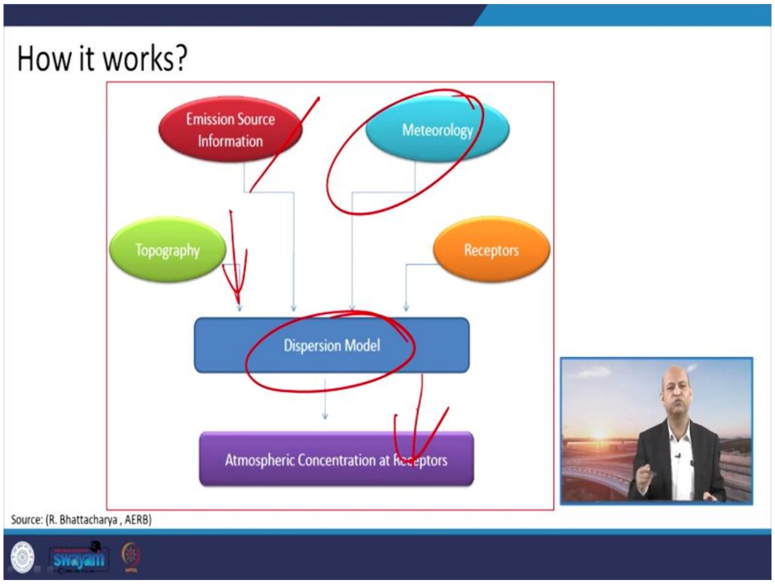

So, these models help to estimate the quantities and then compare with the those data and then you can know whether it is or it is not okay if it is not okay, then you have to provide certain solution for example, like technological interventions maybe you say that in this stretch you cannot allow less than Bharat Stage VI or Euro VI those kinds of vehicles will not be allowed or heavy vehicles will not be allowed. So, many things may come out of those studies.

When how does it work basically when we talk about these input parameters? So, within the dispersion model input parameters will come what kind of topography is there because if it is a smooth terrain or rough terrain, so, certain factors vary according to the topography. Similarly emission sources information that is what kind of pollutants are there what is the emission rate then meteorological parameters wind velocity, temperature, humidity all those kinds of things may be there and then we get this atmospheric concentration as we have discussed.

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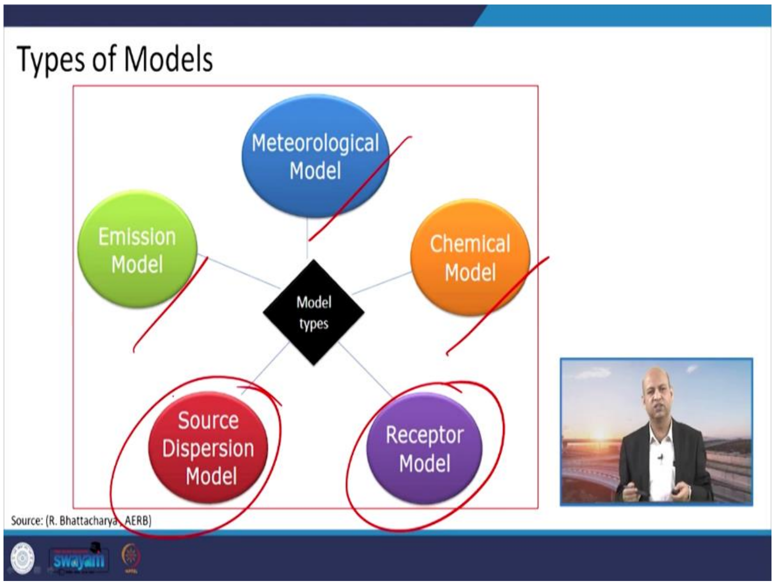

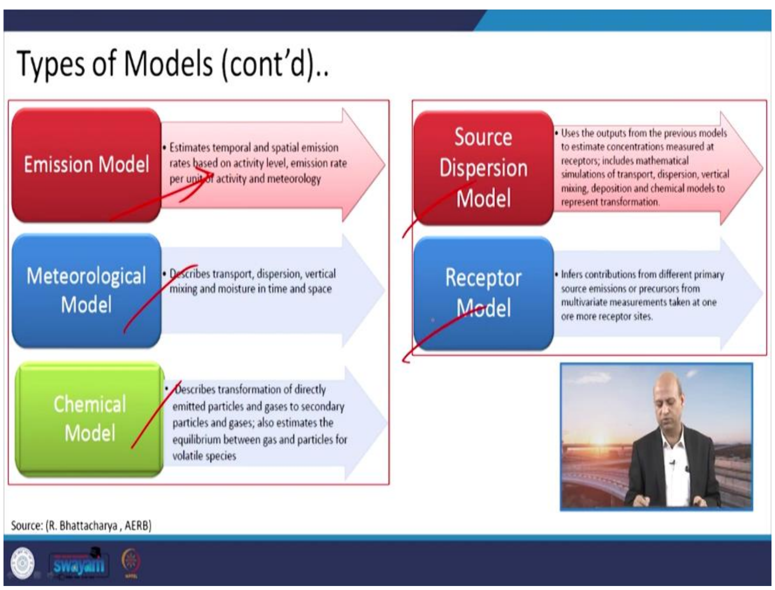

Types of models may be of varied nature depending upon their like principal mechanism like emission models, we already studied metrological models which gives us those metrological parameters which can be input parameter for certain models. Similarly, chemical models which help us to know what will happen when some gaseous components react with the atmospheric constituents or the react with each other than what we like ozone production, ozone is not primary pollutant which is emitted by some source it is produced in that atmosphere.

So, the chemical models help us to know how much ozone will be produced if precursors are being emitted like NOx or CO or hydrocarbons those kinds of things. So, chemical models can be there, then if you want to assess the impact health impacts et cetera or impacts on the crops or impacts on the ecosystem then we use receptor models.

Similarly, source dispersion models which are very popular which we will discuss different kinds of models. So, these kinds of models are their emission models basically as I said it can estimate temporal and spatial emission rates and metrological models which I just discussed with you. So, you can go in laser more details are there with that.

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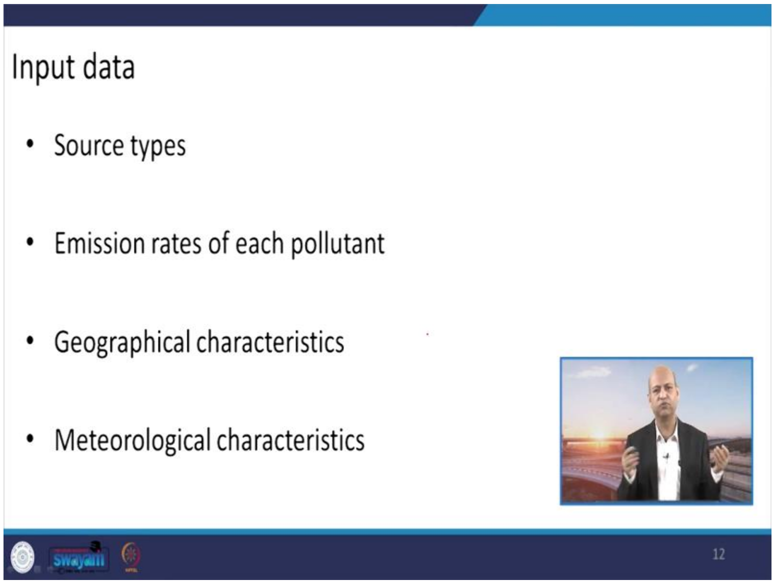

Input data source types so, source maybe like point source, area source and line source et cetera or a static source and mobile source. So, in case of transportation modelling basically mobile source is use then emission rates of these pollutants you should know because you want to estimate the concentration of each pollutant. So, for each pollutant emission data must be there which will be coming from emission modelling which we have already discussed, geographical characteristics as I said because these terrain will impact mythological characteristics.

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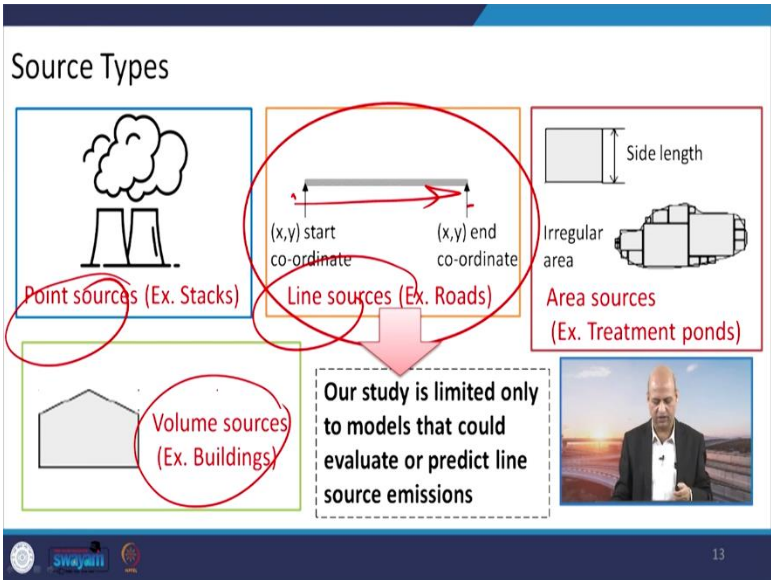

So, source types like point source as I said line source from one point to another how much vehicle movement is there those kinds of things. Then area source can be there in irregular area where like side lengths may be different kinds of volume source can also be there in buildings et cetera when you are going to know like indoor air pollution.

So, in a building how these pollutants are traveling from one corner to another, so, some CFD related mechanism those kind of things can be there. So, modelling can be for a small location or a small area to big area. So, in indoor air pollutants, you talk about like even diffusion of centimetres or so, if it is like cubic meter area of these rooms etc.

But in these dispersion models which are outside then you talk about kilometres you want to know what will be the concentration at 10 kilometre downwind. So, modelling structures change accordingly. So, different kinds of models are used for different kinds of physical properties or domains physical domains and their distances.

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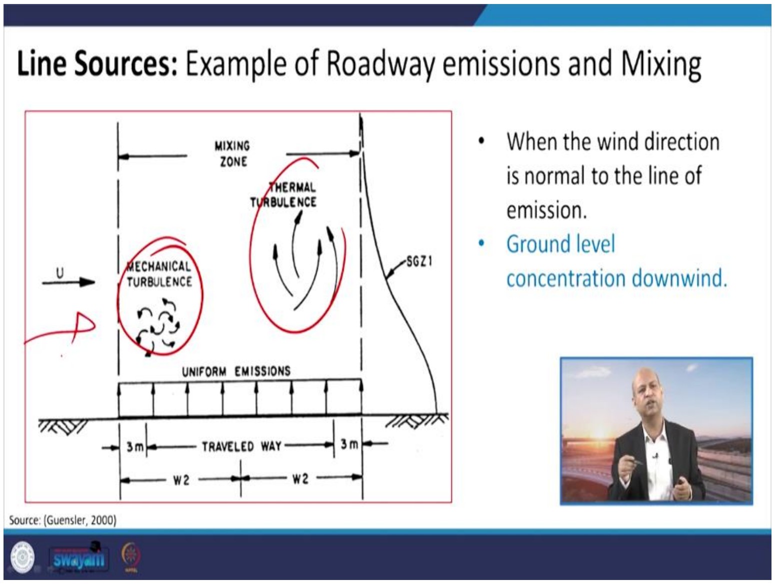

We talk about line source model which is the emphasis of our talk because we are talking about transportation emissions. So, line source model is the basic thing which we should know. So, this is the road like you can see So, on roads of vehicle is moving moment is there so on the vertical of that road length if some wind is moving so, in perpendicular of that how much concentration will be there from the road in the downwind distance.

So, like 10 meter, 50 meter, 500 meter something like that, similarly, there may be like mechanical turbulence, thermal turbulence because of temperature difference so, vertical turbulence may be there and this can you can have this temperature profile et cetera wind velocity can also be there. So, accordingly you can estimate by using those techniques which will which will be discussed soon after these some slides.

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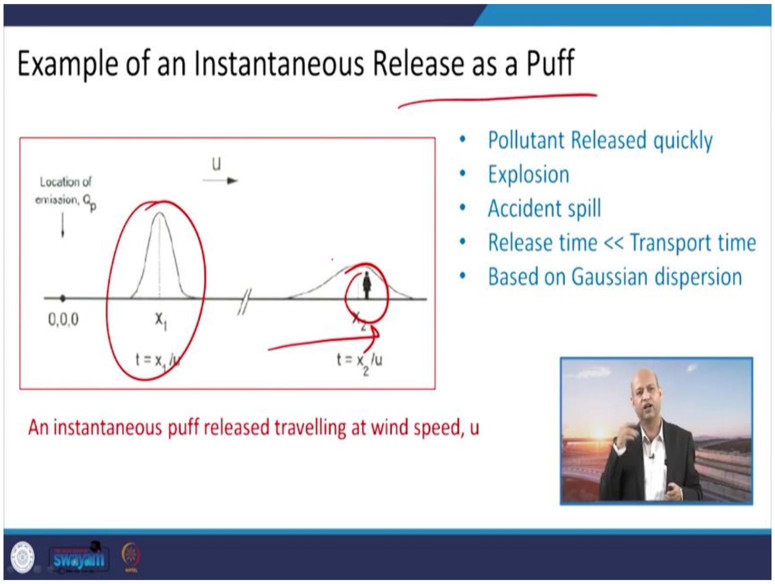

When we talk about like instantaneous release of the puff. So, we see these dimensions after certain time like it goes and up to a receptor some person is there. So, what will be the concentration of that puff because of certain distance it will be diluted, but we should know only then we can be able to learn how much impact will be there on the health of the persons. So, those modelling techniques mathematical equations that will give you an idea about using all these input parameters and knowing the concentration at certain distances from the source.

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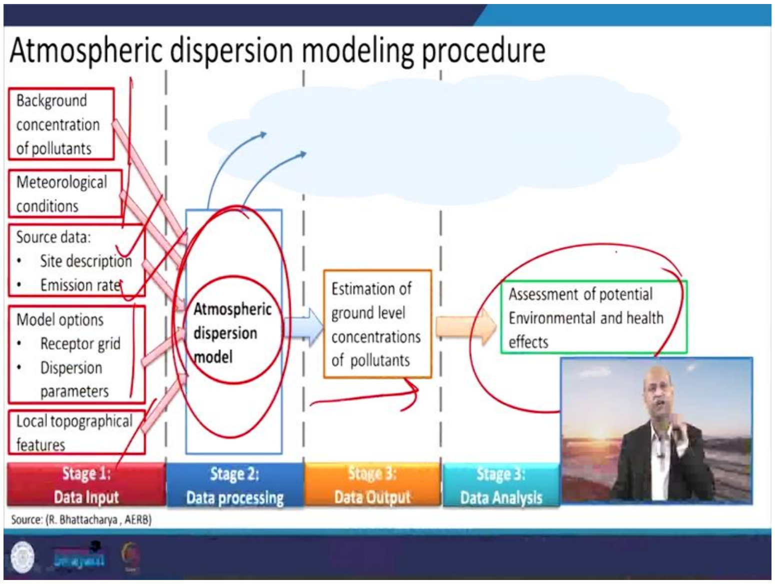

When we talk about dispersion modelling procedures. So, again we can repeat in detail like background concentration of pollutants we should know only then we would be able after adding the calculated concentration whether it will go beyond exceed the guideline concentration or not if it does not exceed, then fine, we can say that that this activity is okay from air pollution point of view it is not contributing in a negative way, metrological conditions must also be known temperature profile wind velocity et cetera wind rose diagram all those things.

Source data like site interpretation or description whether it is city it is countryside, smooth terrain, rough terrain all those things because they will influence the calculations because of certain factors like emission rate, model options, whether it is receptor grid type of model dispersion model parameters are needed, then local topographical features which we have already discussed.

So, these will be the input parameters for atmospheric dispersion model then estimation of ground level concentrations by using that calculations because model is nothing but a set of equations mathematical equations all these input parameters will be part of those in mathematical equations and output will be there in terms of concentration in particular these models.

So, assessment of potential environmental health effects will be there later on when we have the concentration. Then, another models are used for health impact assessment and those kinds of things. Otherwise, dispersion models basically give you output of the concentration and please learn the difference emission and concentrations are two different things. Emissions are quantity of pollutants emitted by source per unit of time and concentration the quantity of pollutant per unit volume of air that is the point here in difference in concentration and emission.

So, you should not get confused that emission is same or concentration is same those are two different things. That is why two different kind of modelling efforts are needed for emissions we have other models like mobile IVE, VAPI those kind of models for concentrations we have another set of models for dispersion models which we are discussing today.

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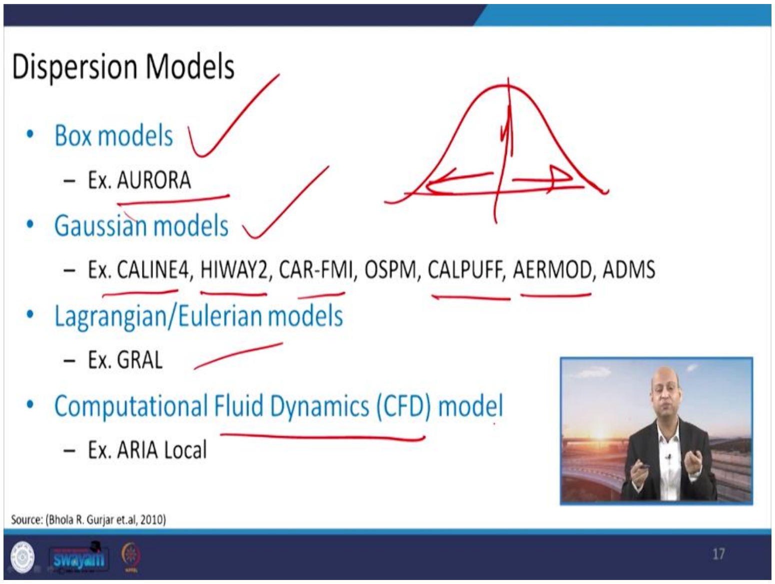

Like types of models so box models, example is like this Aura we will see what is the concept of this particular model. Then Gaussian models, this is very popular technology technique rather that we assume that the model this dispersion occurs in a kind of you know this kind of thing. So, at centre line it is highest concentration it if you go left or right to the central line then concentration is less and after some time it is very less.

So, those techniques are there. So, most of the models are basically Gaussian models and like CALINE4, HIWAY2, CAR-FMI, OSPM, CALIPUFF, AERMOD all these models we will discuss. Another technique is Lagrangian and Eulerian models. So, they this kind of scale is different. So, different models have different scales, computational fluid dynamics model CFD model. So, this is another technique which gives the every model has its own strengths and weaknesses some models require a lot of resources a lot of input data and some models are very simplistic in nature, but their output will be rough, it will not be very precise.

But for policymaking for to begin with having some impression what will happen after a certain activity. So, accordingly some models are chosen and what resources are available with us if we want to go for detail the state if you do not have much money or resources then we have to use simplistic modelling approach.

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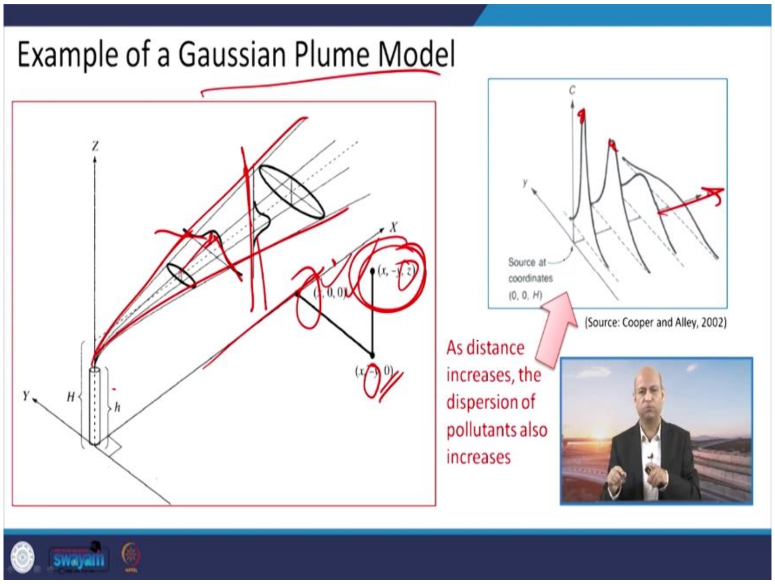

This Gaussian model dispersion as I said, like point source somewhat height is there of the stack. So, emission is coming out and it is dispersion occurring like a conical shape. So, this is as I said at the central line concentration is highest and if you go left right or left then concentration decreases.

Similarly, on vertical direction also when you go up or down the concentration decreases, but with the help of these models, you can get concentration values for X, Y, Z ground level concentrations Z0, this Z is 0 at the ground level concentration at the central line Y is also 0 because y is distance left or right from the central line.

So, if you want to calculate concentration at the central line at the ground level, then only X value will be used that is the distance from the source in the downwind direction Y will be 0, Z will be 0 if you want to calculate concentrations from centreline right or left then there will be some value of the Y but Z will be 0 because ground level concentration you are trying to calculate.

If you want to calculate concentration at certain point in the air hanging so, it has all dimensions X, Y and Z so those values will be put and calculations will be made you can see like near the source the concentration is very high then it decreases it decreases and later on it becomes very diluted. So, no effect is there that is why if you are you know bringing some like industry or highway, then you have to see its impact on some population which is residing there.

So, maybe 2 kilometre there 3 kilometre there if there is a village. So, the concentration from this source whether it is line source or the point source should not exceed in that village more than the prescribed guidelines of the ambient tire concentrations from CPCB and other agencies.

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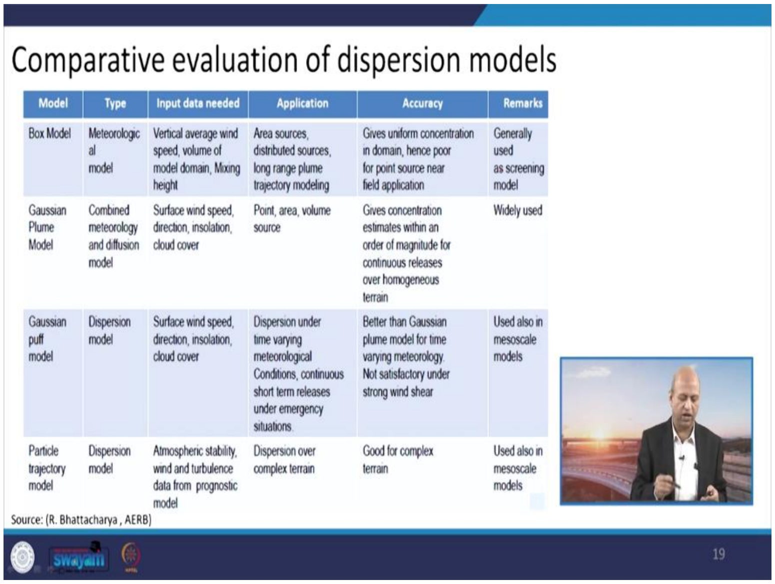

Model	Type	Input data needed	Application	Accuracy	Remarks
Box Model	Meteorological model	Vertical average wind speed, volume of model domain, Mixing height	Area sources, distributed sources, long range plume trajectory modeling	Gives uniform concentration in domain, hence poor for point source near field application	Generally used as screening model
Gaussian Plume Model	Combined meteorology and diffusion model	Surface wind speed, direction, insolation, cloud cover	Point, area, volume source	Gives concentration estimates within an order of magnitude for continuous releases over homogeneous terrain	Widely used
Gaussian puff model	Dispersion model	Surface wind speed, direction, insolation, cloud cover	Dispersion under time varying meteorological Conditions, continuous short term releases under emergency situations.	Better than Gaussian plume model for time varying meteorology. Not satisfactory under strong wind shear	Used also in mesoscale models
Particle trajectory model	Dispersion model	Atmospheric stability, wind and turbulence data from prognostic model	Dispersion over complex terrain	Good for complex terrain	Used also in mesoscale models

When we do not talk about comparative evaluation of dispersion models then you can see there types made which kind of metrological parameters they need and then what kind of input data they need, what is the application area and then accuracy whether it is very precise or very coarse those kinds of things, those remarks these are the metrics or it is given you can go through this. So, every model has its own particular characteristic.

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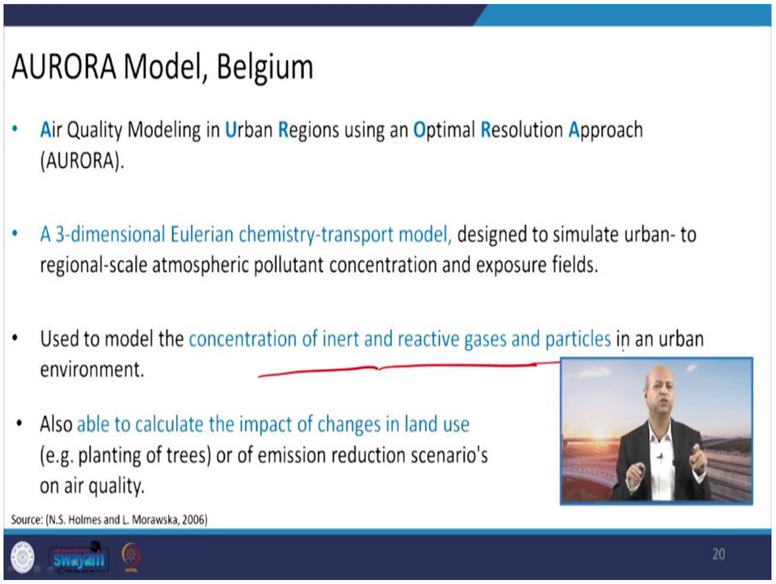

Now, we talk about different models. So, this aura model which was developed in Belgium and it is known like the full name is air quality modelling in urban regions using an optimal resolution approach that is AURORA. And this is a three dimensional Eulerian chemistry transport model. So, very sophisticated in that sense and it is designed to simulate urban to reasonably scale atmosphere pollutant concentration and exposure field.

So, it is a means quite detailed model you can say and it is used for concentration of inert and reactive gases both otherwise more simplistic models are normally for inert pollutants and they are simplistic assumptions are there that no reaction is occurring like even SO2 concentration you are estimating you assume that SO2 is not reacting, whereas in reality, it reacts with the motion it reacts with many things.

But simplistic models, those Gaussian models and they assume that these are inert, but this particular model is basically can use inert and reactive gases. So, those kind of mechanism is there some modules are there when you want to use reactive those reactions or reactive gases, then certain modules will be used otherwise you can use in inert fashion also.

Particles related in urban environment and it can calculate impact of the changes of land use because land use change may be occurring due to like industrialization or some facilities are coming some township or some roads or highways are being so, like planting of trees are there whatever change is there, this will be incorporated in this model. So, that way it is a nice model.

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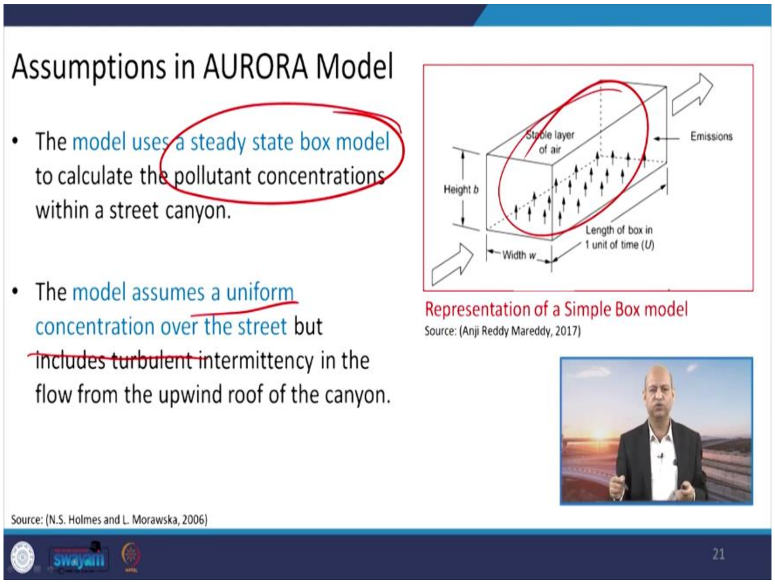

But there are again some assumptions are there because this is the box model. So, it assumes the steady state condition that within the complete box uniform concentration is there whereas, in reality it may be more nearer to the sources. But it assumes that homogeneous concentration is there it is well mixed.

So, this is simplistic assumption for this box model, but it is there it is part. Then uniform concentration as I said in the street also. So, whether this box like a city you have converted it into box length width and boundary layer height. So, that is kind of box so, that box modelling can be there and in that you assume that concentration is equal at every point.

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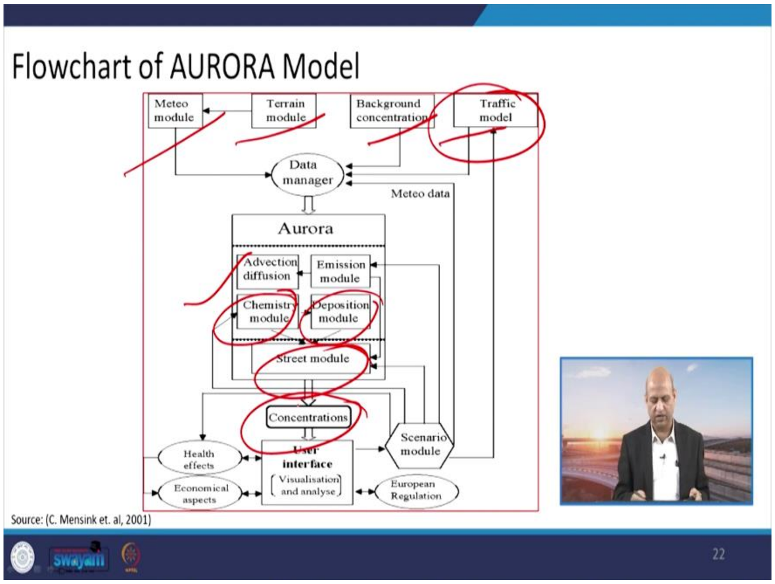

This is the flowchart for this particular AURORA model you can see these metrological modules different modules are there as I said terrain module background concentration module, then traffic module. So, you can use whatever model you want to emphasize if traffic related phenomena you want to study then use this one other modules you can switch off if there is no much application or activities of that kind of nature, then this advection diffusion or means horizontal movement.

And then convection movement may be vertical those kind of and chemistry module is also there as I said for reactive gases, then the deposition module can be there a street module can be there. So, it is a kind of very versatile modelling technique I would say and then concentration is estimated and then you know based on the basis of the concentration, whether it is good or bad, and you can also convert them into some health risk assessment, those kinds of things.

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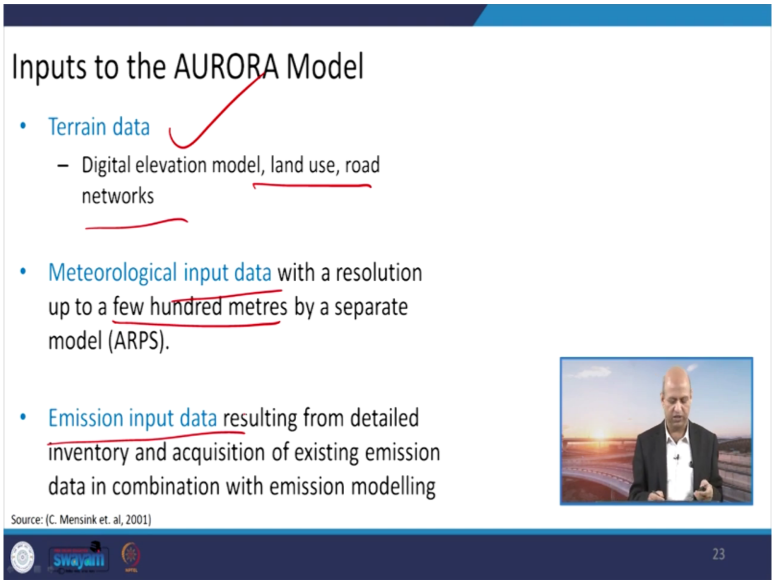

So, input data, terrain data like land use patterns, road networks all those terrain data is the input parameters. So, it is a detailed modelling technique basically metrological inputs. So, few 100 meters by separate models, those kind of modules are their emission input data is of course, every dispersion model will need a mission input data. So, these are the basic input parameters.

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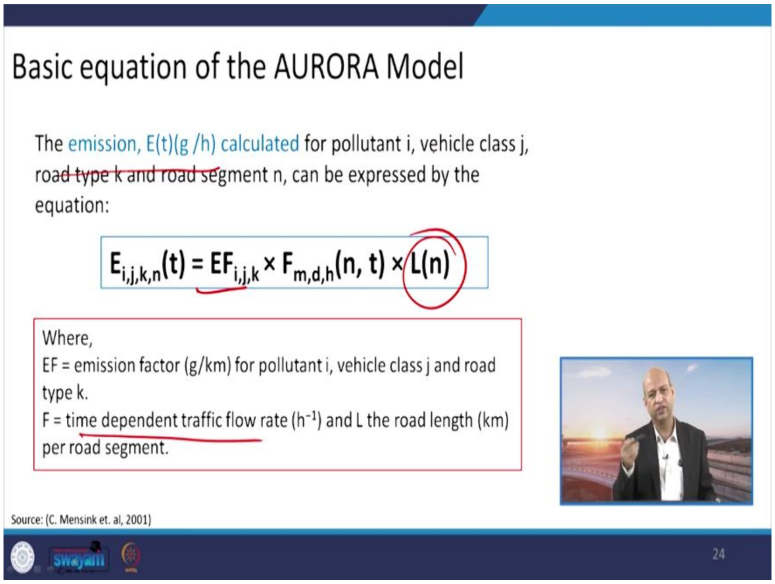

And then the equation like

$$E_{i,j,k,n} = E_{i,j,k} \times F_{m,d,h}(n,t) \times L(n)$$

this emission factor is there and time dependent traffic flow rate. So, total emission can be calculated and length of the road also so, you can get this emission gram per hour calculated for each pollutant for different pollutant values will be different and you can use in the dispersion model.

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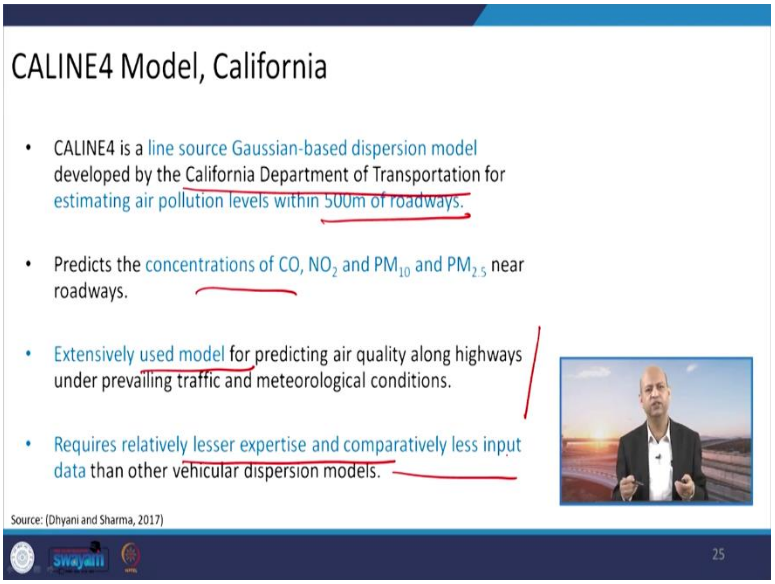

Then another model which is very popular for line source modelling is CALINE4 model which is developed you know in by California department of transportation and this is basically for estimating air pollution levels within the these 500 meter of the roadways on both sides or particularly the downwind side and it can estimate concentrations of carbon monoxide or nitrogen dioxide or particulate matters of PM10, PM2.5 near the roadways.

And as I said it is very popular many people use it for road vehicle or emissions basically and as it is extensively used for policy and for like new road is coming then what will be the impact all those kinds of things are CALINE4 can give you the scenario. It requires lesser expertise and comparatively less input data that is why it is very easy to use simple even if you run once you can train any researcher or any person who knows basics of the this physics and chemistry they can run this model.

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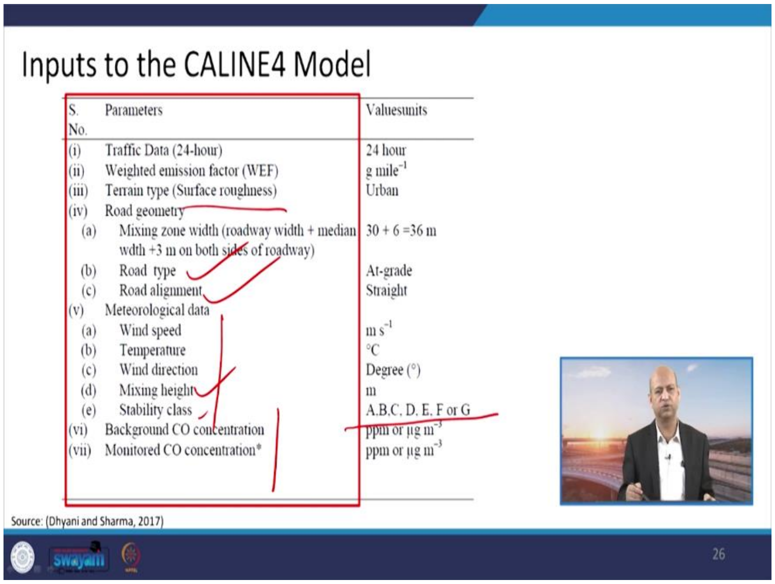

The input parameters, so, you can see like traffic data of 24 hours and weighted emission factors depending upon what kind of age of the vehicle is there, what kind of engine technology is there, then terrain type, surface roughness is smooth or rough those kinds of things. Then road geometry mixing zone width all those road types, that will impact the emissions also, road alignment, it is completely straight or going in different directions, different angles.

Then, meteorological data which is common in all like speed, wind speed, temperature or the wind direction and mixing height and instability classes A, B, C, D those whether it is a stable or highly unstable those kinds of instability classes is to be used because that will influence the dispersion coefficients sigma Y sigma Z if you know the basic modelling then background CO concentrations and monitor concentrations.

So, that you can some of them and compare with those guideline concentrations. So, these stability classes A, B, C, D, E, F, G whatever so, these are the units of the values which are used in the model.

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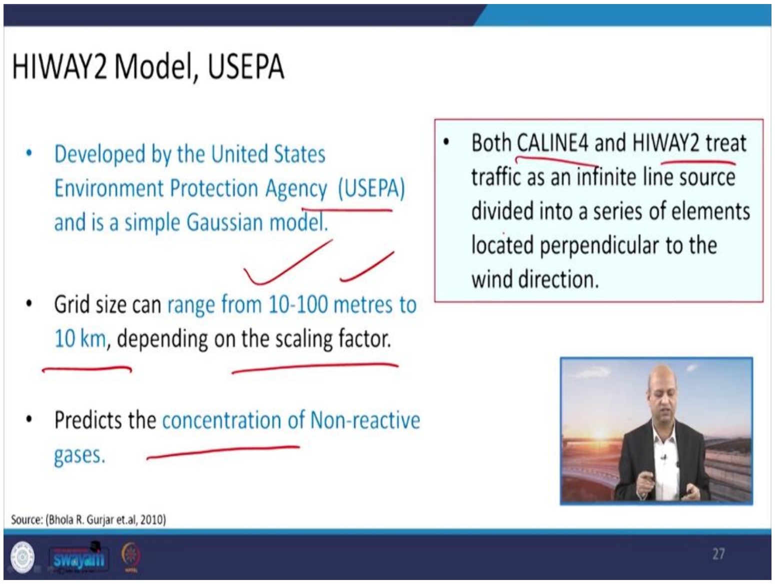

Another model is like highway to model which is again which is from USEPA United States environmental protection agency developed this model and the grid size which is used by this model is 10 to 100 meter and even it can go 10 kilometres also good variation is there for a special differences. So, a scaling factor can be there depending upon the distances and it can be used to estimate concentrations for non-reactive gases. So, inert kind of thing and this both 4 HIWAY highways they treat traffic as an in finite line source not the finite some models use finite length which we will discuss later on.

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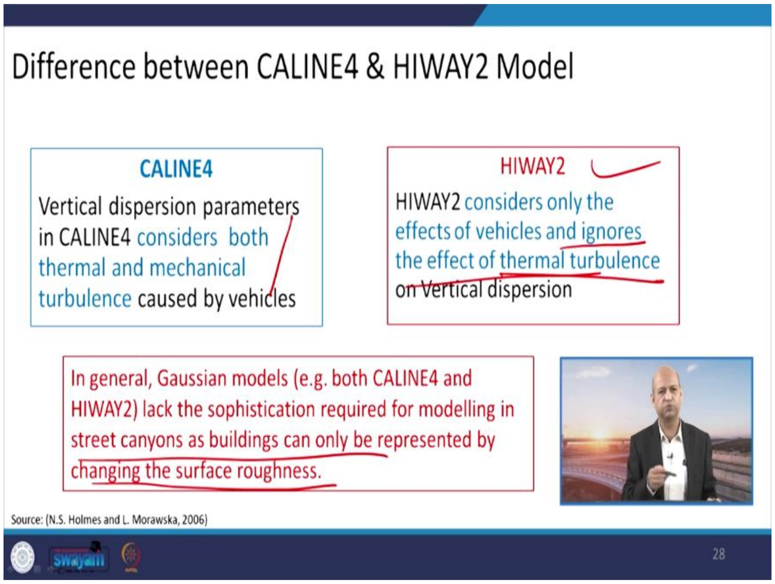

If we talk about differences between CALINE4, HIWAY2 model then certain differences are there like in CALINE4 for both thermal turbulence and mechanical turbulence are considered for estimating dispersion or concentrations varies in these HIWAY2 they ignore these thermal turbulence that means only mechanical turbulence is used in this model, but both models are based on Gaussian dispersion techniques. So, like straight canyons buildings or these are changing surface roughness et cetera they are as per the simple techniques of the Gaussian dispersion.

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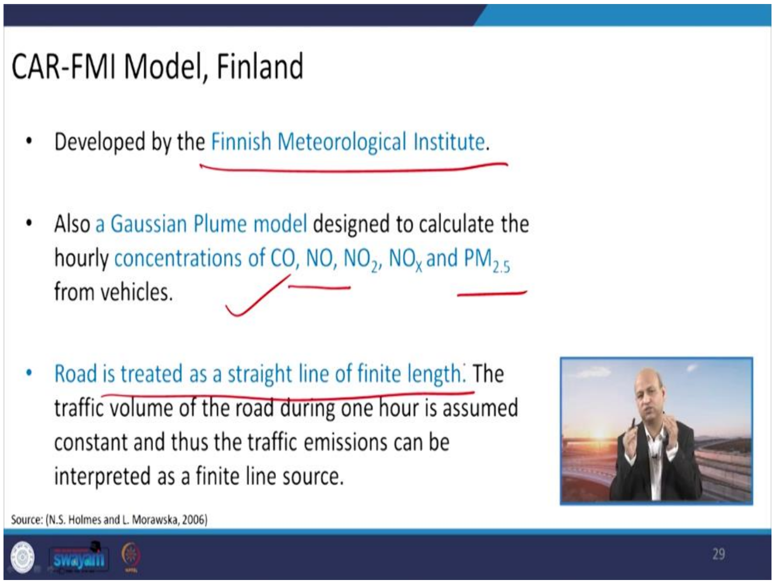

Another model like in Finland they have their own modelling technique or modelling tool which is known as CAR-FMI and this is developed by Finnish metrological institute that is why FMI is there and this can estimate concentrations of carbon monoxide or nitric oxide or nitrogen dioxide means all oxides of nitrogen NOx emissions basically and then particulate matter fine particles like PM2.5 and it treats the road as line of finite length.

So, the remember CALINE4 and other models they treat the road length as in finite but here this model uses some finite length of the model. So, model techniques accordingly differs from model to model.

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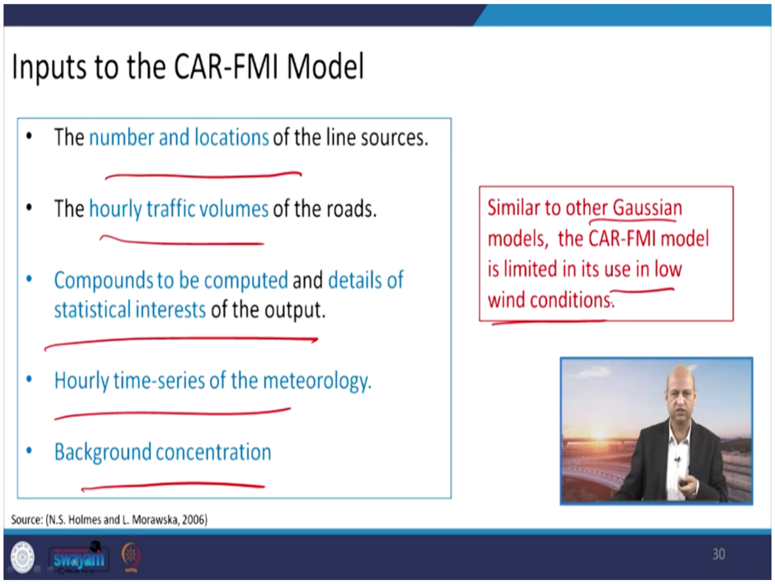

It needs input parameter says for example, a number and locations of the line sources different roads network maybe they are so, if you want to apply in a city so, you should know the complete road network their length and width et cetera hourly traffic volume on those road network that should be known, then it can be like compounds to be computed with kind of pollutants and the statistical interest we want to know in terms of the concentration variations hourly time series of the metrology.

So, because it calculates like hourly if you want to see the daily then also hourly related values are needed for that background concentration each model needs basically and this is similar to the Gaussian model basically, but it is limited in its use in low wind conditions that is the limitation for this model as Gaussian models have this kind of limitation.

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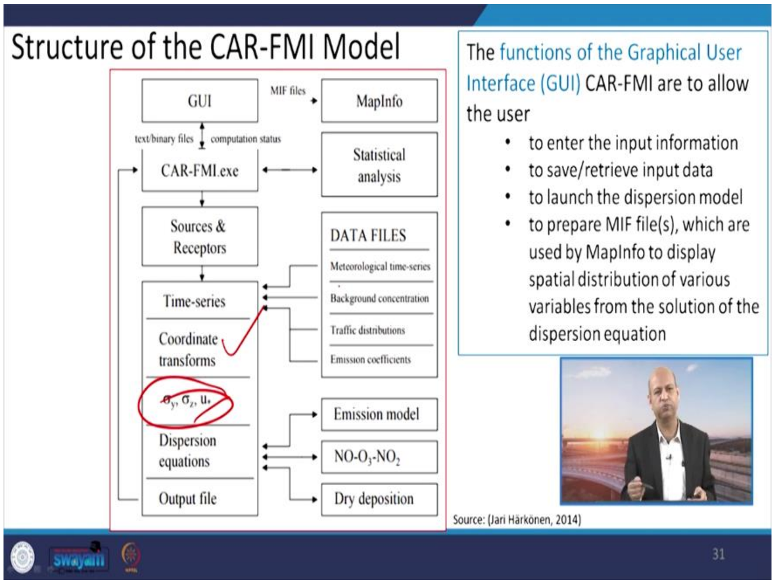

The structure if you want to see in a kind of framework or the flowchart then this gives all parameters like these sigma Y sigma Z that is the dispersion coefficient U-wind velocity value coordinates time series as we have seen and then all these values are input parameters, then output parameters you will get.

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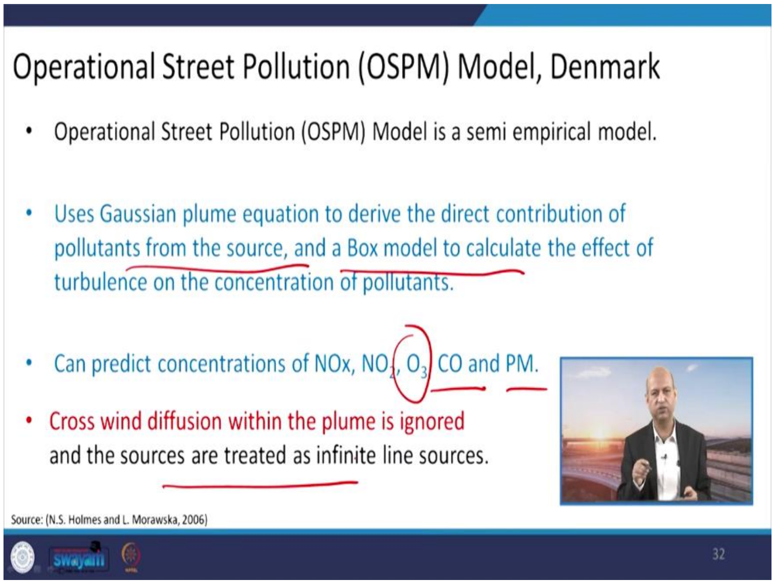

Similarly, another model is their operational street pollution OSPM model which is used in Denmark. So, they have developed their own model for this purpose and again, this is using Gaussian plume equations, which is as I said Gaussian dispersion technique is used popularly by these air pollution dispersion models and it can contribute to pollutants from the source or box model to calculate the effect of these turbulence on the concentration.

So, that is their inbuilt parameter for turbulence. It can predict concentrations of these NOx, oxides of nitrogen, even all ozone so chemical reaction related chemical model part is there CO in particulate matter and crosswind diffusion within the plume is ignored. So, that is one important aspect of this model some other models they use even crosswind diffusion.

So, that is simplicity here and it is these sources are treated as infiniite line sources varies as you know the earlier model this was CAR-FMI they were using finite length of the road in this is rather this one is more into CALINE4 and something like that.

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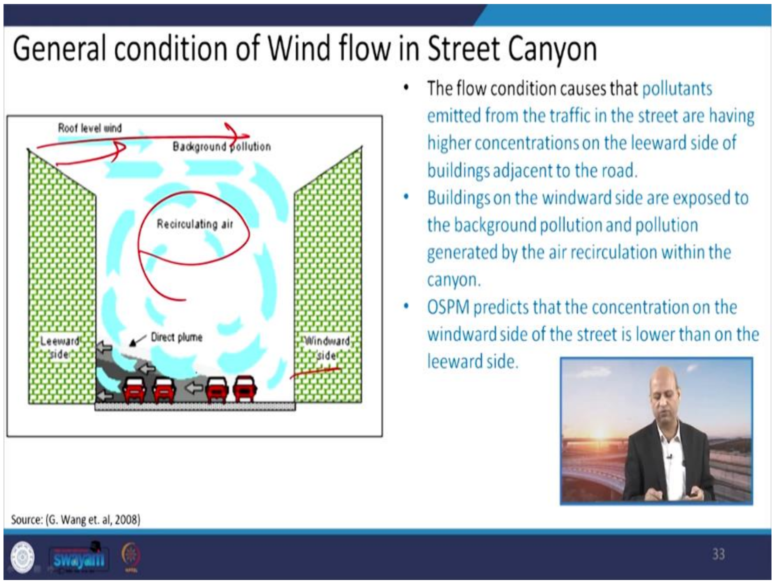

Then general conditions for street canyon if street concentrations you want to estimate So, various parameters are there like roof level wind, how much velocity is there then direct plume and then leeward side or windward side concentrations or their physical features, then recirculating air background pollution all these diffusion and turbulence and dispersion they are mathematically represented by some equations in these models.

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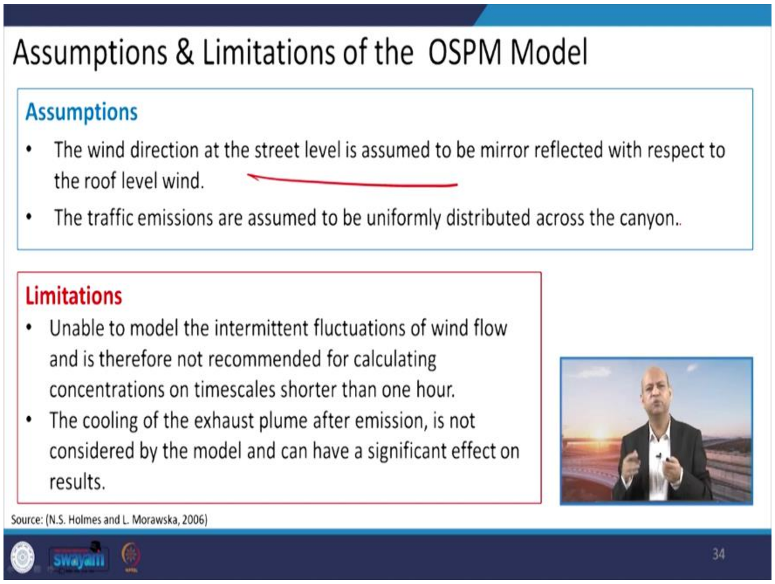

And the assumptions and limitations of this OSPM model is basically like the wind direction this is the assumption a street level is assumed to be mirror reflected with the respect of the roof level wind. So, the way this wind is moving from this direction to this. So, this is taken in this at the ground level also and traffic emissions are assumed to be uniformly distributed across the canyon.

So, maybe somewhere it may be more traffic other it is not so, it will be thin, but for simplistic assumptions, uniform distribution of traffic is there limitations are there for example, this model is not fit for like intermittent fluctuations, because it has some course assumptions of the wind flow.

So, it will assume that this wind is flowing at certain speed for a particular time period. So, those kinds of limitations are there plus cooling of the exhaust in a plume after emissions is not considered by this model it is assumed that the same temperature will be there during this this dispersion. So, those kinds of limitations are there which may give those estimated values a little bit uncertainty or maybe their means it is not it may not be very near to the actual value.

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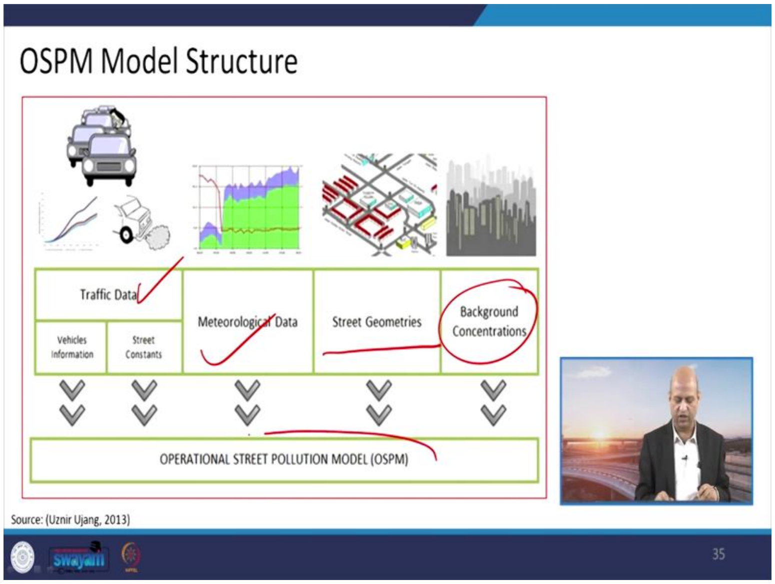

Then OSPM model structure can be seen here traffic data it needs metrological data as other models also need street geometry is important aspect for this because you are applying for a straight canyon then background concentration is also needed, then you can use this model and calculate the concentrations.

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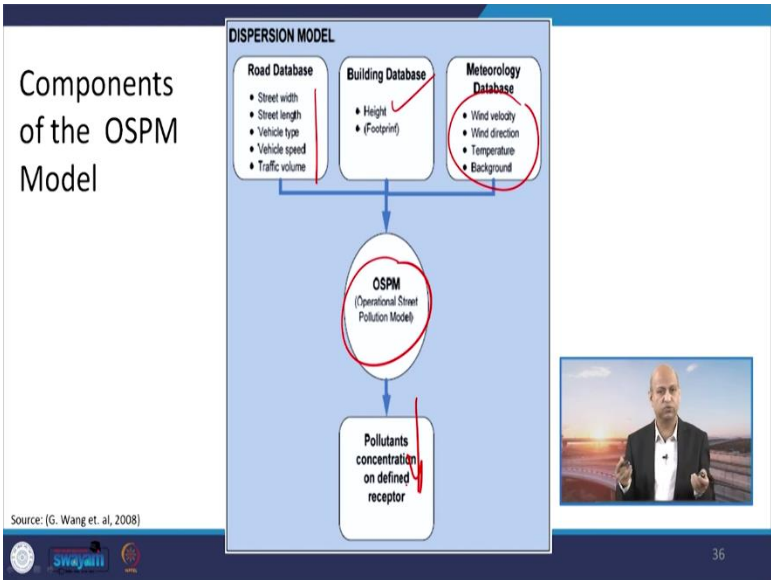

And these are the components basically like building data you should know how much height multi story buildings are there or single story buildings are there what is the height metrological parameters these are common like wind velocity, wind direction temperature all those road database like a street width and straight length vehicle types vehicle speed traffic volume all those values are needed for this OSPM model, then we will know the pollutant concentration on defined receptor if you want to know that some shopkeepers are there. So, how much concentration will be there they will be exposed to. So, accordingly you can calculate.

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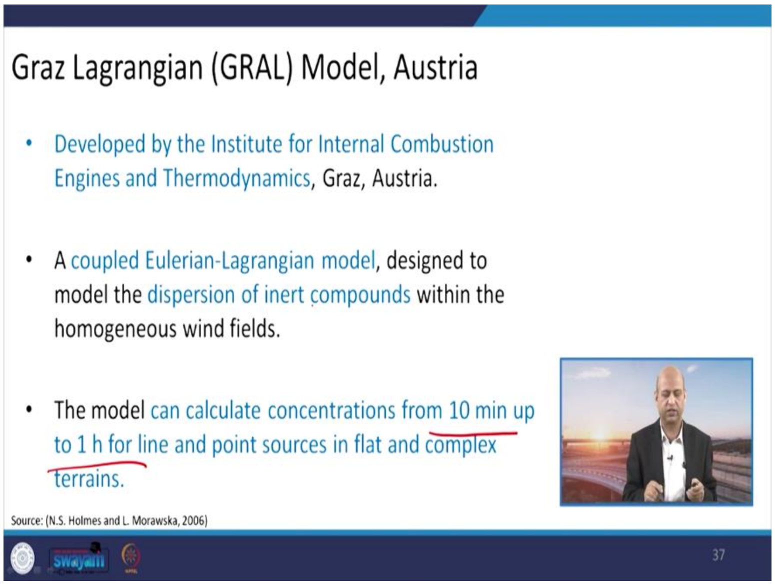

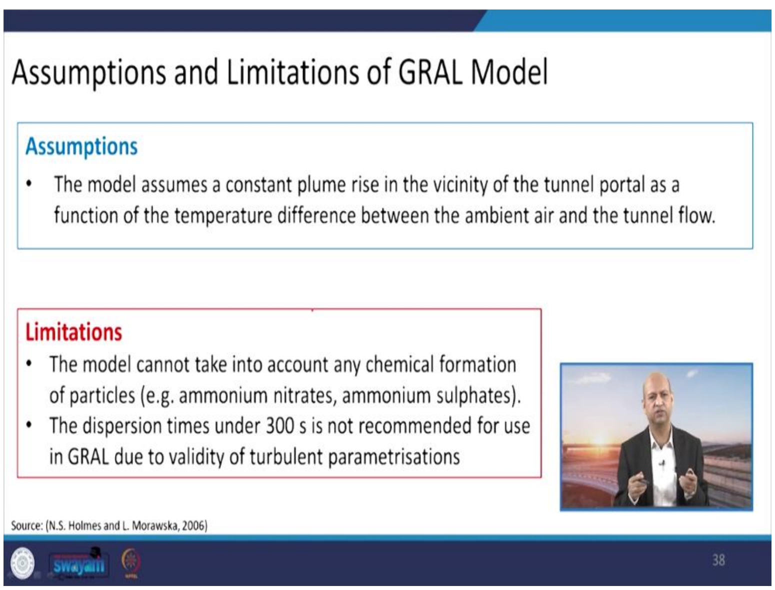

Then this is another technique is there this Graz Lagrangian model in Austria it was developed basically. So, this has certain strengths like from 10 minutes to 1 hour for line and point source in flattened complex terrain. So, it has kind of very finer resolution which Lagrangian model can be used for.

Assumptions are there like constant plume rise in vicinity of the tunnel portals and temperature differences between ambient air internal flow energy function those kinds of exemptions are there limitations may be like it cannot take into account chemical formation of particles like ammonium nitrate, ammonium sulphate et cetera. So, those are the limitations otherwise, like under 300 meter, it is not recommended for use for validity of turbulent parameter. It does not consider those kinds of limitations. Every model has certain limitations as you know.

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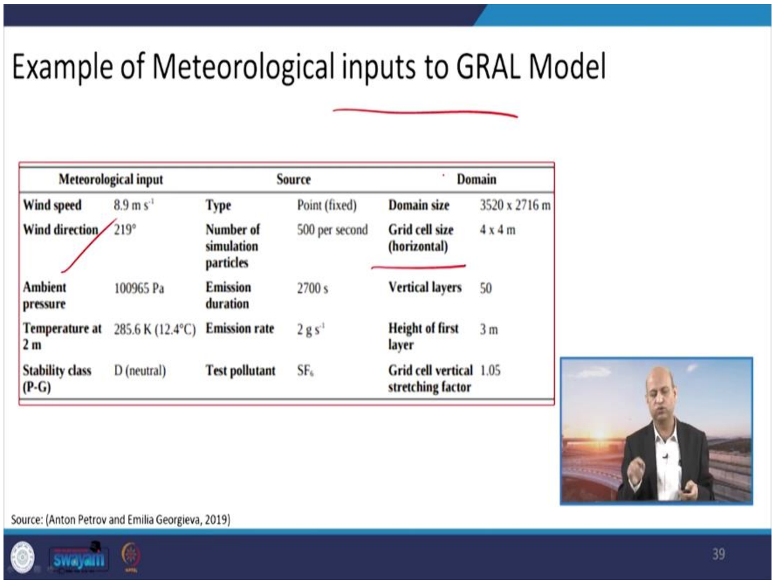

These are the input parameters of the metrological nature. So, this is same as other models like wind speed, wind direction, temperature et cetera. But like grid size domain size these should be defined properly.

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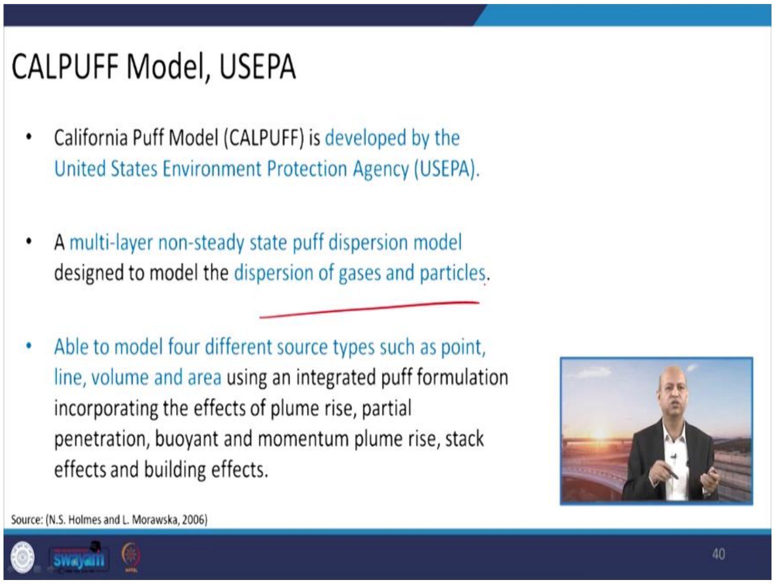

Then there is one CALPUFF model developed by it states the environmental protection agency. So, it has multi-layer non-steady state puff model dispersion model puff dispersion earlier models were plume dispersion model this is the puff model so, this is a different kind of model basically it can be used for dispersion of gases and particles and it can model different source types like point source, line source, volume source all those kinds other plume models also are used.

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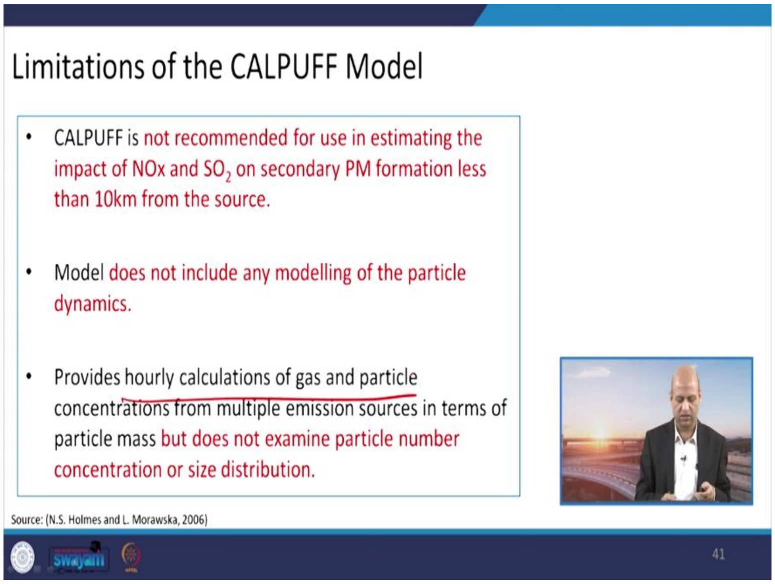

Then this is not recommended means certain limitations are there, this is not recommended for use in estimating the impact of NOx and SO2 on secondary particulate matter formation because it does not consider that kind of chemistry in the air and less than 10 kilometre. So, maybe it can be used for other scale but for that it may not give good results. So, that is the limitation also it does not include modelling of the particle dynamics.

So, those are the related issues and it also provides like hourly calculations of gas and particles concentrations for multiple emission sources in terms of particle mass but does not examine particle number concentration because this when we talk about this much milligram per cubic meter, so, that is mass concentration of the particles, but if we talk about number how many 1000's or 1000000 numbers are there then different kinds of concentration value occurs.

So, maybe if fine particles are there, their mass concentration very low, maybe they are, but their number may be very large. So, the number also plays a role because, now new science is coming where the number and the size and shape of the particles also play a role in impacting our system. So, but this is the limitation it does not give the number related concentration.

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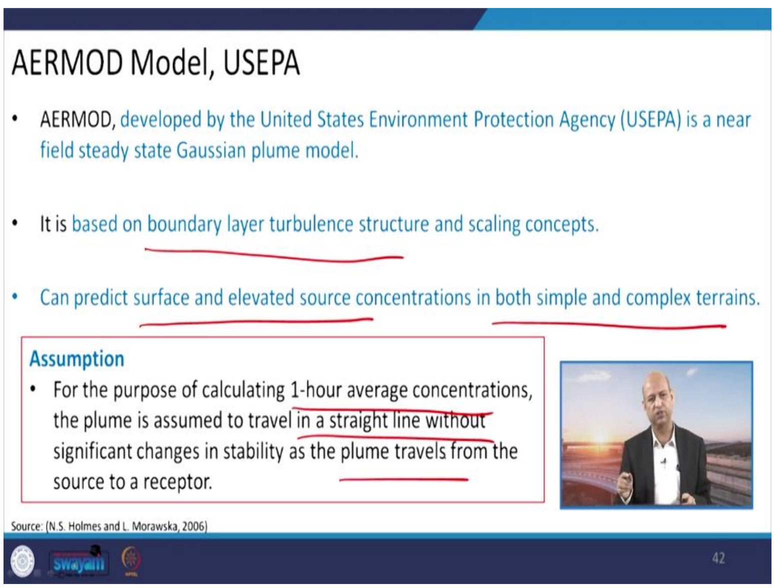

Then one more versatile model is AERMOD mod model which is developed by USEPA and it can be based on boundary layer turbulence structure and some scaling concepts of different nature it can predict surface and elevated source concentration like surface ground level concentrations X Y Z related concentration both for simple and complex terrain.

So, that means, it is a really versatile model then purpose of calculating is one our average concentration and it can also go for a straight line significant changes when instability is there for plume travels from source to receptor. So, these are the assumptions which are part of part and parcel of this model.

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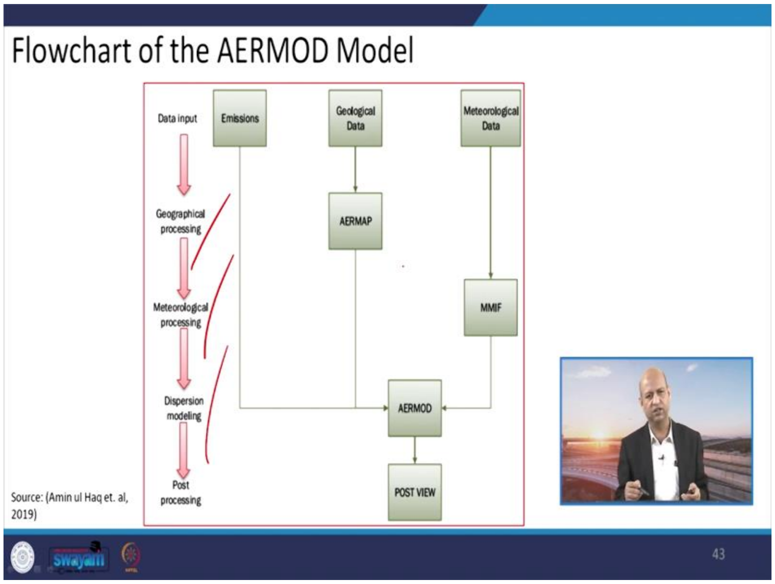

Flowchart if you see same it is like data input geographical metrological dispersion all those things are there but only differs in nature of there is scaling.

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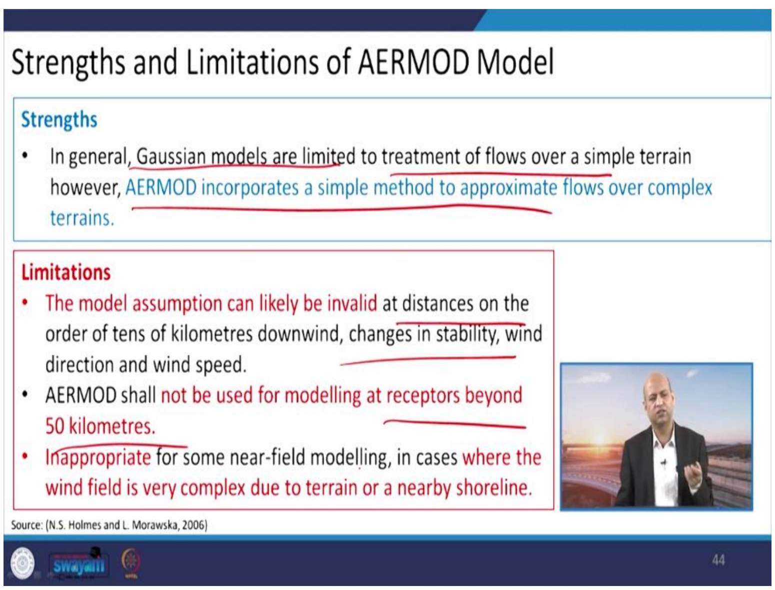

Strength are there because it also uses Gaussian method dispersion model and limited to treat the flows over the simple terrain. But this these Gaussian models have limited the kind of thing, but this model basically incorporates simple method to approximate flows over the complex terrain.

So, that kind of strength is there in comparison to Gaussian related models. So, a little bit better equations are used in this, but there are certain limitations in this model also because it can be invalid at distances on the order of 10's of kilometres downwind.

It changes in the stability wind direction and wind speed so only less than 10 kilometre it can give better results it is not used for receptors beyond 50 kilometres. So, again 10 to 15 maybe some calculations maybe there it is very good up to 10 kilometre then 10 to 50 also some calculations can be there, but beyond 50 kilometres it should not be used.

So, maybe for big cities it may be difficult for modelling in appropriate for some near field modelling. So, where wind field is very complex due to terrain or some shoreline something like that. So, it may not be so good in that sense. So, some every model has as I said some limitations. So, these kinds of limitations are there for this AIRMOD model.

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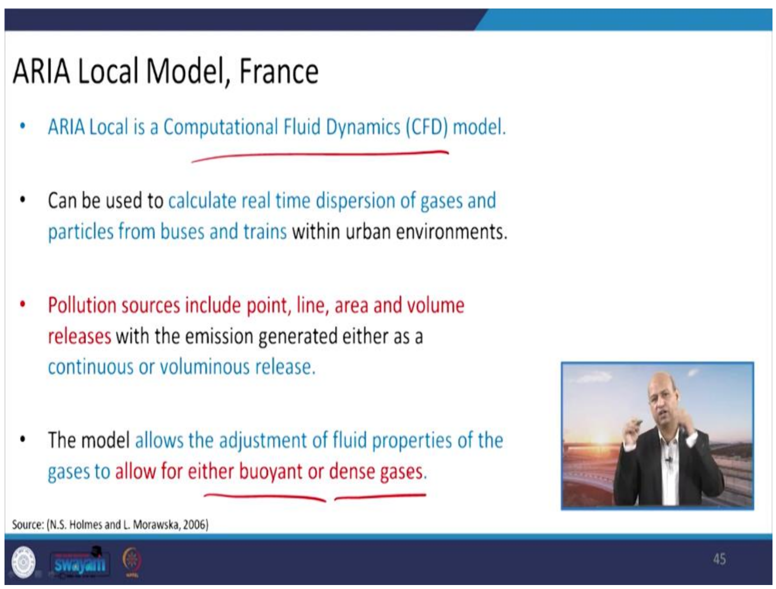

Another model is this ARIA local model France which is developed by technique of computer computational fluid dynamics. So, this is CFD model. So, this has its own strengths basically, which it can allow like buoyant and dense gases, dense cases, like in Bhopal gas tragedy that gas was like denser than the air. So, it was hugging the ground when it was dispersing, but it has this model can be used for general bioenergy like those gases which are lighter which goes up and disperses and heavier than air gases can also be modelled by this model. So, this is one very important aspect of this model.

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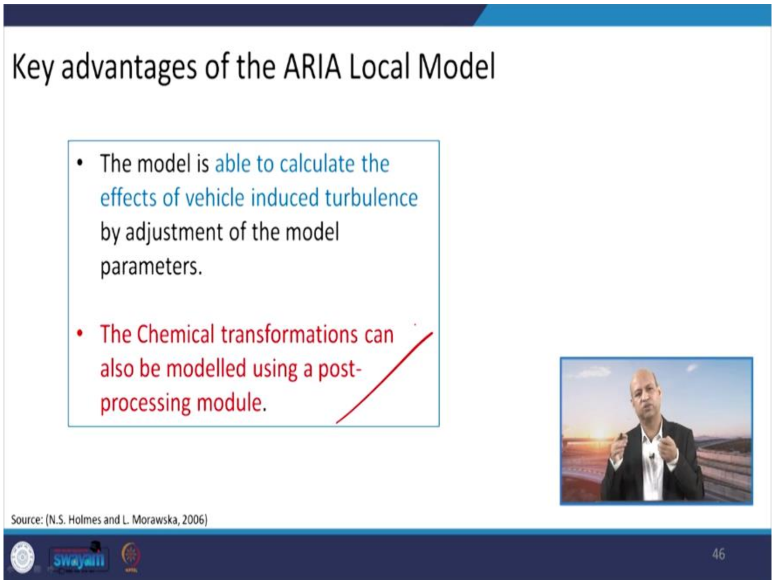

Then certain advantages are also there like it can calculate effects of vehicle induced turbulence adjustment to the model parameters can do and then chemical transformations can be modelled using some post processing modules. So, not only inert but for these chemistry module is also there part of this model.

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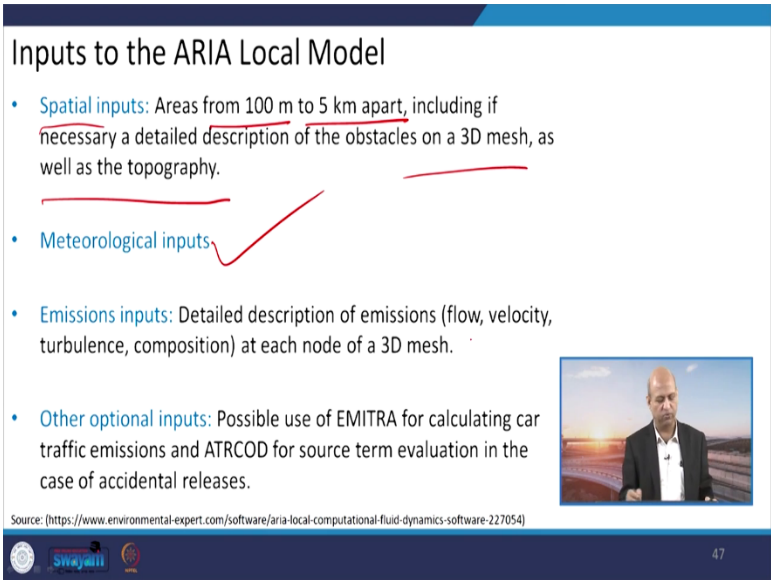

Then input parameters it is almost same for others like as spatial inputs only skills differ like 100 meter to 5 kilometre apart it can include necessary descriptions and 3D mesh it can be taken care of topography metrological inputs wind related temperature related emission input which you know flow velocity etc., and other optional input depending upon what purpose you are using this model.

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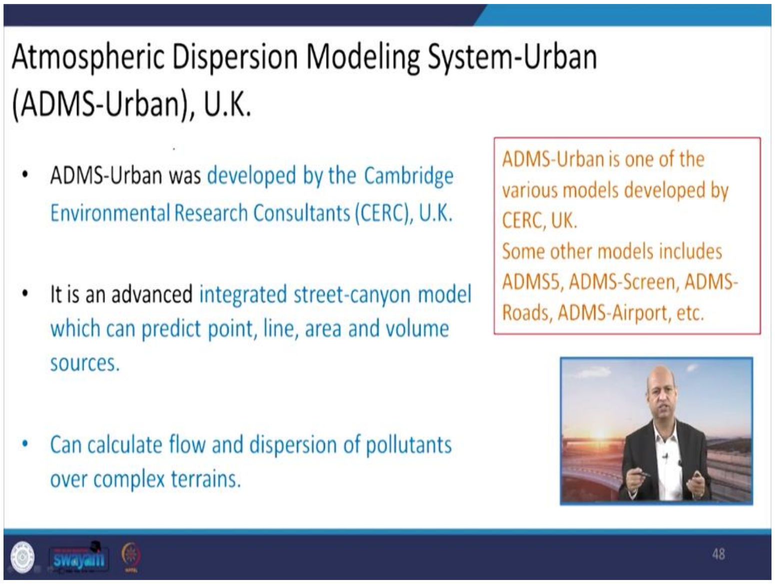

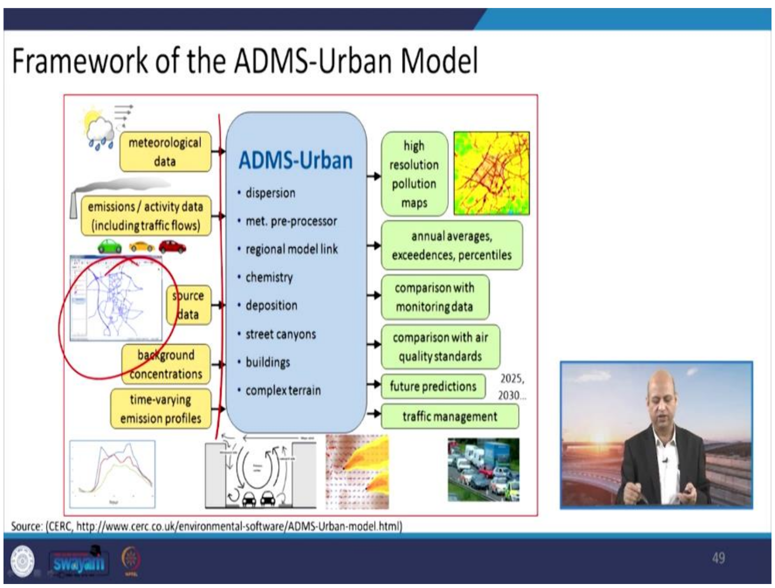

Atmospheric dispersion modelling urban this is ADMS-Urban, ADMS modelling technique, this atmospheric dispersive modelling of UK is of different nature we will see in the table, but this urban related this module is versatile. So, that is why we are discussing it here. Otherwise, there is related to roads also or other sources also but this includes everything like these kind of networking of the roads. So, all these input parameters may be there and it can give grid related all the road network emissions, if available, then concentration it can give these kind of charts you can have and dispersion modelling efforts can be there.

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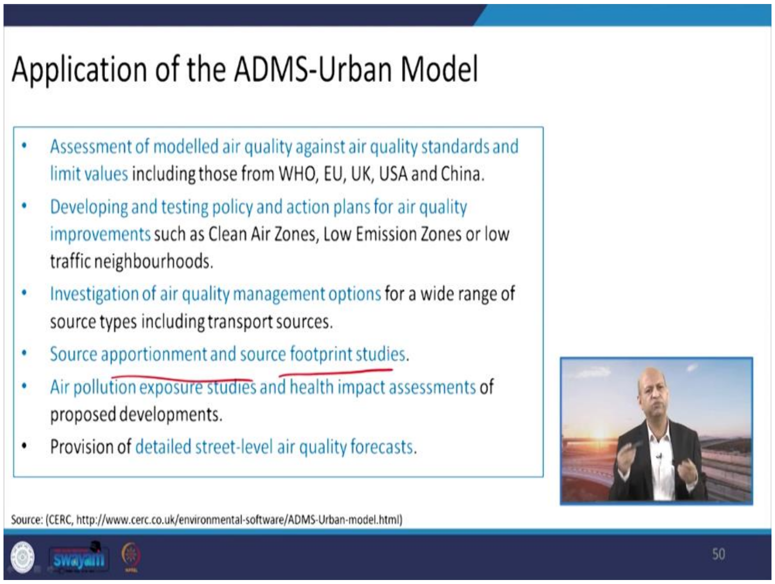

Applications can be it can be used for air quality internet comparison and then developing more testing certain policies what will be the impact which all models are used for source apportionment and source footprint studies. So, it is a very versatile model you can say.

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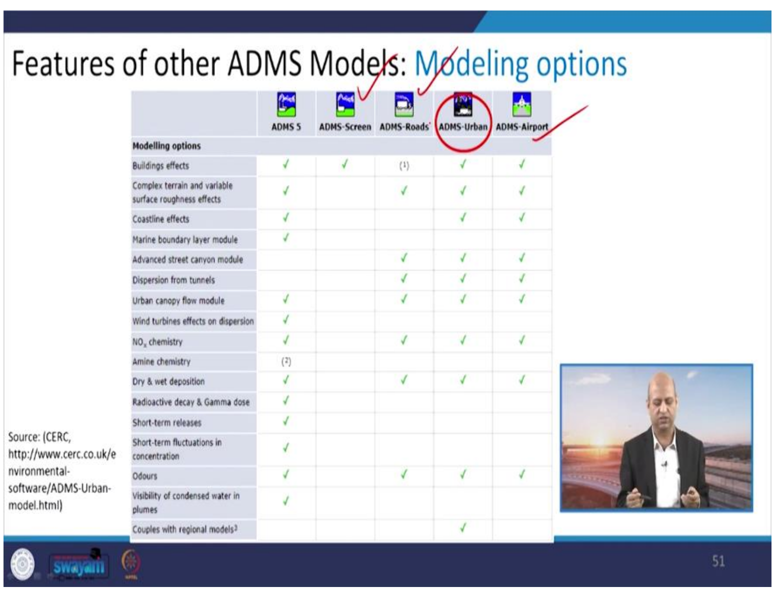

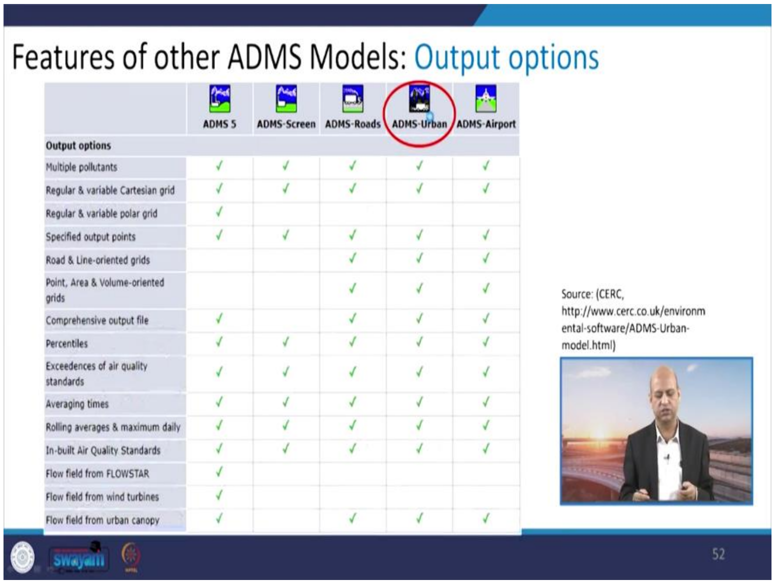

Output options	ADMS 5	ADMS-Screen	ADMS-Roads	ADMS-Urban	ADMS-Airport
Multiple pollutants	✓	✓	✓	✓	✓
Regular & variable Cartesian grid	✓	✓	✓	✓	✓
Regular & variable polar grid	✓				
Specified output points	✓	✓	✓	✓	✓
Road & Line-oriented grids			✓	✓	✓
Point, Area & Volume-oriented grids			✓	✓	✓
Comprehensive output file	✓		✓	✓	✓
Percentiles	✓	✓	✓	✓	✓
Exceedences of air quality standards	✓	✓	✓	✓	✓
Averaging times	✓	✓	✓	✓	✓
Rolling averages & maximum daily	✓	✓	✓	✓	✓
In-built Air Quality Standards	✓	✓	✓	✓	✓
Flow field from FLOWSTAR	✓				
Flow field from wind turbines	✓				
Flow field from urban canopy	✓		✓	✓	✓

And the features of ADMS model as I said, it is like for screen roads and here are four different modules are there but this urban this ADMS urban has all kinds of modules in built in this and that can be used. So, these are the metrics which give us different parameters and values which are used for calculation purpose.

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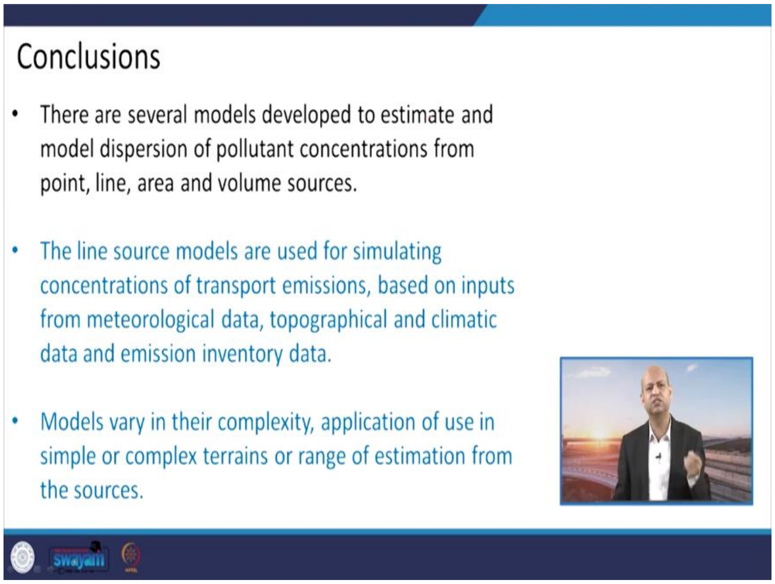

So, in conclusion, we can see that when we talk about emission models, the output of the emission models is the input of dispersion models and depending upon the situation, depending upon the scale whether street canyon or the regional scale kind of modelling effort you want to make. So, accordingly the technique of the model you need to choose and that can be like I have described different kinds of models, very basic things I have given, otherwise every model has a lot of things into it. So, you can go through in detail for learning about those models and these are the dispersion models which are used for concentration calculations based on emission modelling output.

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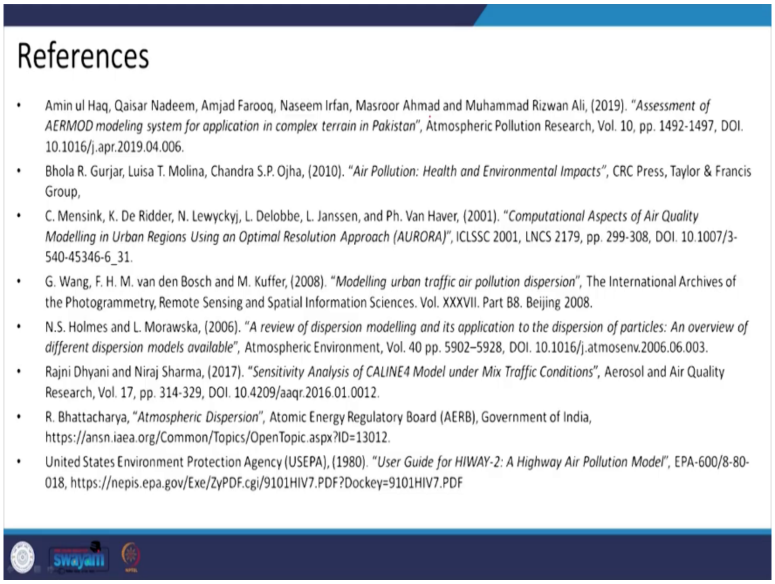

These are the references for additional information. Thank you for your kind attention. See you again. Thanks.