Remote Sensing and GIS for Rural Development
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Week - 06
Lecture No - 01
Intro to GIS Projection and Co-ordinate systems

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Hello everyone, welcome to the NPTEL course on remote sensing and GIS for Rural Development, this is week 6, lecture 1. In the past week, we have been looking at multiple data types in GIS, especially raster and vector data and we have looked at how those could be applied for rural development. It is important to understand that rural development will becomes complex issue, there could be multiple data sets that one can download, it need not be a particular type always one time it could be a raster or a vector.

So, we cannot pick and choose between data set, usage of data for analysis will determine what type of data we will use. Moving on we will look into the aspects of data collection and how data is being collected and then we will use it for our rural development aspect.

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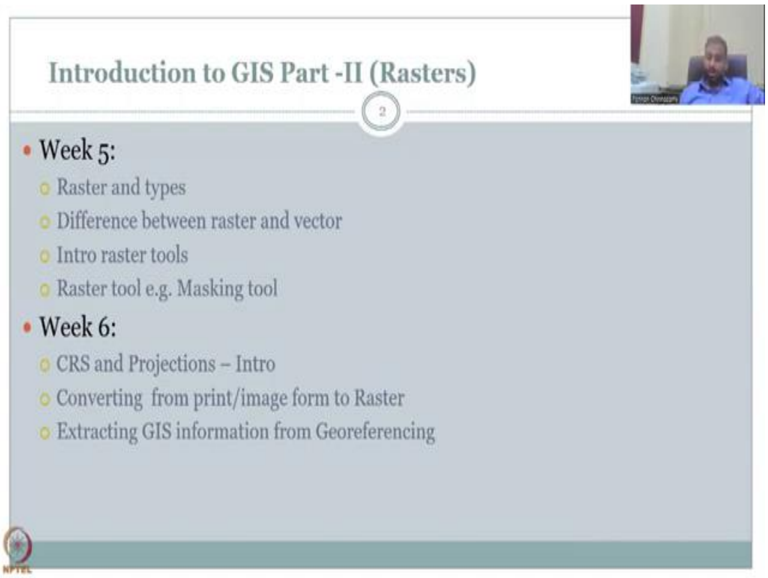

Let us see what we are going to look at in particular in this week. So, in this week, we will finish up one more introduction part that we had in the last week. So, in week 5, we look at raster and types, the most important types were the jpeg, tiff image, grid image those kind of things and we specifically looked into the difference between vectors and raster's.

As I again say which type is correct anyone can ask, but there is no right or wrong here it depends, it depends on your work, it depends on your problem statement and the data availability. If you have very good data for river network and water availability you can definitely use vector data. However, if that data is less and not available, then we one has to use raster data and other kind of proxy data.

Then we looked into the introduction of raster tools with continuation of looking at the vector data types, we looked into the raster data types and tools. Then we looked at some examples especially the masking tool where we developed a entire data frame and then we extracted based on what is needed for us, so that was the masking tool.

In week 6, what we are going to do is? We will combine both now, so vector plus raster in our analysis, before that as and when you download data and when you look into the metadata two things which are very important are the coordinate reference system and projections. It is important to understand this while downloading raster, so I am continuing with the introduction of GIS with raster's and vector data, but when you bring down a raster data from a portal, it is important to understand the projections and coordinate system. This is true for even vectors.

So, let us look into that in this week what does coordinate reference system and projections we will cover this today in this lecture. And then further along the week, we will look at converting from print or image form to raster which means you could have taken an aerial image from a plane or a drone image how can you convert it to raster? Similarly, you would have taken a data point from a data source from satellites, how do you convert it to a raster, we will look into that and that is mostly called Geo-referencing, we will give an introduction to Geo-referencing.

And then throughout the week, we will extract information from this Geo-reference image. Thereby, I will be teaching you on creating new point files, line files and polygon files, these are important files to have for rural development because they do not get updated often. So, the raster’s get updated often via satellites, drones, etc are taking images. But point data gets tricky, one has two develop an updation system to update periodically the data, if you do not update then there is a big lag, so let us jump into that.

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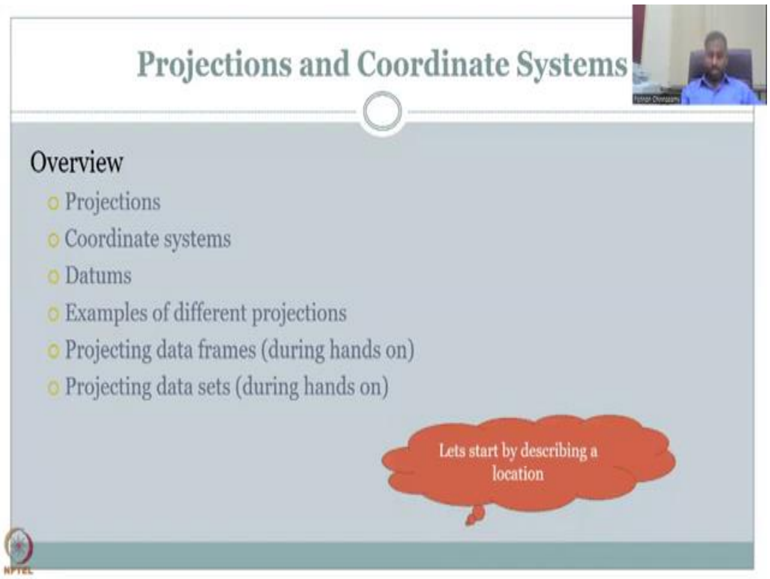

Today, we will be looking at projections and coordinate system in an overview we will look at projections, coordinate system, datums, what is the datum and how it is being created in a projection and coordinate system. Examples of different projections and you will also see some data frames and data sets.

So, this will be more discuss when we do the hands-on, when I say hands-on I will also open QGIS and download the data and show you and in that time we will look at the data frame and how you can convert the projections etc. So, already we have seen some of it in the previous examples, we will have more clarity when we do more examples later.

So, moving on we will look into the parallels of projections and coordinate system description of parallels projections and coordinate system, but before that we will have to look into what is the location.

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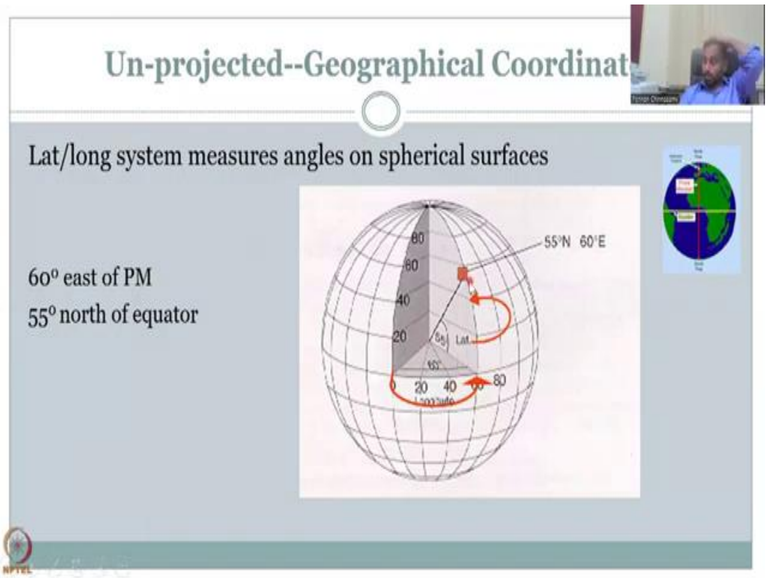

So, we have already looked at location in multiple directions, today, we will look at this from a map angle. So, in an un-projective geographical system you do not have coordinates, let us take a sphere a globe it is not projected, it is a real life real globe and the Earth is kind of model in a globe. So, what we have here is this is a globe which has been dissected into grids and this grids is what gives rise to coordinate system the type of grids and how they what is the degree between it.

So, let us take there is a centre you could see in my pointer shortly that the centre is here and from the centre the entire globe can be gridded and angle, so you have angles for each grid let us show an example. So, this is 0 and this is 0, so from 0 you can go vertically up as an angle. So, this is latitude lines, the latitude lines are running top to bottom let us say for the Earth and then running on the horizontal axis is longitude. So, the vertical one or the top or down one is the latitude, whereas, the longitude runs along the perimeter and it is in the horizontal direction.

So, if you take a centre, so both have centres, so in a vertical also you will have a centre and a horizontal also you have a centre. So, let us take from here and it is the 0 and from the 0 it goes 55 degrees, so that is lat. So, every line is being cut, so the globe is cut into different lines, so like cutting your orange and then longitude is also cut and that is a particular coordinate system. So, every coordinate system has its own way of telling it or describing the 0 and the coordinate system.

So, the lat long system measures angles on spherical surfaces, 60 degrees east of let us take an example 60 degrees east of prime meridian the prime meridian is the 0 line. So, from here you do 60 degrees, so I am going to describe a location. So, the location is from the prime meridian which is the 0 point from the 0 point it is 60 degrees east, so you move 60 degrees east, so you have moved to this point, remember each location should have a lat and a long, it is not a 1D surface value or 2D surface where you can just put one point even a 2D will have X and Y.

So, here we are trying to show an X and Y, so there are two dimensions and X is given by the 60 degree east prime meridian and 55 degree north from this you go up 55 degrees. So, when you go up 55 degrees the 0, the 0 is kept here, so that is the line here and from the 0 you are going up. So, this is the central 0 and there is a Y axis 0. So, then you merge this and from here you calculate what is the angle you want to go, so 55 degrees north of equator, so from here 55 degrees north, so this point is what we want to look at and represent in our study.

So, this is given as the location is given as 55 degrees north which is from the equator the centre you are going up 55 degrees north and 60 degrees east is from the prime meridian even 60 degrees east. So, if you just take one, for example you take this and then leave it here you are you do not know that how do you go up and down. So, at 60 degrees you can have 55 up or 55 down 55 degrees from the centre down, so all this is being created when the coordinate system is driven.

So, when the slices are made the angles are given each the difference between each slice there is a particular angle and that has been taken, why is this slicing done we will discuss this when we compare a globe and a real life scenario.

So, here is where the datum is and the datum is the 0 part, so you have equator and then a prime meridian. So, the prime meridian runs from top to bottom and then the equator runs along the horizontal line, so the prime meridian has goes to the north and south pole, whereas, equator runs along the horizontal part and you could see that they meet at one point in the centre.

So, you have this round and then in the centre they could be along the circumference, when I say meet virtually it is not like they actually meet. So, you can drill down from a 2D surface they meet, however, the globe is a 3D surface. So, this is in the centre, whereas you have it here. So, along the prime meridian you start a 0 and then from the 0 you go 60 degrees and from 60 degrees you go up 55 degrees, this is the example we have done here. So, this location is what we have given as per the 60 degrees east and 55 degrees north.

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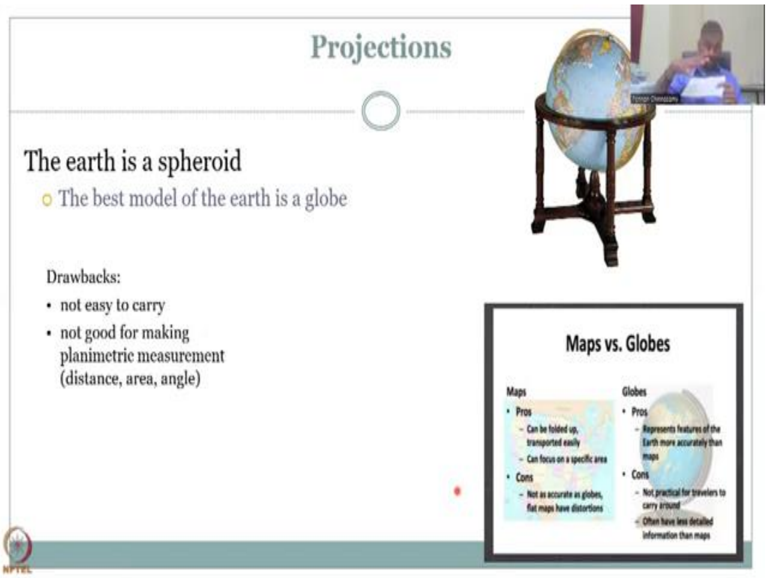

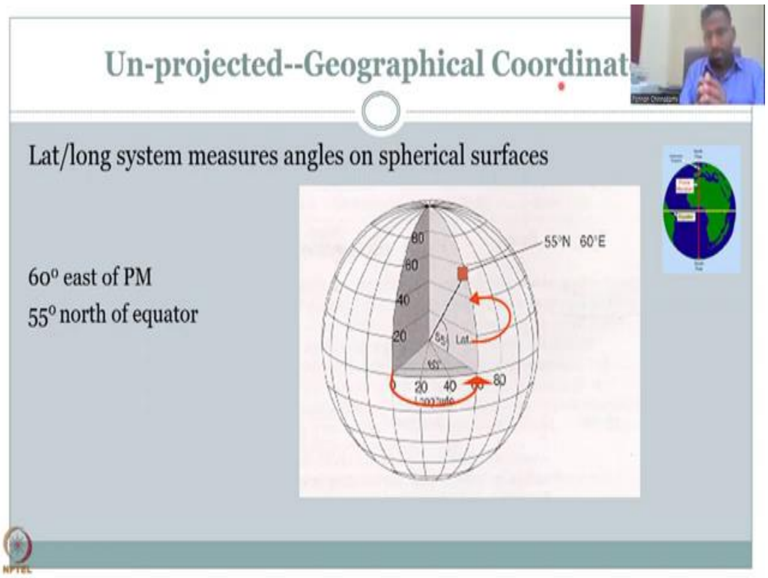

Now, we are going to go to projections, so before that taking a step back to just show that the this is a coordinate system where you are given coordinates to the globe, the globe was a 3D surface, it did not have any cuts it does not still have it is still a virtual line and why we do that is we want to represent in a 2D surface but the globe is a 3D surface.

So, to cover that it is the same like you do integration what you do is you dissect it into small parts and within the small pass you can assume it is a 2D. And then you add on to it for the entire globe. So, just a small, small part you cut and the small part location is given as a 2D surface with two dimensions your north and east lat longs.

So, now we go to projections everyone knows the Earth is not a ball it is not a sphere it is a spheroid which means it is circular, but Stout on the top I will show a real example in a while the best model of the Earth is globe.

So, if you take for example an orange an orange is also a very, very good approximation of the Earth, it is not a sphere, it is not circular fully, what happens is it is these are the poles the poles go in when the poles go in it is squished on the top, so it is not a full clean sphere like a full orange, if you have an orange you have it as a full sphere, this is the different type of Mandarin orange we call globally, so it has Stouts on the top. So, this is pushed down and then it is a sphere.

So, this spheroid which is correct a presentation of the globe is being done applied to all globes, so if you look at the globe here on the top and bottom it is slightly pushed, so if it does not push it is a sphere it is not a sphere the real globe or real Earth planet Earth it is a spheroid. So, slightly it is pushed down, so the best model of the Earth is globe for which you can do mapping and other thing and here also you can see the lat long lines it has been cut dissected into latitude and longitude based on a particular coordinate system.

So, what is in the coordinate system, is a set of the 0 where is your 0 it defines your 0 and the degrees between degree of separation between the lines. So, coming back we cannot use this why, because you cannot carry the globe everywhere, yes this is the best model of the planet but you cannot carry it everywhere, more not good for making planning metric measurements, distance, area, angle, for example, because you have a zoom in zooming in and zooming out is not possible on a globe.

So, for that we have maps and when I say maps, maps are a 2D surface again think about it we are thinking of a paper 2D surface cannot be used for representing 3D unless and otherwise some limitations are addressed, so that part is what we will be looking at, so this is a 2D surface, you have a paper and in this you are going to represent the globe which is 3D, so how do you do it, is by projection, projecting it on the 2D surface. So, we look into some projections and descriptions.

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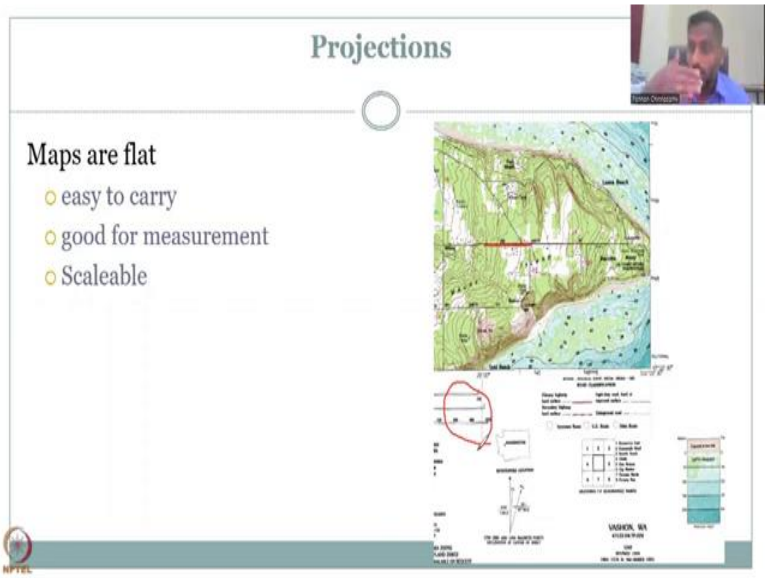

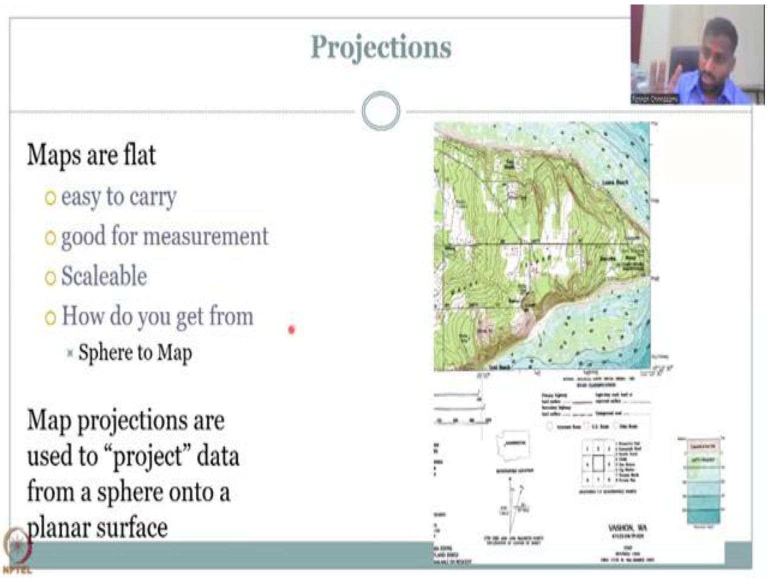

As I said the maps are flat maps are 2D surface, so map is a paper and in that paper you want to bring all the information, when I say map is also the GIS map because GIS is an electronic version of a map a digital version of a map.

So, in this map what do you see? You see the entire globe being focused into that area for that perimeter of your map and you can see as we discussed the latitude is there and the longitude is there. So, latitude is the top to down longitude is this one, so you have your easting northing and the numbers are given here. So, where you are looking at and how the intersection is where you have the lat long description.

So, moving on why are these used? These are used because these are easy to carry, because you are going to use it for some analysis, some representation, you do not carry the globe everywhere. So, this paper map is easy to carry good for measurements I can show you that for example when you want to find the distance from the between here and here you can easily mark points and then estimate the distance, yes the Earth is not a straight line, so you but still you can see how the track goes or the trip grows in a map and then you can estimate the distance.

And then what else can you do? It is scalable, so what you see scale here represent like in a map I have also discussed this when we did QGIS it is how much of the map area is represented in the real life area. So, for example if you take one inch here, let us say we are taking one inch here, so this one inch is equivalent to what two thousand or twenty thousand in the real life scenario. So, that is given by your scale the ratio between your measurement on the map and how much of that is represented in the real life scenario is given as scale.

Then we have scalable benefit of the map because you can zoom in and zoom out, so I will just say what is the scale in terms of usages is you can zoom in zoom out, when you have a globe you cannot zoom into a globe nor zoom out because it is a ball which can be made for different, different respects. So, if I want one globe I can make for water bodies if I want one globe I can make for rural village map, but you cannot change it, you will have to make another one.

So, that is where a map is there, even a map is stationary you cannot change it, this newspaper map what you see on the screen you cannot change it, but the idea in GIS is you can import it you can import it into the GIS software and then you can make wonderful digital maps and data repositories for rural development.

So, how do you get from sphere to map? So, the question should come, so this map is good we all understand that the 2D map is better than the 3D version of the map, but how do you get from sphere or a spheroid to a map that is what is called projections, map projections are used to project the data from a sphere onto planar surface.

So, projections are very, very important to understand because we are converting a 3D image into a 2D image we are converting a 3D real life figure into a 2D diagram and for that we need to make lot of limitations and assumptions and that is what projections does for us.

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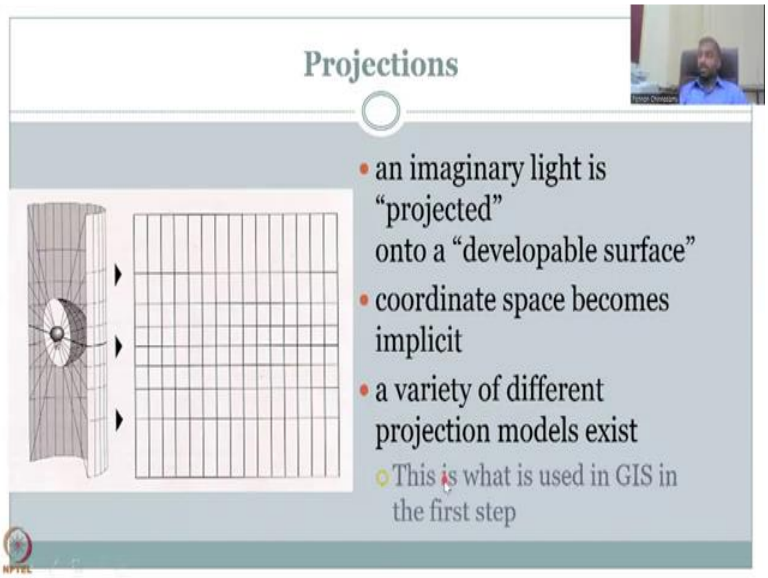

We do not have to create new projections we can but I am saying we do not have to because QGIS have multiple projections. We will see why there is a need for multiple projections in this slide. See imagine you have a paper and in that paper you have drawn the grills, so the grills are already drawn you have taken the lines as shown here. So, you have lines in the paper and you have vertical and horizontal lines.

So, now if I put a, if it is circular, so now the globe is circular and like a spheroid, so it is circular and on inside imagine there is a light bulb, if you have a light bulb you can see here inside the centre then the rays of the light bulb will come out of this paper and let us say it is a transparent kind of paper where it comes out.

So, when it comes out each line is projected differently, so that is what you could see here even though the globe you can see the globe does not want to have differences between the line spacing, we made sure that the line spacing is correct, but because of the projection and the angle of projection in some parts the light travels less distance and so quickly it projects. Whereas, in some parts of the globe the light travels extra time because it is not a circle if it is not if it is a circle radius all are same, but spheroid, so, you have it going out.

So, you could see here this line is traveling a longer distance whereas this is travel a shorter distance with shorter distance there is no distortion of the image and you will have a better representation. So, along the centre because if replace light in the centre along the centre the distance between the grills is same. However, if you go out of the centre you could see that the box gets elongated and that is purely because of the light has to travel longer distance.

It is an imaginary light is projected onto our onto a developing surface, so this surface is an imaginary surface also because it is a 2D image, it is a 2D screen where you are projecting your image. So, as I said you had let us say this is the sphere and inside this you have a light bulb and light bulb is emitting. So, when it emits this is my surface, it hits, so how it hits, at what angles is what defines a projection and it also is important to note that the placement the placement of the light bulb is very important to show where it is getting projected.

So, an imagine light is projected onto developable surface. Coordinate space becomes implicit, the space where it gives projection it becomes implicit and a variety of different projection model exists.

Now, you could see that if I am working let us say the globe is this and this is the equator region if I am working in an Indian region this image is fine I am putting the light bulb in the centre I am getting good image. However, if my study area is Antarctic Arctic, if I am doing a flight calculation from India to US, so you will have to cross the hemispheres, so for that the centre bulb is not just the perfect one you have to compromise too much.

So, that is why there are multiple projections, let me give you some example. And the surface also the surface is not just a sphere and the light bulb you could have multiple, multiple developable surface.

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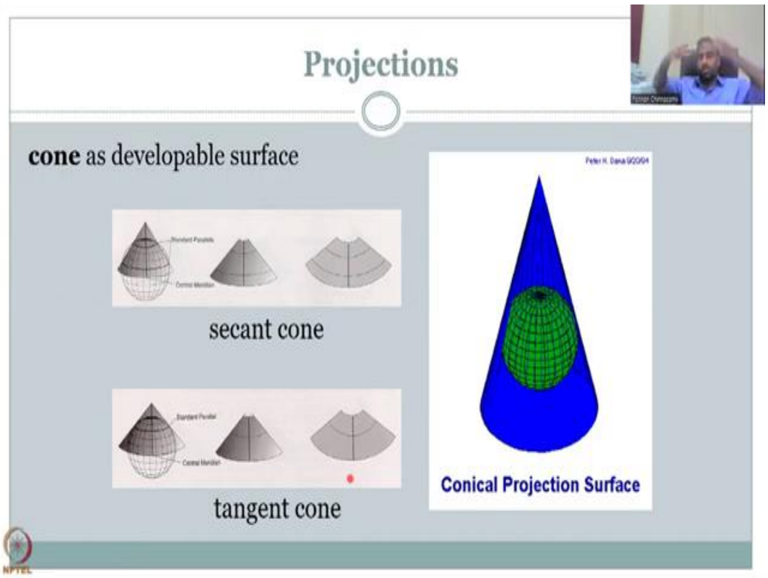

So, this is a conical projection surface where you put the light here and at a distance not in the centre but at a distance from the sphere and you let the light come as a cone and when it comes as a cone your certain parts are highly distorted in terms of elongation, whereas, some parts are well represented. And that is because you have a notion to have more accuracy on the top not on the size you do not care about I do not care about the side data I am not going to work on that part I am going to work mostly here.

So, this is the second cone and within the cone there are multiple different types of cones, so just think about it, a projection can be in the centre or outside of the centre of the globe and multiple locations it can be and within that you have different shapes of how the light can come in, it is like imaginary, imaginary you put a light and you put a shade.

So, think about in houses they have night lamps, so depending on the shade, shade is what they put on the night lamp the light projects. So, under the night lamp you can see light coming down. So, if you make a smaller one it focus that is for reading and stuff, if you make a very spread one it can spread a lot, so that is how you can make different projections using GIS.

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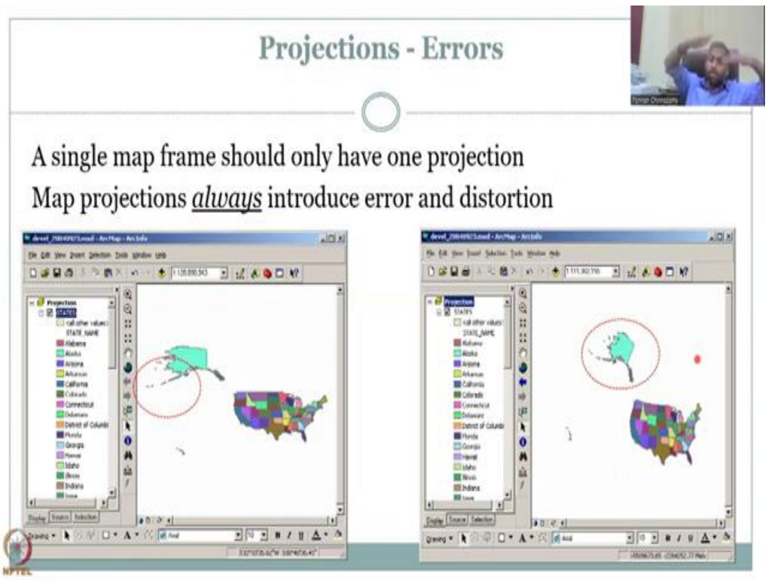

So, three things we have seen you need a centre which is the datum, you need the projection which is where and how the 3D surface is projected on to the 2D surface and we need a coordinate system the coordinate system is how the globe is being cut in what degrees. So, there are a lot of errors in this because you are converting from a 3D to a 2D surface.

A single map frame should only have one projection you cannot have multiple projections, but is this an issue? Yes I will show you why, map projections always introduce errors and distortion always it is underlying, because you are converting a very complex 3D object into a 2D sphere 2D space, so it is not going to be easy, however, we do the best why, because this GIS software is usable for doing calculations analysis etc whereas the 3D model cannot. Nowadays computing can bring 3D image, however the 3D image takes a long time to digest the information.

So, here what we are going to see is just a map you do not have to if you look at the map what you see here is, what you see in the map is you have a different projection and United States there is a reason where you have why you have to have the America here, because we want to show that there is some issues in the projection, let me show you.

So, this is Alaska part, the Alaska part comes because Alaska is part of the United States. So, US if you know is a big part of the US is in the northern American continent you have a big part and then you have Canada and then you have Alaska somewhere outside. So, Alaska is also big, however, it is very, very towards the north and the northern part as I said has a different projection.

So, in this if you use a projection which is only suited for the central United States, then your Alaska is getting distorted. Let us say for example this is Alaska it looks like Alaska in the same map in the same projection same map looks like Alaska is bigger than the part of the United States.

So, look at the states here, some of the states within US is smaller than your Alaska which is not true, Texas for example it is not as small or as big, so it is not definitely that small. So, there is a distortion it is a pull push effort, so this Alaska has been pulled, so how should it be originally, let us look at another projection which captures it in a different way.

So, this projection if you look at the image is not distorted US is not pulled and it is compromising some errors here, some errors here to have the best map. So, this compromise is what is needed.

So, now if you look at Alaska this is the State and you have it as big as some of the states and also bigger than Texas, but more importantly Canada can come here you see the curve somewhere visually if you look at, oh, the world is a curve and with the curve Alaska is drifting like this, it is if you roll it down on paper it is 2D but 3D is what the axial surface is. So, you roll it on a sphere and you can see that Alaska is kind of more curved because the curvature is high on the poles. So, again as I said your poles have more curvature because it is pushed down here we have less curvature compared to the different locations.

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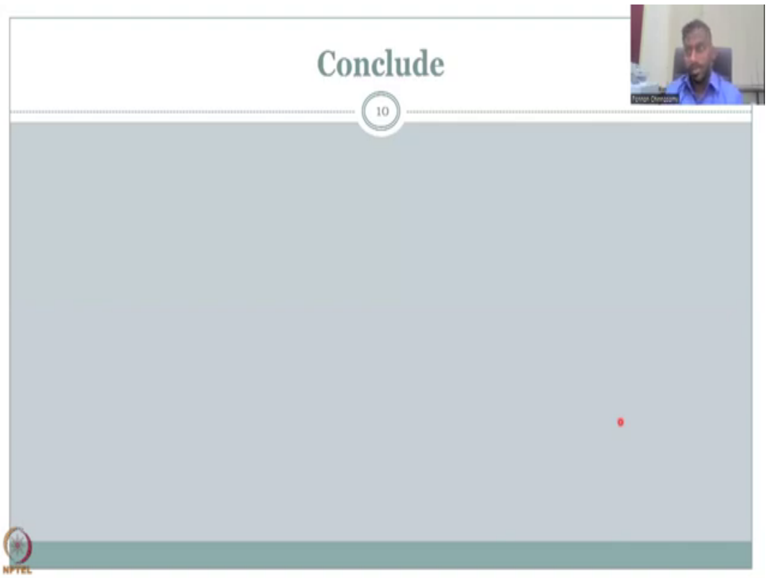

So, the take-home message here is we are projecting data from a real world into a 2D space and the 2D space is because your computer is a screen and the paper map is a screen 2D surface, it is 2D same as your screen and with that there is also need for doing some calculations and analysis for which you need to define the centre of your sphere and how it is being cut, how many small or how many big depending on your need and that is called coordinate system, where you put the light bulb and showcase it on the screen is called the projection.

And these two things at least these two not the datum because datum is part of the coordinate reference system, these two things are very important to understand when you download data, because they would have downloaded, they would have set up the satellites for a particular data type is mostly in raster. And so when you download them you should convert or reproject it into the other data frame.

So, let us say for example your rainfall data from IMD is in X Y coordinate system, but your satellite data on a digital elevation model is an A B coordinate system. So, these do not talk to each other, so you need to convert, so you need to convert one projection into the other, otherwise there is distortion errors. So, please read more on this there is a lot of material on these things whatever we discussed this is just an intro I have given across this today's lecture with this I complete today's lecture I will see you in the next lecture. Thank you.