Digital Elevation Models and Applications
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Lecture – 05
Importance of Spatial Resolution with DEMs

Hello everyone and welcome to fifth lecture of this a course digital elevation models, and its applications. And today topic we are going to discuss about the importance of spatial resolution with DEMs, because a spatial revolution of any DEM will decide the indirectly the quality of a DEM, there are some other things which we will also discuss which finally a, constrain the quality of a DEM. So, first what is spatial resolution those who have gone through the courses on GIS and remote sensing might be knowing, what is the spatial resolution, but those who have not for just for refreshing their memories.

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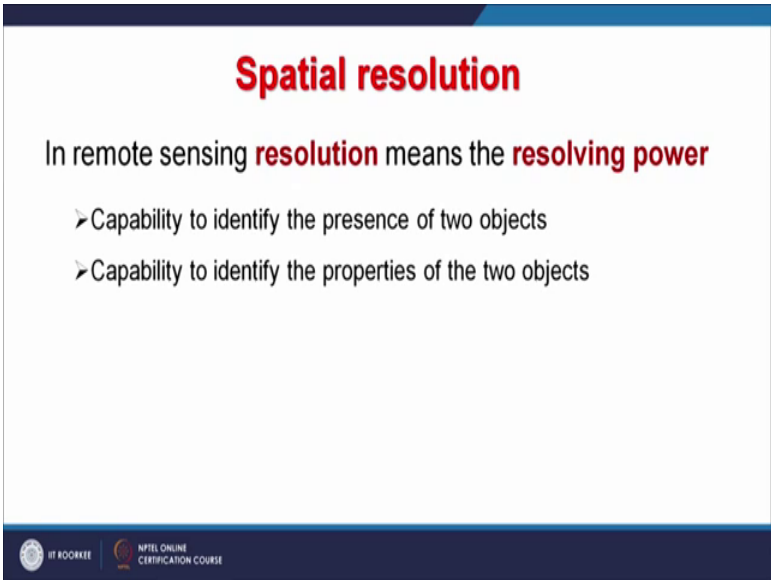

That in remote sensing resolution means the resolving power. And a here that basically means capacity to identify the presence of two objects which are closely spaced, and capability to identify the properties of two objects, how you know what if it is remote sensing data then what is their reflection or emission and so on so forth.

But in digital elevation model basically when we say it is a high resolution or final resolution digital elevation model; that means, we can see much more details of the terrain in a digital elevation model. So, higher the spatial resolution of a digital, elevation model better details we see and in contrary to this if ah spatial resolution of a DEM is coarser then those much of details we will not be seeing. But this is a relative term when we say higher or finer resolution, but today say 30 meter may be a higher resolution, but tomorrow may be 15 meter 10 meter or even 2 meters may be higher.

So, things keep changing and especially when we are using digital elevation model along with a satellite data, then sometimes we try to match the spatial resolution of satellite data as well as digital elevation model, but this is not necessarily, but it becomes convenient to address many issues related with spatial resolution. But most important thing in a digital elevation model that we talk about two types of resolutions one is a basically horizontal resolution, which we refer as a spatial resolution.

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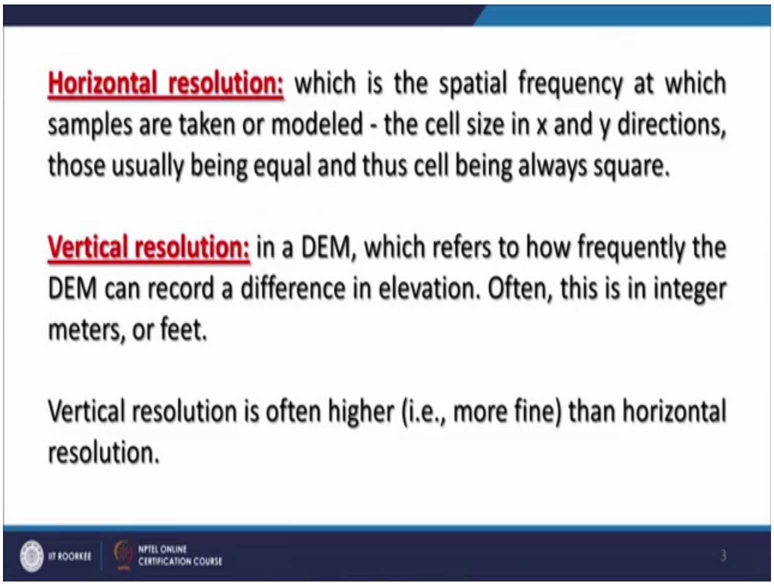

And which is the spatial frequency at which samples are taken or modeled, and though when digital elevation models are constructed, as we have seen using different techniques. The spatial resolution will depend on the input data, if these are being constructed through remote sensing data, then the spatial resolution of remote sensing data will control the spatial resolution of a DEM.

But a if a digital elevation models are being constructed using interpolation techniques, then at that at that stage we can decide what should be the spatial resolution of a target DEM, but this horizontal resolution is basically the x y and directions, in which the data is being generated or recorded for horizontal resolution that is basically spatial resolution. And as we know that this is always a square in shape whereas, there is another resolution in case of digital elevation model, which is a vertical resolution.

And that vertical resolution basically that how frequently DEM can record a difference in elevation, or in other words you can say least count, and this may be an integer value or may be a values in feet generally the elevation values are represented in meters, and a maybe even in decimal so, you may have even real numbers for vertical values.

Now it is generally it is seen or experienced that the both resolutions are not same and therefore, the z factor which plays a very important role while deriving various parameters using digital elevation models for examples slope, and aspect and other parameters, at that stage the we have to see that the that z factor equates the horizontal resolution with vertical resolution. So, it is always good to understand before we imply a particular digital elevation model these two resolutions, what is the spatial resolution that is the horizontal resolution of a digital elevation model, and what is the vertical resolution that is basically the least count. So, generally it is in meters, but you may have in even in centimeters or in decimal and so on so forth.

Generally very relatively coarser resolutions will have in meters least count may be 1 meter, but final resolutions may have in centimeters. So, the least count is relatively very small value. These are two important resolutions related with digital elevation model, and 1 has to remember these resolutions used very carefully when we derive various products using digital elevation models. Vertical resolution is generally higher as compared to or finer as compare to horizontal resolution, you may have a least count of 1 meter for vertical resolution, but you will, may be having 30 meter spatial resolution. So, that is what it is meaning here.

Now, as mentioned in the beginning that alone digital this spatial resolution alone does not determine the accuracy of a digital elevation model, or a quality of a digital elevation model, there are various other factors. So, before we go for other factors two terms which I would like to discuss here, generally many people use a them interchangeably or synonymously which is a incorrect. So, the first term in this in our (Refer Time: 07:14) or digital elevation model domain is the accuracy. And as you know that accuracy is a statically concept, which states the likely hood or probability that a particular set of measurements are within certain range of true values.

So, how what is the, we generally we say what is the accuracy, but then another terms comes this is a precision.

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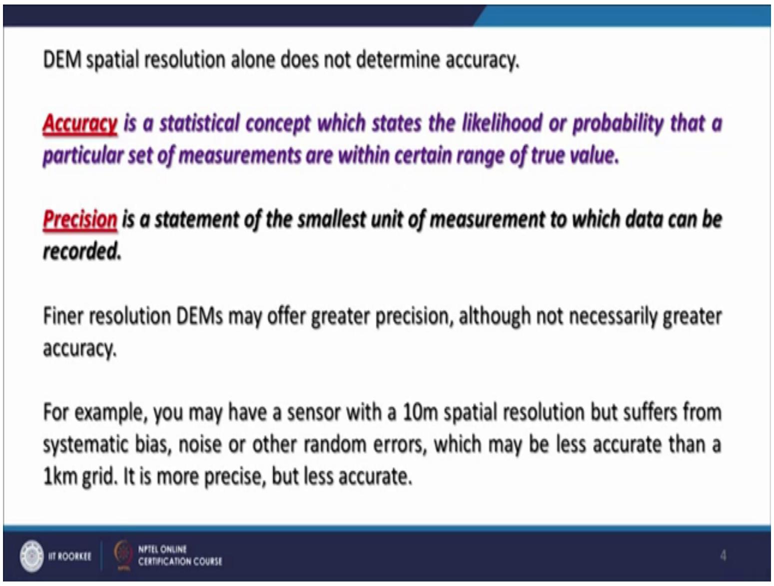

And precision is a statement of a smallest unit of measurement to which data can be recorded. So, a as said in GIS that you know that the accuracy we have to maintain, or kept at this errors, we have to keep at the minimum because error propagates in GIS while doing the processing, same thing we can say in case of digital elevation model that while doing any or deriving any derivatives we should not bring some new errors or; that means, we should not lose the accuracy, but the precision cannot be changed once the data has been generated. For example, precision in case of satellite images we can say the spatial resolution. So, that is the smallest unit of measurement.

So, if it has been recorded at 10 meter 10 meter spatial resolution, then by no means basically we can change or improve the spatial resolution of a dataset. So, the precision cannot be changed whereas, the accuracy; that means the or the other in other words, the errors can be kept at minimum so, that we maintain a high accuracy, these two terms have to be used very carefully; however, as said that sometimes people use them interchangeably.

So, finer resolution DEM or higher resolution DEMs may offer generate precision, or greater a precision, all though not necessarily greater accuracy. So, they have been recorded at a using a very high vertical or spatial resolution; that means, they might be having a better precision, but accuracy wise that means, at the time how what was the error in the datasets, how the processing has been done that will be controlled. So, overall the accuracy or quality of a digital elevation model, also depend on these 2 parameters that is accuracy and precision.

Now, for example, you may have a sensor below 10 meter spatial resolution, but suffers from systematic errors noise, or random errors, which may be less accurate, then 1 kilometer grade and its more precise, but less accurate. So, this keeps happening so, 1 once the data is with us for further processing for to derive various products out of a digital elevation model. All these things should be assessed there is a one term which we use as meta data that is the information about the data, or also we call data about data.

So, once if you have downloaded a digital elevation model, may be a free digital elevation models, a SRTM or global DEM, then one must look through the meta data. And meta data will give you lot of information including the information about a spatial horizontal resolution, and vertical resolution and a also it will give you about the accuracy and precision. So, these values will help us while using such products, and making and using them to derive some other by products for them.

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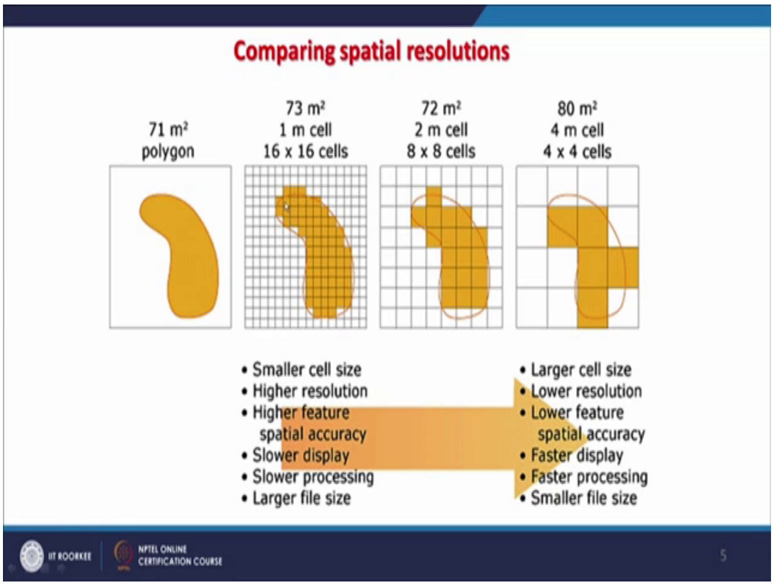

Now, just a comparing different spatial resolutions what we can see here, that when we represent a, you know this area is having 71 square meter, and there is a polygon. So, two different types of units are here, but when we overly agreed of 16 by 16 cells, and the cell 1 get cell size of this grid is 1 meter, the overall area which we are getting is 73 square meter of the only of this shaded part or this a yellow colored, and a what we are actual polygon area is 71 square meter, but a at this resolution we are getting higher area for the same polygon, because of coarser spatial resolution.

But when we go for further coarser resolution we may reduce in this particular case it has reduced to 72 square meter, this is a 2 meter cell 8 by 8 cells grid is there whereas, if we go for 4 by 4 cell; that means, more coarser resolution 4 meter cell 4 meter spatial resolution, and what we are seeing we are getting 80 square meter area, because lot of area of this polygon is not falling, but when we are creating a raster of this one, then we may get a higher area.

So, the spatial resolution (Refer Time: 12:40) can create a wrong areas for different polygons or different areas within a dataset. So, what we can mention in net cell that a smaller cell size is a can bring more close results generally that is a or versus larger cell size, higher resolution versus, lower resolutions higher features that the spatial accuracy, and a lower features that is also spatial accuracy, lower display faster display if a it is a coarser resolution, it will bring faster display slower processing in case of high resolution in case of lower resolution coarse resolution it would be a faster processing larger file size, because of high spatial resolution in case of coarser spatial resolution you would have a smaller file size.

But generally only at the time of in at the time of interpolation we can control spatial resolution, but a spatial resolution if a the digital elevation model have come through remote sensing data, then probably we can note at that stage control the spatial resolution we have to depend on the spatial resolution of the satellite data itself.

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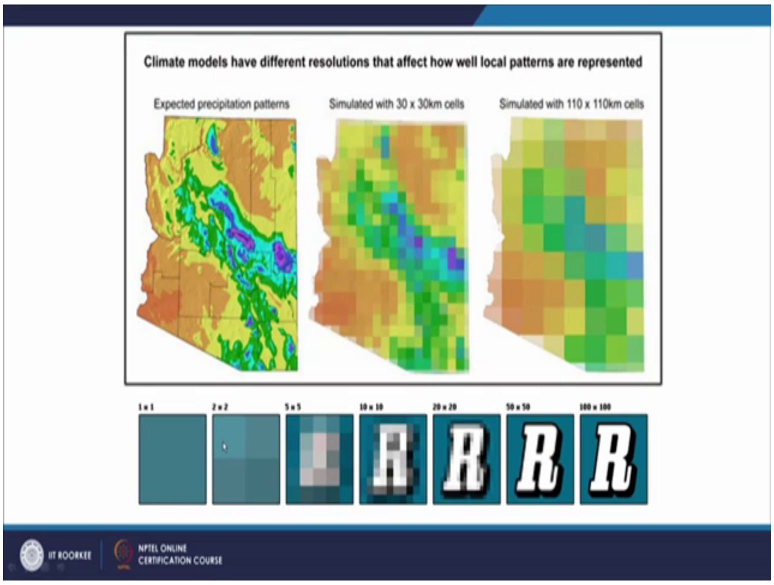

One more example of a how different spatial resolutions will bring the terrain or the area completely differently. So, if we take the right most image first, what we see is a spatial resolution is 110 kilometer. So, each cell is representing 110 by 110 kilometer area.

For a climate models sometimes we may use this, because 110 may become roughly a 1 degree one degree cell, and then if we go for 30, 30 kilometer by 30 kilometer cells, then here what we are seeing that lot of other you know different effects of climate change, or models can be seen much better than relatively coarser resolution, but when we compare this precipitation pattern at very high resolution, then this is how it looks.

So, the original one is deriving from satellite images, now it is lowered resolution at 30 kilometer by 30 kilometer, and then here it is much more simulated here is 110 by 110 kilometer. Why we play with digital with spatial resolution, because sometimes we have to generalize the data, or reduce the data. So, that it fits with our other datasets, because when you are handling such data say on a GIS platform one dataset may be having 10 meter resolution one dataset if it is having 10 kilometer resolution, then it is not good for any kind of analysis.

So, we try to bring sometimes a resolution close to that and then probably, we may deteriorate as per our requirements, modeling requirements, or the spatial model which we are using that may require that the grid side should not be more that this and each cell should be of this size. So, sometime we try to deteriorate the spatial resolution of a DEM or any other dataset, and that time one has to really remember that what kind of losses you will bring or what kind of errors you will bring in to the data, the accuracy part basically.

One more example is here that if a if this character R has to be represented, this is represented by in a in this case a say 100 columns, and 100 rows whereas, if we see 1 row by and one column; that means, single pixel our single cell we do not see anything about this character, but when we move 2 by 2, then we start seeing something, but; obviously, no sense can be made out of this 5 by 5 still not possible when 10 by 10 some character is appearing, but it is confusing whether it is A or R.

But as soon as we go for higher then 10 by 10 say in this example 20 by 20, then the shape of r starts appearing, but still there is a doubt whether it is A or R, but once we go for much more higher resolution, then we get a clear picture about R and when 100 by 100, then it becomes further sharper what does it mean basically that for every type of phenomena, there has to be a up to a certain resolution if we go lower resolution or a for objects we may get a outline, but still there might be a confusion.

So, we need to have a optimum resolution for certain type of processing, where very object becomes very clear. So, in case this is more common in case of satellite images, but still in case of a digital elevation model these things have to be taken care, one more example of a different spatial resolution, and derived from different sources, and of the same area.

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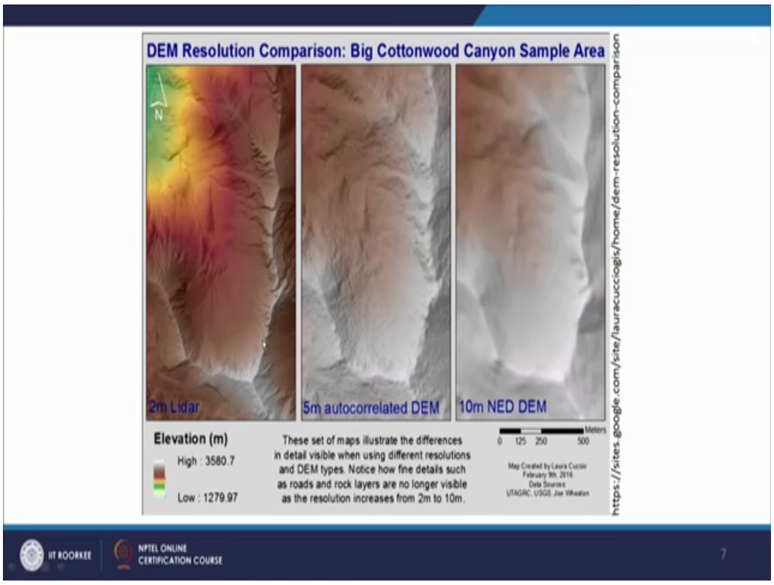

So, on the right side what we are seeing a 10 meter digital elevation model of national elevation data of USA, and this is big cotton wood canyon sample area, and as you can see that it is relatively coarser resolution and therefore, that much details about the terrain are not visible.

If we compare this with two meter spatial resolution of the same area, but derived from ladar lidar technique, and which has produced a very high spatial resolutions digital elevation model, and much more details about the terrain can be seen. In between we are having a 5 meter a spatial resolution DEM, which is a giving much more details as compared to 10 meter resolution, but definitely it is giving less details as compared to 2 meter resolution

Now, it is a not always possible to go for higher and higher spatial resolution, there has to be some limit, and generally when we are covering a large area and a one more you know discussion will come in this lecture about the scale. So, when we are going for you know a small scale; that means, covering going to cover a large area, then generally we do not go for very high spatial resolution and digital elevation model, but when we are covering a very small area; that means, on larger scale then definitely at that stage we require a very high spatial resolutions DEM.

So, different spatial resolution DEMs can serve for different applications that one has to because for a very large area. If we go for very high spatial resolution it would be too much data handling and our results may not or the target or model may not require that kind of details about the terrain or elevation. So, it put me a redundant process if we go for very high resolution digital elevation model.

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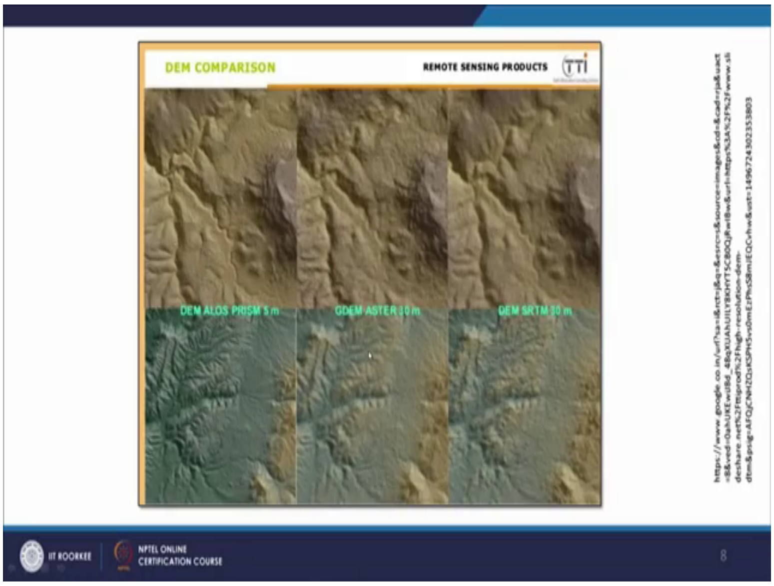

There are some other examples derived of digital elevation models derived from different sources, the that first 2 on the on the left side DEM ALOS, and this is present 5 meter resolution, of the same area at 30 meter resolution with a but this is GDEM, aster GDEM, global DEM, and then SRTM 30 meter again.

So, when we compare this 30 meter though this resolution wise same, but the techniques are completely resolutions. As you know that aster GDEM have been or a this DEM for global DEM has been derived using stereo pair data, from optical remote sensing data, and for a hilly terrain we are seeing quite a nice or sharp you know a digital elevation model same time also with SRTM, which is based on insar or radar remote sensing technique is also giving equally good digital elevation model. But if we go for ALOS prism 5 meter spatial resolutions, since the resolution spatial resolutions has improved significantly therefore, we are seeing much more details about the terrain of a of a hilly terrain.

So this is a important, but as per the requirements we should opt for different spatial resolutions.

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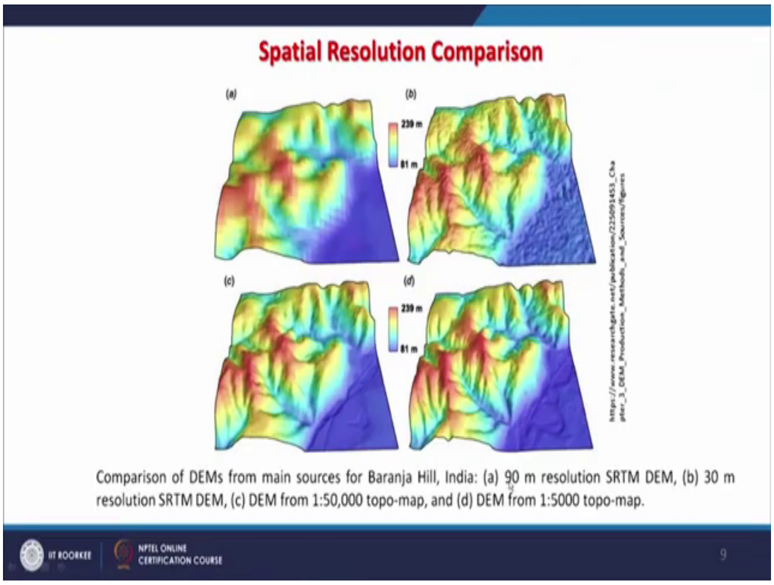

One more example is here that we are comparing of a Banjara Hill, India at a 90 meter resolutions on top left, then we are having a 30 meter resolution top right, and you can compare that huge difference between 90 meter 30 meter it is a 3 d perspective view then c is the DEM which has been derived using survey of India toposheets of 50000 scale, at this stage you can you can control the spatial resolution.

So, this must have been kept at around 60 meter or 90 meter, and then 5000 scale toposheets because the scale is a much improved its a larger scale toposheets, you are getting much more detail may be even at same spatial resolution. So, these bottoms 2 are a really bringing two different a outputs based on two different scale toposheets. So, that stage the scale also the input data scale also matters, this is what it is being reflected here. Now here in case of satellite images we see as a pixel.

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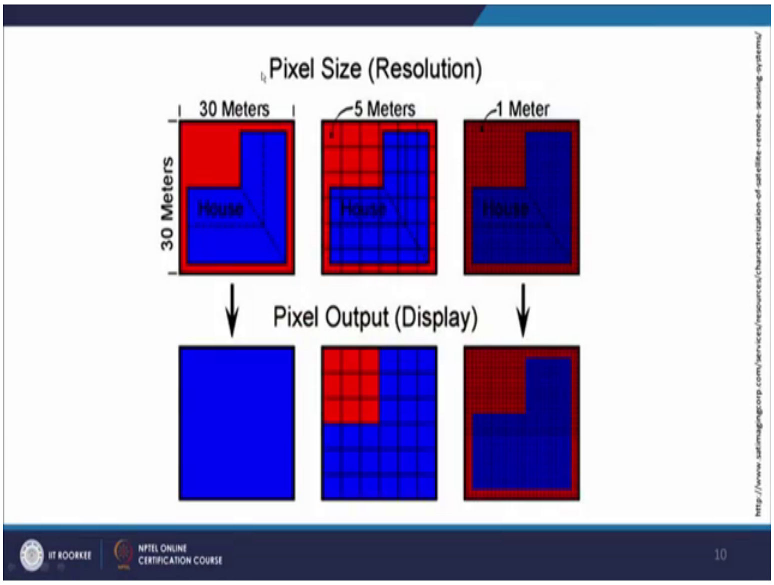

But in case of a digital elevation model or grid, or raster, or a grid we say is a cell. So, it is a same thing here in that sense that here, we are saying pixel but if I take this example for digital elevation model, then it becomes cell size. The example here this is illustrate that if I am having a situation something like this, that in between there is a house and rest of the area is a blank.

But at 30 meter resolution I am getting a completely blue area, I am not getting any detail about this red area, but at 5 meter resolutions when I go for a grid like this at 5 meter grid, then I am getting an area about one fourth area is a getting this red, and three fourth is getting blue. And whereas, if I go for one meter resolution relatively compared to 330 meter it is much higher resolution. So, now I see the blue areas and red areas very clearly.

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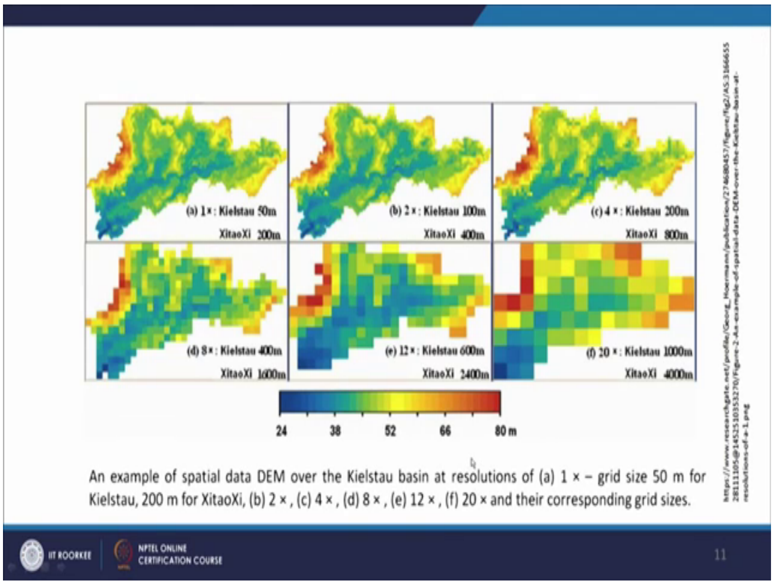

Similarly here also that different scenarios; have been presented here, and this digital elevation model of a Kielstau basin at different resolutions, and what we see the details what we require. So, basically if you are having a very high spatial resolution digital elevation model. You can deteriorate the spatial resolution you can still make the coarser, a spatial resolution by doing the resampling of the dataset.

So, that it fits with other datasets or ah and becomes a suitable for a model may be a climate change model or some other models, but if I am having the data at a relatively a very coarse resolution say you know 10 meter resolution, say 10 kilometer resolution, and if I want to improve the resolution then it is not possible.

So one way; that means, the deterioration going for from finer spatial resolutions to coarser resolution is possible, but going for coarser to finer though in computer you can always do it, but it will not improve the quality of a digital elevation model; that means, it will not bring the details of terrain in a even a resolution has improved, but original input mass at a coarser resolutions.

So, the generally this is one way process, and this is what exactly it has been shown that twenty meter 200 meter, 400 meter, 800 meter, 1600, 24 and 24000 meter, then this is how you start seeing the deterioration of the details, once we go for relatively a coarser resolution.

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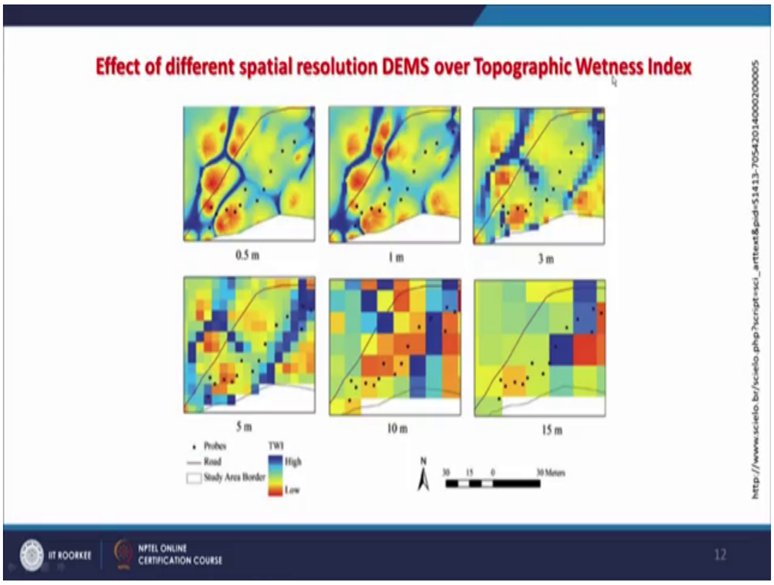

Now what are the effects of different spatial resolutions of DEM over topographic wetness index which is one of the products which, we will be discussing in subsequent lectures?

So, this is one product which we can derive using digital elevation models, and what happens if we use different spatial resolutions. So, three examples are given at 0.5 meter; that means, 500 centimeter 1 meter and 3 meter at 0.5 meter, what we are seeing that a this the topographic wetness index is appearing completely different, then at a 1 meter or at a 3 meter. So, point sorry 0.5 meter, 1 meter, 3 meter, 5 meter, 10 meter, and 15 meter, and in every product this TWI is appearing completely differently.

So, definitely at very high resolution relatively here, 0.5 meter it appears very nicely, but a if I compare with 0.5 to 15 meter, there is a huge difference between this data, and it has been compared with the proves which are located here, as a black dots as one can see here. So, the spatial resolution of a digital elevation model will affect almost all derivatives, which we will be deriving through a digital elevation model all products it will depend, but as per the requirements. If a choice is there, then we have to choose an appropriate resolution of a digital elevation model. So, that we get the, a quite accurate products out of a digital elevation model, and in this process we should not introduce any errors in our products.

So, that is the situation here with different spatial resolution DEMs over topographic one of the examples, he is given here if we because a, we can also use a digital elevation models, along with the surface hydrologic modeling on a GIS platform and can derive the drainage network. So, one products which is topographic wetness index as we have discussed at different spatial resolution the results would be entirely different, but if the same time. If we go for deriving drainage network based on surface hydrologic modeling where input is a digital elevation model, again if that is same exercise is done at different spatial resolution this is what we see here.

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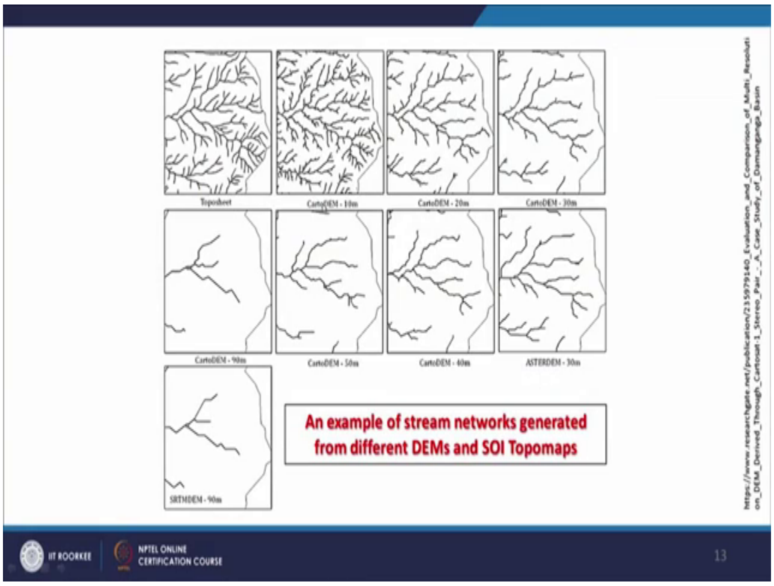

That a actually in a toposheet its a survey of India toposheet at 5000 scale drainage is visible like this, but when we derive a digital drainage network using a cartosat DEM of 10 meter resolution, this is what we are getting much more detailed drainage as compared to what is shown on a 5000 toposheet, but when we go for 20 meter spatial resolution carto DEM. Now these details about the drainage have reduced, we go lower or a coarser spatial resolution, and we start seeing less and less details of drainage 90 meter again this example is a 50 meter, 40 meter, 30 meter.

So, at different and this is again a ninety meter, but this is SRTM so, this is aster DEM at 30 meter. Now you can compare cartos, carto DEM 30 meter, SRTM 30 meter, and a these 2 can be compared very easily and whereas, the outputs are coming completely differently though the processing may be the same, that mean the surface hydrologic modeling has been applied on different DEMs in a similar manner, but the output you get completely different.

So, higher spatial resolution DEMs might bring more detailed drainage network as compared to relatively coarser spatial resolution DEM, as shown in these two examples of 90 meter resolution, but one thing one has remember well when we derive drainage network using a particular digital elevation model in surface hydrologic modeling, we can also constrained by number of cells which will be incorporated to derive a drainage line.

So, if we choose a smaller threshold we are bound to have more drainage than choosing a large value for example, if I choose if 100 cells; that means, a if and in a and contribute new area is more is 100 or more then 100, then there will be a drainage network which will be derived. So, up to 100 cells drainage network can be derived, but if I choose a threshold at 500, then coarser or less detailed drainage network will be derived.

So, while doing this comparison or comparative study one has to keep this threshold at constant, then only you would be able to see these kind of result, but if we keep changing this threshold value, then we will not get the accurate results in that sense. So, that drainage density also depends what the threshold we choose while doing this surface hydrologic modeling using a particular digital elevation model.

So, a if a one more topic which comes here is now that we will be seeing about the scale because, here once or twice we have already a brought this discussion say here toposheet of 5000 scale.

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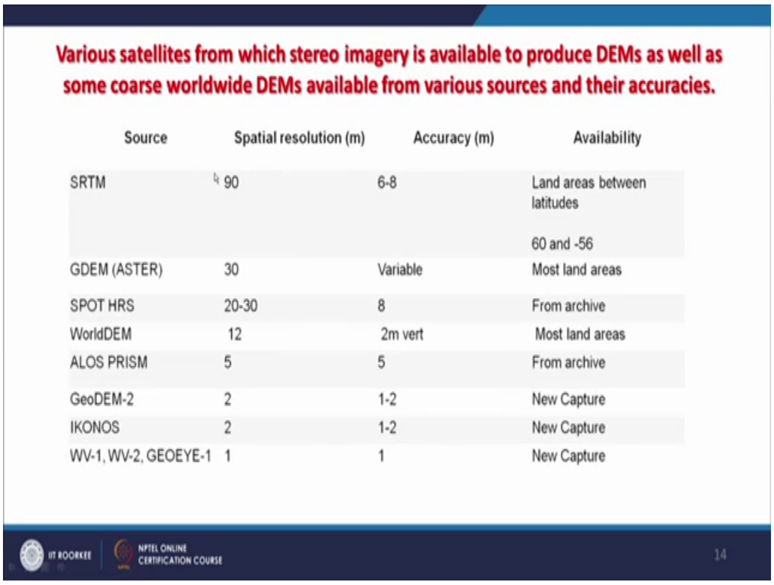

But before we go for directly towards the scale there is a some comparison between different digital elevation models, and there most of these are free digital elevation models, their spatial resolutions, their accuracies, and a which has been collected through meta data, and then their availability is also there.

So, first we go for SRTM one of the very first free digital elevation models, initially it was available at 90 meter. Now it is also available at 30 meter, and the accuracy was about 6 to 8 meters, and when we say this accuracy here this is we are talking only about the horizontal accuracy GDEM which is global DEM aster, derived from a stereo data of 30 meters resolution this varies, because for hilly region it is different for plane areas it is different. And same is with a spot hrs and though the readymade digital elevation models are not available, but if we derive digital elevation models using say 20 meter 30 meter resolution data we can achieve of about 8 meter accuracy.

Then world DEM ALOS prism can provide a very high spatial resolution relatively. So, far and very high accuracy as well, then GeoDEM to IKONOS, IKONOS provides the data at 1 meter resolution, you can have resolution at 1 meter, or 2 meter and you will have accuracy of 1 meter 2 meter and so on. Most of these data are many of such datas are available on internet which can be downloaded few are also getting added here in the list.

Now, as we have discussed that the spatial resolution is the key characteristics of a DEM.

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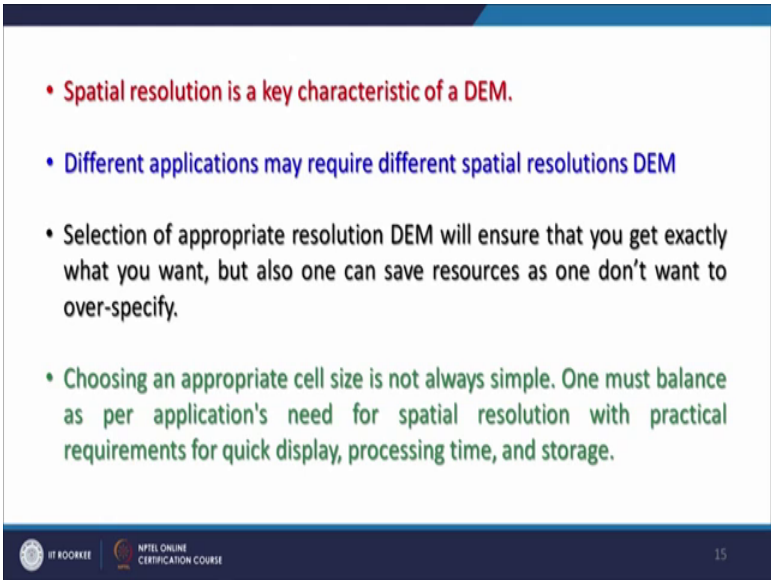

And different applications may require different spatial resolution, and DEM which we have also discussed. So, depending on if one is working on a climate change model or in a hydrological model, which is covering a very large area. Then perhaps you may not require a very high spatial resolution DEM, but if somebody's working in a very small area, then definitely one should go for as far as the highest available spatial resolution DEM.

Selection of a appropriate resolution DEM will ensure that what that you get exactly what you want, but also one can save resources at ones do not want to over specify; that means, that you know though area is a very large, though you do not require a very high spatial resolution DEM, but unnecessarily you are handling a high spatial resolution DEM, and at later stage you might deteriorate the spatial resolution to fit with other datasets of the model and therefore, that is redundancy is present.

And choosing an appropriate cell size is not always simple, and this choice becomes you know this question may be raise that what does spatial resolution I do not know anything about my area, I do not know much about what I am going to do with this. So, what spatial resolution I should start because a, choices are becoming wide. Now and therefore, this question may become little larger.

So, the best thing is one has to see what are my targets, what for what I am going to use digital elevation model. And accordingly one should go for that particular spatial resolution and these are the factors which should be considered while spatial resolution of a DEM.

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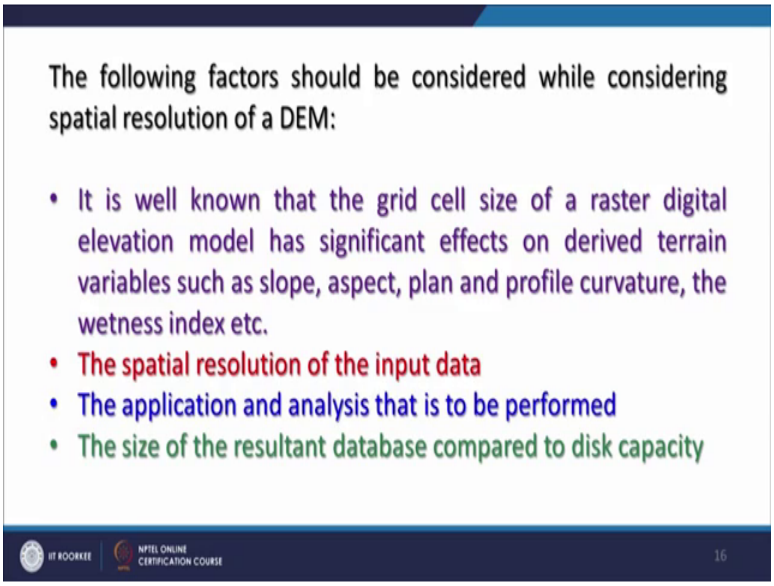

A can be decided that well known that the it is well known that the grid cell size of a raster grid elevation model, has significant effects on derive terrain variables, because these variables will depend on what is the spatial resolution, and examples are given here like slope aspect plan, or profile curvature wetness index drainagement network, and many parameters which we derive from a digital elevation model.

So, choosing an appropriate spatial resolution DEM is very very important, that is for the input data and the application analysis that can be performed using such digital elevation, and the size of the resultant database compared to discs capacity because, we may be using a high spatial resolution may not be required an unnecessarily we may be occupying a large space on the hard disk. So, that is the redundancy, if it is not required one should not go for high spatial resolution unnecessarily. And a also one should not think the desired response time processing time and other issues as well.

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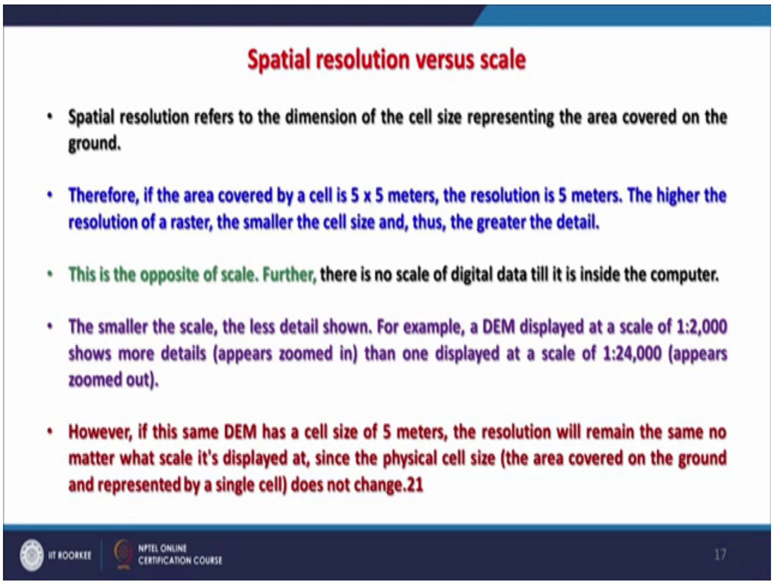

So, spatial resolution versus scale now, that spatial resolution refers to the dimensions of the cell size representing the area covered on the ground which we know now. And therefore, if the area covered by a cell for example, by 5 by 5 meters, the spatial resolution we call as 5 meters higher spatial resolution of a raster the smallest the cell size, and thus greater details are there, but the same time it will occupy a large space on a hard disk, 1 and same time it will require more processing time.

So, if you are handling a very large area at very high resolution, you know that what kind of problems one is going to face while doing the processing of such dataset. And this is the opposite of a scale that, but before that there is a statement which is very very important to understand here is that a as long as the data inside a computer on a hard disk there is no scale; that means, the digital data does not have any scale the scale is frozen, or fixed ones it is displayed or printed on this 1.

So, one has to remember that a scale is not directly dependent on a spatial resolution. So, digital data do not have a for example, a satellite image that image may be representing an area of 100 kilometer by 100 kilometer same may be given example for a digital elevation model. So, that may be representing a 100 kilo meter by 100 kilometer area. So, now that digital elevation model I can print on a A4 size or I can print on A3, A2 size or A3 size. So, now when I print the same area on A3 size, I am improving the basically I am printing on a larger scale, but this spatial resolution is frozen there. So a, the scale has changed, when I have printed, but as long as when inside the system, then there is no scale only in spatial resolution is controlling everything.

So, one has to remember that scale is fixed or frozen once the data is displayed or printed, but if it is as long as it in the digital form on side a computer, then there is no scale the spatial resolution is more important. This is the major difference between while handling the digital data. So, a smaller the scale less detail it will show for example, a DEM displayed at 1 raise to 200 scale, then shows more details appears zoomed in then displayed on 1 raise to 24000 scale. And similarly if a this DEM has a cell size of 5 meters, then the resolution will remain same no matter what a scale it is displayed.

So, you may change the scale, but also as mentioned earlier that the resolution will not go is not going to be changed when you display or print it. So, that is a is very very important here. So, this brings to the end of this discussion about a spatial resolution, vertical resolution, and horizontal resolution of a digital elevation model. And 2 other parameters, which we consider while, assessing the quality of a digital elevation model that is the precision, and accuracy, and then resolution versus scale, and remember that finally, that digital data do not have a scale till they are in the system, once you print them or display them then the scale is fixed or frozen.

Thank you very much.