Remote Sensing and GIS
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Lecture – 22
Geographic Information System – II

Before I start my today's lecture, let us quickly go through what I have covered in my previous lecture. So I started my lectures with the definition of GIS. So, I hope you remember that topics which I have covered to you in the previous lecture. So, I am just going to highlight a few of the very important aspect of that. So, here GIS allows to integrate many data in a single map which enables to visualize question, analyze and interpret data to understand relationships patterns and trends more efficiently.

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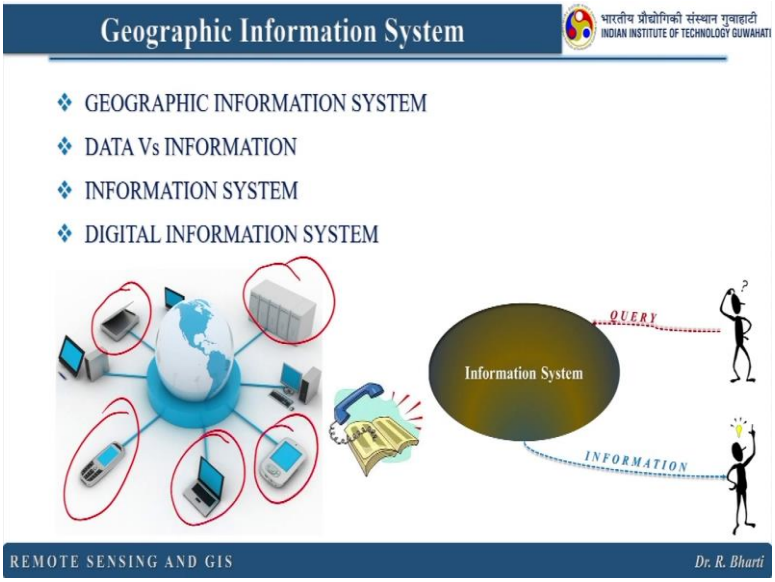

So, this is the beauty of GIS, where you can integrate many or n number of data sets together and you can run a query that will give you some answers, which are hidden in those data sets, right. So, we started with data and then what is the difference between data and information then information system then digital information system, I hope you remember these figures so here basically, this is very good information of a information system where you can easily find out the information hidden in this telephone directory by just identifying the first letter of that word, right. And this is how we are going to access are we are going to get our answers

by sending a query to this information system and this information system will provide you an answer right. And this is one example of digital information system.

Where you can find the answers available to you through different modes or different places right. So, here you are not going to manage this, you are not managing this you are not managing this you are not managing this. So, data has been captured and analyzed by others, but that is available to you through an information system. So, all these data sets are available to you in digital format. So, that is how this digital system or digital information system is in the picture.

Now, the next component which I have highlighted in my previous lecture was geographical information system components. So, what are the different components we actually see in a GIS. So, first one is computer hardware, second is software.

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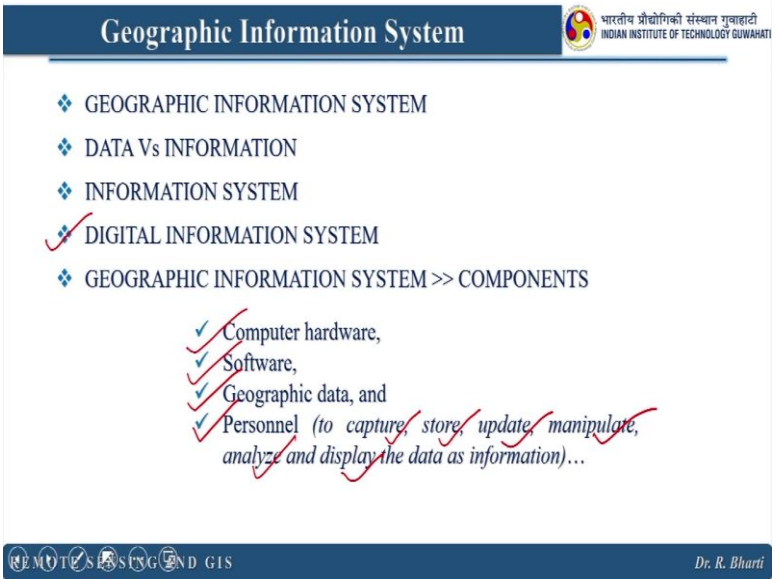

Third is geographic data or the spatial data and the last one, but the most important part is to a person who captures stores ,update, manipulate, analyze, display these data set as a information. So, it is very important to note that, that here, all these capture, store and update. Basically this requires a group of peoples not only one people.

So depending upon the size of the data or the quality of the data or what kind of data you are going to access. There are many individuals or many organization or many groups are involved in this one. So that is how this geographical information system components are very important. So, none of them are insignificant all of them are significant and they are

playing a critical role in this GIS. Data type, that also I have covered in my previous lecture. So, there are two different major types of data set. First one is raster second one is vector. So, what are the difference raster is basically your images right images where you have grids, pixels or elements whereas in vector,

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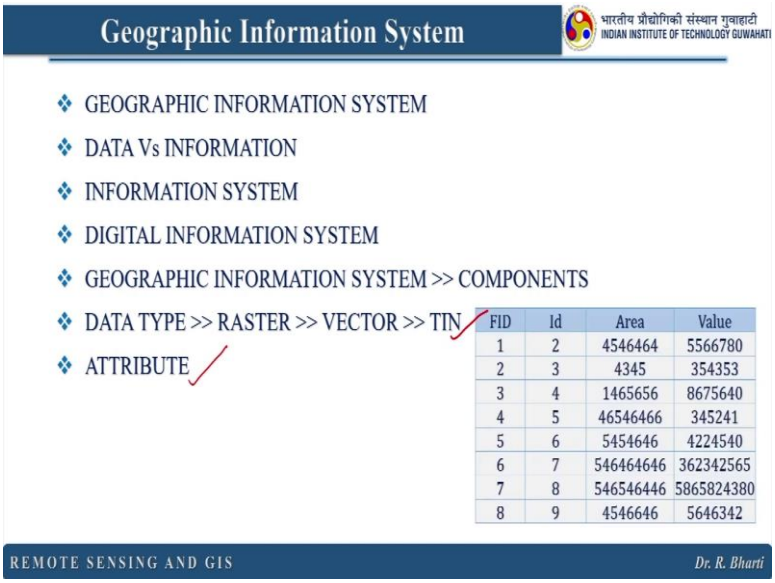

you have point line and polygon and there is a third type of data which is known as TIN triangulated irregular network. So, in this one, this is basically considered as a different category this TIN is considered as a different category where we do not consider this TIN into either of raster or vector. So, this is third category of the data type. Now, this TIN is very important in generating the digital elevation model or maybe the parameters which you have collected and you want to interpolate. So this triangulated irregular network is very nice and the next topic which I have covered was attribute so all these data set raster, vector or TIN, they can have attribute table attached with the main file attribute table may look like this. Where do you have many other parameters apart from FID and ID, right. So here, you can use this table to interpolate or to extract the information what you want. Now, the next component was Topology

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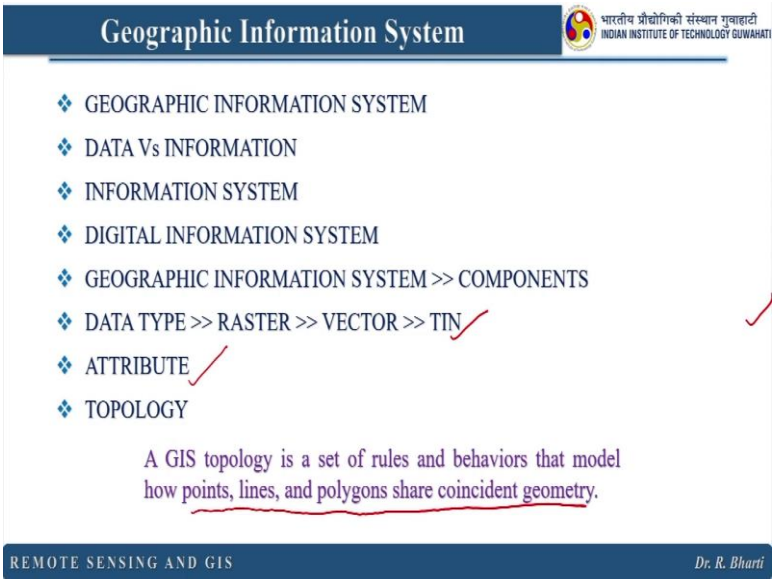

because when you dealing with vector data topology plays a very critical role, because it defines the rule or behaviour, how these point line and polygons are connected with each other or how they say the geometry with each other and what is the position and location of each individual line point or polygon, whether they are inside or whether they are sharing the boundary or whether they are just overlapping each other. So, those information can be stored when we have this topology right. Our typical GIS structure was also discussed in previous lecture, where I have shown you a flow chart.

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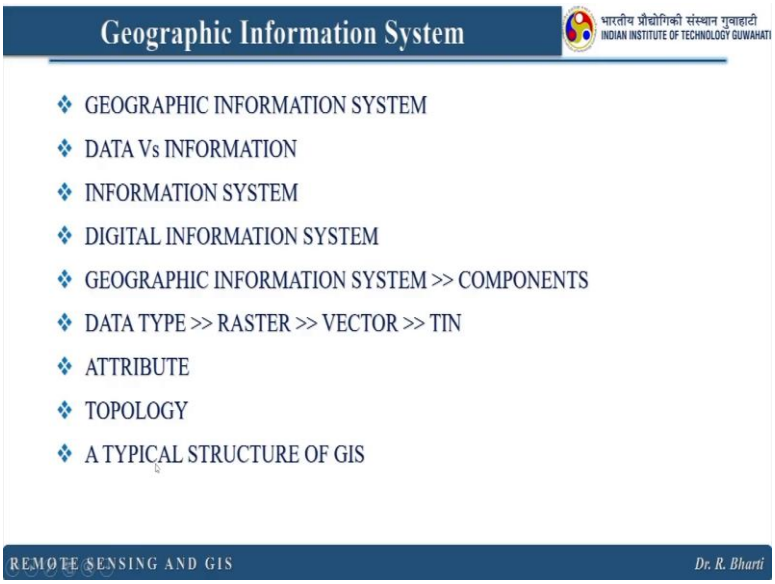

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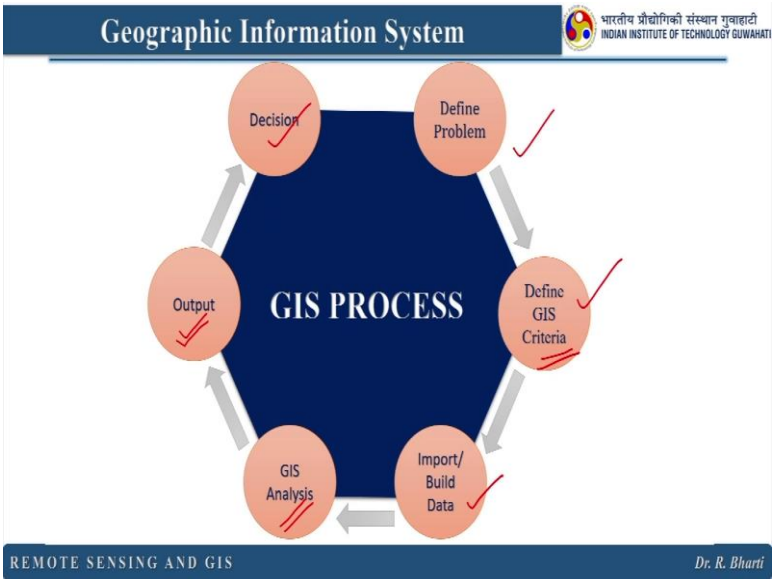

Like this in GIS basically we start this flow by defining the problem. So, first step will be define your problem, then defined GIS criteria which can help you to achieve this particular objective right and then third will be import or build data and that will be from different sources GIS analysis because you have already defined the criteria. So, here you will perform the analysis and at this stage you will receive your output or the result then you have to analyze them and you have to make a decision if it is for early warning system or any such application. So, this was the flow which we have discussed in my previous lecture. I hope this is very clear and you can use this flow to define your problem. And then you can work with GIS and remote sensing.

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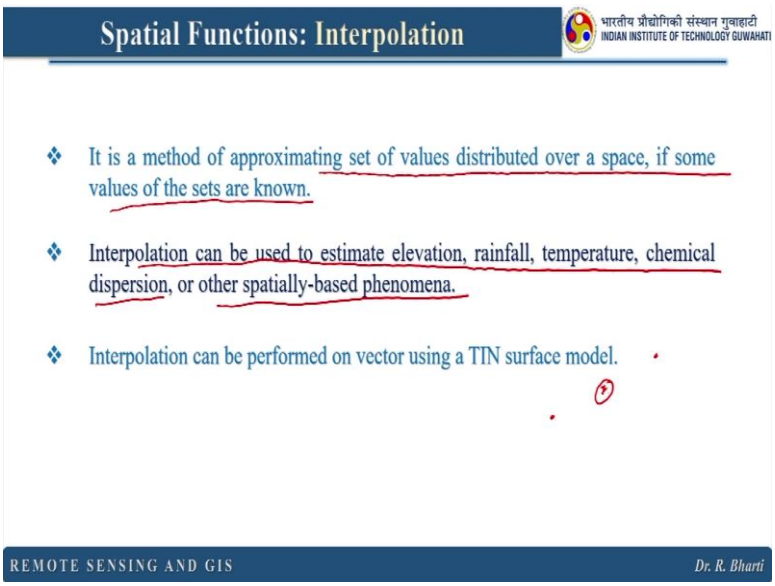

After that I started explaining you the different spatial functions which is or which can be done in GIS environment, so, to continue with that topic, let us start with the interpolation.

So, interpolation is a method of approximating set of values distributed over a space if some values of this set are known interpolation can be used to estimate elevation rainfall temperature chemical said dispersion or other spatially based phenomena.

So, basically here you have two values and you want to derive this particular point value or what will be the value at this particular location. So, this is known as interpolation, interpolation can be performed on vector using a TIN surface model. I hope you remember the TIN triangulated irregular network. So, here basically this is in simple words what exactly we do in interpolation.

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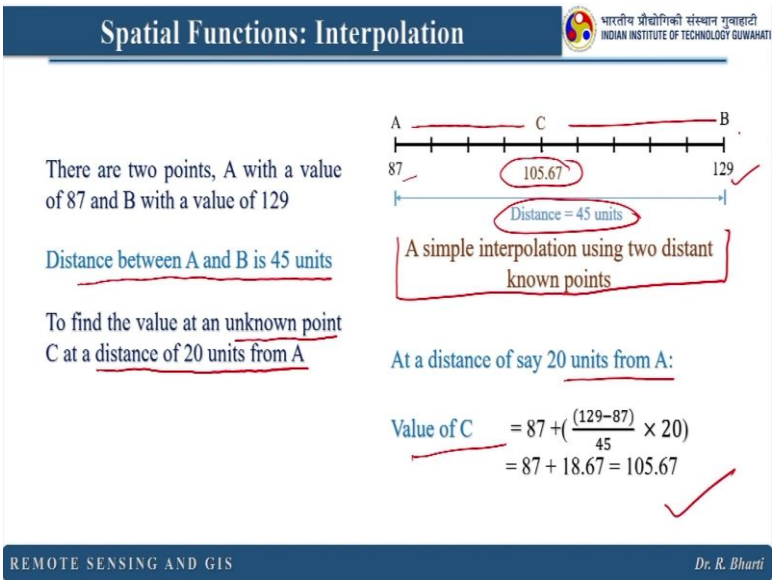

So, here you have A and B and the value of A is 87 and value of B is 129. And I want to calculate the value of C and with this is unknown, this is after calculation. So, how do we exactly know that this is the value of point C and which C may not be at the center of this A and B. So, what we will do? First we need to divide it into different units. So, here distance between A and B is 45 units, this you have to calculate.

Then, to find the value at an unknown point C at a distance of 20 unit from A. So, this is basically 20 and here you have 25 that means, the distance is 45 between A and B at a distance of say 20 unit from A value of C can be calculated like this. So, this is very easy when you are having only two points and you want to calculate. So, you just have to estimate the distance and divide the values into different segments and then you can easily find out what will be the value of C. So, this such operation can be easily done with GIS where we have location attached. Now, here this is another example.

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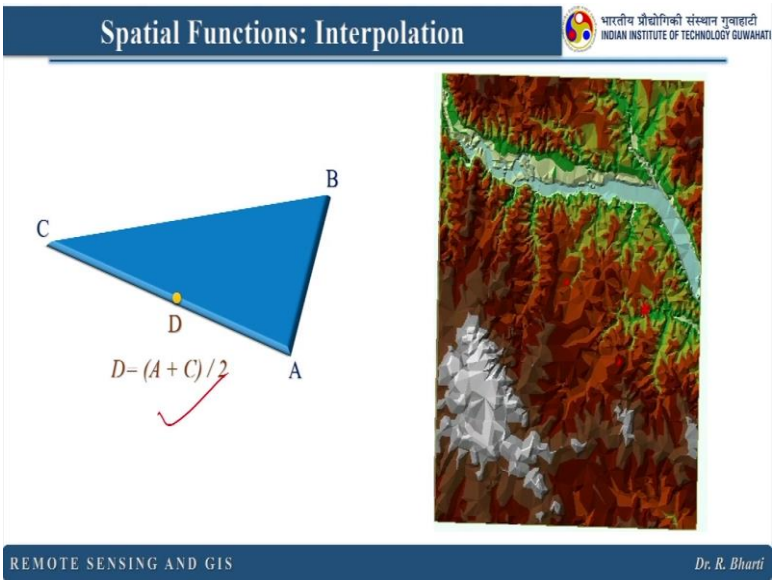

So, this is the image so, let us say you have one value here, one value here and one value here and you want to calculate for this particular location. So, how you will do that similarly, like we have done in the previous slide, so, you have this triangle. So, ABC and A and C is having a point D which is at midpoint.

So, here it will be very easy. So, D is equal to A plus C divided by 2. So, just half of the A and C, right these are very basic operation of interpolation. Now, let us see what else we can do in interpolation.

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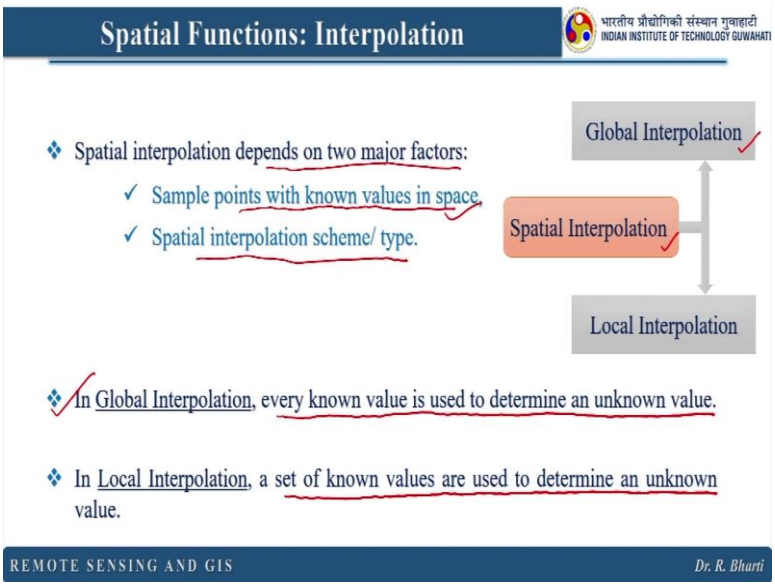

So, spatial interpolation depends on two major factors. So, first one is you need to have known points without that you cannot do or you cannot perform interpolation. So, sample

points with known values in space spatial interpolation scheme or type. So, what scheme or type you are going to follow while performing this spatial interpolation.

So, here you have a spatial interpolation and it can be done by global interpolation or local interpolation. So, in local or global interpolation, what exactly we do, Let us see here. So, in global interpolation, every known value is used to determine an unknown value. Whereas local interpolation a set of known values are used to determine an unknown value. So, this is the basic difference between global and local interpolation

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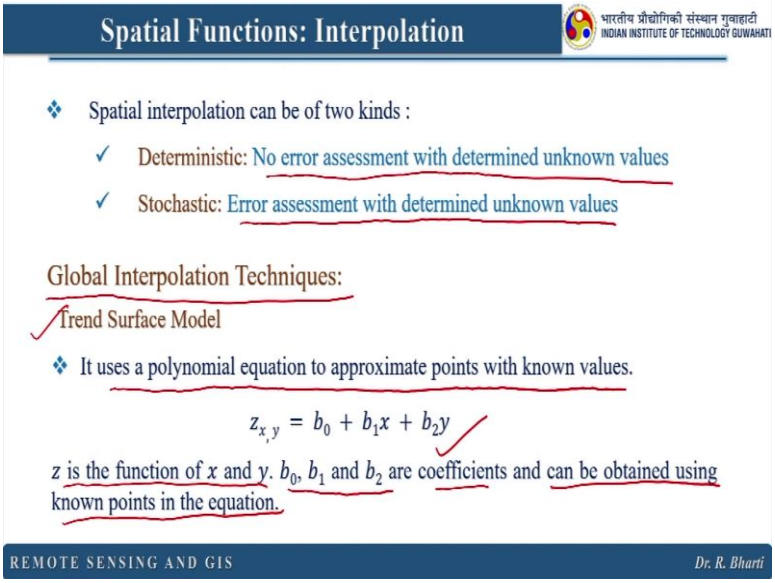

Spatial interpolation can be of two different types. So, first one is deterministic and second one is stochastic. So, in deterministic basically no error assessment with determined unknown values whereas, in stochastics error assessment with determined unknown values. So, this is the basic difference between the stochastic and deterministic and accordingly you have to choose which method you want to perform or apply for this spatial interpolation.

Now, the next one is global interpolation technique, as I told you, we have two different techniques either you have to perform global or local interpolation technique. So, let us start with the global interpolation technique. So, here we have the first one which is known as trend surface model, it uses a polynomial equation to approximate points with known values.

Where you can use this polynomial equation and you can easily find out what will be the value of unknown point right. So, here the z is a function of x and y b0, b1, b2 are

coefficients and can be obtained using known points in the equation. So, I hope you have understood this part because this is the basic or fundamental polynomial equation you can use here you can increase the level of polynomial equation here or the degree of polynomial equation here. So that you can achieve more accuracy.

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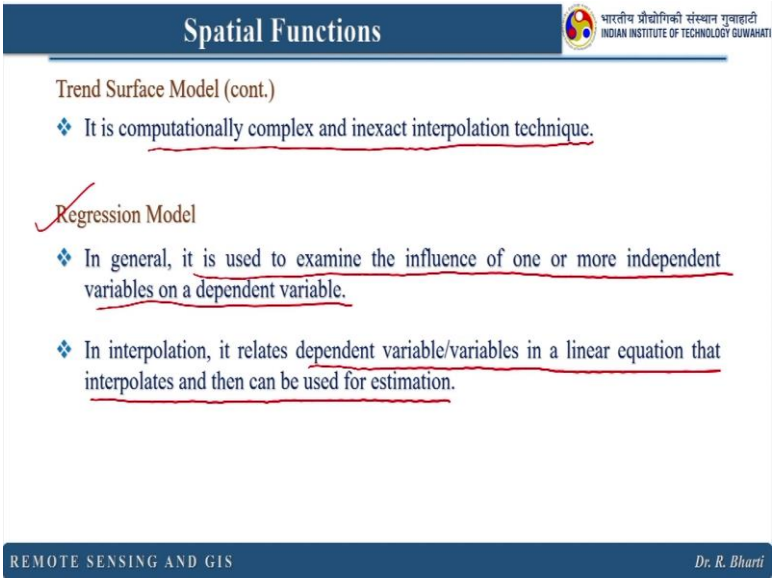

Trend surface models are computationally complex and inexact interpolation technique. So, this is the continuation of this trend surface model. Now, let us see what other method we can apply in the global mode. So, here we have a regression model. So, regression I hope you are familiar with regression. So, because in maths we generally use this regression polynomial equations right. So, in general it is used to examine the influence of one or more independent variable on dependent variable. And in interpolation it relates dependent variable in a linear equation that interpolates and then can be used for estimation **s**o, that is the advantage when you are having this regression model as your interpolation technique.

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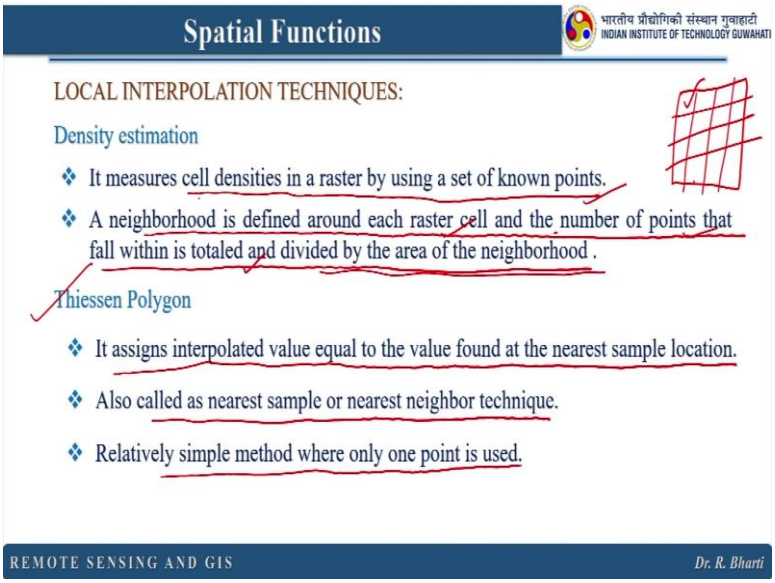

Now, for the local interpolation technique, we have density estimation. So, it measures cell density in a raster by using a set of known points and neighbourhood is defined around each raster cell and the number of points that fall within his total and divided by the area of neighbourhood. So, again here you have to correlate with your satellite data where you had pixels. So, what it says is cell density in a raster by using a set of non-points.

So, the cell density means what is the value which you are looking for that density you have to estimate by using the known location or the known values. A neighbourhood is defined around each raster cell and the number of points that fall within is totalled and divided by the area of the neighbourhood.

So, this is how you have to apply this density estimation. Now the next method is Thiessen polygon. So, Thiessen polygon is one of the popular method in interpolation, but it is little bit complex than others. So, let us see how exactly you can perform this. So, it assigns interpolated values equal to the value found at the nearest sample location right also called as nearest sample or nearest neighbour technique.

Because it is going to take the immediate neighbour value. So, it is more accurate relatively simple method where only one point is used right now, let us see how exactly we performed this one

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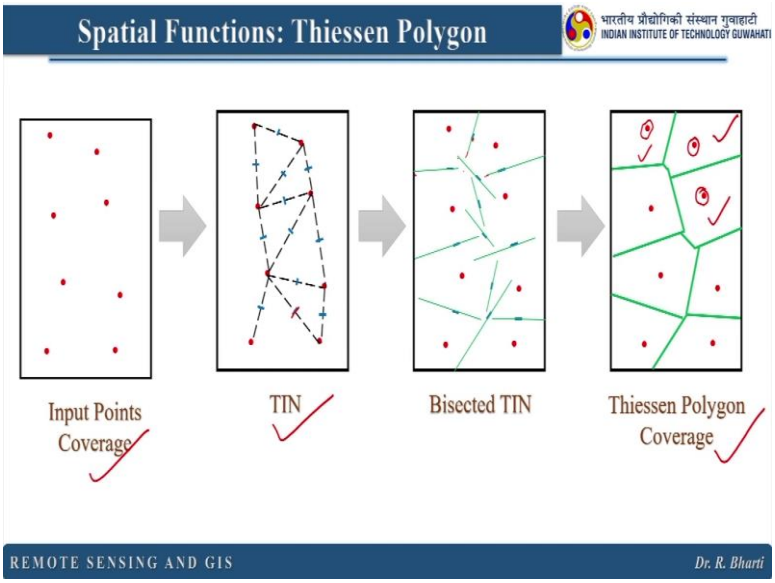

So, you have some set of points, so input point covers. So all these points' values are known. Now what we will do, we will connect all the nearest elements and we will make the triangle. So, that will give you TIN triangulated irregular network and then we will identify the midpoint here and we will draw a perpendicular.

So, that will be bisected TIN and you can see here for all the points, we had this sides and where we have dissected and this bisected TIN is going to be these sides of your Thiessen polygon. Now, what do you have to do you have to extend them and you have to join them right. So, that will look like this. So, here you can see, this is the value for this Particular polygon, this is the value for this particular polygon this is the value for this particular polygon. So, it is expected that your output or your result will be more accurate than other values or other methods. Why, because it works on the nearest neighbours concept.

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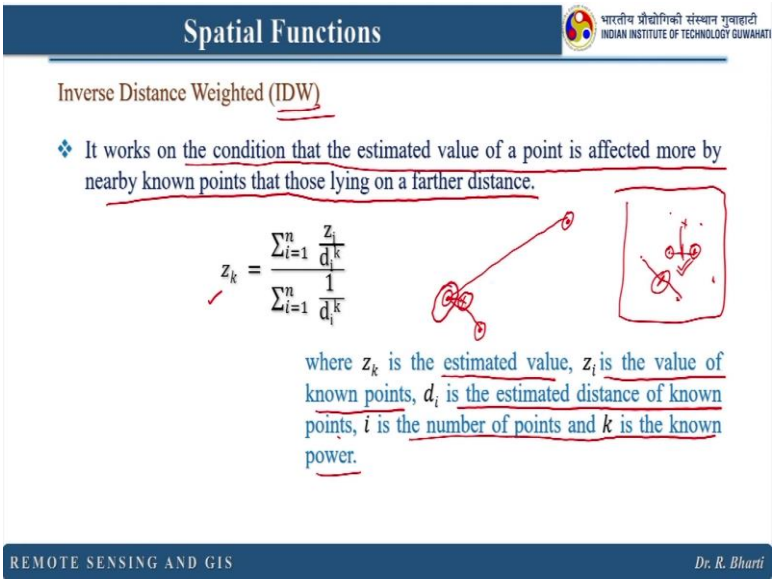

Now, the next is IDW inverse distance weightage method. Now, slowly it is gaining its popularity, because this is giving you more accurate data. It works on the condition that the estimated value of a point is affected more by nearby known points.

That those lying on the farther distance here you can use this particular equation to calculate this inverse distance weighted. So, where Zk is the estimated value. Zi is the value of known points Di is the estimated distance of known points and i is the number of points and k is the known power. So, basically, if you have four or five or let us say these points you have, which you want to interpolate by using this inverse distance weighted method.

Then, if I consider this and this particular point these two points and if I take the average or if I take the this divided and if I estimate the value of this particular location, this may give you good result, but what if these two points are connected and you are going to use these values to calculate the value for this particular location. So, it may be wrong or in another case, let us say this and this value are lying very far from each other.

And there is one more value here. So, if I say if I want to calculate the value of this particular point, then if I use this relationship or this relationship, which once would give more or better result. So, it is expected that the weightage of this particular points should be more on this particular location. Why, because it is near to this position right or near to that place. So, that is why we have started thinking towards this distance weightage.

So, as the distance is decreasing, the weightage will increase as the distance is increasing weightage will decrease.

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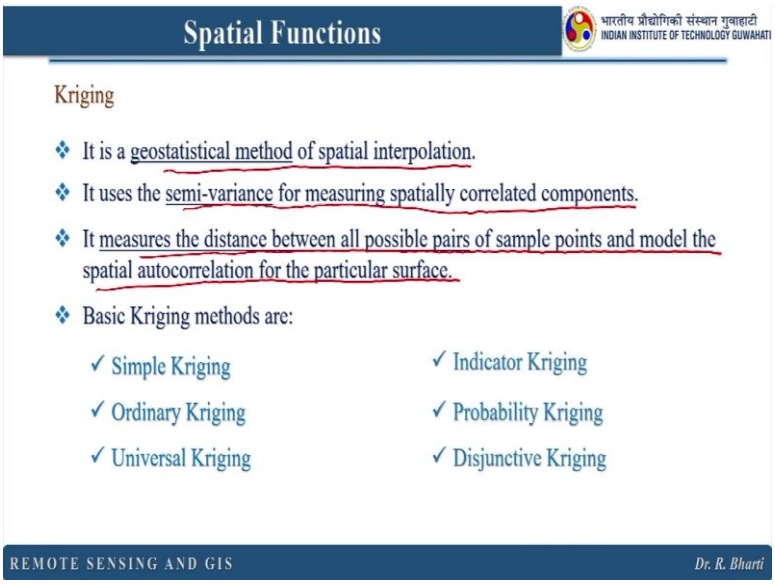

Now, the next method is kriging. It is a geostatistical method of spatial interpolation it uses a semi variance for measuring spatially correlated components, it measures the distance between all possible pairs of sample points and model the spatial auto correlation for the particular surface. Basic kriging methods are simple kriging, ordinary kriging universal kriging and so on. You can search for this.

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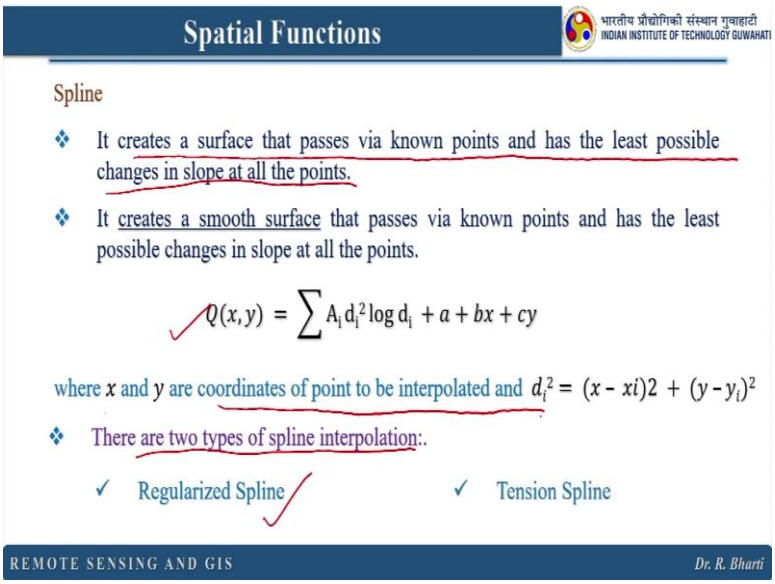

Now, we have next method which is known as spline so spline is one of the best method if you want to perform a smoothing effect on the spectra spectral measurement hope you remember from hyper spectral remote sensing section. So, this because when you acquire a spectra or when you take a spectra from library right so the acquired spectra may have this kind of behaviour. So, but this is because of some noise which has been introduced either by instrument or maybe different topography or illumination condition or atmosphere. So basically we want to remove this particular effect. So for that we need to have some method which works well on the smoothening of such a spectrum. So, for that we have a spline.

It creates a surface that passes via known points and has the least possible changes in slope at all the points. It creates a smooth surface that passes via known points and has the least possible changes in this slope at the point spline can be performed using this equation, where x and y are coordinates of point to be interpolated.

And Di Square is basically a square of x minus xi plus square of y minus yi . So, this can be used to perform or apply this spline or the smoothening on any given data. There are two different types of interpolation in spline. So, first one is a regularized and second one is tension spline,

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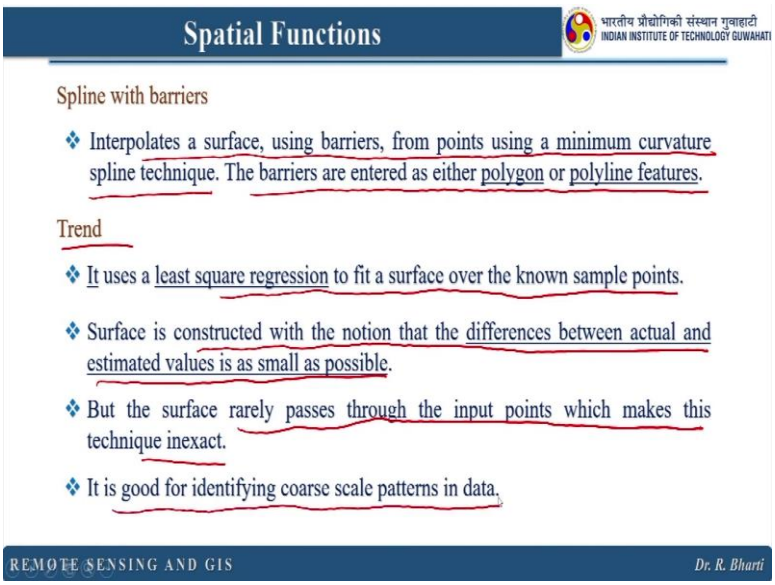

Here you have flexibility to apply this spline with barriers. Now, let us understand what is the concept of barrier in interpolation technique. Because, if you use either IDW or kriging or a spline everywhere you can apply or you can use this barrier. Why, Let us understand this.

So, let us see you have this point data, right and which is maybe x parameter now this x parameter you want to perform this interpolation and you want to generate a value for each and every pixel or location of this map right. So, for that what we will do we will run the spline or maybe IDW or maybe kriging, but if you see all the data sets are actually concentrated in this particular location.

So, if I do interpolation for this area, whether this will be correct No, because this will again get changed to extrapolation. So, instead of interpolation you will end up with extrapolation and extrapolation value or extrapolated values are not correct. So, here what we will do we will define this boundary that all the interpolation whatever method you are going to use it should run only within this particular boundary.

So that is why this is known as spline with barrier. So here it says interpolates a surface using barrier from points using a minimum curvature spline technique, this barrier are entered as either polygon or poly line feature that I have already explained to you. Now, the next one is trend. So, you might have heard about trend analysis this is just part of that. It uses a least squares regression to fit a surface over the known sample point surface is constructed with the notion that the difference between actual and estimated values is as small as possible. But the surface rarely passes through the input points which make this technique inexact. So that is why you have n number of techniques but you need to understand their advantages and disadvantages and what is the utility of that method in your application accordingly you have to decide your technique.

So, in case of trend, it is a good first identifying course scale pattern in data. So, in case if you want to perform the course resolution data analysis or where you want to perform the interpolation, then this trend method will give you good result.

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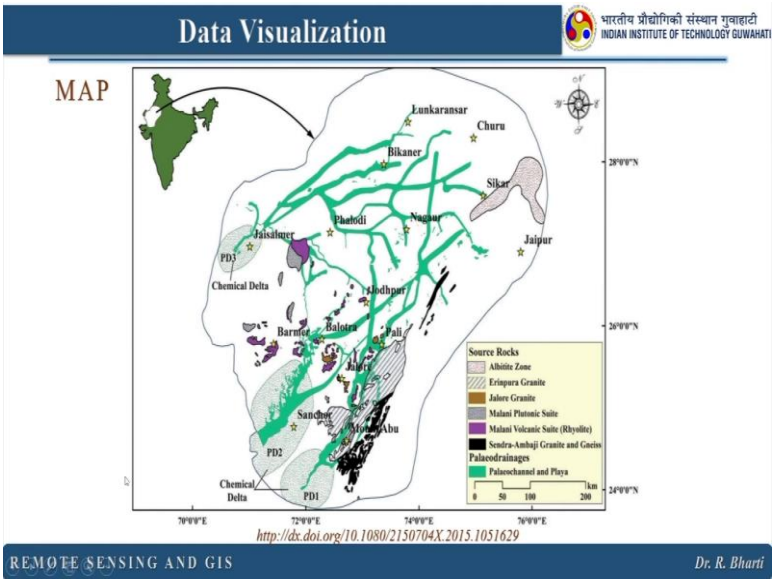

Now, coming back to GIS, so, in GLG is a very important objective is data visualization. So, how do you visualize your data or how do you prepare your result that makes your analysis more strong. So, here you can see this is one of the map prepared in GIS environment where you can see different layers are integrated together.

And you can see all the elements of a map. So here you have north and south arrow. This is your scale. These are the legends. And here, different colour and textures are used to highlight different components of this particular map. So let us understand more about these map in GIS.

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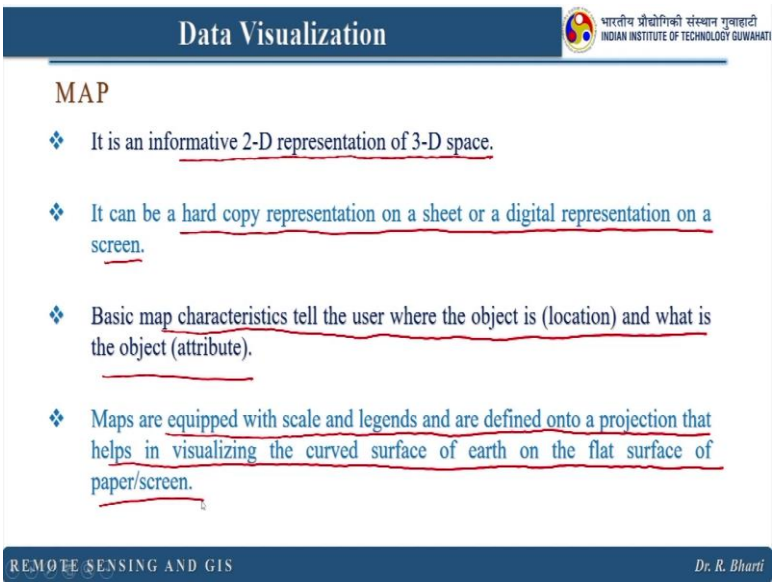

So here it is an informative 2D representation of 3D space. That is the definition of a map. So we want to present our real world pictures or objects in 2D right on a plane paper. So it can be a hardcopy representation on a sheet or digital representation on a screen. So both are basically map. Basic map characteristics tell the user what the object is and what is the object or attribute.

So instead of writing all the values like it is high or low or medium or moderate, you can use different symbol different texture or different way of representing your data. So, that is the beauty of your GIS environment. Map are equipped with scale that you have already seen legends and are defined onto a projection that helps in visualizing the curved surface of the Earth on the flat surface of paper or a screen.

So, this is very important as we are working in GIS, so spatial data is always there. So spatial data means where you have latitude longitude or a location value is attached , right. So here how do we define or how do we say this is the location of this particular position or object or material.

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So we need to have some kind of a standard. So, that we will see slowly what reference we are using why we are using. So, those things we will cover in this lecture. Now, let us go with this map, I hope you remember my initial lectures where I have explained the analog and digital photograph. So, here you can see this is the Analog map where all the object or materials have been highlighted by using different colours. So, this anybody can prepare right. But when we are talking about digital map you can see here.

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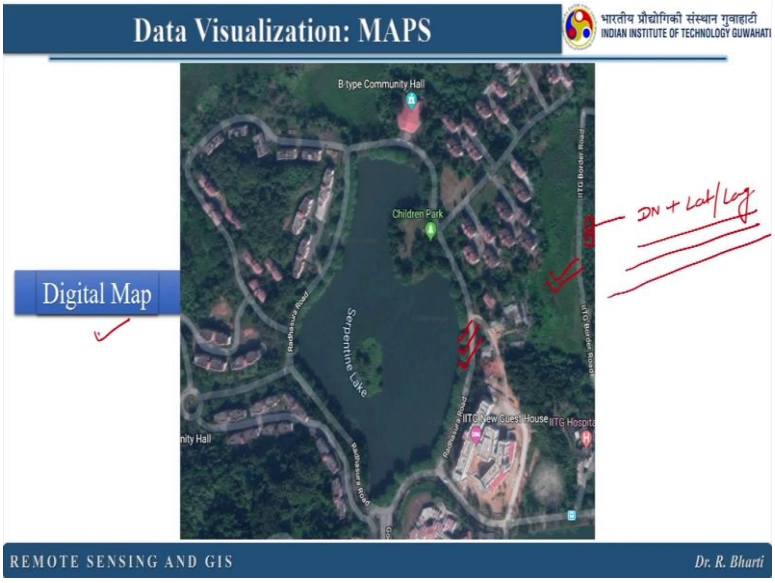

So, all these areas have been captured by your satellite, where elements the smallest element of this particular map will be a pixel right. And when we are involved in remote sensing from space or maybe airborne sensors, then we have one DN value and with this DN value, you have latitude and longitude. So, these three values will be there in your data. So, that gives the strength to this GIS. Where we always consider spatial data, spatial data should have latitude longitude or some location values.

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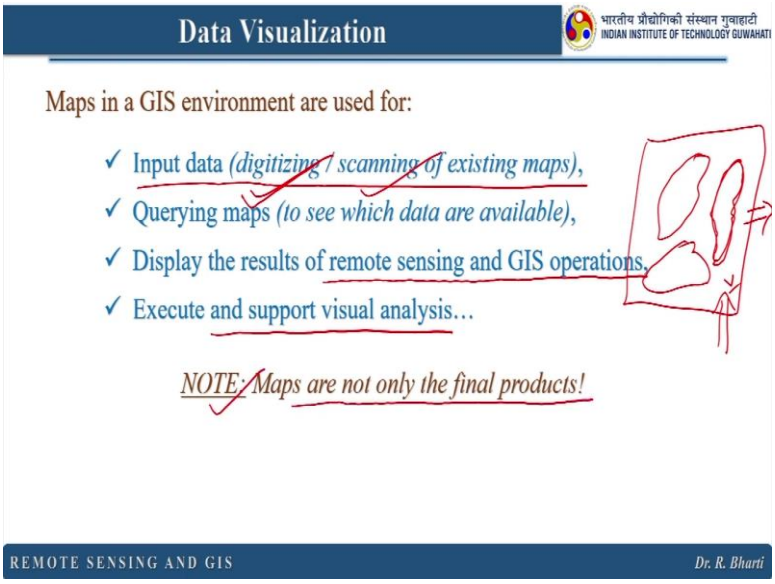

So, mapping GIS environments are used for digitizing, scanning of existing map. So, in case if you want to generate a digital map from analog map, so, let us consider you have visited a field and you have drawn some features and with the location values measured by GPS and

that you have produced in a hardcopy. Then I need not go and visit that place. I can simply use your map I can scan it. And then I can georeference that map using the latitude longitude measured by you and I can produce the digitized or scanned map right. And if you have a raster map, where do you have all these different objects were in GIS, you have a flexibility, you can overlay a vector layer here and you can make a polygon by tracing these features.

So, ultimately, you are going to reproduce this result in vector form. So that is known as digitization. So by digitizing you can convert this raster data to vector data. In raster data you have pixels in vector data you have point line and polygons. Next one is Querying map. So considering you have 10 different layers in GIS environment where one component is let us say population, second one is available drinking water.

Third one is available shopping mall and fourth one is what is the rain in that particular area? So, if you have all these information, you can easily find which place is good for you to find a new home, right. So, you can just run a query show me very good drinking water quality or the available drinking water plus low rain plus less populated area plus available market place. So, that will give you a result or that will highlight a location where you can simply go and find your new house.

So, this is one of the example how we can use this GIS for our day to day life problems display the results of remote sensing and GIS operation. So, as I told you all the maps, which has been generated using a remote sensing data that has to be under go through this GIS processes, right, execute and support visual analysis. And remember, maps are not only the final products, there are many other forms through which you can generate the result in GIS environment right. Now, let us see what are the different characteristics of a map? So map provides answers to questions related to basic components of geographic data.

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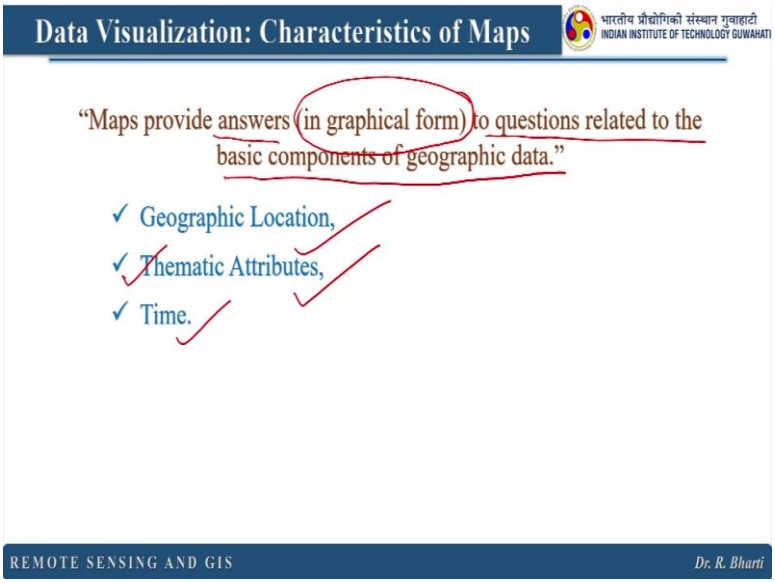

So basically, this is in your graphical form. So this can give you geographic location and it can have this thematic attributes like what is the population distribution in a particular area, what is the groundwater depth in some cities, what is the air pollution level? So, those things, if you have as your theme and you have an output in form of map, they are known as thematic maps, then time, so, time is also one important parameter. So, whenever you are producing a map that time stamp should be there, why, because that says these parameters whatever I have used in my map generation that has been captured at particular location and point or time right. So, let us see what exactly this geographical location means.

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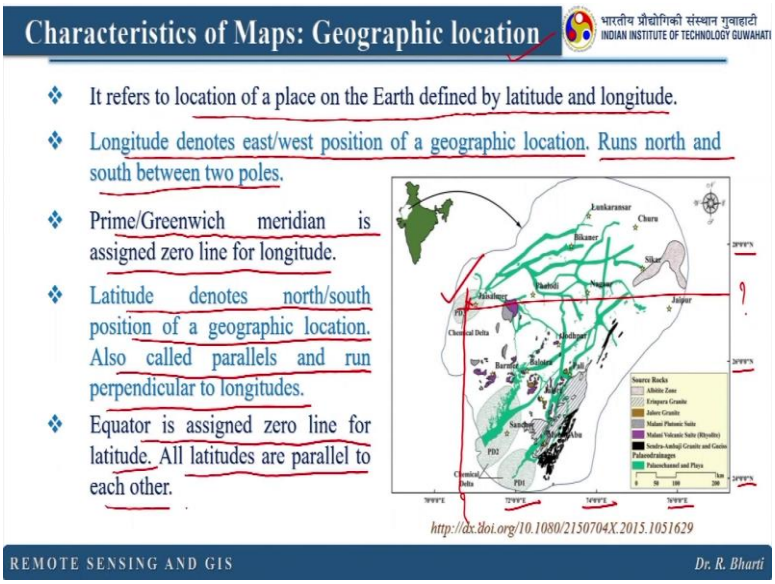

So, here you can see this particular map where you have latitude and longitude written. So, if you want to find out what is the location of this particular point. You can easily find out by just extending these lines and you can find out what is the value here what is the value here

and then you can always find what is the location value for a given or for your study area or for your object or material. So, here it refers to location of a place on the earth defined by latitude longitude, longitude denotes East West position of a geographic location runs north and south between two poles, prime or Greenwich meridian is assigned zero line for longitude. Latitude denotes north south position of a geographic location, also called parallels and run perpendicular to longitudes equator is assigned zero line for latitude all latitudes are parallel to each other. So, these I have written in very layman language. So, you can easily understand what exactly these latitude longitude means and how they are varying and remember they are perpendicular to each other. So, they have variation in different direction from each other.

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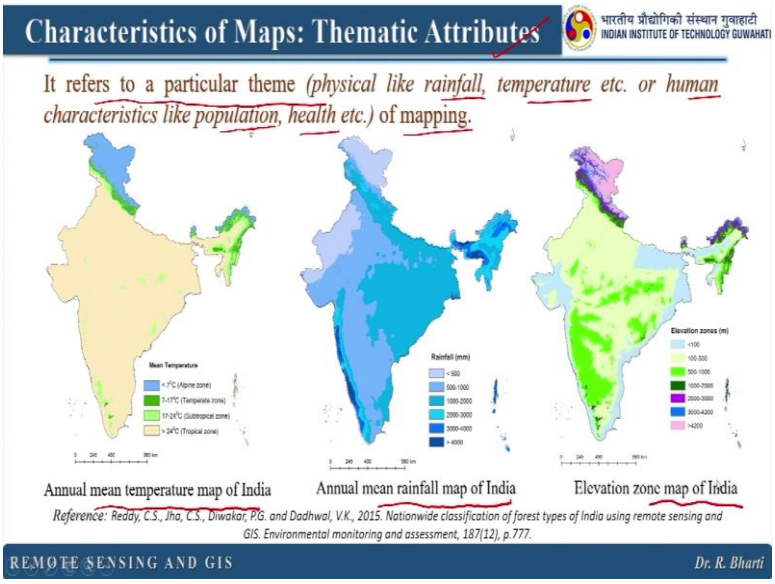

Then when we say thematic maps or thematic attributes attached to a particular map, what exactly it means. So, it refers to a particular theme like rainfall temperature, human characteristics like population health etc. of mapping So, here this is one example, there is the example of thematic maps. So, here this is annual mean temperature map of India right this is another annual mean rainfall map of India and this is elevation zone map of India. So, these are thematic maps because each of them are having different theme or different information. So, in the next example, we have this three maps

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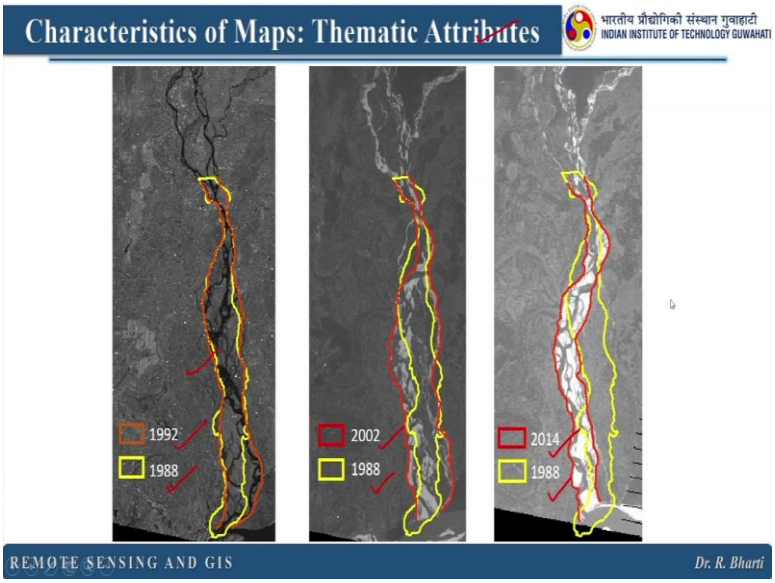

And you can see in 1992 and 1988, how this river was behaving, whereas, in 2002 and 1988, how it is behaving and with respect to 88 in 2014, how it has changed its course. So, this basically explains how this particular river is meandering. So, here basically again It explains the theme. So, this is related to hydrogeomorphic problems. So, here if you have such information, you can predict or you can extend this behaviour of this river. To predict in which direction it may safe in coming five years. Now, the next important parameter in your map is time.

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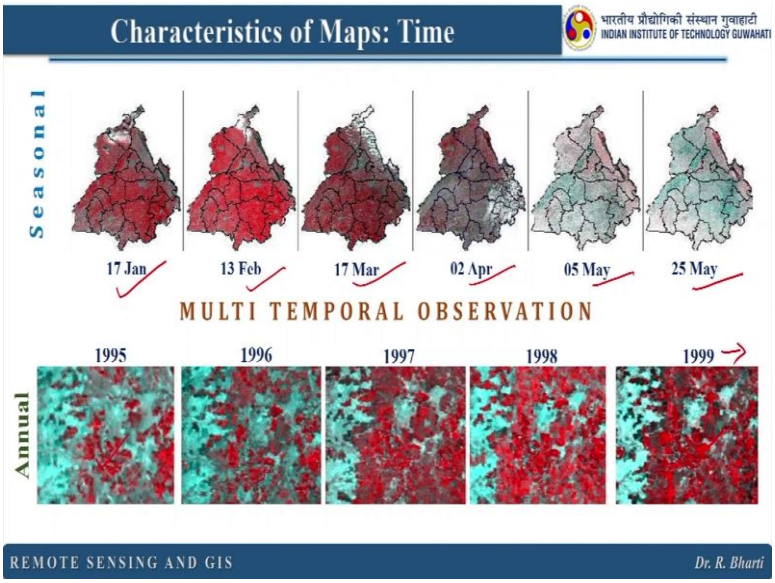

So, let us see this one at Jan, Feb, March, April, May, right, how this area is getting changed. So, the seasonal behaviour is also very important when you are involved in agriculture, forestry or water related problems. I hope by now you are familiar with this standard false colour composite.

So, this red colour basically represents the vegetation in your study area. So, here you can see how this red colour is changing through all these years. So, this gives you very important information about your problem through the time. The next important parameter of this map is how do we represent our values? So, in case if you have population data for Guwahati city or maybe Delhi, how do you represent it the next very important parameter of this map is visualization of the value. So, how do you explain or how do you represent the densely populated areas or very less populated areas in a single map. So, you need to use some conventions so that people can understand or I can understand you can understand

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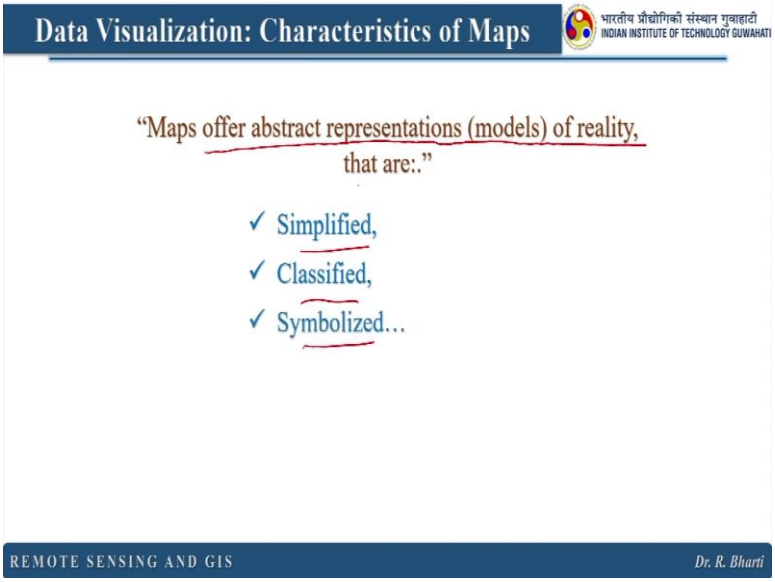

How these values are changing with different places. So map offers abstract representation of reality. So first one is simplified, then classified and then symbolized. So all these three different types, you can use to represent your data in a map.

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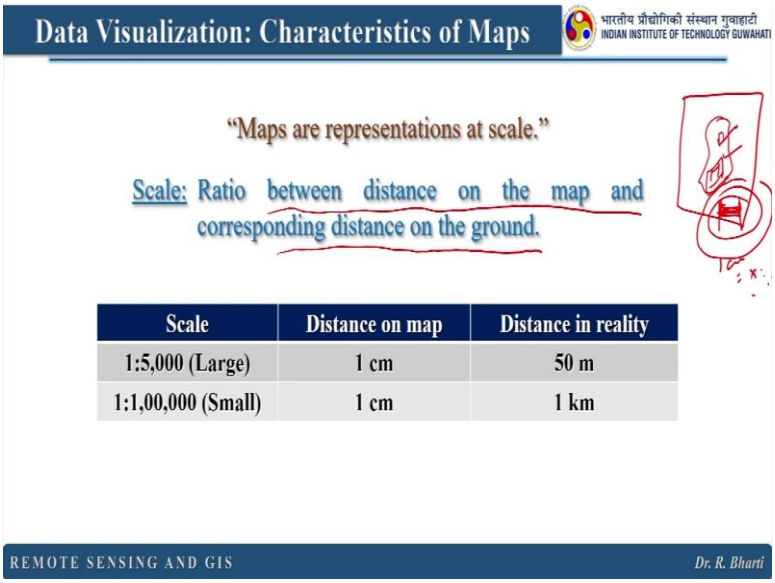

So maps are representation at a scale that already you have gone through. I have explained you all different types of scales in my lectures. Now the scale is basically ratio between distance on the map and corresponding distance on the ground. So here I am talking about this scale of this map, right. So, here you have a map. And this is the scale where it says one centimetre is equal to some x kilometre or meter. That means, this particular scale can be used to identify or to measure the distance between two places are the other geometric parameters within this particular map. So how this is going to help you when you are having all the digital data. So basically here this is scale is important when you are going to print this particular map. And you are going to keep it for a few years. So, after five or 10 years what will happen? The paper will shrink and then simultaneously this scale will also get shrunk. So then this scale and this map is shrinking together. So this scale can be used to identify even after 10 years or 20 years. So, that is why we always put scale bar in our output map. Next important parameter is how we represent our data. So, you can use some shapes to symbolize different parameters within a map. So here you can see for a given area,

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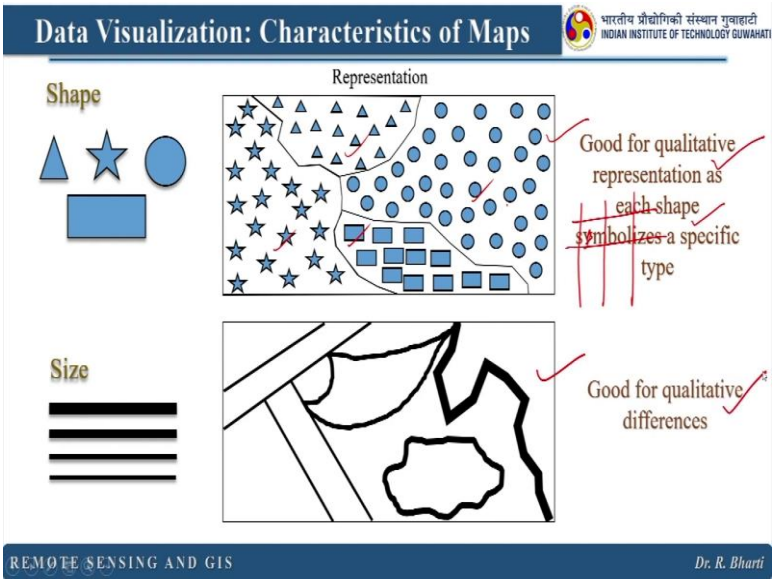

You have this this, this and this. So, all these things will be listed in your legend. So, what exactly star means, what exactly this circle means, that will be there in your output map. So, it is good for qualitative representation as each shape symbolizes a specific type, then you can use the thickness of the line that also helps to represent your data. So, this is also for a qualitative differences. Now, the next is colour hue,

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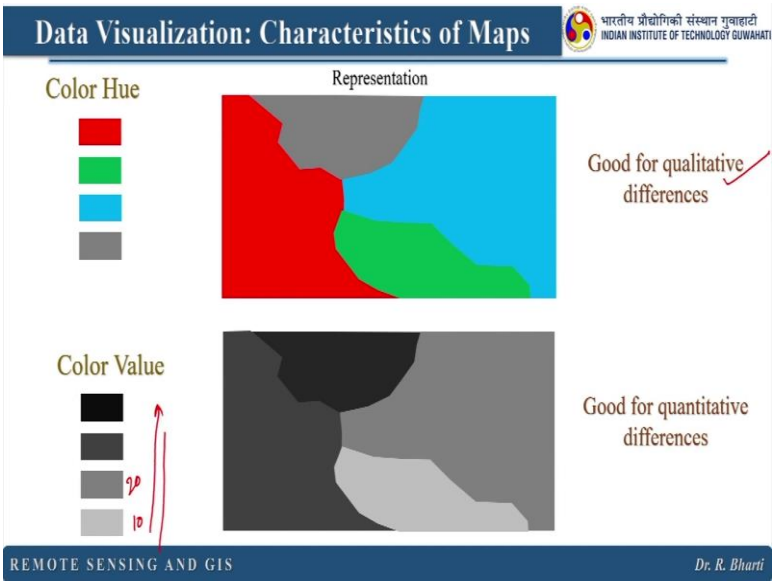

Where you can use this different colours are different intensity of the colour, but here not only one single colour in different intensity that will fall under the next category. So, you can see here this is also for qualitative analysis, then, colour value here you can use to represent you are quantitative data. So, like this may be 10 this may be 20 or in a scale you can put how it is changing right. The next is colour intensity.

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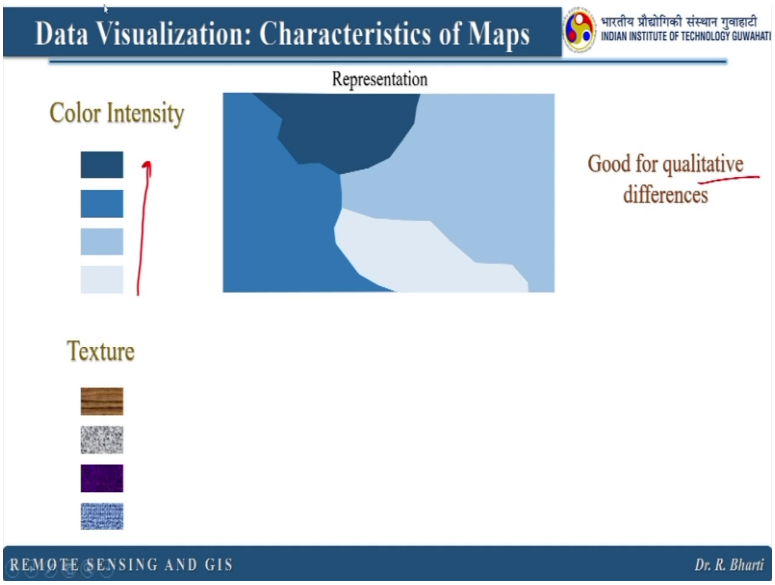

So, the colour intensity can also be used as the previous one. So, where I have shown you different scales. So, here you can also put a scale of a single colour and this you can use for qualitative or quantitative also. Next one is textures, because why am I telling you all this because whenever you are preparing a map in GIS environment, you may have n number of input data sets. So, you have to highlight all the parameters coming from different maps in your output. So, for that you may need different types or different convention to highlight all the parameters and that should be independent from each other. So, there may not be any what to say doubt between this and this. So, immediately if I see this colour and the legend, I should not get confused with this. So, if you are using this texture you can use for both qualitative and quantitative data. So, this is summary. So, you can see the shape can be used for qualitative size you can use. So, the biggest size may represent a high population or the high or the very bad air pollution level. And this may be the lightest one

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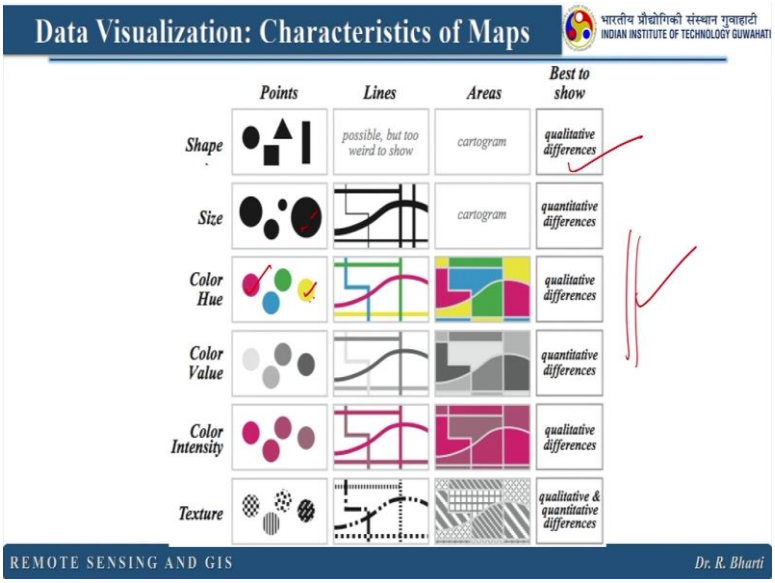

Maybe safest zone this may be the danger zone. So, depending upon your application you can use all these convention or all these different types of shape size, colour, colour intensity textures to represent your data in a map. So here this is one of the simplified map

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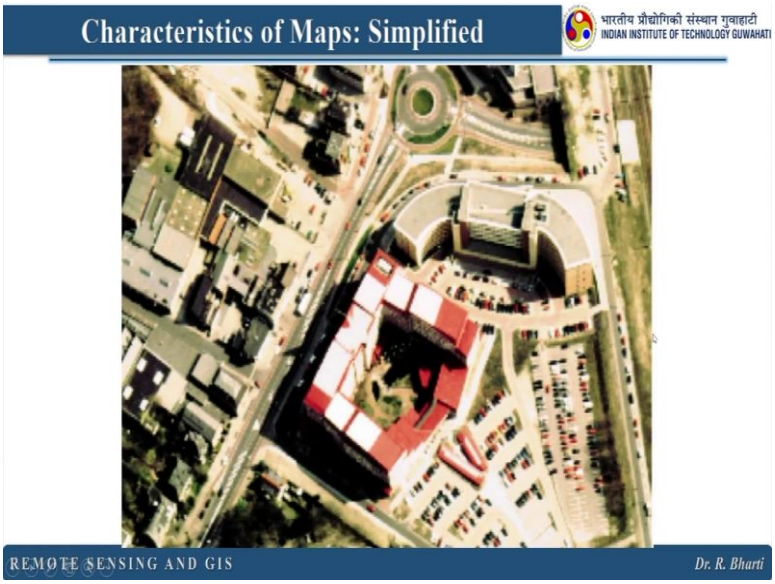

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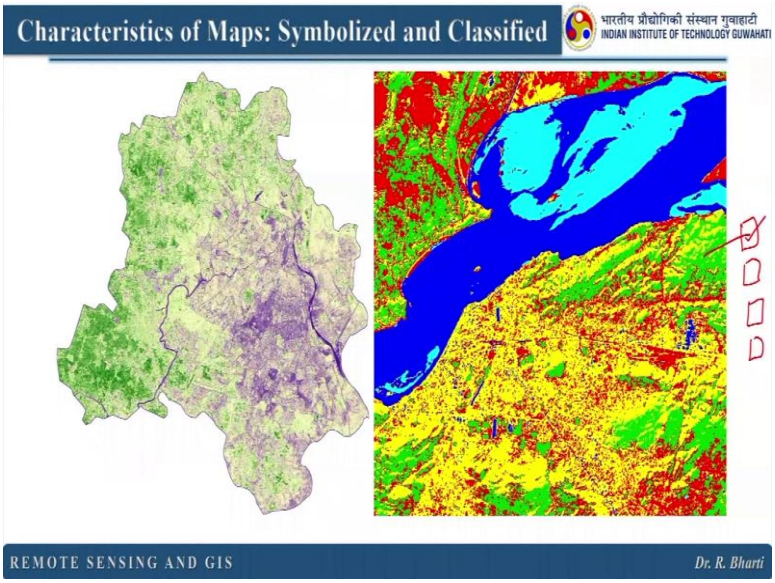

This is classified and simplified. So, you can see all these data sets. So, in symbolized and classified, you can see this result and I hope you remember my classification technique lectures. So, this is basically coming from there. So, all these colours will be listed in your legrnd and each legrnd will explain what parameter or what class you are representing with this particular colour.

Now, let me ask you one question, you might have seen this kind of figures in internet right. So, whether this is a good representation or bad representation or whether it is a good representation of our Earth Yes or no? So, I will give answers. So, that is no forget about all these boundary conflicts.

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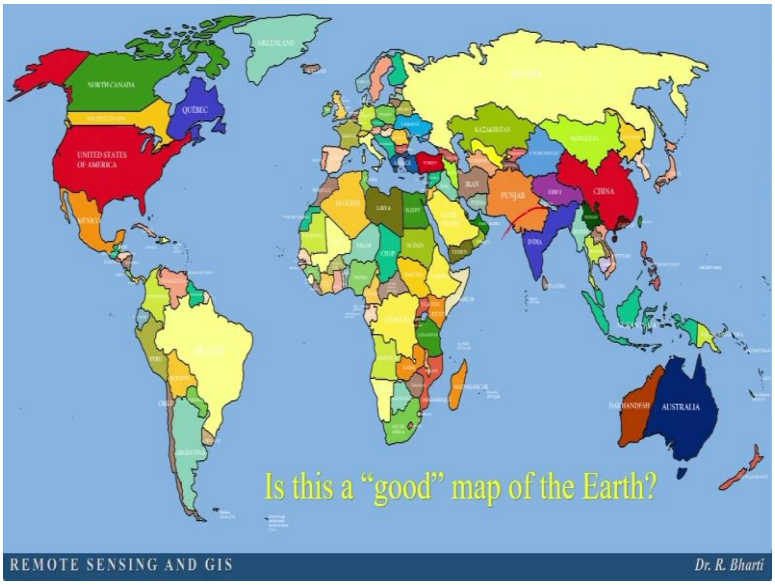

So, I am not going to use this as any country specific, so, here just I wanted to show that if you put some colours or textures that does not mean it is a map. Now, you see this particular map,

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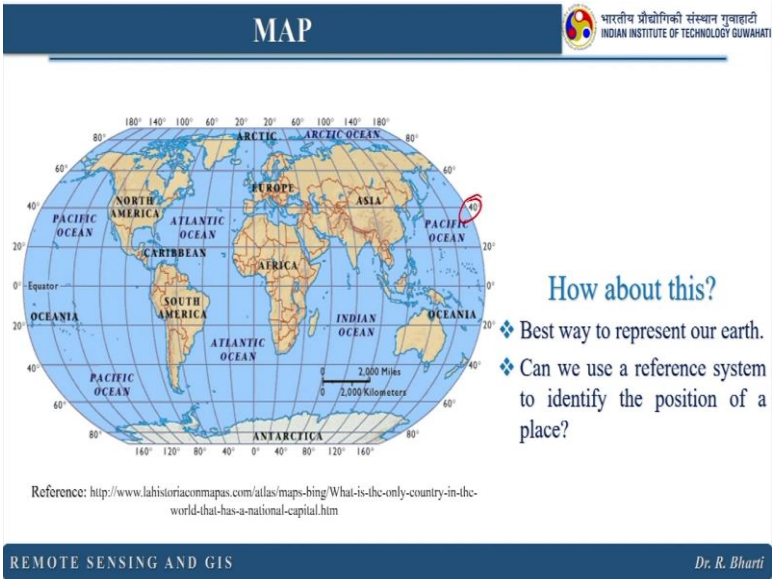

What do you feel about this? So, here you have some more information from the previous map. So, here you have location which is in the form of latitude longitude. So, definitely this map is better than the previous one. Here you can easily find out the position of any given location right. So, this kind of representation is expected in your output map. So, let us see, what reference system we are following to represent this whole world in latitude longitude, because there should be some convention by which we are identifying a particular location or position. So, for that we always refer our Earth a spheroid or ellipsoid.

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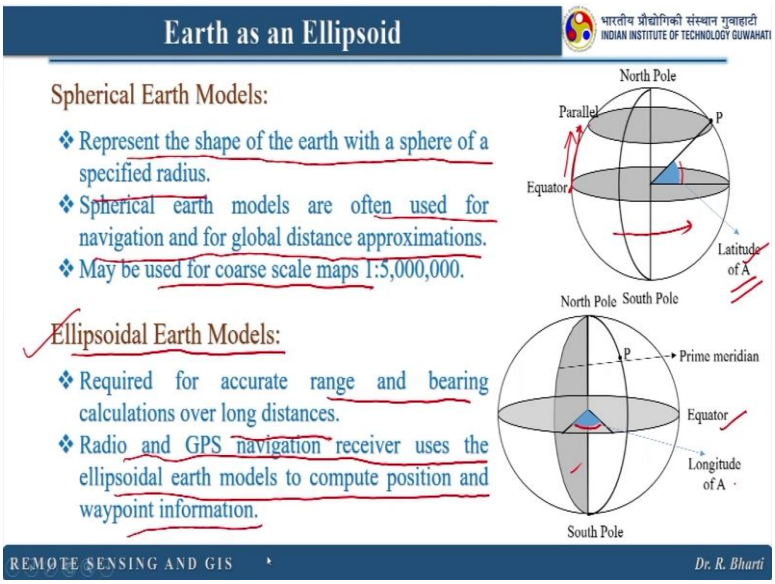

Let us see, when we consider our Earth as spheroid what happens and when we consider it as spheroid what happens. So, spherical Earth model represent this shape of the earth with sphere of a specified radius right, you might have seen this kind of figure many places. So, here basically this gives you the latitude and this is the parallel so, and this is equator. So, how it is moving.

It is shifting from here to here or how it is varying in this direction, whereas, this is varying in this direction, right. So, a spherical Earth models are often used for navigation and for global distance approximation may be used for courses Scale map, because as we know our Earth is not a spherical model, right? So it has to be different from his sphere. So that is why we have shifted ourself to ellipsoid and where this is actually best representing our earth, where we have this Prime Meridian.

You can see here equator longitude again it is coming in this direction right. So, it requires for accurate range and bearing calculation over long distances. So, this is more accurate, when we are considering spherical Earth model that was used for global approximation. So, very coarse scale map can be generated when but when we want to find out very minute or very small places and exact location of that, then we should go for the ellipsoid.

So, the radio sand GPS navigation receiver uses the ellipsoid earth model to compute position and waypoint information. So, let us see when we consider earth as ellipsoid, what parameter or what are the details we consider in that?

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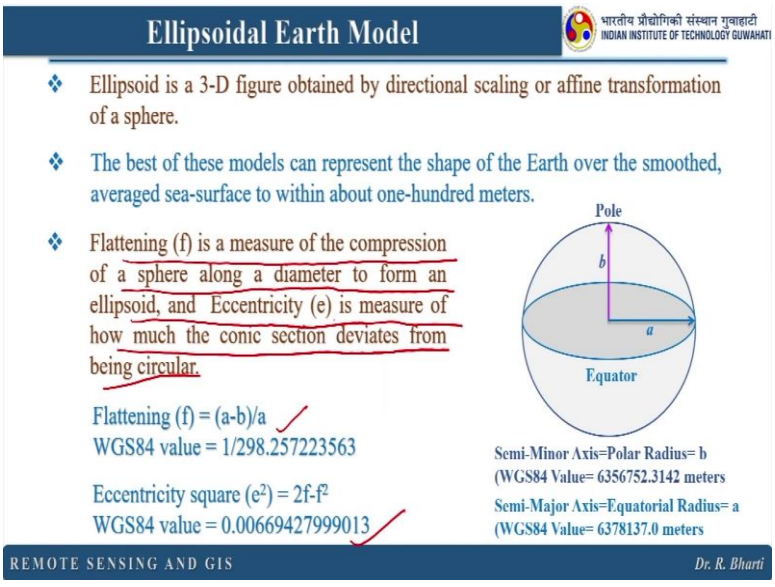

So, ellipsoid is a 3D figure obtained by directional scaling or affine tough a transformation of a sphere. The best of these models can represent the sphere of the earth over the smooth average sea surface to within about 100 meters. So, you can see this particular figure. So this is our earth and these are the pole and equator. And when we see semi minor axis and measure axis, so basically the major will have the greater value.

So if you see which one is minor or major suppose this is your ellipsoid. So, this is your semi minor axis and here this is your semi major axis right. So, in this ellipsoidal model it is very important to estimate the flattening flattening is a measure of compression of sphere along a diameter to form an ellipsoid and eccentricity that is e is measure of how much the conical section deviates from being circular right.

So, flattening can be calculated using this formula. And for WGS84 value this is the given value right. And eccentricity is basically two f minus f square and the WGS84 value is this much. If you want to understand more about this ellipsoid

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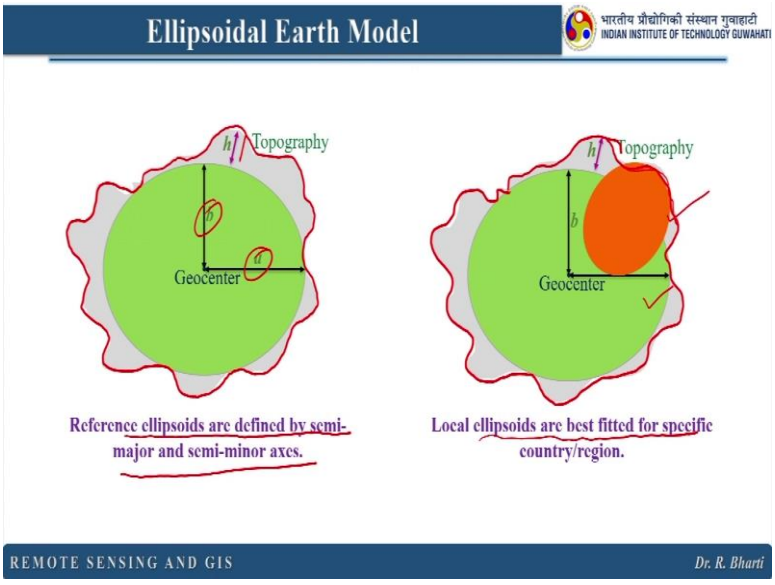

Let us understand about the topography and what are the mathematical surfaces we are assuming here. So, this is the topography. So, I hope you are able to see this. So, this is basically your topography. Now, this is known as a small edge and this is the semi major and semi minor axis A and B and this is the Geocentre. So this is the reference ellipsoid are identified by semi major and semi minor axis.

Now, here again this topography you can assume here So this topography small h you are familiar with Now, when we consider our earth as ellipsoid, still it is not getting fit with this particular typography, when we consider this ellipsoid to represent our Earth's surface. So, this is not fitting with our topography. So, for which we need an additional imaginary ellipsoid.

Which can represent our typography in a better way. So, for that, if you can draw this kind of ellipsoid here, that may give you better fit than this global ellipsoid so, that is the benefit when you are having local ellipsoids. So, for all the countries this local ellipsoid are different so, when you are having more undulations, your local ellipsoid size should be very small. There is another important concept in this GIS.

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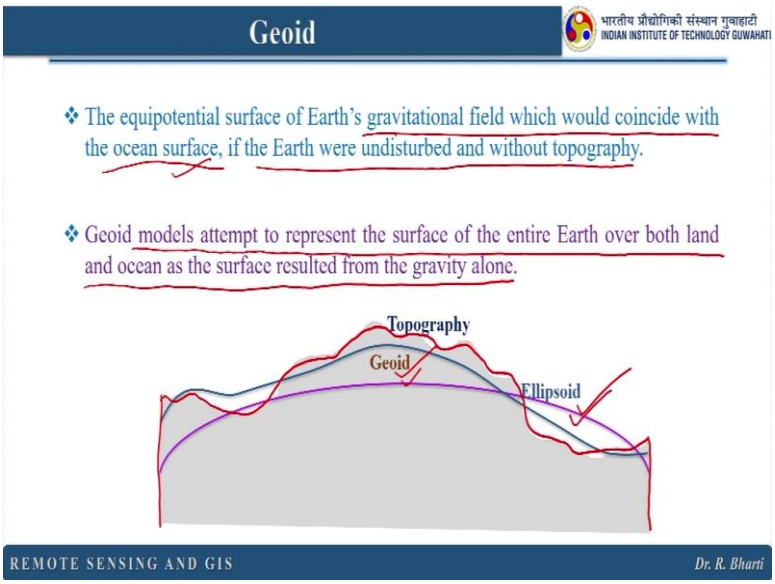

So, that is known as Geoid the Equipotential surface of Earth's gravitational field, which would coincide with the ocean surface if the earth were undisturbed and without topography. So, that will exactly match with your sea surface. Geoid model attempt to represent the surface of the entire Earth over both land and ocean as the surface resulted from the gravity alone.

So, here the gravity is same throughout this Geoid line. This is what was highlighted here, the gravitational field which would coincide with the ocean surface, that means, this is the equipotential gravity line So, here, if you see this the topography right and you have an ellipsoid here and this will be the Geoid So, does not matter which ellipsoid you use, it cannot be better than your Geoid.

Because Geoid can pick up the local variation because it is based on the gravity. So, this ellipsoid and geoid both are important to represent or to model our surface and then we will ultimately use some referencing system to identify a given position. Here, if you see

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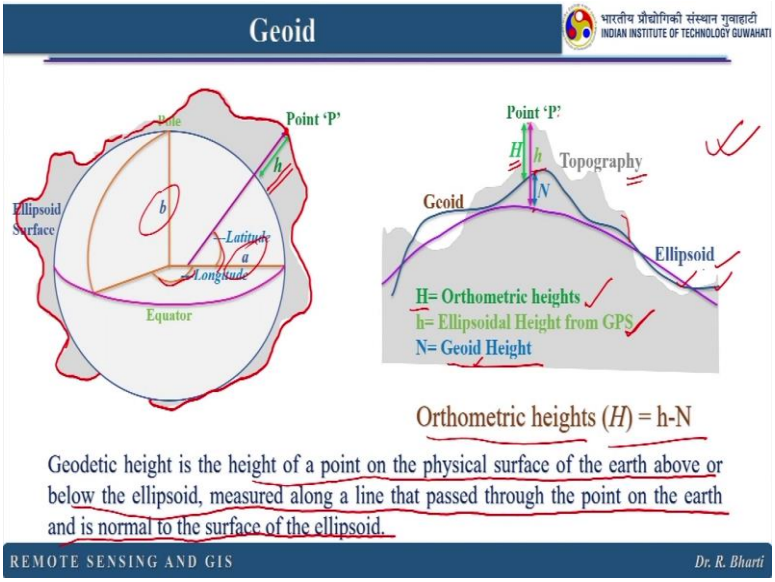

Let us assume this is the topography here. And here you have equator ellipsoid surface and this is the point for which I want to measure the height. So, that reference will be from Geoid because the sea surface level is our base level right. So, if you see the major and minor axis here, so, the major is A and minor axis is B. Now, here if you draw a line or perpendicular, you can see here this is your h which I expressed in a previous slide.

So, here if you know this is the h and this is the latitude and this is the longitude right. Now, how do we use this particular concept to identify a height for a given point So, I hope you are able to see this particular typography here. Now, this is the ellipsoid and this is the topography right you can see these lines. Now, I want to estimate the height for this point P and the distance between the ellipsoid and the point P is small h and this is the Geoid. So, from Geoid again you may have this height.

So, from ellipsoid you have small h from Geoid you have capital H and the distance between Geoid and ellipsoid is capital N so, you can use this particular equation to estimate the orthometric height. So, this edge which is basically from the Geoid to your position, that is your orthometric height is small h basically from your ellipsoid capital N is the distance between your Geoid and ellipsoid. So this is known as Geoid Height.

So, geodetic height is the height of a point on the physical surface of the earth above or below the ellipsoid, measured along the line that passes through the point on the earth and is normal to the surface of the ellipsoid. So this is what we have seen here. So this was related to the height estimation of a given point using this ellipsoid and Geoid so that is all for today. Thank you.