Digital Elevation Models and Applications
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Lecture – 04
Various Techniques to Generate Digital Elevation Models – 3

Hello everyone and welcome to the 4th lecture of digital elevation models and application course, in this particular topic we will be discussing again various techniques to generate digital elevation model this is part 3 of this one and last part of a this a techniques for generating, one more technique which you will I would like to discuss though it generates only at a coarser resolution.

But the advantage is that the data is available free, it can be generated as we have seen that we can generate a from using so survey topo sheets using ground information, we can also generate stereo pairs, we can also generate through using radar or INSAR technology. We can also generate using LIDAR technique; that is, in this particular one we will be briefly discussing how thermal infrared data can also be used to generate digital elevation model.

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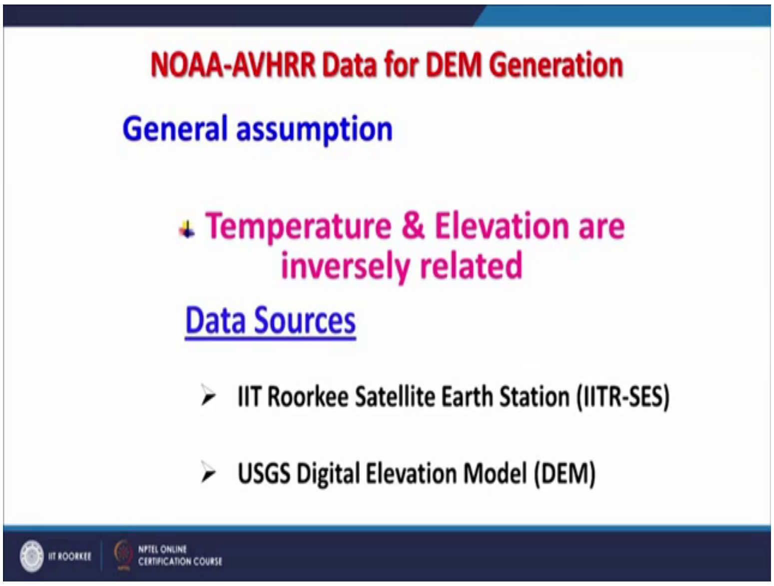

See this is a general concept that the temperature and elevations are inversely related and this relationship inverse relationship has been exploited. And this can only work where a you are having a natural a undisturbed or less disturbed terrain, and especially if you imply the night time data, as in this example we can generated digital elevation models, but here the example which I am going to show you we has generate digital elevation model at 1-kilometer resolution that is at 1000 meter.

But now a days a digital a the this thermal data is available at a 60-meter resolution from landsat oli series and therefore, we can also generate digital elevation model implying night time landsat data at 60-meter resolution, because a one can argue that a since I am having a 30 meter already available digital elevation model so why I should go for 60-meter resolution or 1-kilometer resolution?

See the no digital elevation is perfect. So, we have to keep trying different techniques for our utilization sometimes a very higher resolution digital elevation model is not required. And then if you downgrade it you might create some problems, but if you imply already a generated digital elevation model at that particular resolution which is required for your work then it is good. So, in this example we have used the NOAA AVHRR data and the data was acquired by IIT Roorkee satellite earth station which has been operational since October 2002 is still running and night time data we employed, and what we see that a it can create a digital elevation model at 1-kilometer resolution.

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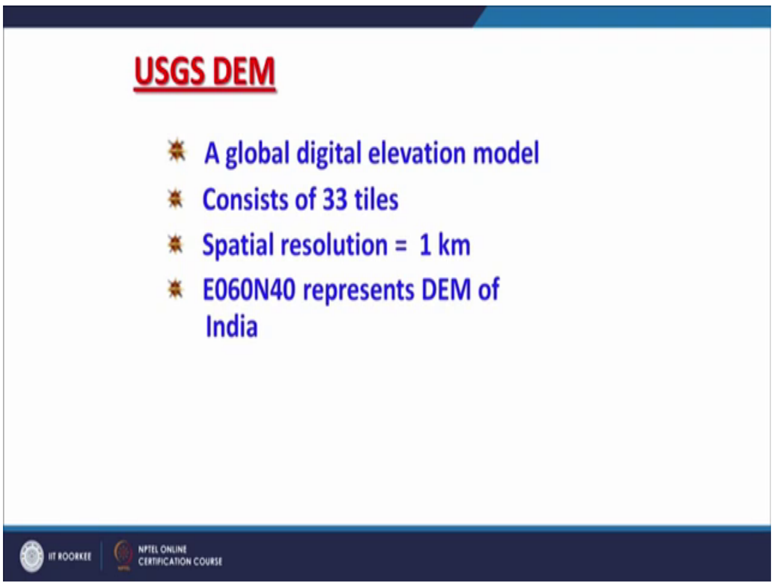

And in this one we have employed a particular for comparison also we have used USGS 1-kilometer resolution data.

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NOAA-AVHRR : Data Specifications

PARAMETER	SPECIFICATION
Sensor	AVHRR On board NOAA
Channels	5 or 6 depending on the satellite
Altitude (km)	833
Temporal Resolution	4 images per satellite per day
Radiometric Resolution	10 bits
Spatial Resolution (km)	1.1
Scan Rate	360 scans per min
Scan Angle	±55°
Swath Width (km)	2800
Instantaneous Field of View (IFOV) (μr)	1.3
Inclination (degrees)	98.70
Orbital Period (minutes)	102.301(makes 14.1 orbits per day)
Telemetry	HRPT
Frequency (MHz)	1707.0
Temperature Range	180 k to 335 k or -93.5°C to 61.85°C

Source: http://www2.ncdc.noaa.gov/docs/klm/

So, the details about that one is also given and these NOAA specifications are also given, especially 2 things I would like to mention here that the radio metric resolution it is 10 bits data. Like in a spot or a cartosat generally you are having either 8-bit data or 6-bit data. So, the radio matric resolution of NOAA is very high and therefore, you may get a better digital elevation model at that particular resolution say at 1-kilometer resolution. So, that is the advantage because here the radio metric resolution is higher than your land sat data and or other data and a spatial resolution of course, is around one kilometer and rest of the things are also here for our.

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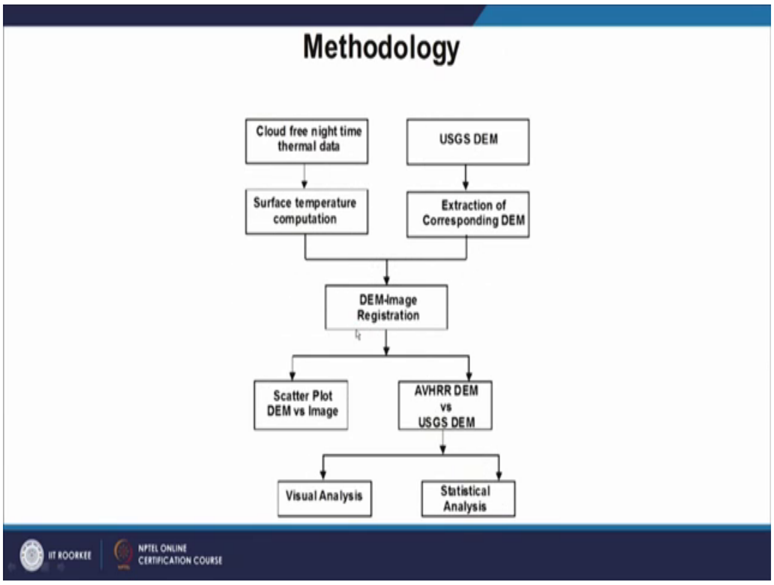

Now we will we will compare with the USGS DEM. And so, that we have to register the images together so that we can do the comparative analysis and then finally, visual analysis and statistical analysis has also been done just to show that how close it is to USGS DEM. So, these are 2 digital elevation models one is generated using.

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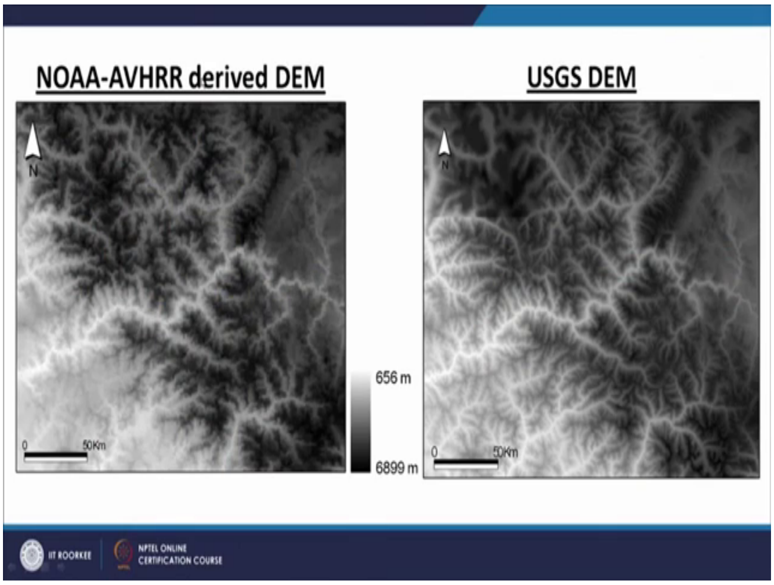

NOAA AVHRR data exploiting that inverse relationship between a temperature and elevation and this is a USGS DEM of the same area. Though this is generated using interpolation techniques, implying the contours which are available in survey topo cities, but here this has been generated using NOAA AVHRR night time data and which is available for almost every day and therefore, you can employ such.

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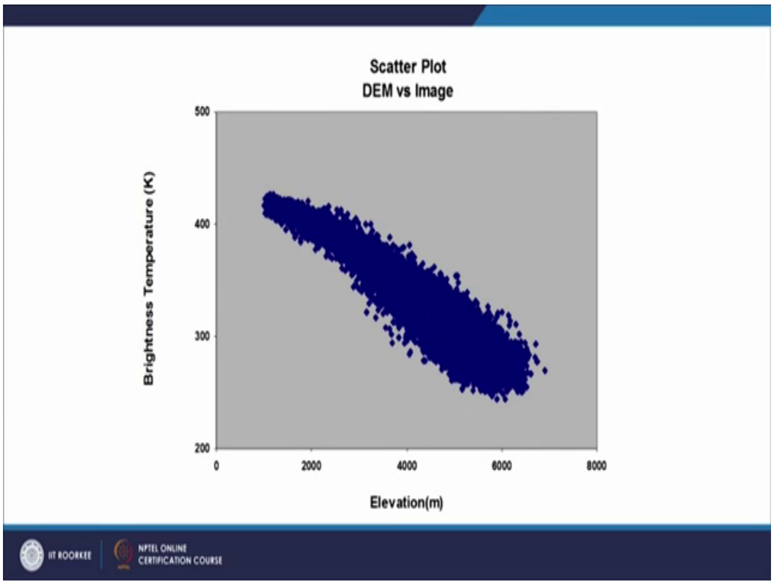

If we see the if we start comparing this things through a scatter plot what we see this is the inverse relation which I was talking, which is also reflected in the brightness temperature and elevation as elevation goes this a go higher and higher we get the less brightness temperature value which is in Kelvin.

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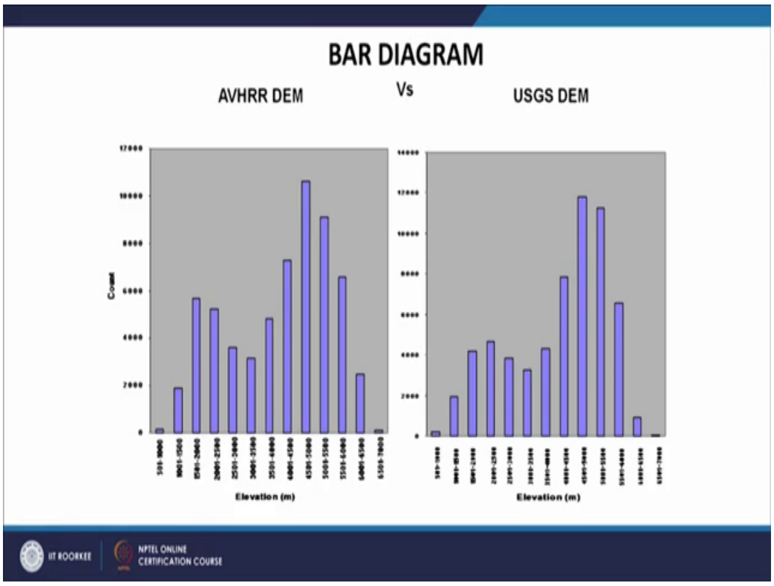

Now we also see the comparison here where NOAA DEM for different range of elevations and USGS DEM. So, we see that it is a having almost the same pattern as AVHRR DEM.

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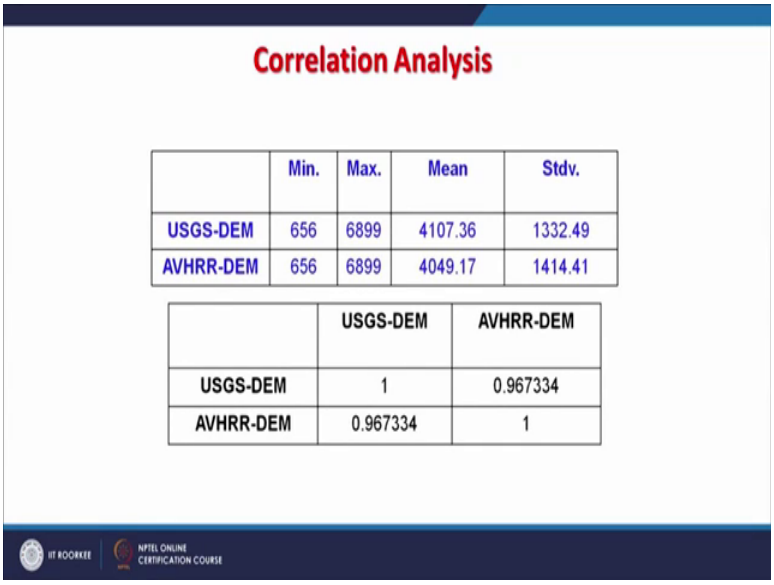

	Min.	Max.	Mean	Stdv.
USGS-DEM	656	6899	4107.36	1332.49
AVHRR-DEM	656	6899	4049.17	1414.41

	USGS-DEM	AVHRR-DEM
USGS-DEM	1	0.967334
AVHRR-DEM	0.967334	1

So, 2 different ways the comparison was done here now this correlation analysis is also there and what we see they are highly correlated USGS DEM and DEM generated by using NOAA AVHRR data 0.96. So, instead of leave 0.97 correlation has been seen between these 2 DEMs so you get a very good results by implying no AVHRR data similarly landsat thermal data can also be used at 60-meter resolution and one can generate digital elevation model.

What are the implications of that? That as I mentioned that landsat etm or oli series data can be used what are the limitations here? The require it requires the highly accurate geo referencing because you are working at a relatively very low-resolution data. So, that part is very much important here it is best applicable only in a highly rugged and natural terrain least disturbed terrain for hilly terrain.

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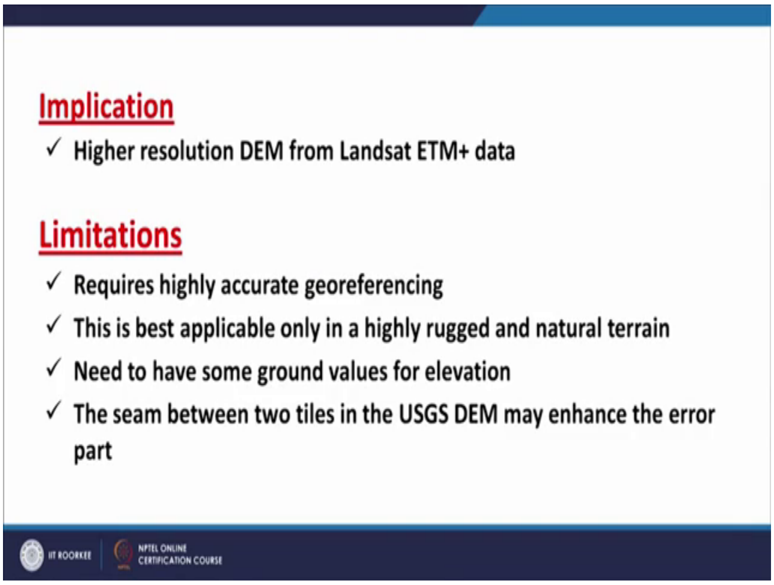

Generating a digital elevation model has always been very difficult, but here employing this inverse relationship one can generate digital elevation model even using thermal infrared data and need to have some ground values for elevation for validation purposes and the sometimes because if we compare with USGS DEM which is a 1 kilometer resolution, though the because USGS DEM might be having some seams because between 2 toposheets if they are in 2 different projections when they were joined the seams where they are in built in the USGS DEM.

So, seams may create some problems otherwise for comparison only that problem will be there, but a digital elevation models can be generated using thermal infrared data, and the there are sources of DEMs which I have been mentioning from where we can get digital elevation models for our work or projects. One of the way we have already discussed using survey of India

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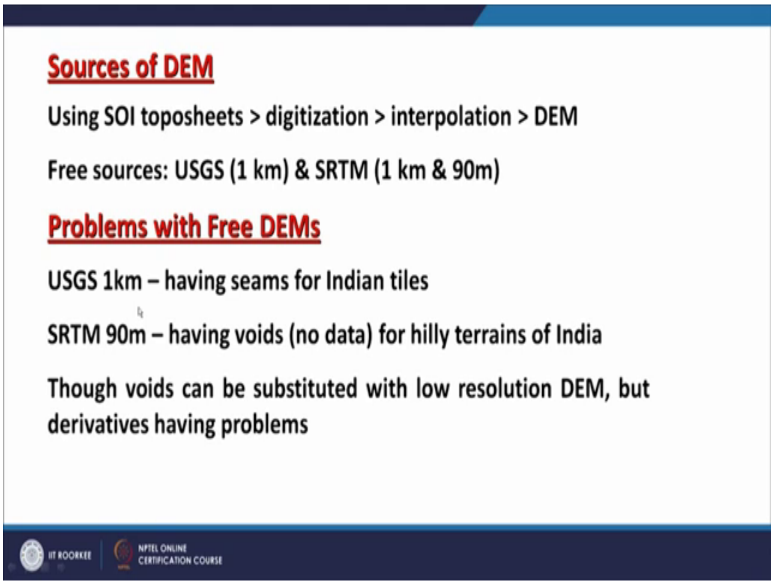

Toposheets or any toposheets of any country we have to digitize this perform the interpolation do some validation ground checking may be through GPS data or others and DEM can be generated.

So, the resolution we can control here if we ourselves are generating there are various free say in DEMs are also available like example we have just touched USGS DEM at one-kilometer SRTM was available at one kilometer 90 meter now it is also available at 30 meter there are some problems because none of these products are perfect if I take example of USGS 1 kilometer. So, it is having the seam problem especially for hilly terrains of Indian part of Himalaya, SRTM if I take example of 90 meter it is having voids and we will see some examples voids means no data void has occurred because it is based on radar remote sensing data and as I have mentioned that a if it is having lot of a snow or a these a ruggedness of Himalaya creates a problems in the radar data and therefore, voids or no data values were left.

So, then it becomes a really none usable, but the techniques were developed and a true make these data sets void free, and now those void free data are also available or void free DEMs are also available, but these voids are a substituted with relatively low-resolution data. So, for some areas you are having a very high-resolution data, but some areas though it is a resampled, but original data was at low resolutions.

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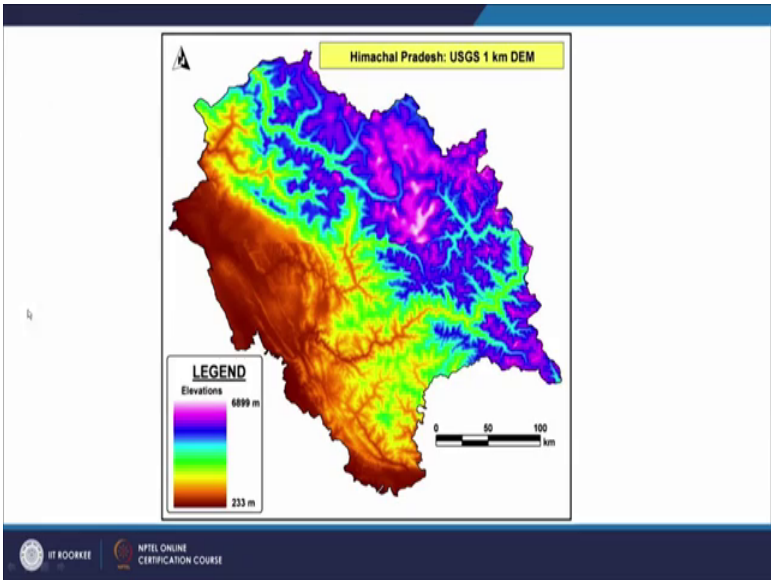

So, let us see the example here at this stage that what we are seeing a digital elevation model of a entire Hmachal pradesh at a 1-kilometer resolution the DEM by USGS generated based on survey toposheets means using contour and then interpolation and a

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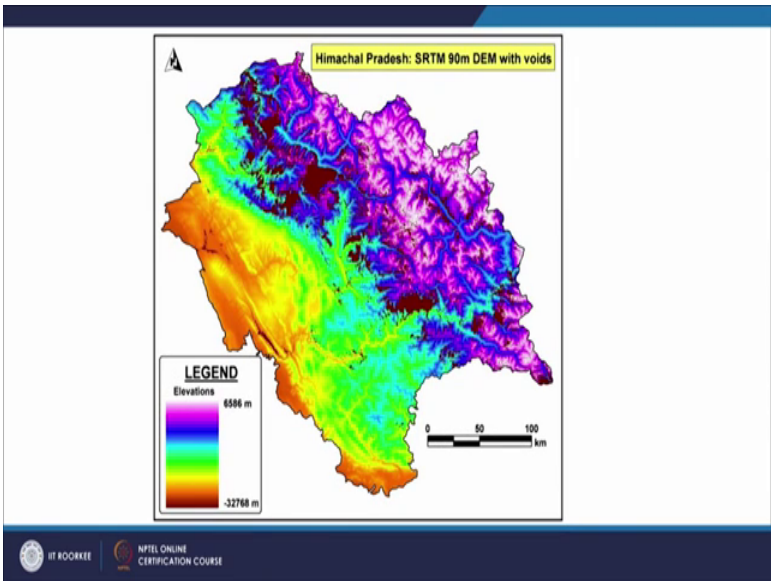

This is the DEM of the same Himachal pradesh at 90 meter resolution a and a with voids, and what we are seeing here that these are the voids and basically these are the no data values therefore, the values here are very, very low values which are assigned to the no data value and if we such DEMs even at 90 meter resolution with voids then we cannot imply DEM such DEMs for any use, but if we use a if we use this a 1 kilometer resolution DEM which is void free and a these voids if we fill and get substituted by low resolution values elevation values then we can make a completely void free digital elevation model and that too at 90 meter resolution.

So, let us see again one by one that what we are seeing is digital elevation model at one-kilometer resolution without any voids, but the resolution is 1 kilometer whereas, here we are seeing digital elevation model from SRTM at 90-meter resolution, but with voids. So, if we use both and fill the voids from the first one which is at a 1-kilometer resolution that is USGS then we can create a better product and this is how things can be and improved.

So now a days a even bright free digital elevation models SRTM 90 meter and 30 meter for almost a 8 percent of the globe and are available for our uses, but they the voids have been filled any SRTM DEM which you download for your area or project area will have in some parts if it is of hilly terrain it will have some parts which are filled with a relatively low-resolution data. So, this one has to remember while using SRTM digital elevation models there is another comparison that USGS 1-kilometer resolution for the same area this is SRTM 1-kilometer resolution and this is.

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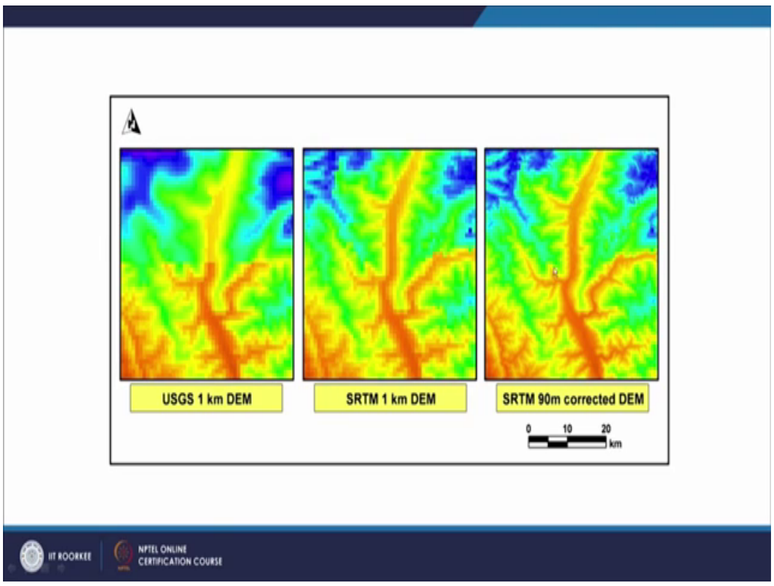

SRTM in 90 of course, 90-meter resolution looks much, much better whereas, in USGS DEM you see a seam.

Seam has been a big problem with USGS DEM because these are based on the input data is toposheets from where the contours have been digitized and later on these contours have been use to interpolate the surfaces or create the digital elevation model, but seams where left here and sometimes such data becomes unusable, but a SRTM had voids problem USGS have the seam problems, but implying some substitution techniques or some processing you can improve the data and can create data at the different resolutions.

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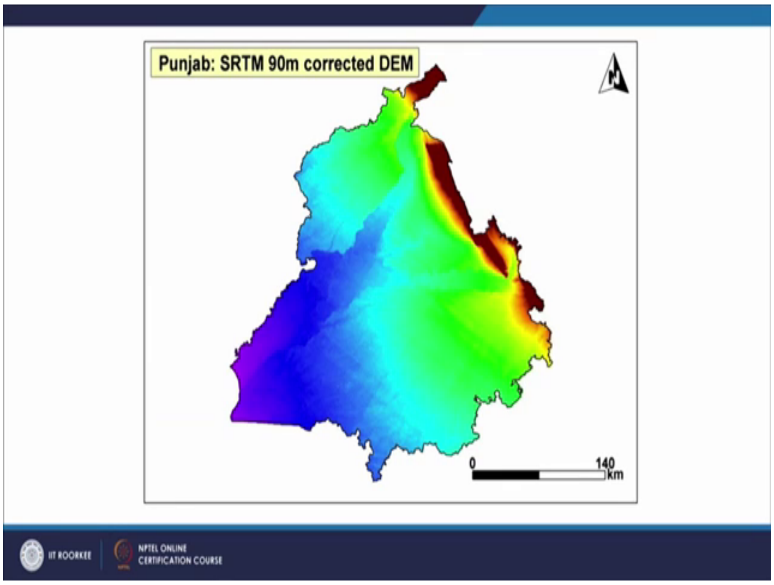

One more example of SRTM which is corrected or filled void free, but if it is a see this the example is may of Punjab area which is which does not have much hilly terrain or any other thing. So, except for a very little in this northeast part you have little very small scale or hills some simple hills are there. So, the radar data didn't have any problem and therefore, the corrections are not much corrections are required and a perfect digital elevation model at 90 meter or 30 meter can be used.

These are the further different sources of DEMs with different applications at what is scale you are looking this table will give you the idea like a the application.

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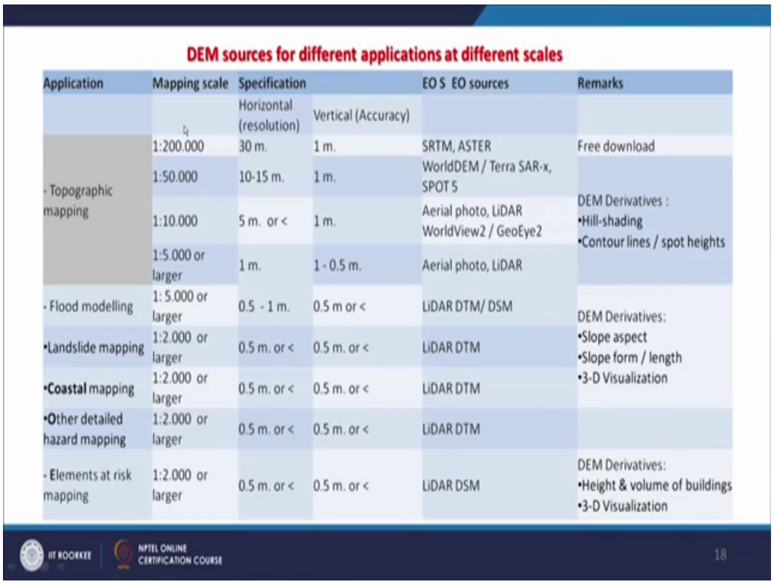

DEM sources for different applications at different scales

Application	Mapping scale	Specification: Horizontal (resolution)	Specification: Vertical (Accuracy)	EO S EO sources	Remarks
- Topographic mapping	1:200.000	30 m.	1 m.	SRTM, ASTER	Free download
	1:50.000	10-15 m.	1 m.	WorldDEM / Terra SAR-x, SPOT 5	DEM Derivatives : •Hill-shading •Contour lines / spot heights
	1:10.000	5 m. or <	1 m.	Aerial photo, LiDAR WorldView2 / GeoEye2	
	1:5.000 or larger	1 m.	1 - 0.5 m.	Aerial photo, LiDAR	
- Flood modelling	1: 5.000 or larger	0.5 - 1 m.	0.5 m or <	LiDAR DTM/ DSM	DEM Derivatives: •Slope aspect •Slope form / length •3-D Visualization
•Landslide mapping	1:2.000 or larger	0.5 m. or <	0.5 m. or <	LiDAR DTM	
•Coastal mapping	1:2.000 or larger	0.5 m. or <	0.5 m. or <	LiDAR DTM	
•Other detailed hazard mapping	1:2.000 or larger	0.5 m. or <	0.5 m. or <	LiDAR DTM	
- Elements at risk mapping	1:2.000 or larger	0.5 m. or <	0.5 m. or <	LiDAR DSM	DEM Derivatives: •Height & volume of buildings •3-D Visualization

If you are for topographic mapping different scales are available depending on your project requirements according with different resolution data are possible, with this is these are the sources of where from where the data and be acquired, whether it is free or a it is it will cost that information can also be seen here.

For flood modelling what kind of a mapping scale data what kind of resolution data you require? And which are data which will be useful like LIDAR DSM because LIDAR provides the digital surface information and therefore, they are DSM and in flooding that is very helpful and these we have also discussed earlier. So, a plain or bare DEM is not good for flood modeling as DSM which is acquired by LIDAR will be more useful.

For landslide mappings again, LIDAR DTM digital terrain model can be used for coastal another's, but a LIDAR digital elevation models are not available free it is very expensive technique, and a also satellite based on not yet available, but rest of these are available which we can employ here. So, this brings to the end of a this a various technique of a digital generating digital elevation models this was the last part of this.

Thank you very much.