Digital Elevation Models and Applications

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Lecture - 20
DEMs Sources, Limitations and Future of Digital Elevation Models

Hello everyone and welcome to the last lecture of digital elevation models and applications as we know that every good thing has to end. So, this course is also the now at the last step or last discussion, and in this one we are going to discuss 2-3 things together and quite a brief manner. And one is the different DEM sources and from where we can get the different digital elevation models of different spatial resolutions. So, I will be discussing one by one those known sources of digital elevation models and also we will be discussing some limitations of a digital elevation models after all nothing is universal. So, everything has got the limitation. So, digital elevation models and especially the digital elevation model which are freely available at a global scale.

So, that we will be also discussing, and also we will throw some light about the future of digital elevation models, in which direction this development of digital elevation models and its derivative is going. So, all mean three these the three things we are going to discuss briefly in this discussion. So, let us start first with thespatial resolution and then we will progress accordingly as per requirements. So, as we know that nowadays for an any analysis which involves the terrain at digital elevation model has become virtually necessary or indispensable for such analysis.

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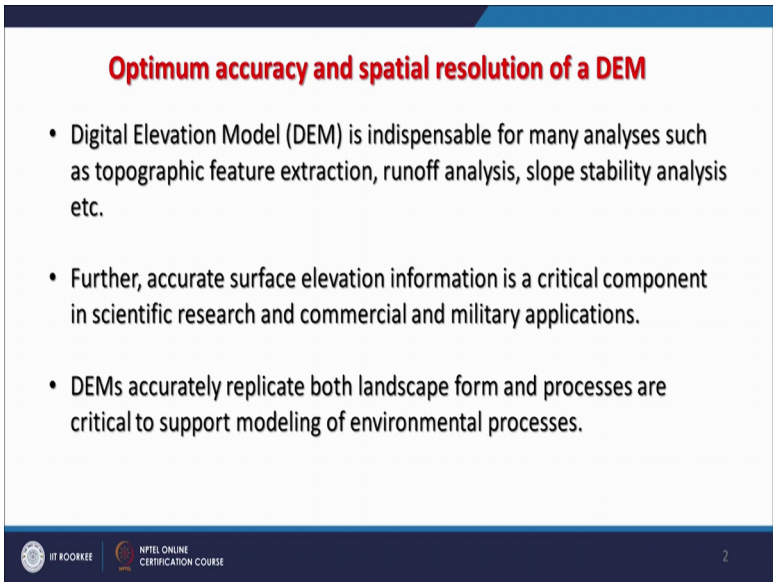

Where topography is involved terrain is involved it maybe topographic feature extraction maybe slope aspect ordinary network derivations maybe run off analysis, maybe for flood analysis, maybe for slope stability analysis, soil erosion analysis even for sighting of a tower or a building or a mobile tower, we need a digital elevation model.

So, these are indispensable nowadays that and same time lot of availability of digital elevation model is also there. So, that is playing very important role. But the same time we are also always looking for accurate digital elevation model or representation especially for the scientific research and sometimes for commercial or hazard related things, and the military applications alvo also sometimes looks for very accurate representation of digital surface through a digital elevation model. So, those requirements are also there and DEM you know that accurately to some extent replicate the landscape form and processes which are critical to support modelling of environmental processes. So, almost in various applications these DEMs are playing very important role. Now there is there can be always be a discussion.

at the end of this lecture we will have a also little more discussion on what is basically the optimum resolution and optimum accuracy which is expected from a digital elevation model. As time is progressing we are in going towards better accuracy as well as improved or higher spatial resolution. So, this higher or coarser spatial resolution is always a relative term, when we had enough one kilometre spatial resolution DEM for

entire globe, we developed variable we used such a digital elevation model in various applications, then came 90 metre, that became the higher spatial resolution then came 30 metre. So, then that became that became the highest spatial resolution.

Now people are talking about 50 centimetre spatial resolution DEM at globe scale for entire globe. So, that kind of discussion will go on, but basically we have to see what are our requirements for which or which kind of projects, which kind of applications or which kind of hazard I am going to use such at terrain information. So, that is going to be a more important than this, but as we know that for infrastructure network planning conducting a military interventions in unknown terrain or analyzing terrain features for a while and gas exploration, precise reliable elevation data or a space digital elevation model can bring these analysis highly reliable.

. So, everyone is definitely looking for accurate as well as high spatial resolution. Spatial accuracy also depends on spatial resolution that we will discuss little later.

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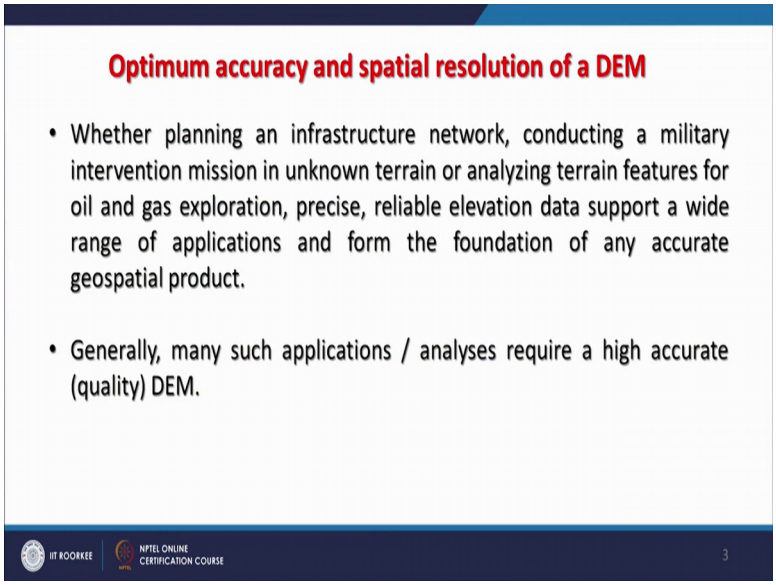

Generally many such applications analysis require a high accurate quality.

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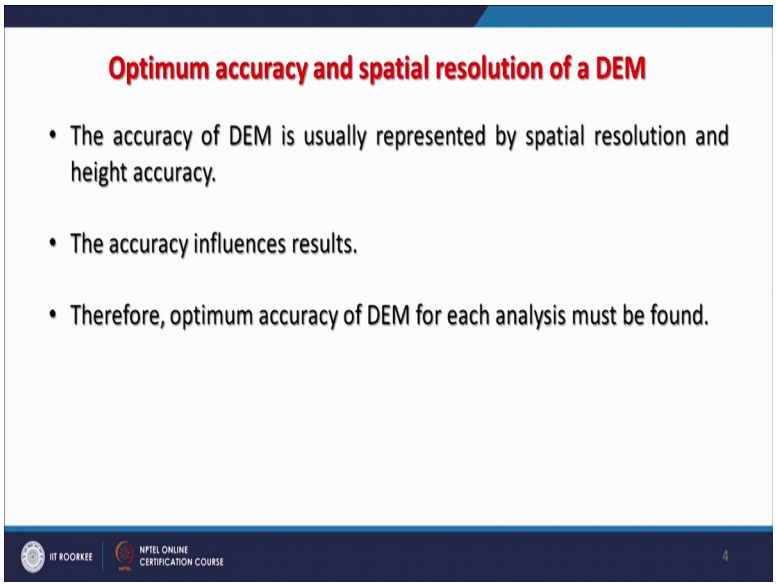

And DEM and accuracy of DEM is usually represented by spatial resolution not depending on spatial resolution and height accuracy. Because height accuracy has been an issue with the earlier digital elevation models and if they are having a accuracy of 5 metre or 10 metre plus minus 10 metre then at that time it was considered completely unreliable, but now accuracy is has improved this height or vertical accuracy is improving coming within one metre in this global scale digital elevation model and of course, spatial resolution is also improving. So, this accuracy part is definitely improving.

The because the accuracy if the input DEM is not accurate then; obviously, the results are also not going to be highly reliable. So, before we put digital elevation model of a certain area for a very serious applications maybe military or some hazard related thing or some commercial or scientific, it is always better to analyze the quality of a digital elevation model and quality includes the accuracy part as well. This discussion we had earlier that if we are having this height information from some other sources, independent of digital elevation model and then we can compare with that randomly distributed points of observations with the cells available in the digital elevation models, then we can we can then we can know or assess that how accurately digital elevation model, which I am going to use in that particular analysis.

So, this is always required for very serious applications, that one should first assess the quality of digital elevation model no matter from whatever the source it has come to for the analysis this optimum accuracy of DEM for each analysis must be found that can be determined based on what are our requirements. If requirements if our project requires a precise outputs, then we have to for a highly accurate digital elevation model. If it is a small area sometimes this can be also generated using field investigation first and then, digital elevation models generations and then applications of that. Now these are the sources of the very popular free digital elevation model that is available.

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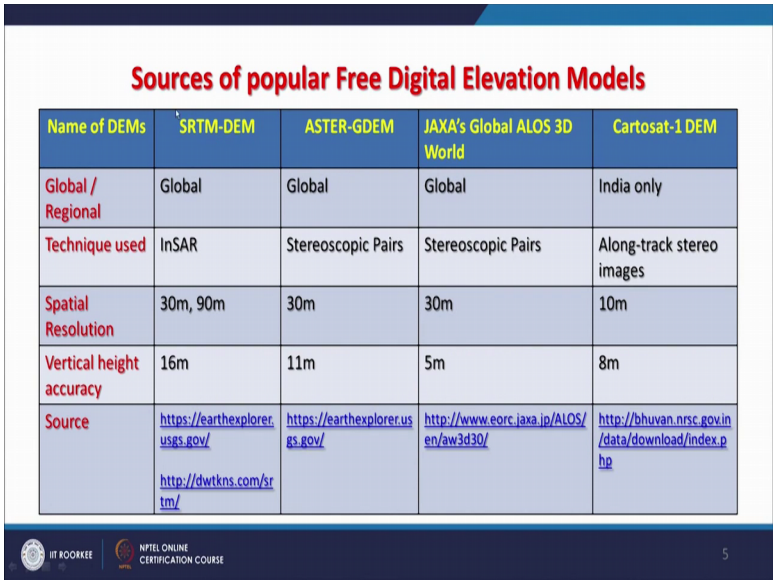

I will go one by one through different characteristics of digital elevation models. like this is a SRTM-DEM that is shuttle radar topography mission digital elevation model. Of course, it is global about eighty pe 85 or 90 percent of the globe has been covered, and the resolution earlier it was available for 30 metre now it is also available. Earlier it was available for 90 metre now it is available for 30 metre the technique which was used to generate this said SRTM-DEM was inSAR sarinterferometric technique vertical height accuracy as you can see was relatively poor as compared to said Cartosat-1 DEM, giving 8 metre or JAXAs Global Alos 3D world DEM which is giving 5 metre.

So, compared to that is relatively poor these are the sites from where one can download these digital elevation models generated through this SRTM-DEM. Now these most of now these sites are bring have already processed the data and they have removed the

voids, which was a big problem as also we have discussed during this course the issues of voids in the inSAR data now the data which I am or the size which are shown here most of these sites are providing data which is completely void free. If we go for Aster-GDEM which has been generated using a different technique instead of inSAR this is based on stereoscopic pairs or stereo pairs data using optical data.

It is also global digital elevation model, this has been generated at 30 metre resolution and there is a little improvement in the vertically accuracy instead of 16 metre. Now it is having 11 metre and this can be downloaded from this earth explorer site of usgs and then we are having a this is a not as that popular as sSRTM or Aster-GDEM, but it is now becoming prime popular because of this vertical accuracy part this is also global the JAXAs which is Japanese agency space agency alos with their views the alos the 3D alos data generated using the stereoscopic pairs the same technique has been used as in case of aster spatial resolution that is 30 metre, but vertical resolution what height is this is 5 metre much improved accuracy is here and therefore, it is becoming very popular nowadays.

It can be downloaded from this site and then our own Indian digital elevation model mainly available for India and not all parts of India, but many many parts of India and in few years' time hopefully for entire India this would be available. The best part here with the Cartosat that it provides the spatial resolution at 10 metre, vertical accuracy is also quite good around 8 metre and this is little different stereo period techniques and have been used this is along track stereo images which is a new invention was done when this Cartosat was designed instead of side looking it is along track. So, two cameras one was looking forward one was looking in a downward orbit, but and likewise stereo images is generated and then these have been processed to generate digital elevation model at 10 metre spatial resolution with 8 metre accuracy this can be downloaded through bhuvan which is a sort of equivalent of Google earth.

So, four types of a digital elevation models are available for India three for global and one only for India.

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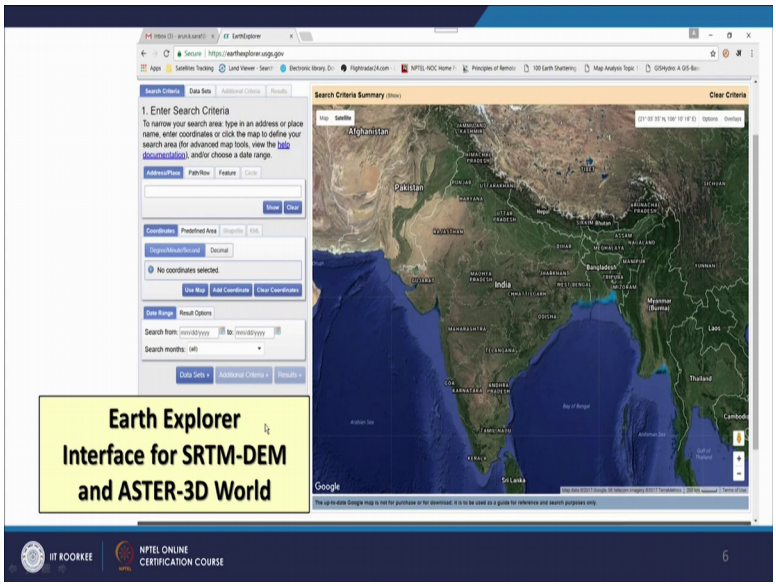

One by one I will take these sites also which I have just mentioned in the previous table this is the earth explorer site. So, when can choose this is completely interactive, and one can choose the type of data which one would like to download, search the area of interest and then you get the links and which you can later on download.

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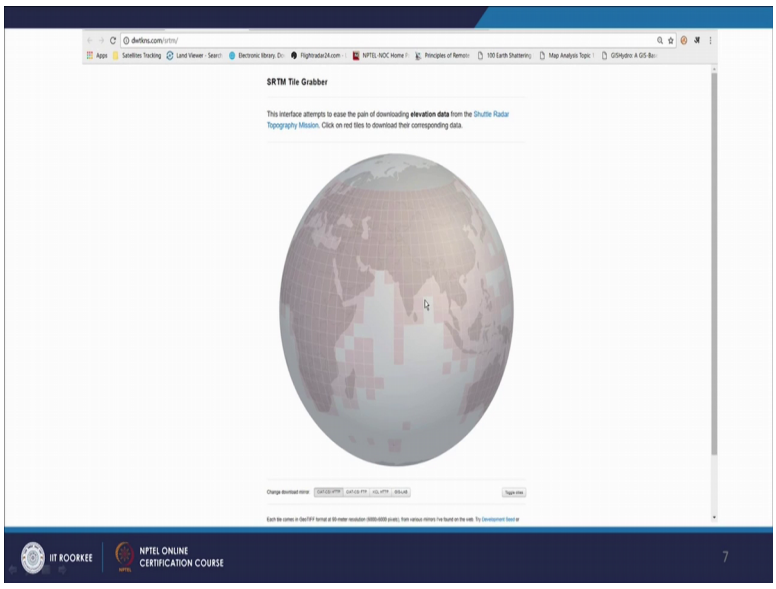

So, this is earth explorer interface for SRTM-DEM and ASTER-3D world which is which is also can be downloaded. Now this is spatially SRTM tile Grabber. So, large tiles of SRTM 30 meter resolution can be downloaded from this site which is SRTM tile

grabber and this is well processed data all voids have been remove large tiles are available.

So, this makes things little simpler compared to the other sites and this can be accessed from there then we are having.

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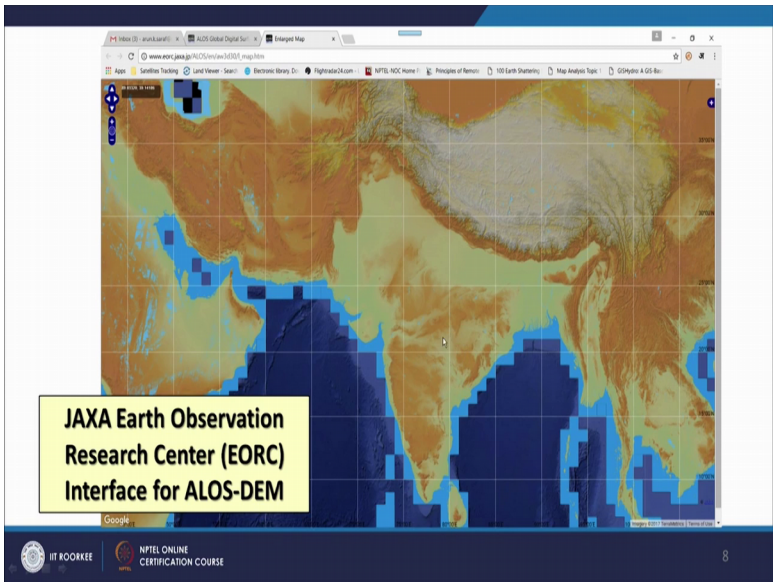

Another site of the JAXA that is Japanese agencies of Alos DEM and that can be again large tiles are available. So, those tiles can be downloaded for any part of the globe because this is a global. So, this is just JAXA earth observation research centre eorc interface for ALOS-DEM.

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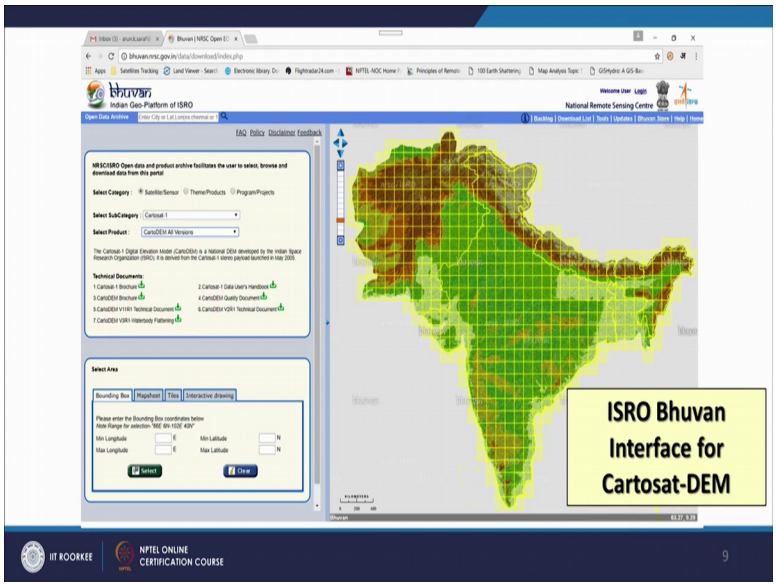

This is the bhuvan interface and here also the grade will be there as in other sites and you select the grid, and then link is available you download the DEM of Cartosat. So, high resolution digital elevation model for almost a large part of India are available for downloading and because of it provides better spatial resolution relatively better spatial resolution and also higher vertical accuracy.

Therefore, for Indian studies of Indian areas and this is can be used extensively.

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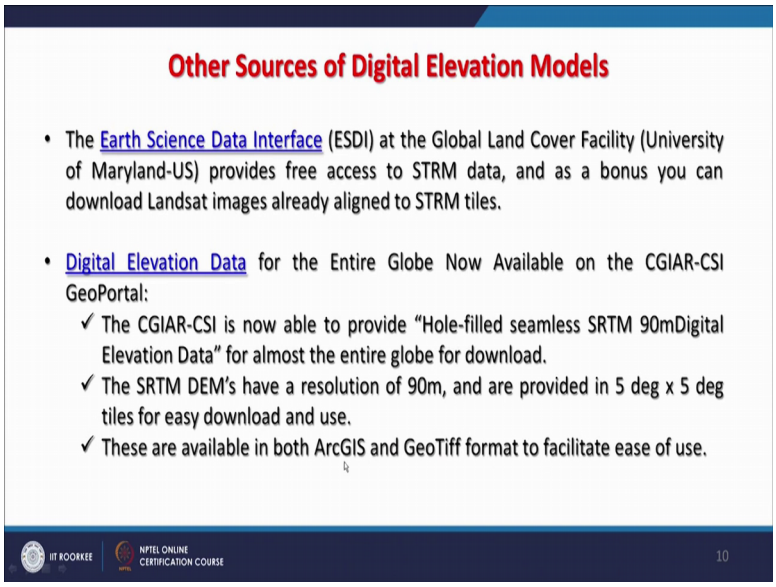

Now, other sources there are some other sources of a digital elevation models also exist like a ESDI us maybe the data is same, but the sites are different. So, there interfaces are different, the way they allow you to download is also different somewhere like this way and this ESDI I like personally I like this site, because the interface is quite good and very interactive and as per my requirements it can give immediately the number of tiles which tiles I have to download. So, that is available there is another digital elevation data.

CEIAR-CSI GeoPortal which also provides the global data and this is void filled SRTM data is available for entire globe, then 90 metre at 5 degree by 5 degree tile then also 30 metre by 1 degree 1 degree tiles.

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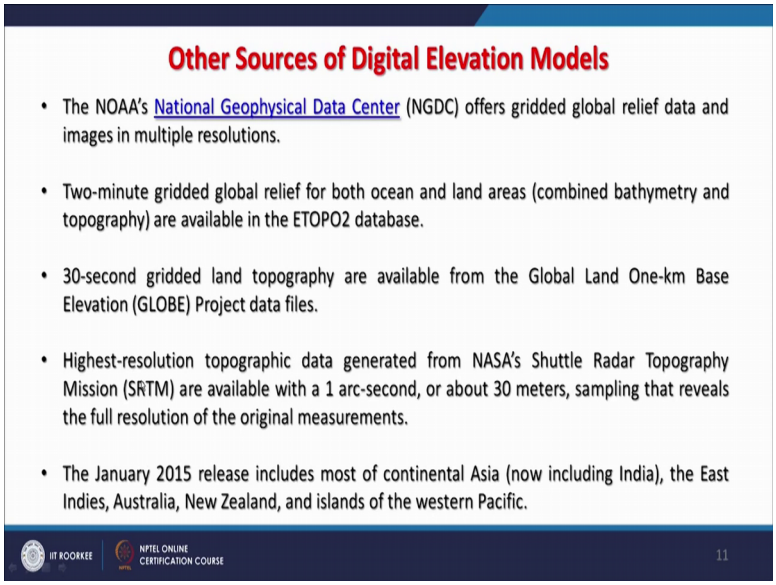

There are some other sources like this national geophysical data centre NGDC of US which is again digital elevation models of multiple resolutions can be downloaded and of course, the earlier the topography based the ETOPO2 database is also available for downloading 30 arc 30 sec arc seconds thirty seconds gridded land topography data is also available that is one kilometre then you are having one arc second that is 30 metre is also available SRTM. So, many sides are now becoming sort of depositories of digital elevation models of different organisations which have been generated using different techniques. So, that is one of the advantages that you just a if you forget about this sites

the best way is to just type in say in Google digital elevation model free download, and you will get almost all these links one after another.

So, whichever the interface you like whatever the requirement of your work, at the spatial resolution other things you can just go learn little bit about that interface. Maybe sometimes you have to create a login username id and password, and then after that you are allowed to download it. So, all free all resolutions whichever I have discussed all are free freely download available digital elevation models of almost all part of the world except for Cartosat which is available for India only. Now we will discuss little bit about limitations of digital elevation models, as mentioned earlier in the beginning of this discussion that no tool or no technique is in universal or perfect, everything has got the limitation. So, does digital elevation models.

And the biggest limitations or discussion point always has been with digital elevation model is spatial resolution. As they also indicated that when we had one kilometre spatial resolution still that was useful. Some people when they are working at global scale for climate change other things they may not like to have a 30 metre or a 10 metre spatial resolution digital elevation model because of the use handling or extensive handling of a digital elevation model. So, they might prefer even one kilometre digital elevation model initially, and later on for very small original studies, but may go for higher spatial resolution.

So, spatial resolution basically it is always thought in relative terms, and I always considered as per requirements. If a requirements if I am going to cover entire area then 10 metrespatial resolution may not be advisable depending on again the application if I am working for a flood related studies then I might require a high spatial resolution. But if I am working for you know some vegetation related thing or some other phenomena like drought and other things I may not require that kind of spatial resolution. So, spatial resolution is always considered in relative terms as well as per requirements.

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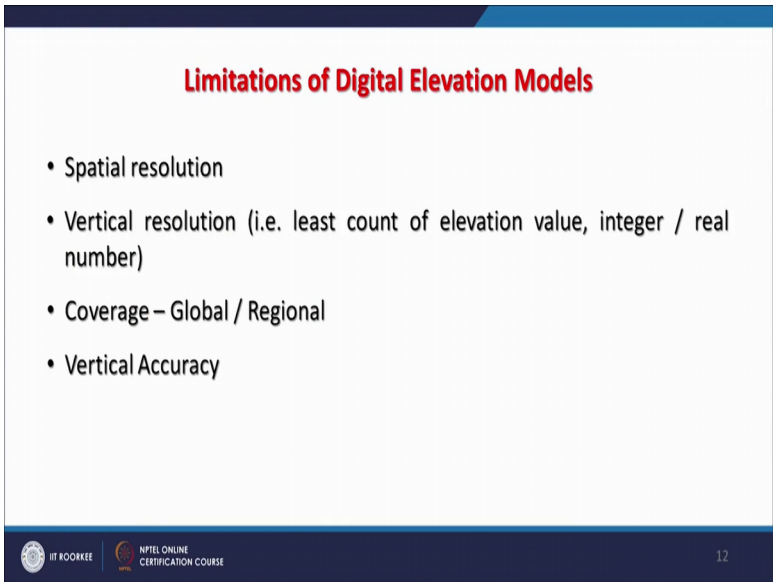

vertical resolution as you know that this is basically the least count you can say whether the values are varying in terms of metres or in centimetres generally, the values of cell of each digital elevation models are given in real numbers.

So, the values are even available at centimetre level. So, that vertical resolution is good at the vertical resolution and vertical accuracy are two different things. Vertical accuracy can only be assessed once we are having some standard data or data height data available from some other sources, where vertical resolution is at what is the as you know the resolution or the precision of the data in terms of height. So, that vertical resolution is different here and then coverage if I am going to work on a very small area I do not bother about whether globally the same digital elevation model is available or not.

So, if I am working in a part of say Uttarakhand or central India, I would be and my area of research is quite small area of interest is small I would like to use the Cartosat because it will high spatial and vertical resolution and accuracy wise is also quite good. So, vertical accuracy we have already discussed that plays very important role. So, these while and considering a digital elevation model for any study, one should assess the ability of digital elevation model on these criterias which I have just discussed. That spatial resolution, vertical resolution, the coverage and the vertical accuracy. Now further on this limitations that areas related to DEM uncertainty that affect the use of DEMs the DEM error.

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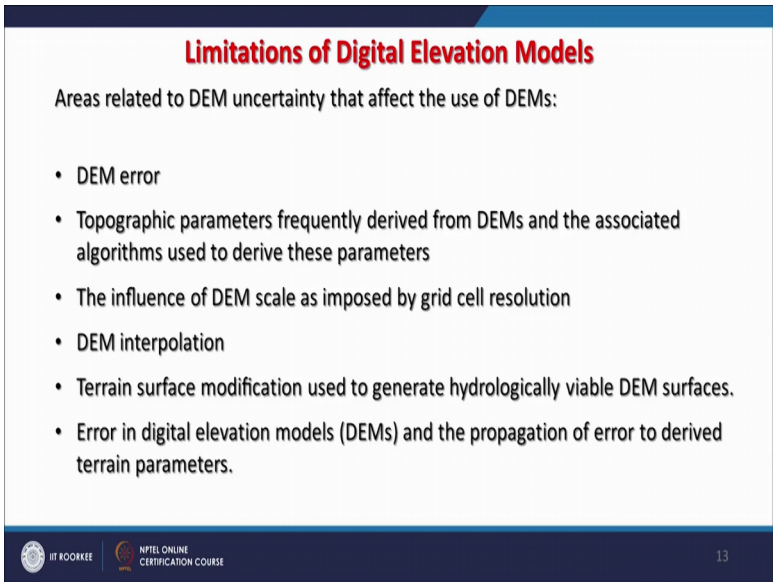

If while a if interpolation techniques have been used to generate digital elevation models what errors, have come through while interpolation was done that one should know. So, errors may be the technique inSAR interferometry, which has been employed there will be some introduction of errors. So, one should at least aware about the errors, because as you know that in processing of digital elevation model on a juisgis platform error propagates. So, if we know the error then accordingly we the care can be taken. So, that error does not propagate or if at all then we should know the reliability or the confidence in our results. So, if are having highly accurately DEM, we know how we can have a high level of confidence, but a if we know very well that our DEMs which I am going to use in this certain analysis are having errors then my level of confidence is going to be quiet low.

And the other thing which is also related with this is that topographic parameters, which we derive from digital elevation model and the algorithms which we use to derive these parameters. While discussing like slope map aspect map I have discussed the jet factor. So, these are the though they looks very small, but if jet factor have not taken care the entire output becomes unreliable; that means, that entire slope map aspect map or any other output which involves jet factor and becomes unreliable.

So, while driving such parameters all options even in software has to be first understood then only we should proceed for processing. And the influence of DEM scale is imposed

by grid cell resolution. So, scale will come as mentioned also during the discussion in this course, that scale is frozen once we either print or project it is digital elevation model.

. So, if I am having a medium resolution digital elevation model, and then on a small printout and then there accordingly it will fit in that scale. So, generally high resolution digital elevation model when I print or project I may get a get a very sharp picture, but scale is a little different it is only fixed ones things are printed as long as digital elevation model is in digital form that is inside the computer or in a computer memory or a disk or other things then scale is not there.

So, it does not have this scale only it is having the spatial resolution. DEM interpolations I have already discussed that if I am generating digital elevation model using point data, then different interpolations techniques as we have discussed in this course will might bring some errors. So, it is better always to check at that time which is the best suitable technique for my dataset number one and how much error it might be carrying.

So, that assessment has to be there. Now this a these modifications about the terrain surface which are required while doing this same hydrologic modelling surface hydrologic modelling. So, that is also very much has to kept in mind because we fill the sinks and we are because we are going to use that digital elevation model for a surface hydrologic modelling. Now the probably the same digital elevation model should not be used for other purposes.

So, the terrain surface modifications which we are doing the modifications to our existing digital elevation models generally we go for in hydrological modelling, but may not be required in other one. So, that may become error for other product, but it is a error it has to be removed for surface hydrologic modelling. Errors in digital elevation models and the propagation this part I have already discussed that error propagates, when you derive certain products or certain derivatives outputs from digital elevation model.

So, if I know that how much error is there, I accordingly I can assess the errors in my output as well. Now different application may require different spatial resolutions DEMs because all applications do not require for example, very high spatial resolution digital elevation models as given the example that if I am working on a global scale then relatively coarser resolution digital elevation model maybe more than sufficient, but if I

am working on a small area at a very large scale, then I then I would definitely prefer a very high spatial resolution digital elevation model.

So, I am giving you some examples though it is not perfect, but based on certain experiences of different people like Sharma et al in 2012 has assessed that for hydrological applications.

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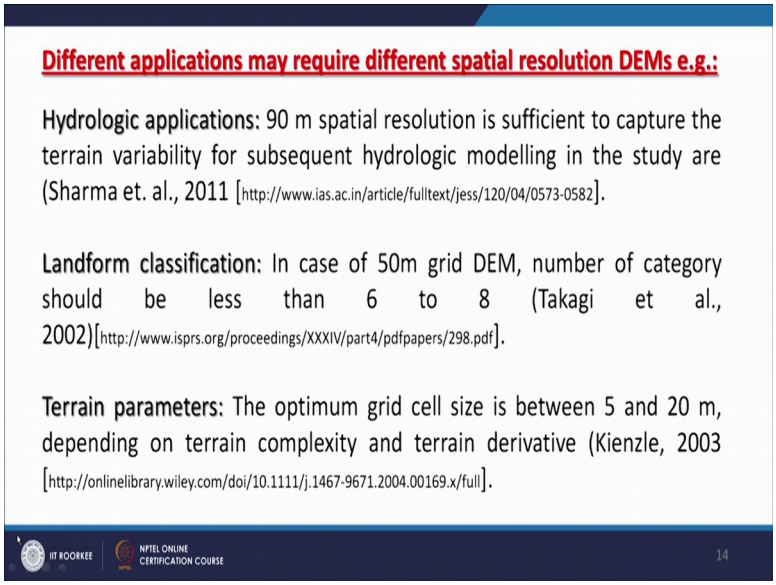

90 metre that is most popular one is SRTM DEM which we are earlier launched void free DEMs may be very sufficient spa sufficient and spatial resolution for such hydrologic applications. And another example for landform classification is topographic positioning index, which we have discussed and there if 50 metre or 30 metre digital elevation model can be implied for that purposes. And this of course, when we will use a relatively coarser resolution digital elevation model, the number of categories of landforms should not be large we can restrict our cells to 6 to 8.

So, if in a terrain landform categories are not varying they are just 6 to 8 in range air of estimation, then correlatively medium range is spatial resolution and DEMs maybe suitable this was assessed by Takagi et al in 2002, And the for the other terrain parameters like slope aspect another things, and may be for a small area the then optimum grid cell size or the spatial resolution maybe of range of 5 to 20 metre. Again these will depend on terrain complexity and terrain derivatives; the terrain complexities means whether terrain is highly rigid or smooth or a plain area. So, if I am working in

plain area I would like to have more vertically accurated digital elevation model may not be high spatial resolution digital elevation model. But if I am working in a hilly terrain then I would prefer that I should have a relatively higher spatial resolution digital elevation model and of course, as better the vertical accuracy is.

So, depending on our applications we may choose different digital elevation models the best part is the nowadays all kinds of options about the spatial resolutions of global digital elevation models are available for our choice. Another thing is highly accurate DEMs are required for flood.

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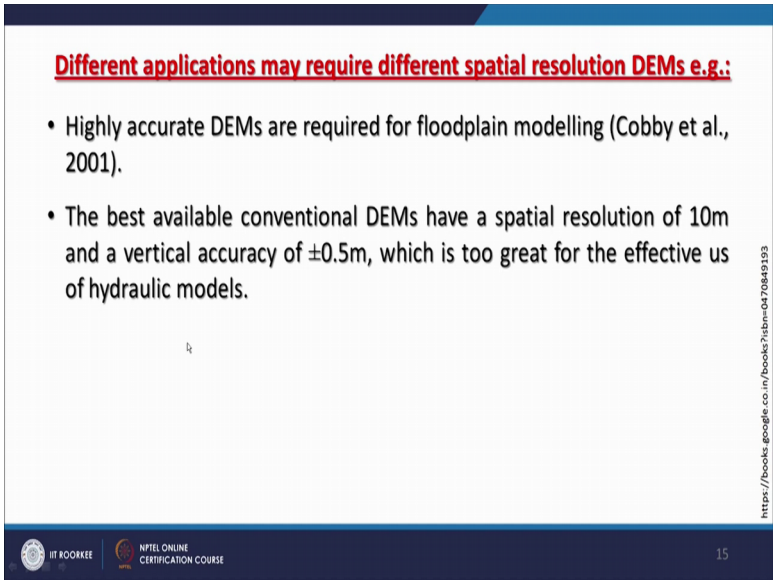

Plain modelling because this is where every inch of water or every centimetre of water will inundate more area and accordingly therefore, we always look for high spatial resolution and especially high accurate; that means, vertical accuracy has to be very good if I am going to use digital elevation model with the flood related studies and modelling. And the other conventional digital elevation model s which are maybe available of 10 metre spatial resolution may be from spot and others, but for small area, these are not available for global scale they this.

This is a diagram from or this figure is from a word of remote sensing.

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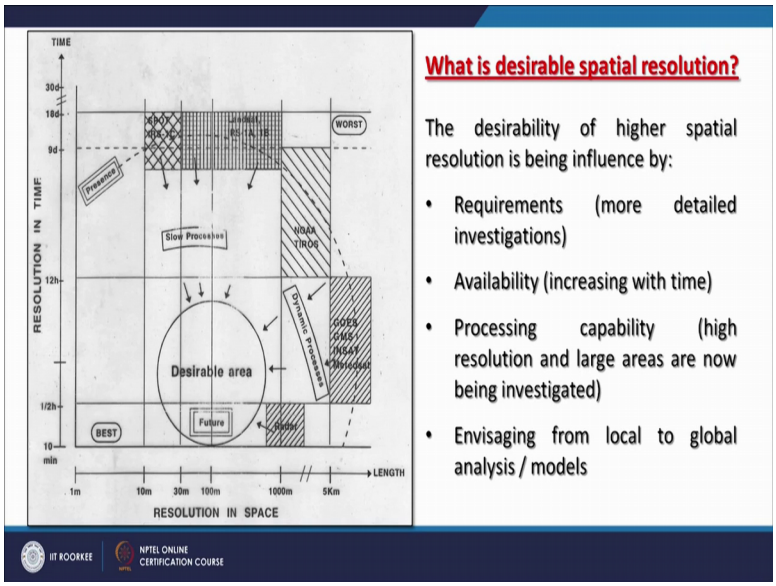

But it is still applicable that probably what is desirable? When we would say that now we have got sufficient spatial resolution di digital elevation model. Though this diagram is little older, but it brings the same thought as I wanted to discuss here, that this circular area these values are changing. So, instead of 100 metre we may talk now 10 metre here that is the desirable spatial resolution as things are improving, our we are moving towards more lower or higher and higher spatial resolution; that means, lower values and towards the origin of this xy plot.

So, this is the desirable area, but this desirable area has shifted now to about 10 metre, where people are finding very is useful for areas or for studies which involves a local area. So, this has if you see that at because lot of digital elevation models are coming based on different satellites and different techniques and all are indicating towards that. Though as I am I have been saying that this is this has to be shifted now little bit around this 10 metre instead of 100 metre because this whole figure it was true in case of remote sensing data few years back, but now things are changing improving if we us to call, then it is keep shifting to that extent. So, the desirability is always for higher spatial resolution in most of the cases.

But I would definitely suggest that if I am working for a large area, and going to cover a continental scale or global scale, then moderate resolution or coarser resolution digital elevation model would be more suitable, because the handling data processing

requirements. If I go for very high resolution digital elevation model, then the processing requirement would be huge I may not be wanting results at that resolution. So, requirement based utilization of different elevation models should be there, availability what is the availability of digital elevation model for that area like Cartosat is not available at global level.

So, we if we are working for India is fine; but if we want to work on some other area. Then we have to look the availability the processing probabilities because higher spatial resolution means more processing and so on. And this we have to understand about the local to global and that analysis is to be done at global scale or local scale accordingly the spatial resolution should be decided. Now the last topic here is the future of digital elevation models in which direction we are going. So, we have moved from 1 kilometre to 90 metre to 30 metre now we are talking about 10 metre and do we have something higher available or thinking or some developments are taking place. So, it is the best time in this course to discuss at the end what is the future of digital elevation models.

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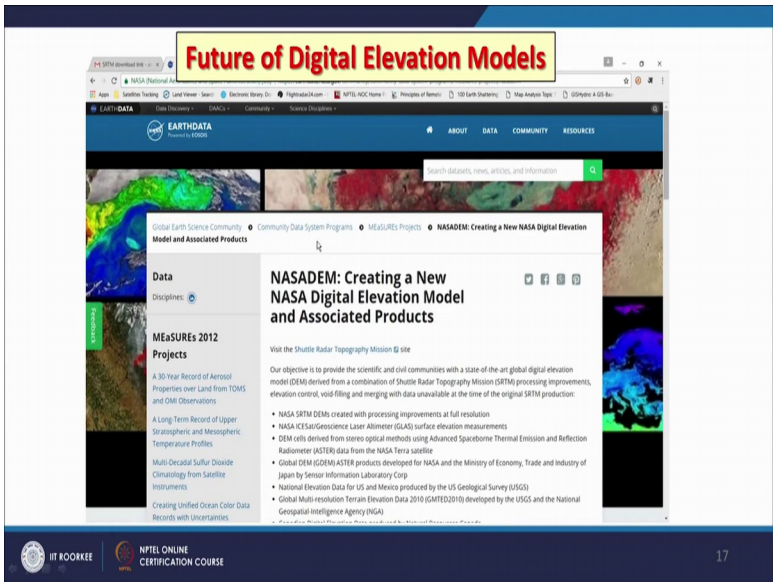

So, NASA is going to create a NASA DEM which would be more accurate than other DEMs and they have planned in a big way, and this will be again a global DEM of course, they will be utilizing all SRTM data and other data sets including aster and other data sets and then will bring a digital elevation model at global scale that would probably be called NASA DEM.

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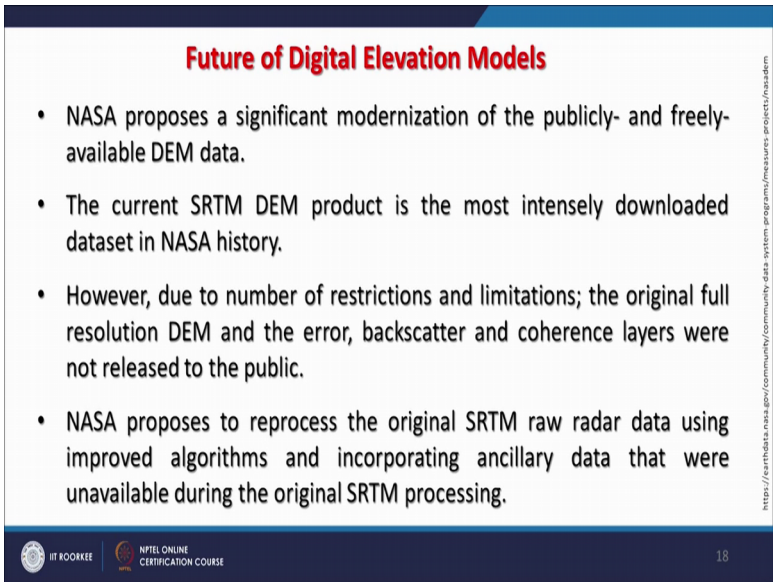

Now this is a NASA has proposed a significant modernization of publicly and freely available DEMs and the current DEMs SRTM 90 metre thirty metre the these are mostly most intensively downloaded dataset in the history of NASA and; however, due to number of restrictions and limitations, the original full resolution DEM and the error backscatter coherent layers were not released to the public.

Because initially only 90 metre resolution digital elevation model of SRTM was released later on 30 metre now these more processing I will improve data processing probably will improve the resolution and we may get in future maybe SRTM thirty 10 metre resolution.

So, that is probably also the one of the targets of NASA DEM and NASA also proposes to reprocess the original SRTM, raw data involving improved algorithms and incorporating other data sets which might be available from other sources to improve the existing SRTM DEM. So, that NASA DEM hopefully would have much more better accurate maybe higher spatial resolution DEM. Now if we look little bit about the global digital elevation model market, the first thing we can say is highly dynamic things are changing at a very rapid rate only few years back the highest spatial resolution digital elevation model at globe was available in 90 metre now for India we have started talking about 10 metre.

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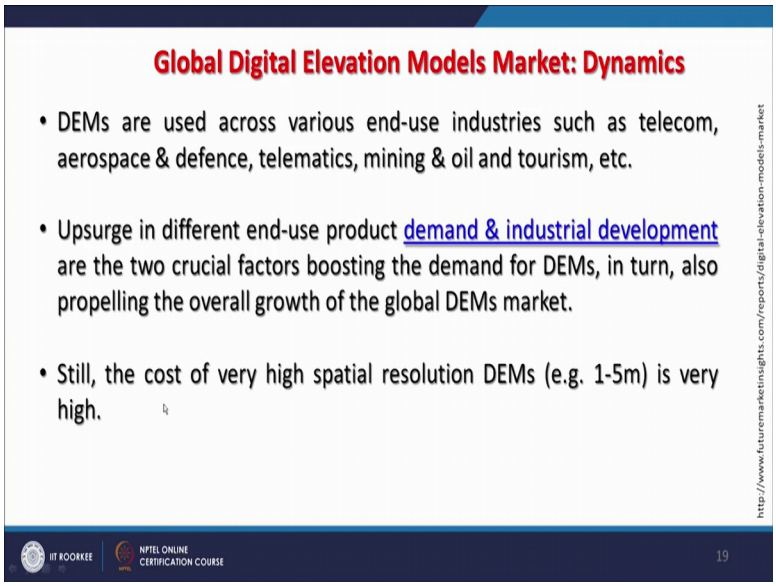

But maybe in even 0.5 metre which I am just going to discuss in few second time as we know that DEMs are used for different purposes, there is a upsurge in the use of digital elevation models and therefore, therefore, lot of demand and lot of supplies at of digital elevation models accurate different resolutions is also going to grow from global to local market. If we go for highest spatial resolution digital elevation model maybe for 1.1 metre to 5 metre still it is very high because these are not available freely and neither they are available at global scale only for a local scale. So, you have to order then processing will be done employing higher spatial resolution either inSAR data or your optical data.

Now this the always end users may be looking for higher spatial resolution and data, whether that demand can be fulfilled by the industry or developers that will be seen in future. And the as I have said that market is very dynamic, today whatever we say is high spatial resolution tomorrow that becomes the coarser resolution or medium resolution. But there is another focus on the accuracy not only the resolution, but accuracy of digital elevation models. So, that is also improving day by day and the quality and the availability of remote sensing data is improving that is digital elevation models and this is the accuracy and spatial resolution is increasing and therefore, also there is a intense increase in the utilization or applications of digital elevation models few applications.

Few products we have discussed, but as I have been mentioning in this course that digital elevation model is a storehouse of information, some of the information we know how to extract, but still there might be some information we may not be knowing about that. And this the digital elevation global market has always looking for high resolution, there are different techniques, but for very small area these high spatial resolution high accurate vertically accurate, digital elevation models are available.

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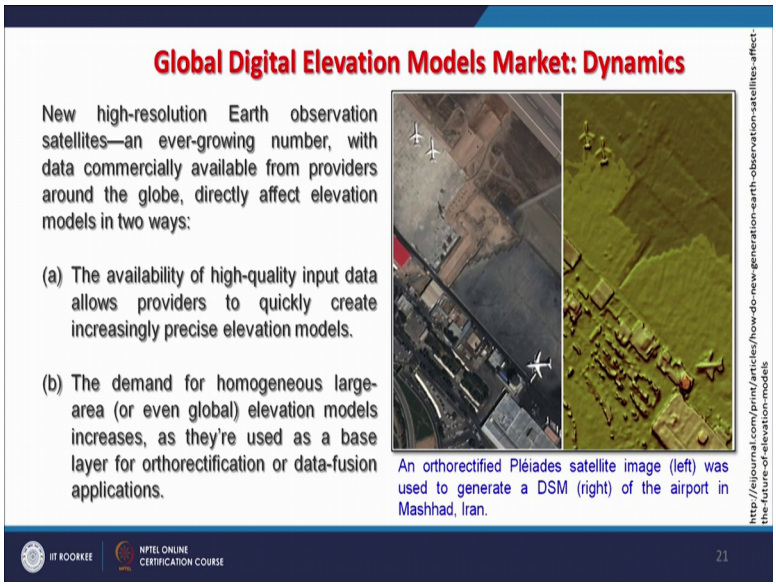

Of course, as per demand on the based on the customer such high resolution digital elevation models or digital surveys models are generated maybe for some airport maybe for some construction site. And some other thing and now the future is one more thing is coming from this satellite which is Pleiades which is going to offer 0.5 metre spatial resolution DEM, through the probably the same with the stereo data.

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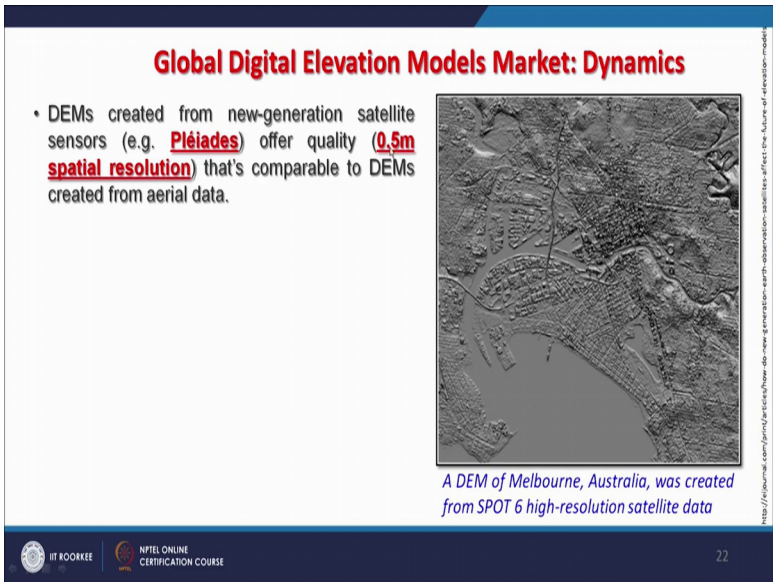

And this is the one example of that of Melbournes city of Australia which has been created this digital surface model here with this spot 6 and at 0.5 metre that is 50 centimetre spatial resolution. So, now, we are going some metre spatial resolution.

So, this is going to use the stereo data and it can generate, but this is not yet in market it will be coming very soon and. So, this brings to the end of this lecture and also end of this course we have discussed from beginning to end what is different types of digital elevation models, what are the accuracies spatial resolutions we have also discuss various types of derivatives and also in between we have discussed where digital elevation can be applied can be used and where these are being applied through some examples as well.

And also we have looked the limitations of digital elevation model and future of digital elevation model. So, basically this brings to the end of this lecture and this course I have I am sure you must have enjoyed it.

Thank you very much all the best.