Introduction to Geographic Information Systems

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Lecture - 12
Spatial interpolation techniques

Hello everyone, welcome to the 12th lecture on Introduction to GIS. In this particular one we are going to discuss a technique which is called Interpolation. Since, we go for spatial data therefore it is also called Spatial Interpolation Techniques. There are variety of interpolation techniques are available depending on your requirements, but there are few things which I would like to mention here first that, generally the interpolation is done from using discrete data to make them as continuous.

So, from vector to raster you go for interpolation. In generally the input data can either be a point data or even line data. Line data you know that line is made from several nodes and these nodes can be treated as point so sometimes you might be having input as contours, so these contours can be converted into points using the tools available in your GIS software and then point to surface that is going from discrete to continuous. Another important thing is here is basically why interpolation is required. This is because your point representation or contour representation as mentioned is discrete representation. So, say think that between a two contours you do not have information there is a gap in the information. So, suppose this is one 100 meter contour this is 200 meter contour.

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Now, we do not have any information between these two contours. Same with point data and therefore we call them as discrete that between two points we do not have an information about the; what if we consider as a height then we do not have the height of these locations where no observations are available. We do not have any height of information between two contour lines. So, if we want to create a surface that will represent the terrain in case of elevation then we go for interpolation. Now there is a assumption or a belief which one has to have before we go for interpolation that a once the information no information is there then whatever the mathematical way we can drive information that has to be assumed that it is going to be accurate.

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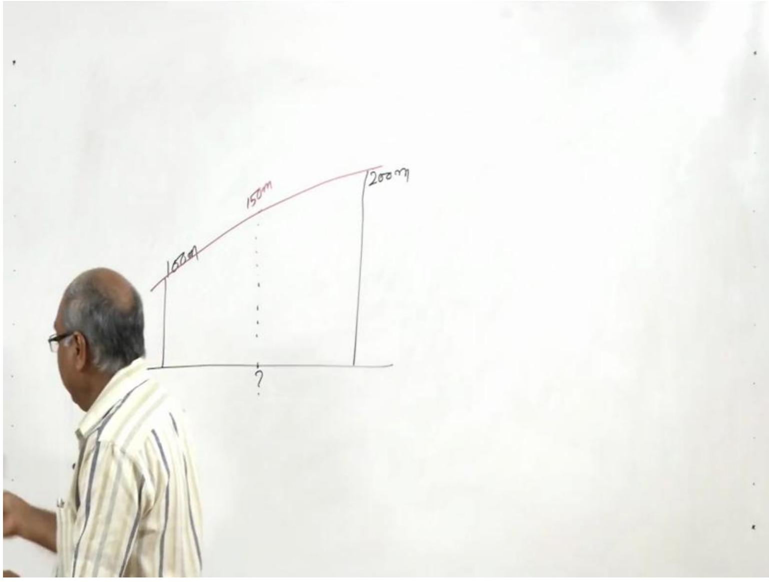

For example if I take a simple example here that I say this is 100 meter and this is 200 meter height and I want to know the height of this point about this, so a very simple way of thinking that linearly we can connect this one and say that the height of this point if it is in the center may be 150. This way this is the called linear method of interpolation, but this is in 2 d we need to have in 3 d. That means, we are going to create a surface. So, all these details we will see slowly slowly; what are different methods, what are the advantages and disadvantages with different methods. And also we will try to think that which interpolation will suite to my data set that can also be thought on here.

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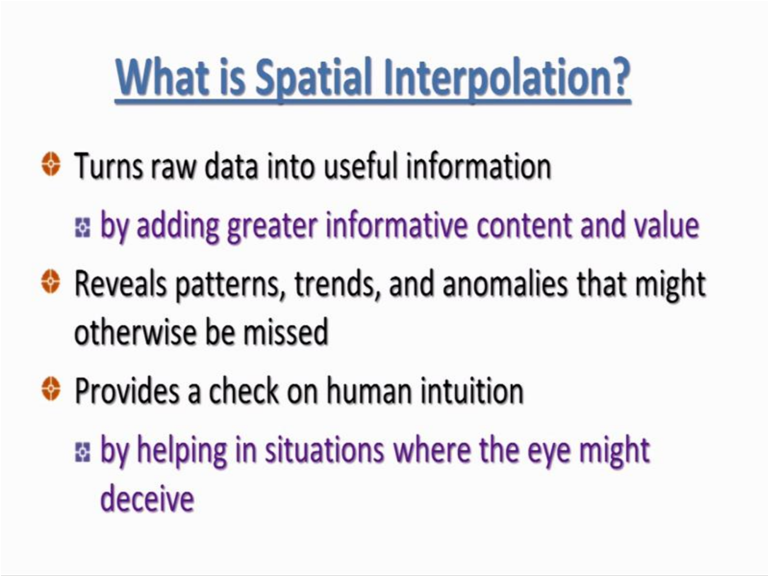

So, what is basically spatial interpolation? As that it turns raw data or your discrete data into continuous data or useful information. So, it adds the greater informative content and value because it is very difficult to assume a terrain using just point data or contours data, but if you are having a surface representing the same area then terrain can be understood very well. And the best example of these kinds of terrain surfaces are now days which we use digital elevation models. Many of them have been tried from satellite data or either through the interpolations using contour data and point heights.

Once we convert a discrete into a continuous or point into surface then it can also reveal the patterns, it can reveal the trends and also anomalies may be higher locations maybe lower locations and so on so forth. It is not necessary that only input will be elevation values. It can be any values, suppose somebody is working for ground water it can be the ph value, it can be ground water quality value - cations, ions and a total dissolve solids all kinds of values can be used. So, for sub surface conditions interpolations can be done if the data is available. For surface conditions also the interpolations can be done. It provides a check on human intrusion. So at least based on certain mathematical concepts it will predict a value for a unknown location, for a location for which you do not have any information and a then try to help in the situations where I might decide where we cannot think, but a mathematical surfaces can be drawn which will give a near true representation of a phenomena may be elevation may be other quantity qualities.

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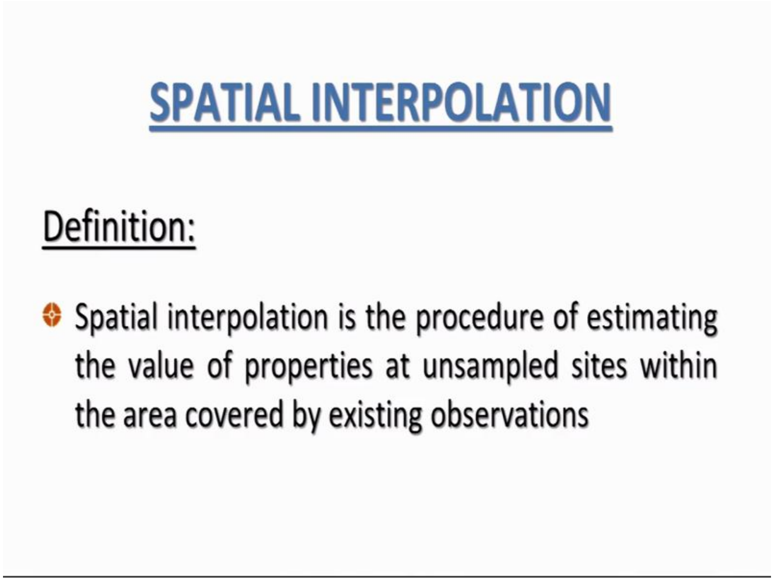

Now, if we go to the definition of a spatial interpolation, well which is the procedure of the estimating the value of properties. Properties can elevation or chemical properties may be ground water level or water table and other things at unsampled sites for which we do not have any observation or data within the area covered by existing observation. So, when we cover the area if we are having point for area and it is distributed, so beyond a beyond observations then we call as the extrapolation, but within the observations it is called interpolations.

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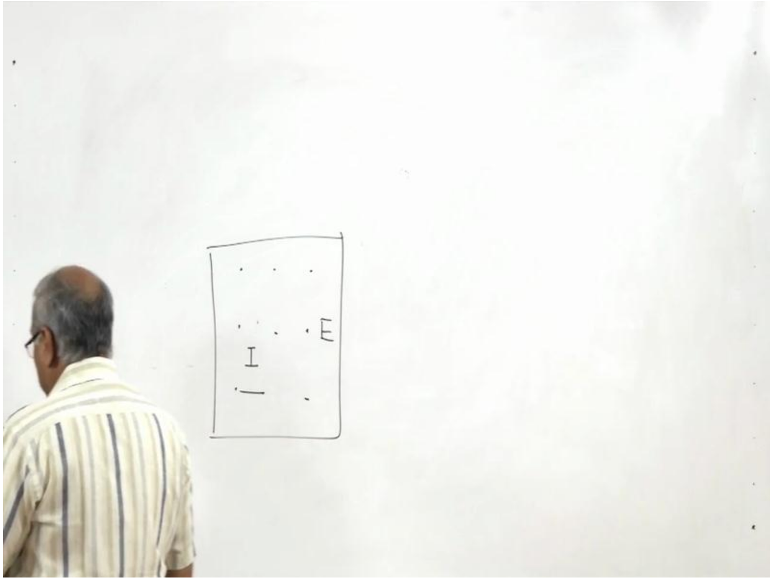

So, if your are having data say like this and do the interpolation for this area then this part we will call as interpolation, in this part we call extrapolation because beyond this point these point on the right side we do not have any observations.

So, in the tools which are available in GIS can be used when you go for using point data to create surface and these interpolation extrapolation are done simultaneously.

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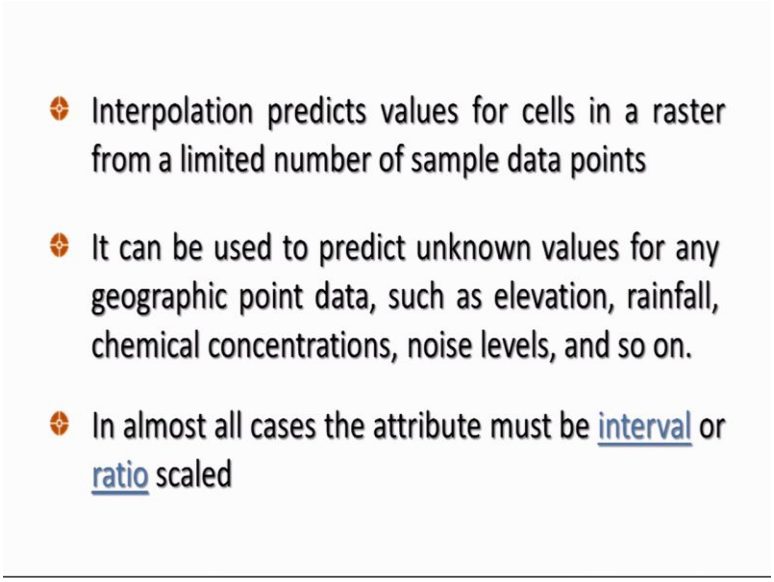

Interpolation predicts a value for cell in a raster from a limited number of sample data points and that is the advantage also with the interpolation that you might be having say hundred observations for an area. Now you can create a surface which will represent and give you lot of information which is otherwise very difficult to extract or near impossible to extract just using the point data. It can used to predict unknown values for any geographic point data such as elevation, rainfall, chemical, concentration noise level and so on. And in all most all cases the attribute must be interval or ratio.

Since we have discussed different types of attributes so remember that like for a cyclic data interpolation cannot be done. For counts and amounts interpolation cannot be done. And for nominal data interpolation cannot be done. So, you need to have either interval data or ratio data where you can do the interpolation.

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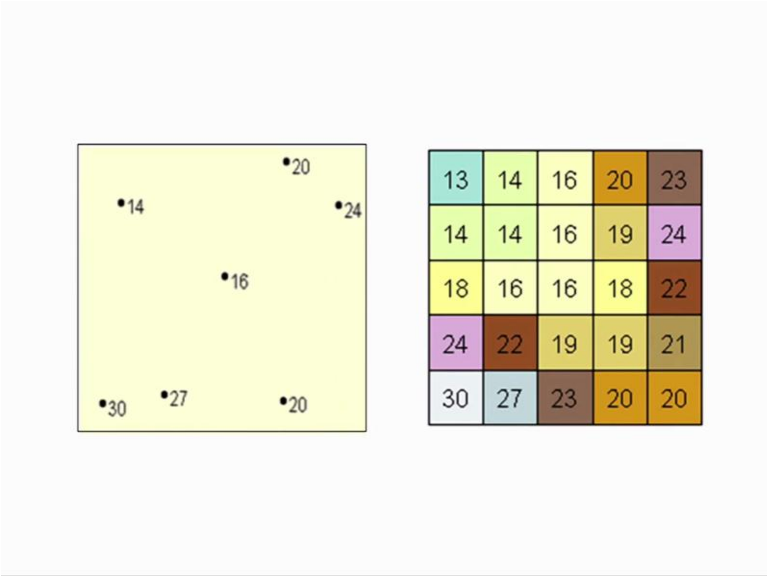

Example is shown here that the input is a point data and their values are written here. Assume these are the elevation values. When we decide the size of the grid or the surface which we are intended then in this one the original values for each cell are intact here. So, when we 20 and 24 wherever it is falling here the same values are in the interpolated cells, but remaining values have been predicted here. So, these may consider a sort of exact interpolation we will see different types of interpolation technique, so converting from discrete data here to a continuous surface as raster through the interpolation.

Also here shown here now you are having lot of points are there they all they will have a values in your attribute table and you choose a particular field where the values are there for which you want to create a surface and then whatever the method you will choose accordingly a surface will be created.

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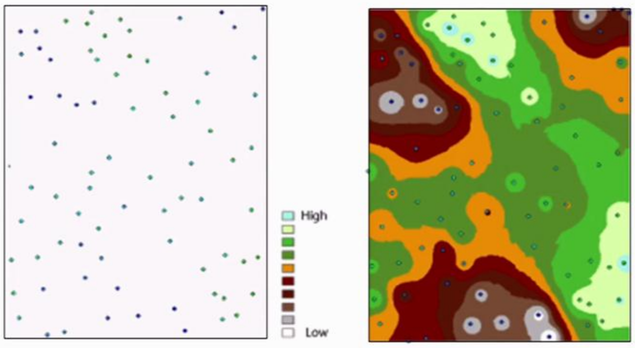

Here it is shown just in a continuous fashion and some colors have been given which are representing range of say if these are elevation values range of elevation values are represented through colors. And if it would have been elevation model we can call as a relief matter.

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- Can be thought of as the reverse of the process used to select the few points from a DEM which accurately represent the surface
- Rationale behind spatial interpolation is the observation that points close together in space are more likely to have similar values than points far apart (Tobler's Law of Geography)

So, interpolation can be thought as a reverse of the process used select few points from a dm which accurately represent the surface. The purpose here the rationale behind interpolation is that the where we do not have observations. We want know or we want to predict that value and therefore we go for interpolation. And this concept is based on Tobler's Law of Geography which says that again the neighborhood rule is coming here that the unknown point for which you want have the value whichever the closest observation will have the maximum influence on this one, if I take example here then the prediction for the say this value at this location will have maximum influence from this value rather than from this one.

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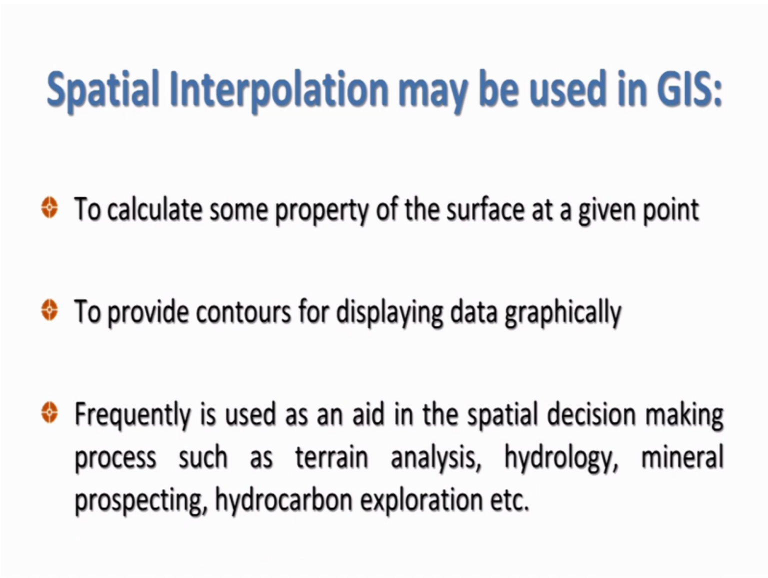

And if it would have been middle then both will have the same influence. So, this is based on the concept of Tobler's Law of Geography. And now interpolation may be used in GIS to calculate some property of surface at a given point may be elevation, may be ground water or water table or water quality, to provide contours for displaying data graphically and it is frequently used in the spatial decision making process and in such as terrain process hydrology, mineral prospecting, hydrocarbon exploration etcetera.

Because when you use the point data create a surface from point data say point data is elevation data you have created a surface which you will as digital elevation model. Now there are various derivatives of a digital models can come like, slope, aspect and maybe gradient map, maybe using surface hydro logical modeling in GIS you can create (Refer Time: 12:32) networking, you can create water set boundaries, you can create the sediment power index erosion index and many, many things.

And this is what is that terrain analysis you can perform once a data is in the surface form or in raster; you can also use in hydrology or in ground water hydrology and or you can drive various outputs which are useful for hydrology, also you can have cut and fill analysis you can have dam simulation reservoir simulation and so many things can be used once the data is in the raster form or in the surface form from derived through interpolation from point data.

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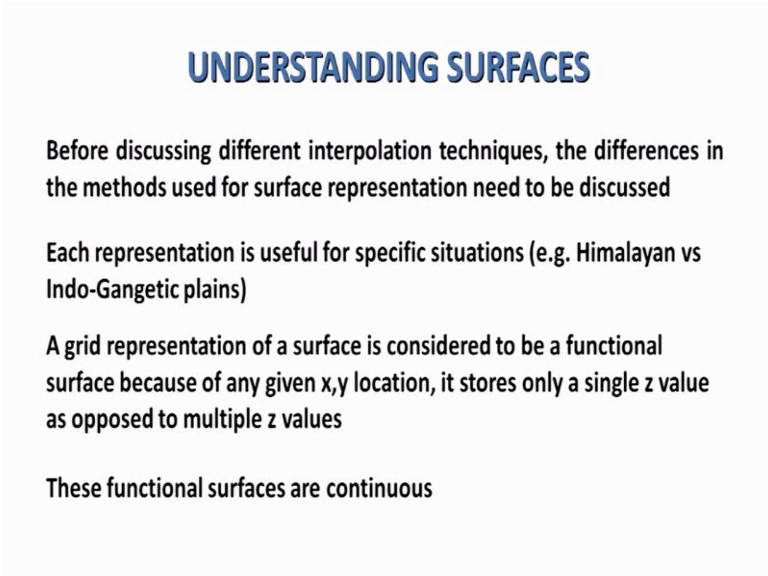

Now as we know that this raster surface is for each cell you are having a value. And these are equal size cells you are having and as you know that for different situations because the terrain conditions might be different for Himalayan terrain the conditions are different. So, the interpolation techniques might be also different. For the point data for off indignant plane again interpolation might be different. So, there is also very much. Before we go for interpolation we must understand that phenomenon 1 and local information if available for that area that would definitely help us to choose a right interpolation technique.

Then in grid representation because we are representing as a raster and that two uniform of grid rather than an image, so you will have your x y locations and z value that is your singular attribute in raster and that z value can be your elevation value or other concentration value, depth value, hide value etcetera. And this functional surfaces are continuous because raster is continuous not discrete.

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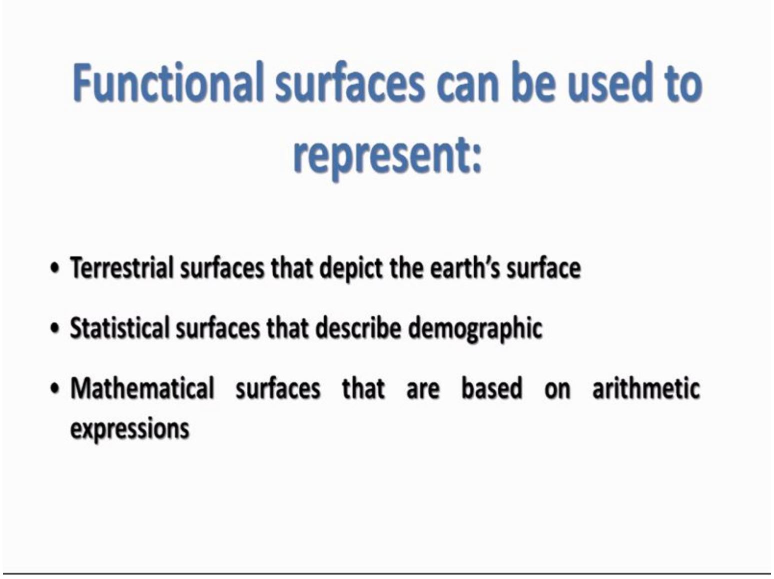

Now, these functional surfaces can be used to represent your terrestrial surfaces terrain which depicts the earth surface terrain conditions, we can also use in a statistics or mathematical representation so we call as statistical surfaces that describers the demography mathematical surfaces based on the arithmetic expressions. Hence this surface representation in it is simplest form is done by a storing x y and z value in the defined location of a sample.

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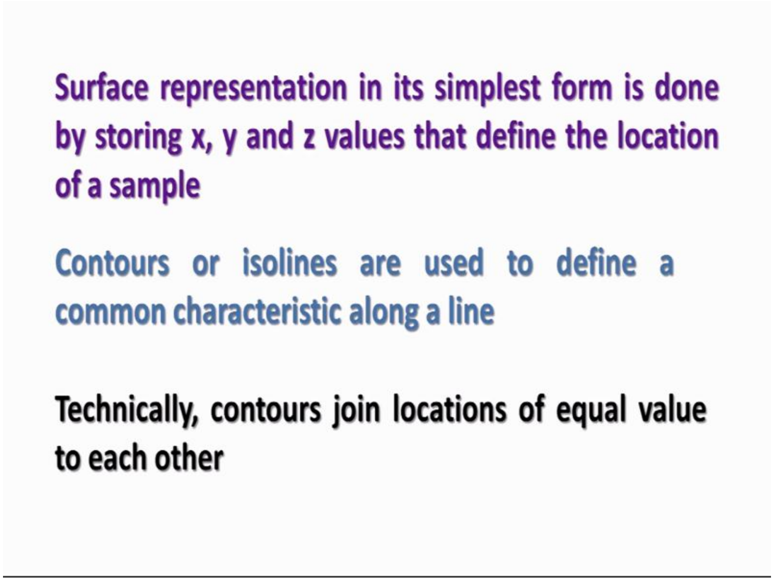

You can later on you can also create contour lines or isolines, but it is sort of backward process because again from going for continuous to discrete, but sometimes we have to do it because many people are very good to understand contour data rather than surface, so they would prefer the contours. So, it is very easy to create contours at desire levels using a surface very easily in any standard GIS softwares. As you know that the contours typically join the equal value or equal height if these are topographic contours.

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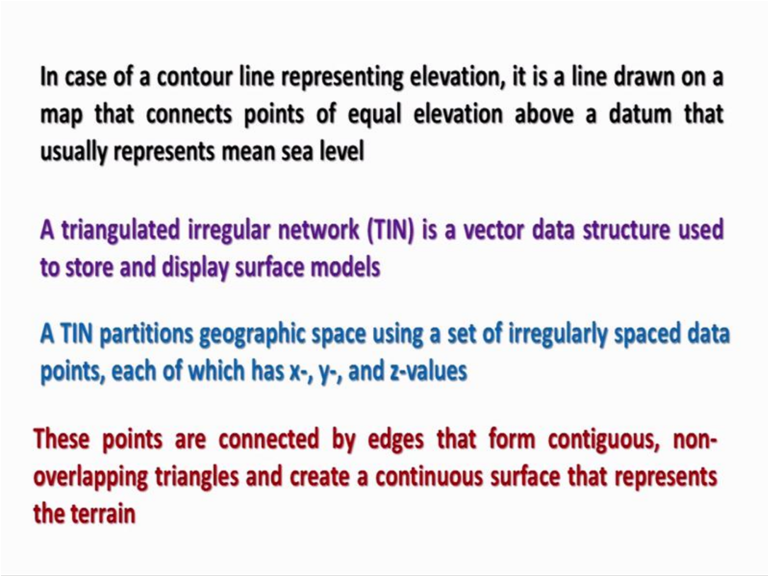

And in case of contour lines representing the elevation it is a line drawn on a map that connects points of equal elevation above the datum that we know. TIN is sometimes also considered as interpolation where because the point input is there and then you create triangles so there you know different way of representing the surface which TIN is since we have discussed so we moved here from here.

Grid your surface generally that like digital elevation model are in form of grid and we known that each cell will represent a value.

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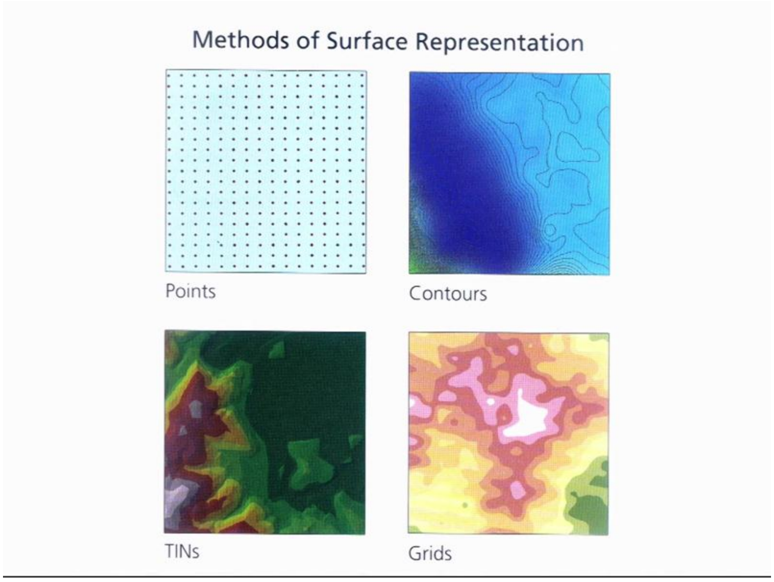

Some examples are here that in a discrete form your point data is here. We can also represent in contours, we can also represent the same point data in form of TINs and the same point data can also used through interpolation to create surface raster grids.

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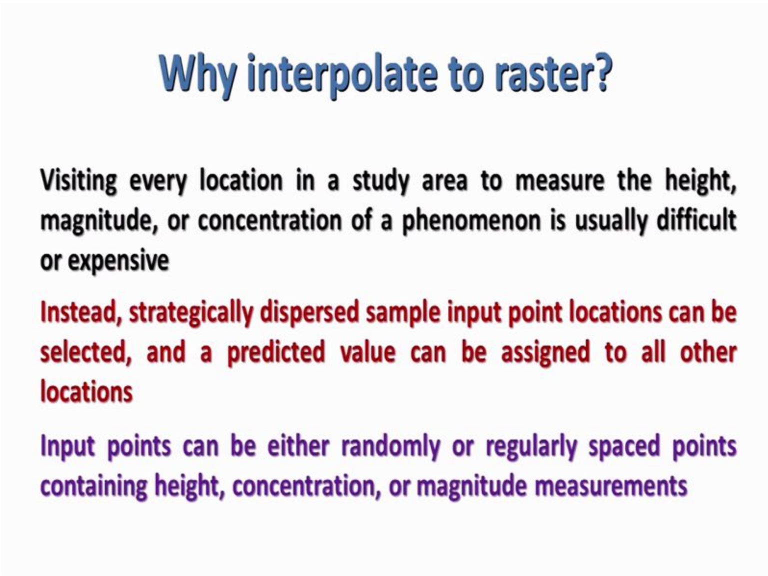

At this point we have already discussed while interpolate because we do not have information where everywhere which where we want all the time and therefore interpolation. So, visiting every location in a study area to measure the height magnitude or concentration of a phenomenon is usually difficult or expensive. And instead strategically dispersed sample input locations can be selected and a predicted value can be assigned to all locations and input points can be either randomly or regularly space points containing heights concentration or magnitude measurements. It is not necessary that the input points should be distributed uniformly; not at all wherever the observations are available using those point surfaces through interpolations can be created.

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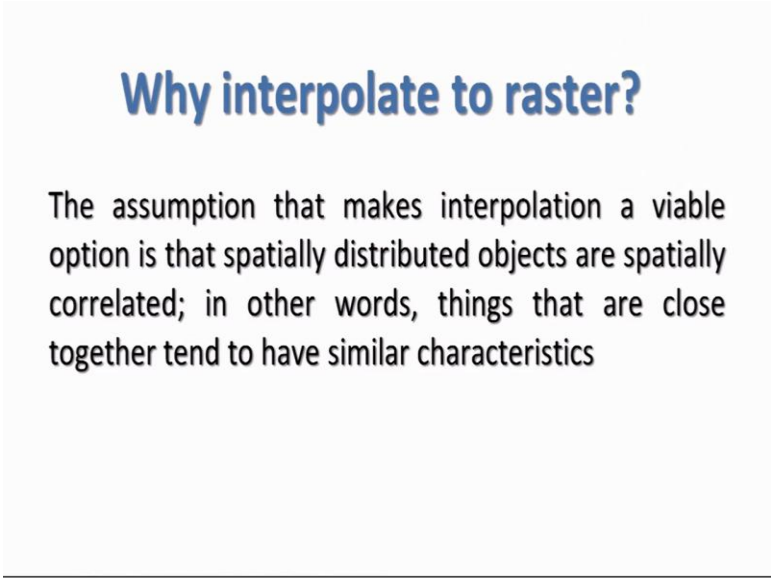

As I said that the major assumption or belief is that interpolation makes viable option that a spatially distributed objects are spatially correlated. In other words things that are close together tend to have similar characteristics; this is a Tobler's Law of Geography.

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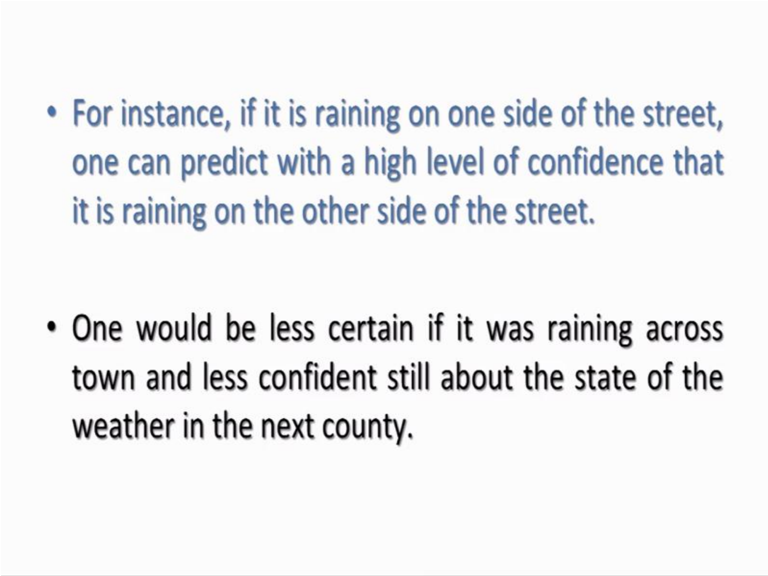

For instance, if we say that if it is raining on one side of the street one can predict with a high level of confidence that it is raining on other side of the street. And one would be less certain if it was raining across town or less confident still about the state of the weather in the next country, because closer the point higher would be the confidence level and it is easier to predict with high level of confidence rather than a point which is very far and we do not know and it is it becomes very difficult to predict.

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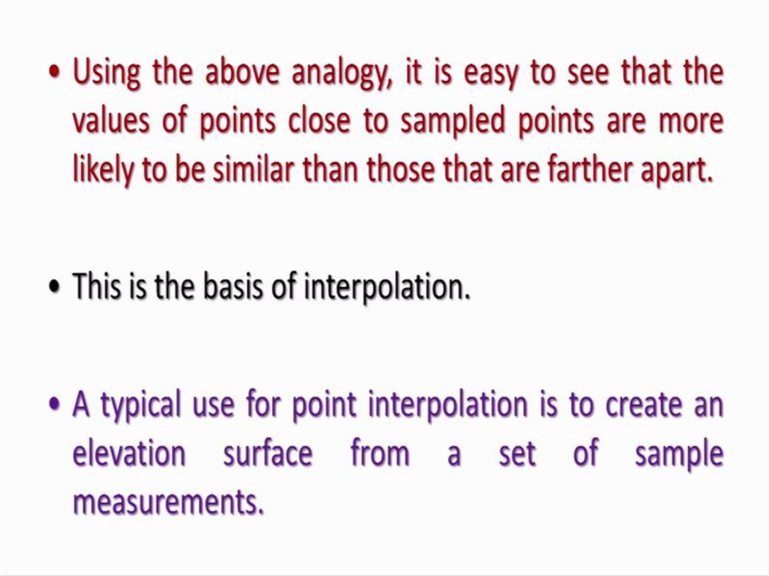

So, the same concept has been employed into interpolation and the same logic or analogy is that it is easy to see that the values of points close to sample points are more likely to similar then those that are further apart. And this is the basis of interpolation. A typical use of a point interpolation is to create to surface from discrete data to a continuous surface. There are methods various methods are available for interpolation which we will go in a sort of generic forms then individual interpolation techniques which have been implemented specially in GIS software's so we will also see.

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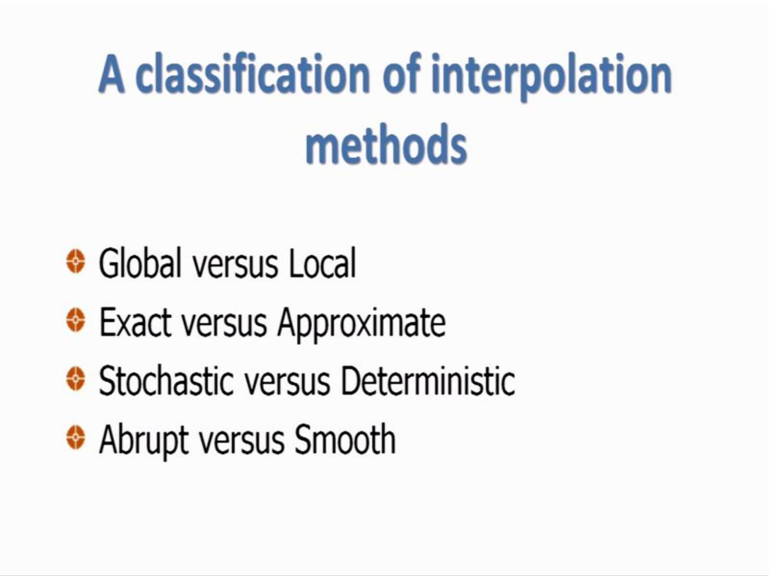

First one is global versus local another is exact versus approximate and stochastic versus deterministic and then abrupt versus smooth.

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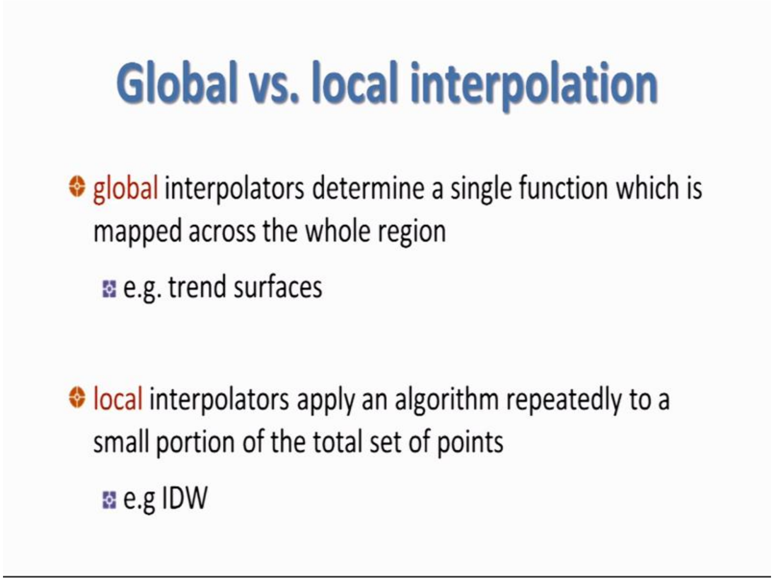

A global versus local, that the global interpolaters determine a single function which is mapped across the whole region. For example, a trend surface where the function has been calculated and determined and that function is applied throughout the data sets and that example is trend surfaces. And local interpolators apply an algorithm repeated to a small portion of the total set of points. And example is universe distance waited method. This method has been implemented this interpolation techniques into the standard GIS softwares, so that can be also used here.

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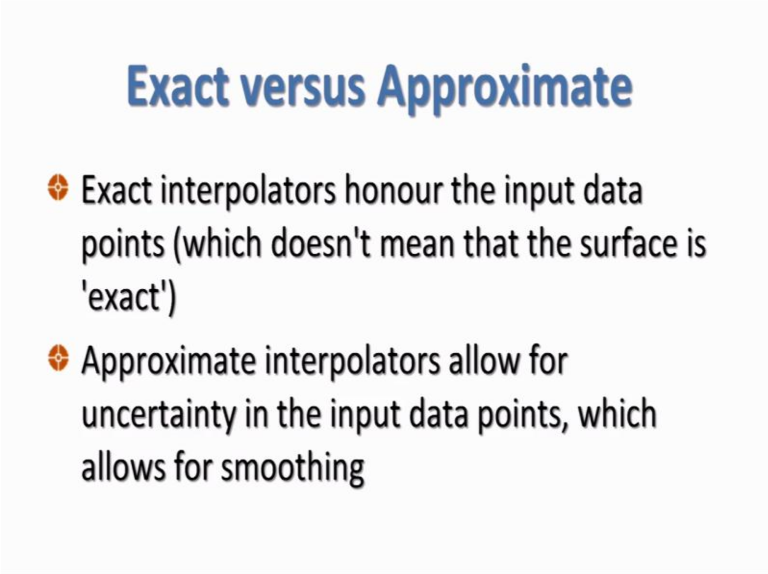

Now exact versus approximate, that exact interpolators honor the input data points which does not mean that the surface is exact. That means, that a the input value when a surface is being created it tries to have that value intact as far as possible, but not all the time it would have the same value. Approximate interpolators allow for uncertainty in the input data points which allows for a smoothing. So, when we go for approximate interpolators that means, we are going move towards null linear and interpolator. And when we go for null linear interpolation techniques then we the original values are not kept in the raster data and there lot of variations might be there but the surface which it will create through this type of interpolation is going to be quietly smooth, but if we go for exact interpolator then surface it is going to create is not going to be the smooth.

So, it depends on the phenomenon. If we know that I am going to interpolate for a terrain light indogangtic plane we know it is a very smooth terrain. Then the approximate interpolators would be more appropriate than exact one, but when we know now say example I am going to do the interpolation for a terrain like Himalayan TIN which is highly rugged. And therefore, the smooth interpolators or approximate interpolators are not suitable then I would prefer exact interpolator. And that is why it has been mentioned that we must know the phenomena which phenomena I am going to use, which type of data is going to come for interpolation. If it is elevation data then what is the terrain condition, if prior information is there then it will allow us to choose appropriate interpolation technique.

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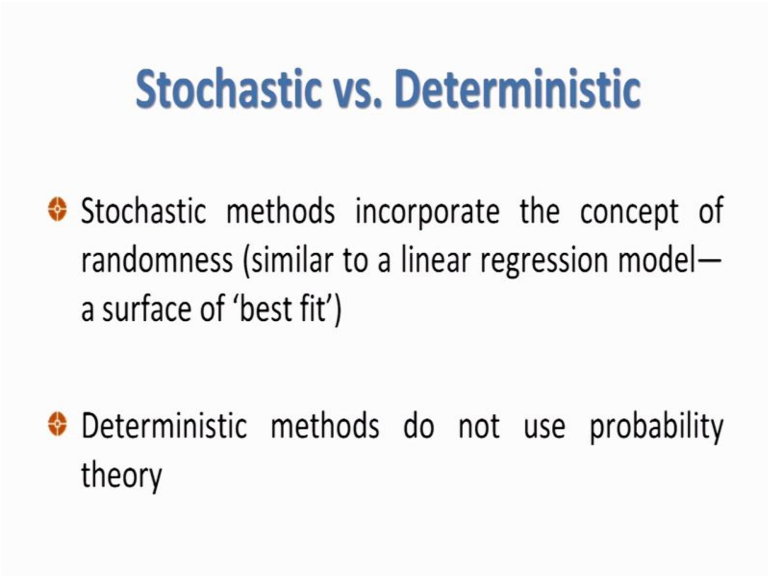

The fourth one is a stochastic versus deterministic. In stochastic methods which incorporate the concept of randomness similar to a linear regression model or a surface of best fit. Whereas in deterministic method do not use probability theory. So, these types of you know generic form of interpolators are there of about 8 types.

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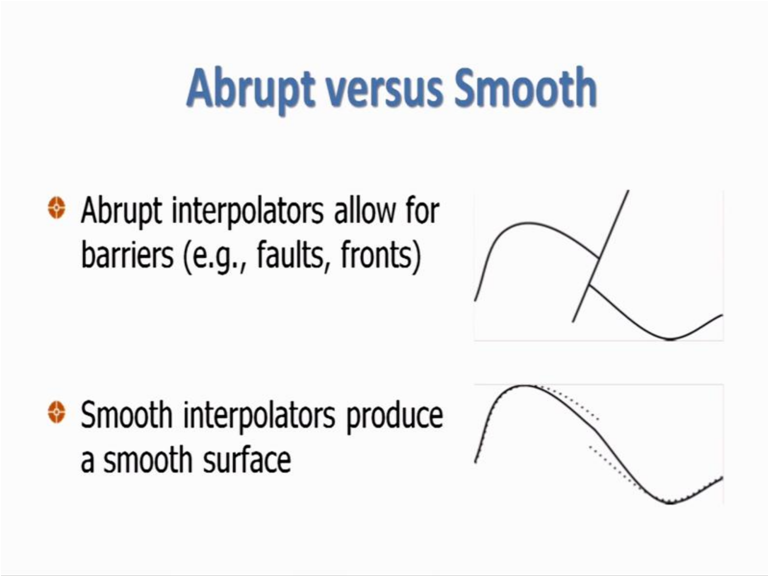

Now in case of abrupt versus a smooth like some times in nature there might be some 10 certain barriers and you want to keep the information about those barriers. The influence in the surface while creating a surface from point data and those barriers can also be used in the interpolation and that means you would prefer the abrupt interpolators rather than a smooth interpolators. And example here in this case, suppose I am working for ground water I know there are say some dice or quasaries are there and quasaries will serve as barrier which will not allow flow of water from one end to across these quarries and the water might not flow smoothly.

And therefore, these quarries will serve as barriers and if I ignore them and create a surface about the water table it is going to be the smooth surface which is going to be inaccurate representation of a true water table or water surface. Therefore, I need to incorporate such barriers while creating the surface which should be more close to the real thing. And that is why these abrupt inputs are allowed in different interpolation techniques and we will discuss little later about this.

That, abrupt interpolators allow for barriers, for example; faults, fronts, dice, reefs etcetera a smooth interpolators produce a smooth surface, so depending on your requirement, depending of the phenomena, depending on the terrain conditions one would choose interpolation.

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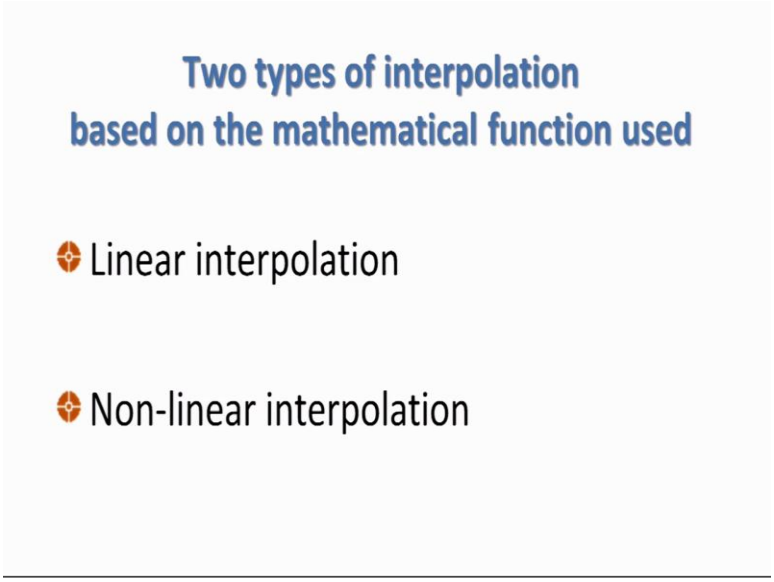

Now, these same interpolation techniques can be divided into different way in two different categories; one is based on the mathematical functions, one is the linear interpolations. Where initially earlier I gave the example it is easy to predict and therefore some for certain phenomenal linear interpolation works very well or then you can go for non-linear interpolation.

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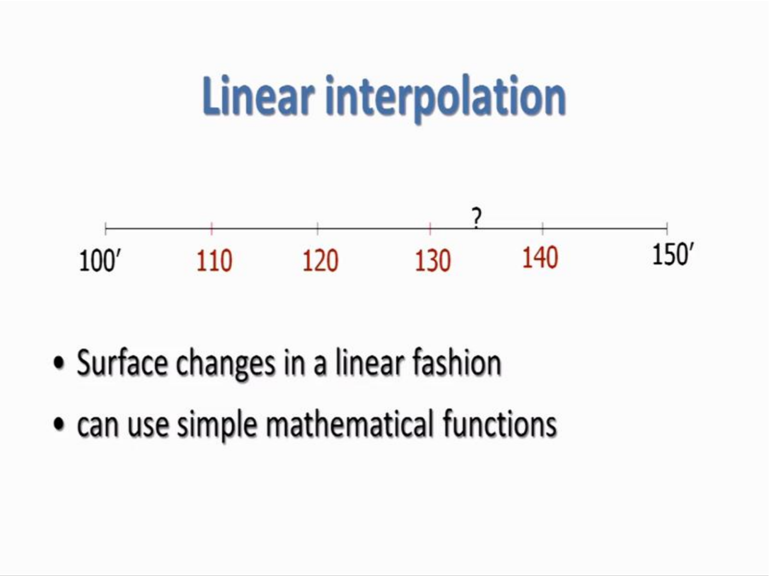

Now in linear interpolation, as a value for this can be predicted because this location the unknown value is more close to the 130 then 140, so it will have more influence here. And it is very easy to predict that value. So, a linear prediction is much easier and surface changes in a linear fashion and can be simple mathematical function.

Now, point based interpolation because in most these interpolation tools which are available in GIS the input is maximum time is point data. If it is only point data and your having say contour data and you want to create a surface no problem you can convert line to point and then point can go for interpolation.

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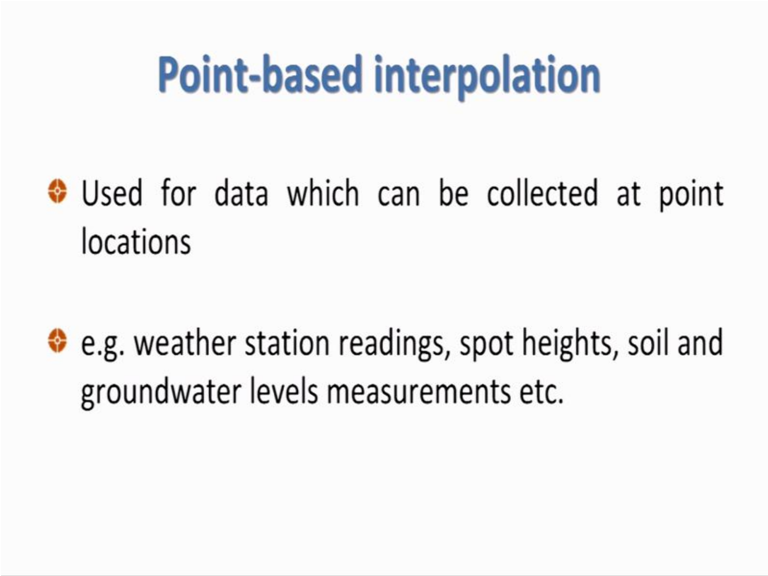

So, that is why it is also called point based interpolations which is used for the data which can be collected at point locations. For example, if I am going for rainfall or other phenomenon related with weather then weather readings may be heights or spot heights may be soil may be ground water levels or water quality and other things.

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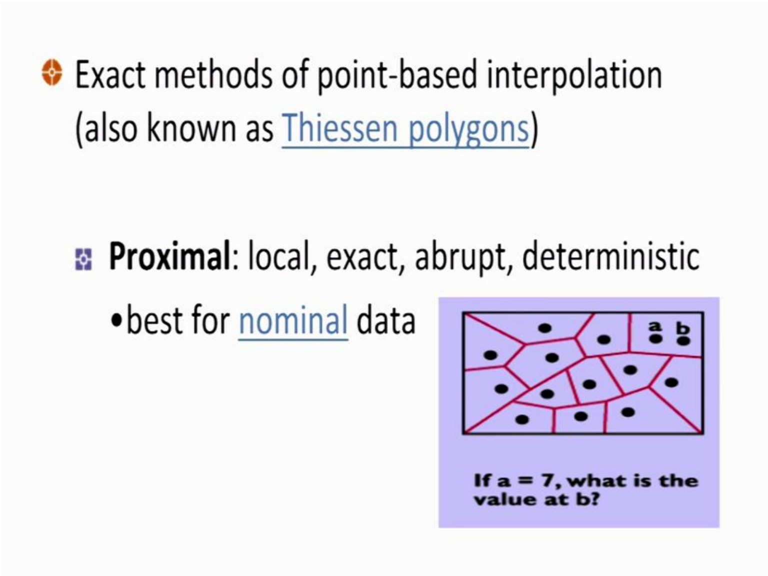

Let us take a one example of exact method for point based interpolation which is also known as the Thiessen polygon. Then we did not have this GIS tools. In hydrology lot of people use to have the input as a rainfall surfaces they used to go for Thiessen polygon. So, what it is done that along around this is observation points the polygons are created and their perpendicular distance is kept like this and then lines are drawn and then these polygons are created. So, this is a proximal which is a Thiessen polygon is also called local, exact, abrupt, deterministic all four things are there and the data can be input data or ratio data.

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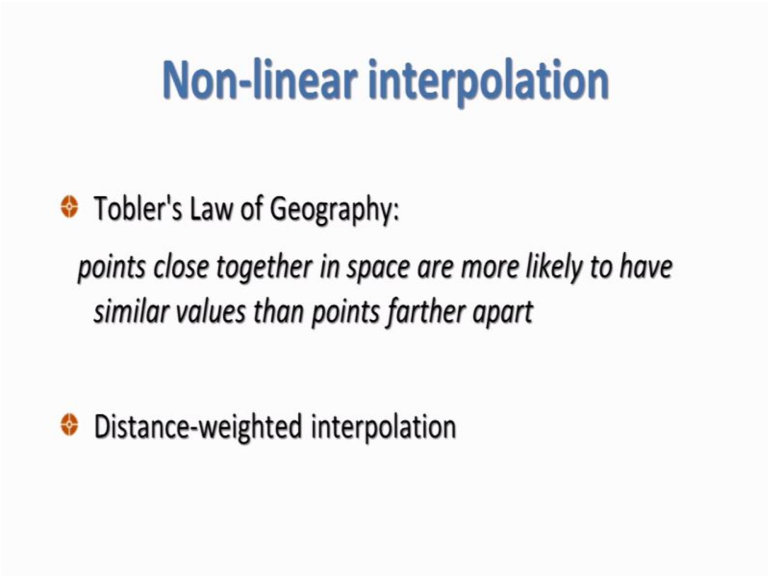

This kind of non-linear interpolations which base on the Tobler’s Law of Geography points close together in space are more likely to have similar values than points farther apart. And also distance weighted interpolator example is IDW, as the closer the distance to the observation already available data it will have more influence. The further it will have less influence and because is a inverse relation is used that is why it is called inverse distance-weighted method.

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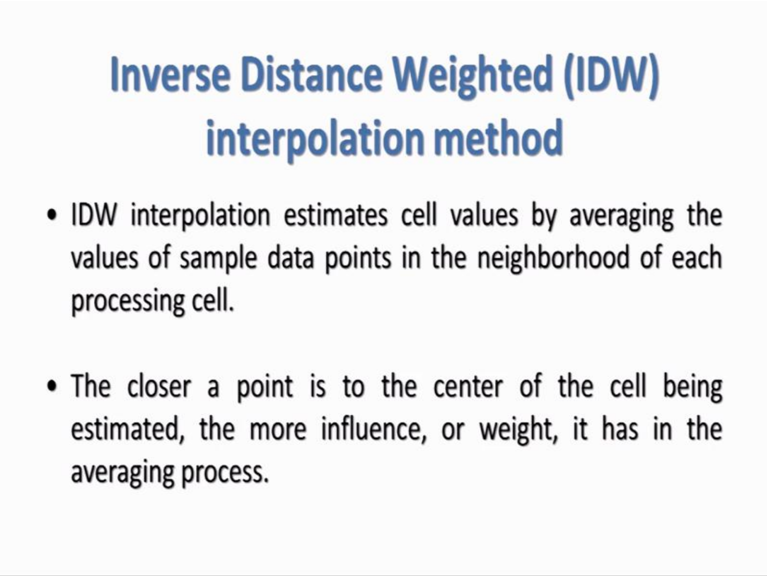

So, in these IDW interpolators estimates cell values by averaging or of your cell values of your raster or surface by averaging, the values of sample data points in the neighborhood of each processing cell. Now if there are several observations are available around for unknown value for giving location then the distances will be measured and the points which will have observation which will have the closest distance will have more influence, more weight while determining the cell value for location. Closer the point is to the center of the cell being estimated, the more influence or weight it has in the averaging process.

Recall the re-sampling technique in geo referencing. It is almost the same concept and that is why also I mentioned there that sometimes interpolation these re-sampling techniques people also put them as a under the interpolation category, but they are not really meant for re interpolations from point to surface. They are just to find out the pixel value for or a cell value once the registration and polynomial (Refer Time: 29:50) transformation function is formed. So, the purpose there is different but the concept wise it is same thing here.

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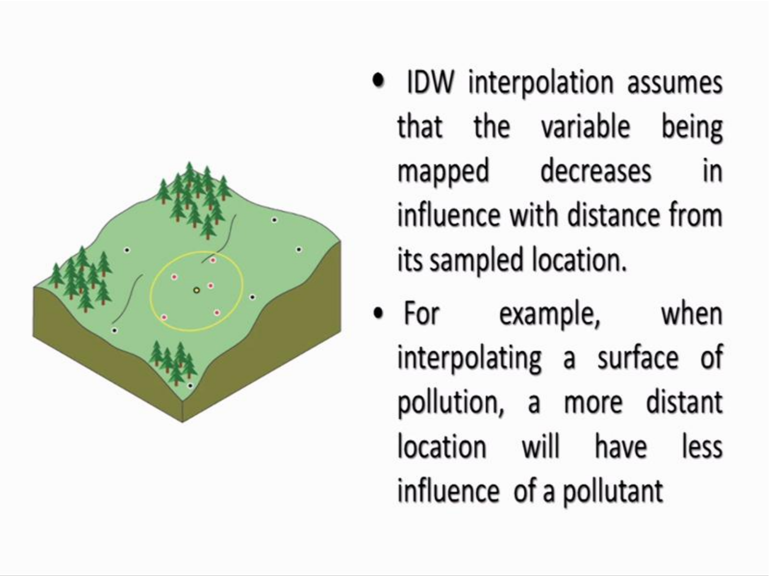

Now, IDW interpolator assumes that the variable being mapped decreases in influence with distance from it is sample location, very logical here. For example now another advantage which we can have either we can fix the size of this circle the search radius we call as search radius or we can fix number of points which will be used as inputs to determine the value for this center point. So, it is you know for example when interpolation a surface of pollution we know that the more the distance location will have less influence of pollution.

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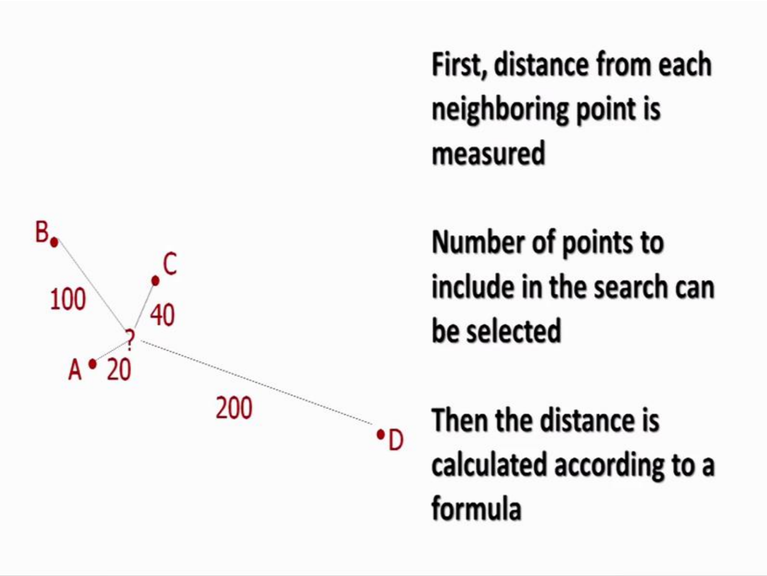

A same here the example is shown that it at our point for where the question mark is shown here it will have the maximum influence of point A and comparatively it will have less influence point C, but point D will have the least influence. So, depending on the distance it is inverse relation, so further the distance least the influence it will have.

So, first distance from each neighboring point is measured and then number of points to include in the search can be selected. If then we go for interpolation which I will show certain through the options which are available in a one particular software there we can restrict either using a search radius or number of points. So, this is the number of points to include in the each cell can be selected and then distance is calculated according to the formula.

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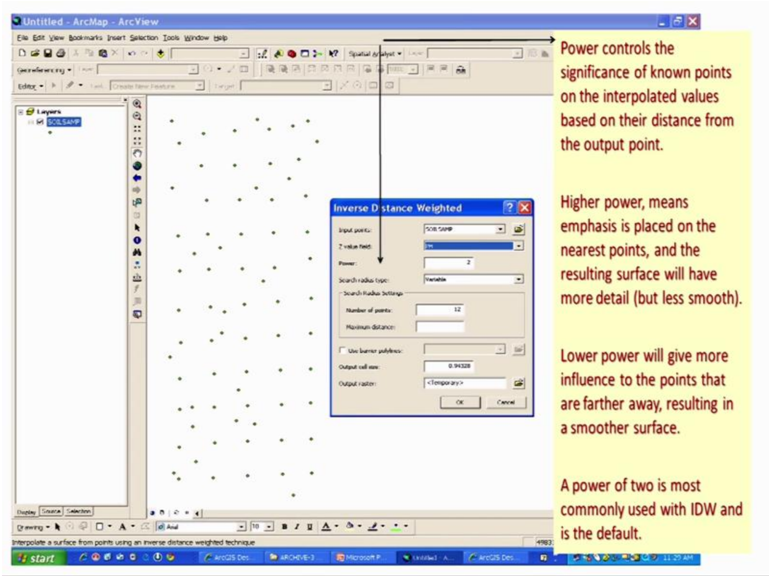

And example is here like in RGIS software when I go for interpolation here you can see that the point locations are there and the value which I am going to use to do the interpolation is the ph value the input map is file and a these details we will see little later. The search radius is chosen is very well, whereas number of points we have fixed is 12. So, if you I he fixed it here then you need not to do anything here and then what you can decide at this stage what is going to be the spatial resolution of your output grade. So, that also you can decide and where you want to store and once you choose say you choose these things go for interpolation then the surface will be created.

Now, let see that what the meaning of power here is. That power controls the significance of known points on the interpolated values based on their distance from the output. That means, the high power; higher power means emphases is placed on the nearest point and the resulting surface will have more details, but less smoothing. So, depending on your requirements sometimes when we do not know the best thing is to look for some help first understand and then create surface, rather than just choosing the default value and created a surface and then you do not know what kind of accuracy it is carrying. And the same is just reverse of high power, low power value if you give then more influence on the points that are farther away resulting in a smoother surface.

So, it depending on what phenomena here it is ph we can assume that it is power two will have a quite good influence and we are not looking for a very smooth surface and then we can go for interpolation. So, the power two is most commonly used with IDW and that is why it is kept in default. Similarly, the search radius as I have already mentioned that you can fix the size of the search radius or you can keep as variable and then fix the number of points and then interpolation is done.

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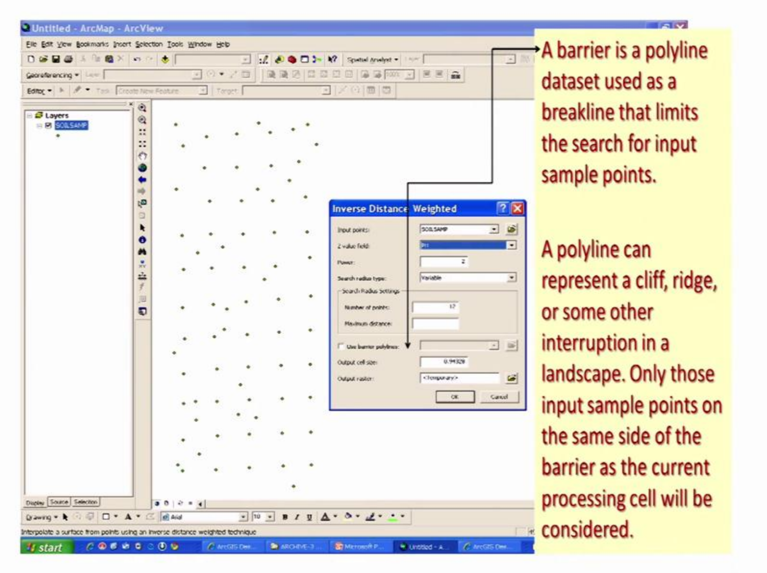

And similarly the barriers this is the point which I wanted to bring here use the barrier and poly line. So, whenever you go for use the barriers that means, you are not going for smooth interpolators you are going for abrupt interpolator, because your requirements, because the terrain or phenomena on which you are working is having those issues. So, this barrier information has to come in form of a poly line. A line theme has to be added then you can go choose this option and then a near real surface will be created though it might be abrupt. So, as we can see that poly line is a basically is a barrier maybe fault line maybe quasar, if maybe a dice and so on so forth and in sometimes in surface water flow we can use river as a barrier as well. So, polyline data sets used to break line that limits the search for the input sample points and polyline can represent a cliff ridge or some other interruptions in a landscape. Only those input sample points on the same side of the barrier as the current processing will be considered.

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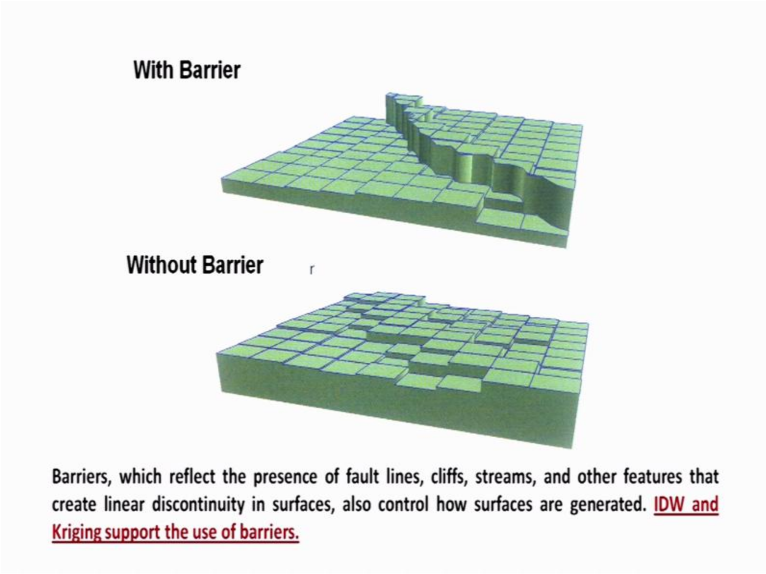

See the surface has been created which is shown here as in a 3 d without barriers it is quite a smooth, but when I will use the barrier as giving as one of the additional input as a poly line then a abrupt surface is created. This it depending on the phenomena if we are having information we must bring that information during interpolation, so you create the surface which is more close to the reality.

So, a barrier which reflects the presence of fault lines cliff streams and other features that creates linear discontinuity in the surfaces and also controls how surfaces are generated, not for all interpolation techniques various are supported only in case of IDW and crane supports the barriers. This is about the search radius. You can have either maximum number of points, so once a if you have decided 12 number of points then it will search only 12 number points in the neighborhood all around and then use those points measure their distance and accordingly the influence and then value is determined. Whereas, in the case of fixed radius whatever the number points which will fall as per the size of the radius it will use those points again measure the distances and calculate the value. So, both options are available here numbers you when you fix the numbers it is fine.

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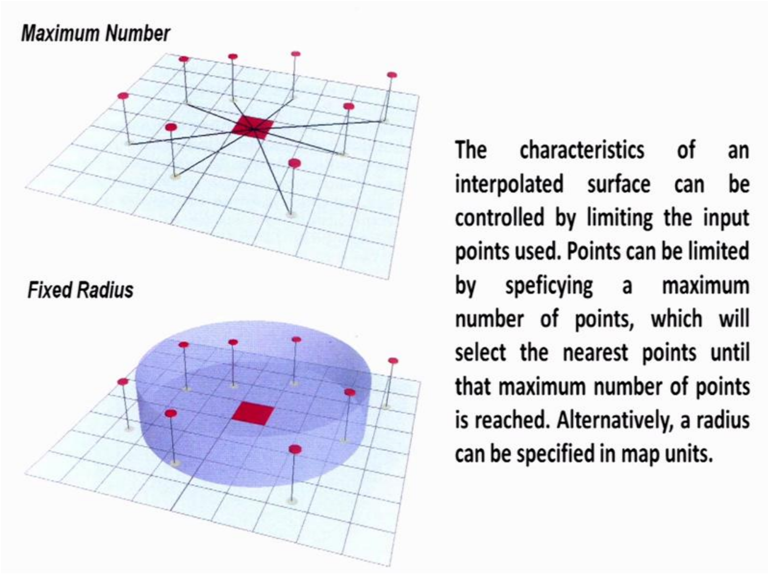

Now the problem might come at the edges with beyond which you do not have, so if am calculating a value for the boundary line areas there might be some problems. So, maybe interpolation extrapolation might be done in those cases. This I have already explained to you about maximum number or a number of fixing or either fixed radius and so on.

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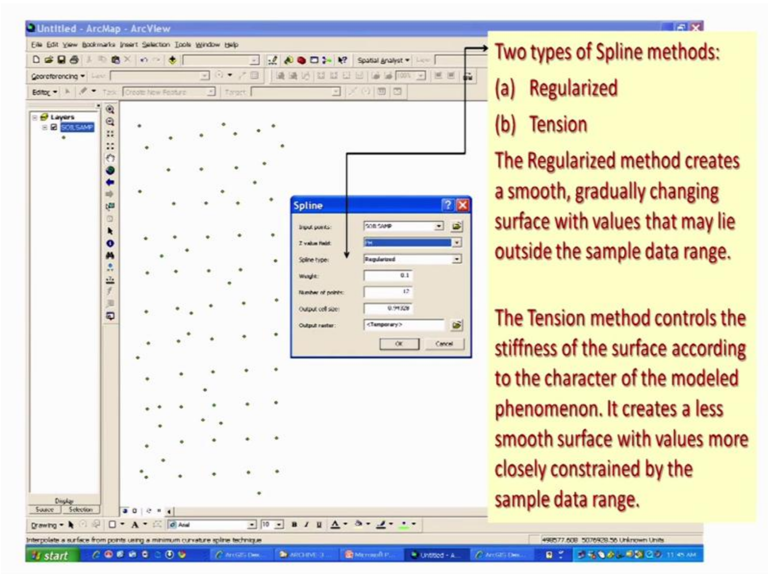

Now here this is another interpolation technique which is spline and in this technique we can have different variants of spline. Like in default you might be getting regularized or tension, when you go for regularized method it creates a smooth surface. Gradually changing surface with values that may might lie outside the sample data range. That means, whenever you go for any smooth interpolators you have to prepare mentally that the values are not going to be exact values, values may go beyond your observational ranges, because the surface you have asked is a smoother surface. When you use the different again instead of regular if you go for tension then tension controls the stiffness of the surface according to the character of the model phenomena. It creates less smooth surface as compared with regularized one with values more closely constrained and by the sample data range.

So, you will have value near real values, but not as a smooth surface had in case regularized. Now also the concept of spline theme of course from mathematics but it is called the french curves and lots of you know architect and other people used to have the curves for drawings and these were nothing for the smoothes the lines they were creating.

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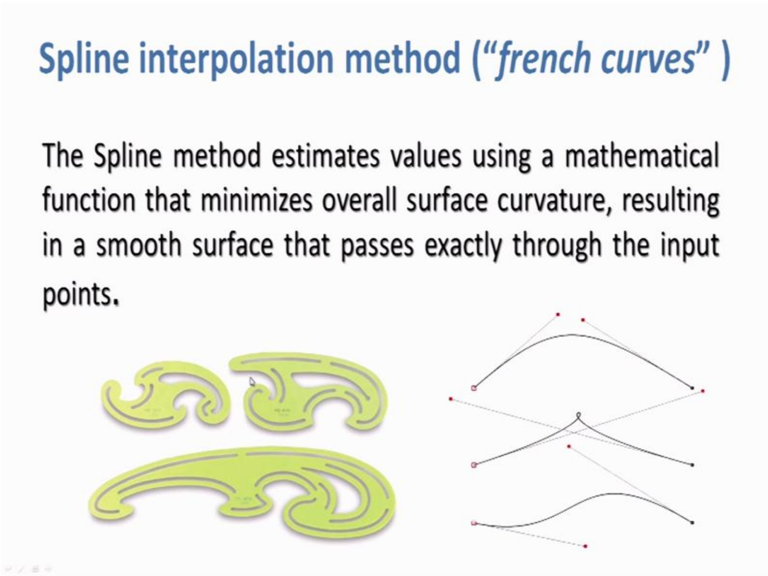

So, spline method estimates values using a mathematical function that minimizes overall surface curvature resulting in a smooth surface that passes exactly through the input points and these use to be these french curves of made form acrylics. And people wherever the observations are there they used to fit these french curves and then draw the lines.

Now, mathematical ways of doing in GIS are all available so we go for spline interpolator very easily. And there are different options are there which can be used in your GIS software. As I have said that there are variant of spline method two; major one is the linear spline interpolators and quadratic at spline and then third one is the cubic spline interpolators.

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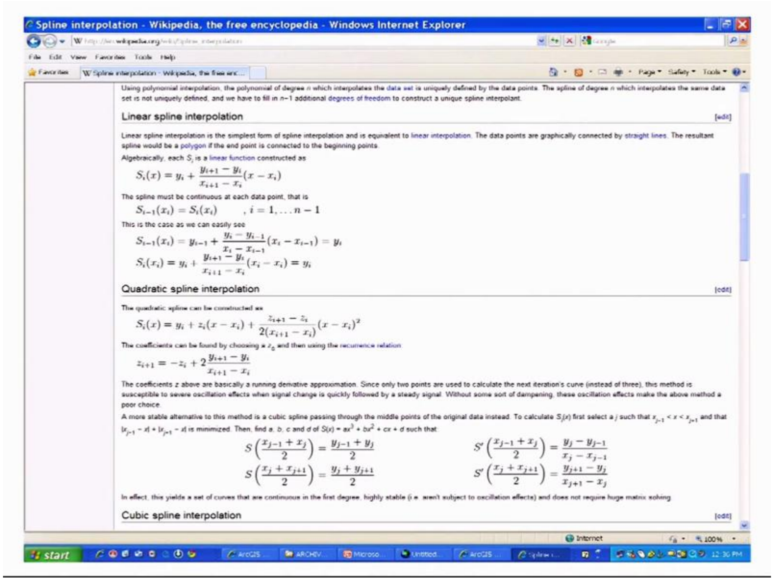

The mathematics behind is also given here. Why I am showing this particular slide the purpose here is whenever you go and start using GIS using particular software in the beginning of this series of these lectures I have said that one should resort to the help. And sometimes online or offline helps of the software are very very helpful.

So, whenever you suppose you are going for a interpolations some options are being displayed you do not understand what is the meaning of this option, then before go and create a surface check for the help and very detailed helps with extended GIS softwares are always available, maybe online or offline. And online is better because it is updated all the time, so, if you are having access to net you can go for online help and read before you choose the option for interpolation creating a surface. And that is why you know which one to choose whether in default it might be linear spline is coming.

Now a question, when you go and scroll down you would find that a two more methods are there. Which are those two methods, what are the variations, what the mathematics behind that these, that you can check very well through online resources.

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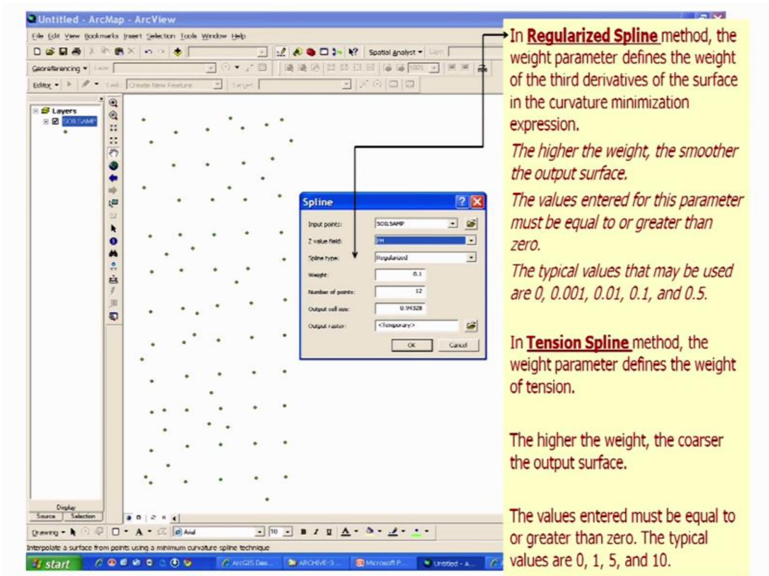

Now, spline methods again here are regularized, and then have the tension one and those other options are already there. So, you can have the weight and other things number of points maybe in the default you may get 12 you can choose as per the smoothness you want in your data. There is no basically fixed number of guidelines here, but generally the default values are kept which are commonly used values.

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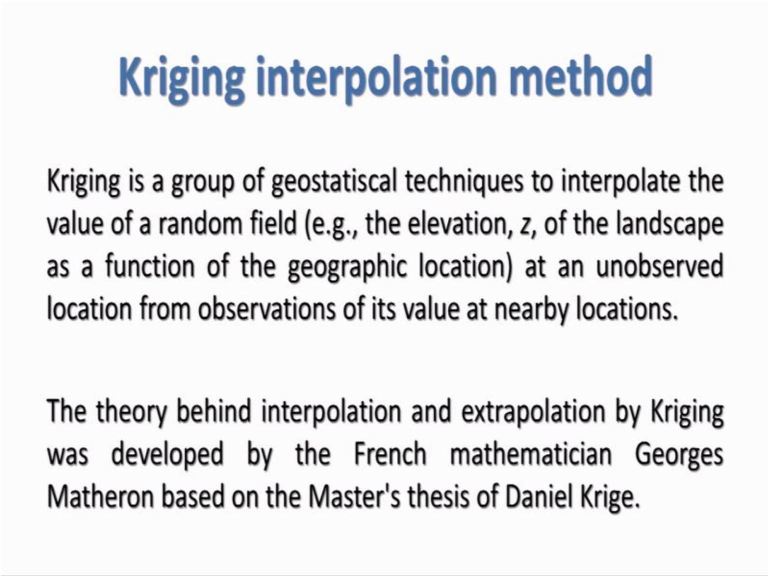

Now the last type of these interpolation techniques which is very very popular and has been implemented into standard GIS softwares is Kriging method. A Kriging is group of geostastical techniques to interpolate the values of the random field may be elevation z value of the landscape as a function of geographic location. At an unobserved location from observations of it are values by nearby locations.

The theory behind this Kriging interpolation that interpolation and extrapolation by Kriging was developed by a French mathematician whose name was Georges Martheron on based on the Master's thesis of Daniel Krige, and so they his named was carried and then Kriging method was developed.

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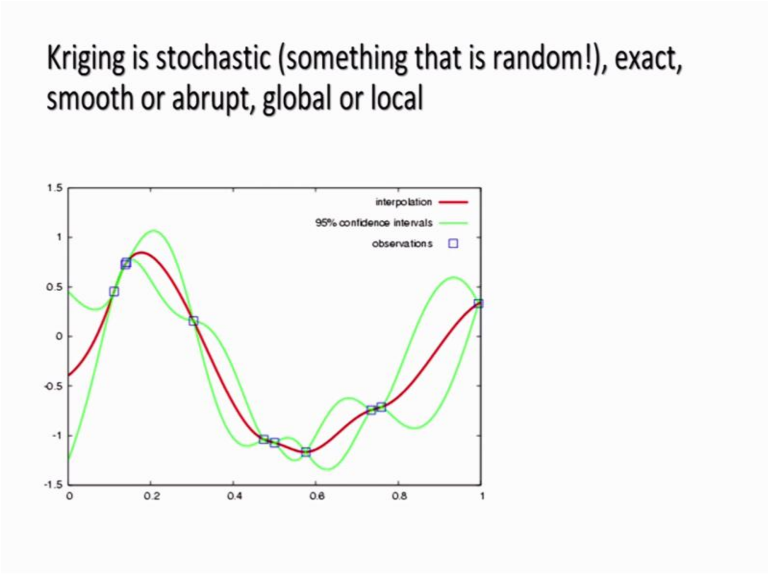

Kriging stochastic something that is random exact smooth or abrupt global or local. As you can see here in a tool two degree or in a linear fascinate as been shown that these blue boxes are showing the observations and these interpolated surface through Kriging is a is shown in the red line and this is 95 percent confidence intervals on the both sides of your interpolated surface.

So, the advantage with Kriging method that you can also estimate errors after the interpolation you get the estimation of errors where as with other methods that kind of estimation is not available. So, Kriging is found to be one of the best interpolation techniques, but again it depends on the phenomena and local or local conditions terrain conditions. A natural data’s are difficult to model using the smooth function because normally random fluctuations and measurement error combine to cause irregularities in the sample data values. What does it mean basically? That the natural data like elevation points for a Himalaya is different than indogangtic plane and therefore one has to be care full while choosing interpolation technique.

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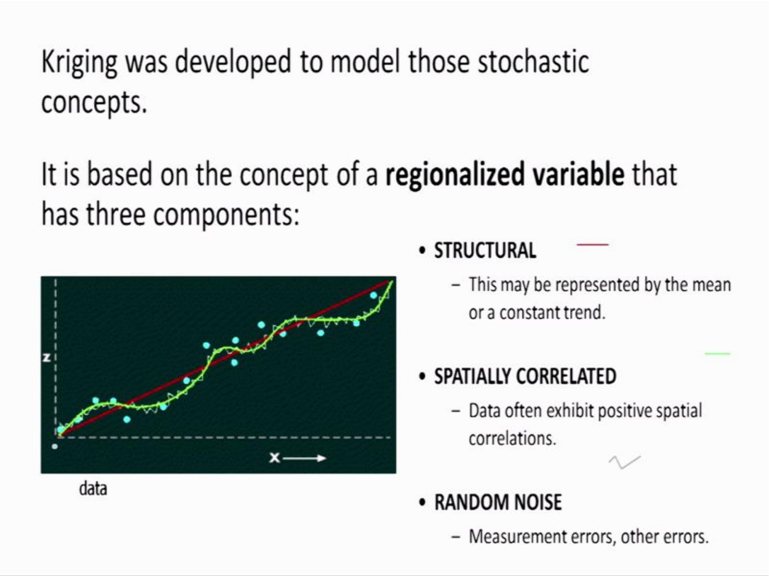

Kriging was developed to model those stochastic concepts it is based on the concept of a regionalized variable that has three components; one is your data and then it is having structural, spatially, correlated and random noise. As I have said the errors measurements are possible or error estimations are available with a crane. We see in this xy plot what do we find that these blue dots are the showing the observations and then you are having a best fit line here which is shown in red, then you are getting a green line which is connecting trying to connect all these points and these Kriging along the green lines are showing your random noise or errors.

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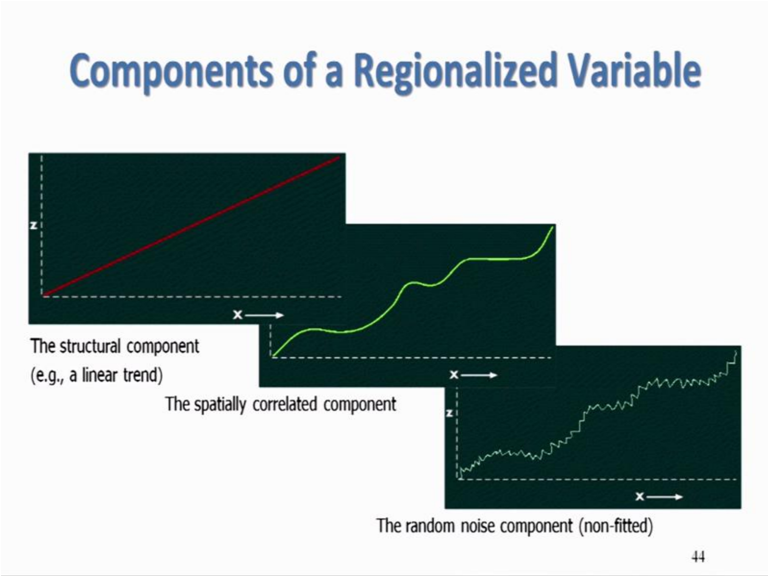

So, error estimations are also possible using Kriging. Now there are regionlized variable that is components of a Kriging, we can in the previous view graph it can be segmented. So, we can see that this is structural component which is the straight line fit and then we can have a spatially correlated component which is going through all your input data which is varying with the distance. And the third one is the random noise component which is non fitted data. So, this extra information which comes with the Kriging is not available with other interpolation techniques.

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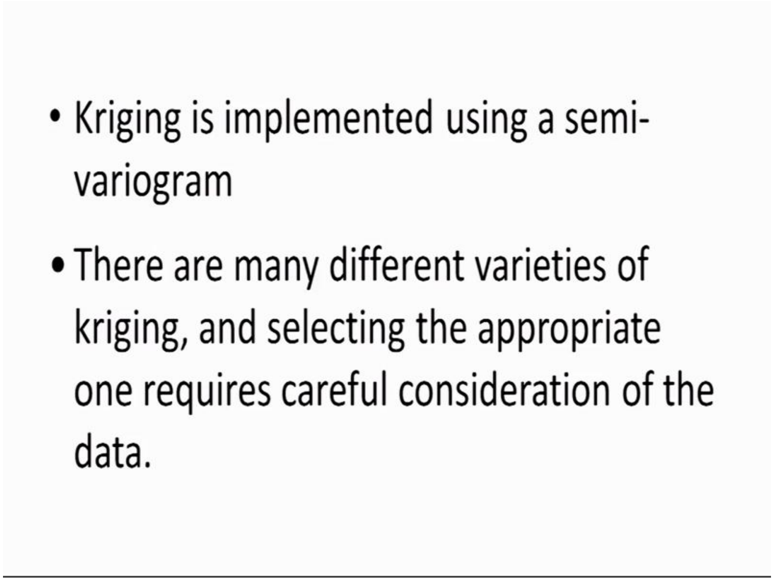

Kriging is implemented using a semi-variogram and there are many different varieties or variants of Kriging are also available and again this becomes sometimes difficult which one to choose. So, in your software various option might be available one has to be very careful before you go and press button, the options which are available are you going are you selecting the right one or not because it ultimately the computer will create a surface, but that surface has to be more realistic near to reality than just simply a surface. And therefore, understanding option variants of different Kriging techniques is very much required.

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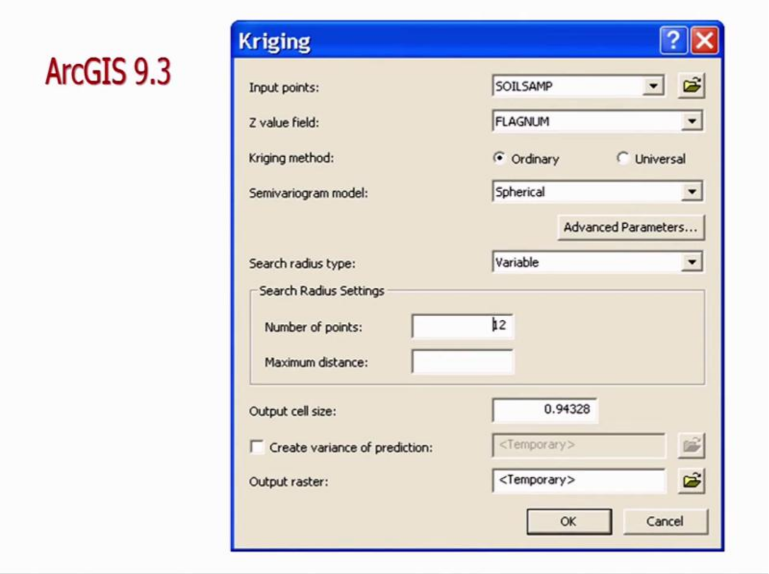

In a in a softwares like ArcGIS these are the options which are available same example which I was showing here, z value you can have here a ph value or some other value then you can choose the method either ordinary Kriging or universal Kriging, semi-variogram model you can choose various models and then search radius you can have variable or a number of points are fixed and always you can control the resolution of your grid which you are going to create. And if you are having some variance of predictions already available that to you can use here and can create that one.

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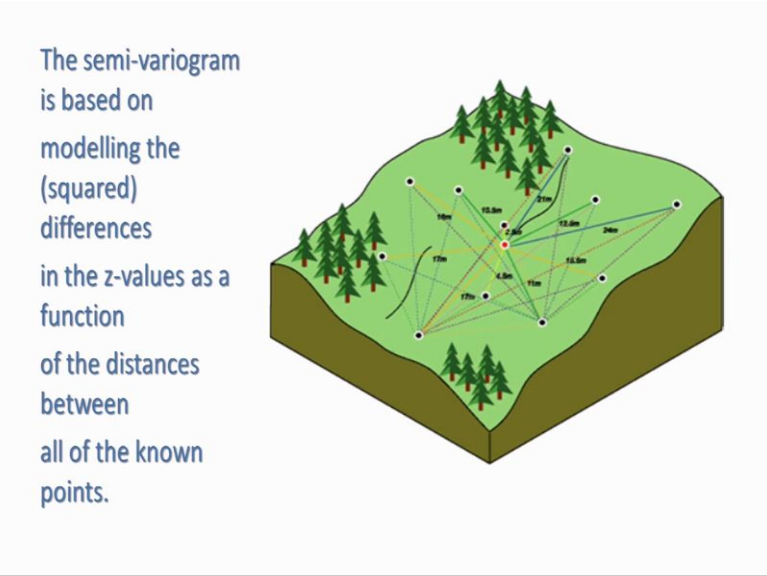

Here is the example that the semi-variogram is based on modeling the squared differences in the z values as a function of the distance between all of the known points which is shown here as well.

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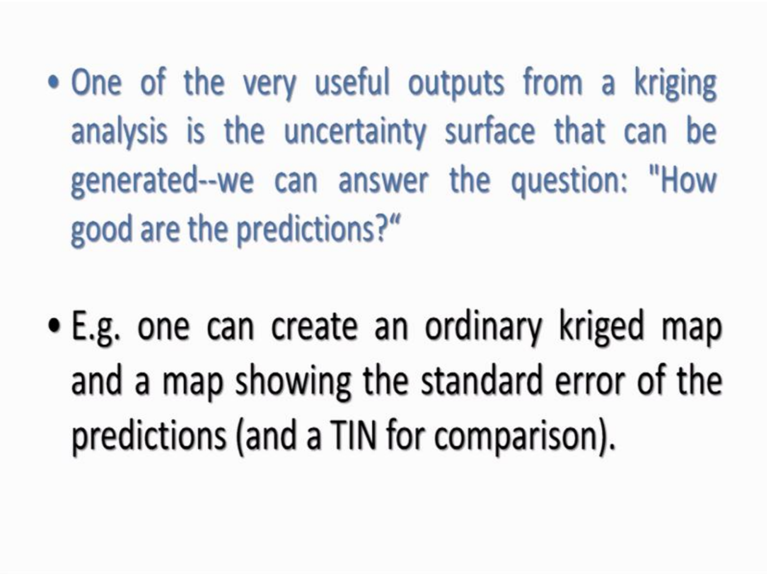

One of the very useful outputs from a Kriging analysis is a uncertainty surface that can be generated. We can answer the questions how good are the predictions. That means, basically error estimations which are not possible with other interpolation techniques. One can create an ordinary kriged map and a map showing the standard error of prediction, and then we can compare with the models like TIN and others one.

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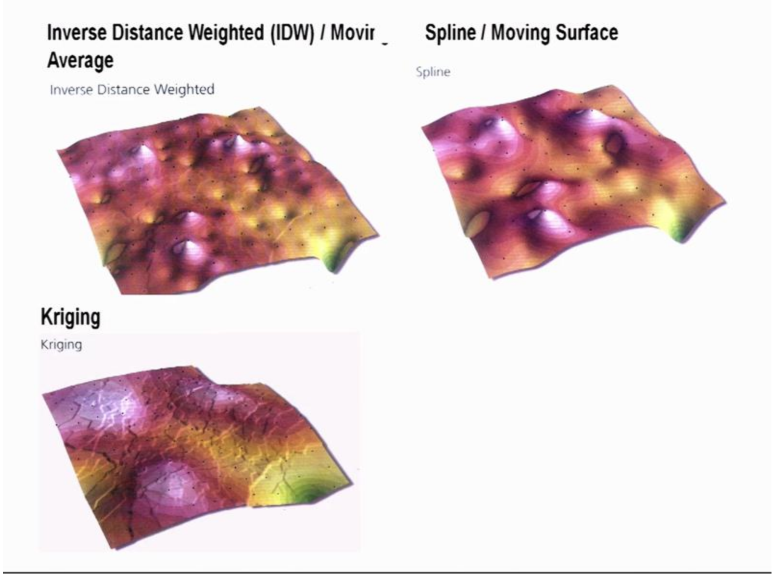

Some examples are here using the same input creating the different surfaces using different interpolation techniques; first example is IDW, then spline and Kriging. See the input data is same and many options are kept same, but is still the output surfaces are very very different here.

And same if we go for a 2 d representation or trying to understand then this IDW is coming as a green surface your spline is coming as a blue your observations are shown as blue dots and then krige surface is that a blue one it is coming here.

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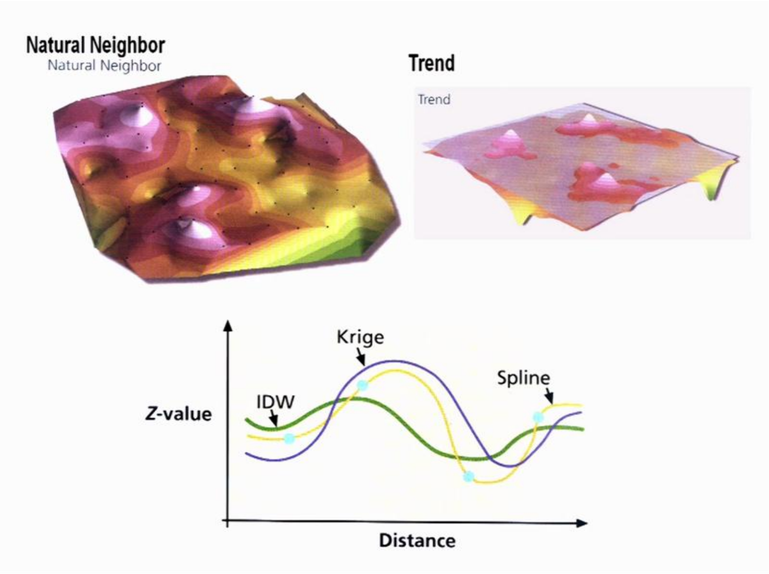

So, all different interpolation techniques are going to create different surfaces as you can see. Now problems with interpolations because whenever you interpolate from point data to a surface a question can be asked how accurate this representation is. So, this accuracy so will always come. And here it becomes very difficult to answer except if you have done Kriging then you can provide that kind of values, but if you have used some other interpolators probably you do not have the exact answer.

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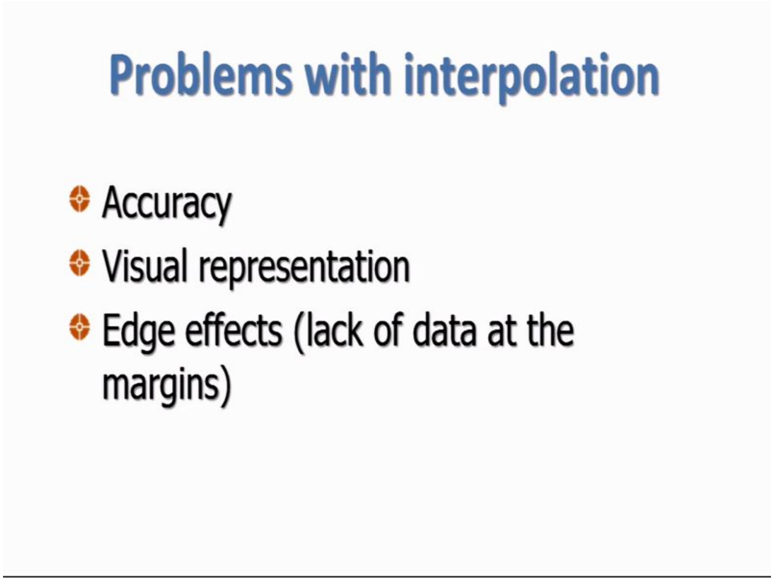

So, accuracy so will always be there. There are certain ways of choosing appropriate one and avoiding large errors in your interpolations and this question of accuracy may be handled quite easily. Now, visual representation is very much there. So which surface it looks more close to the real one that is also has to be seen. And edge effects or lack of data at the margins.

Like in this example also that here the data where you know area of interest is available fine, but when we go beyond this one then we do not have the data. Along the margins along the borders this will remain there in case of interpolation, because then extrapolation is done and extrapolation may not be as accurate as interpolation. So, these issues are always associated with this interpolation.

Thank you very much.