Digital Elevation Models and Applications
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Lecture – 03
Various Techniques to Generate Digital Elevation Models – 2

Hello everyone, and welcome to the third lecture of a digital elevation models and applications course, and we will continue on this ah topic major one that is the various techniques to generated digital elevation model. So, this is part two in part one we have discussed how from point data, we can generate or from topographic maps, we can generate digital elevation model's ah by employing a interpolation techniques, but here we will some other techniques which can be used.

So, like a digital elevation models as you know that can be generated using the interpolation techniques, which we have already covered digital elevation models can also be generated using remote sensing techniques, like a stereo pairs data may be from a spot this is the technology started with first spot, using the Photogrammetric techniques and CARTOSAT data which is our own Indian satellite data and various a satellites are providing the stereo data, you employing those stereo data we can use a these digital elevation models aster has also created a global digital elevation model using the same photogrammetric technique and of course, the remote sensing data.

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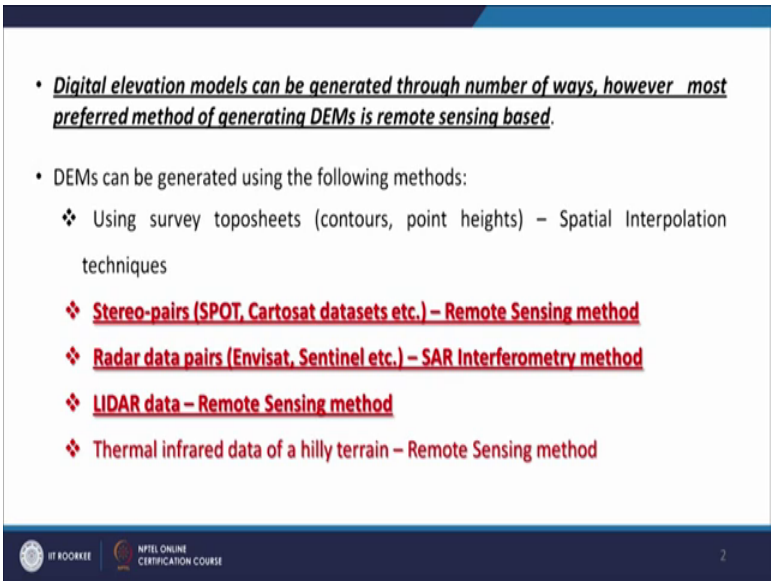

Another way of a creating digital elevation model, by employing the SAR interferometry or INSAR technology, which is again a remote sensing based technology and the again here, we have to use a the data pairs two data sets of the same area and the data set can come either from nv set of course, nv set is no more available, but older data is available, but for latest data the sentinel data, which is again free of cost is available on net and a software's are also available to process the data, which are also in public domain.

So, just implying the this technique, which is a INSAR or SAR interferometry we can also generate digital elevation models, and digital elevation models can also be generated using the LIDAR data, again this is also a remote sensing method. So, we will see some examples how digital elevation models can be generated using LIDAR data, especially the DSM digital, surface models one more technique which a developed few years back by that the thermal infrared data of a hilly terrain can also be developed, using remote sending method, but at a relatively courser resolutions. So, we will see that example as well.

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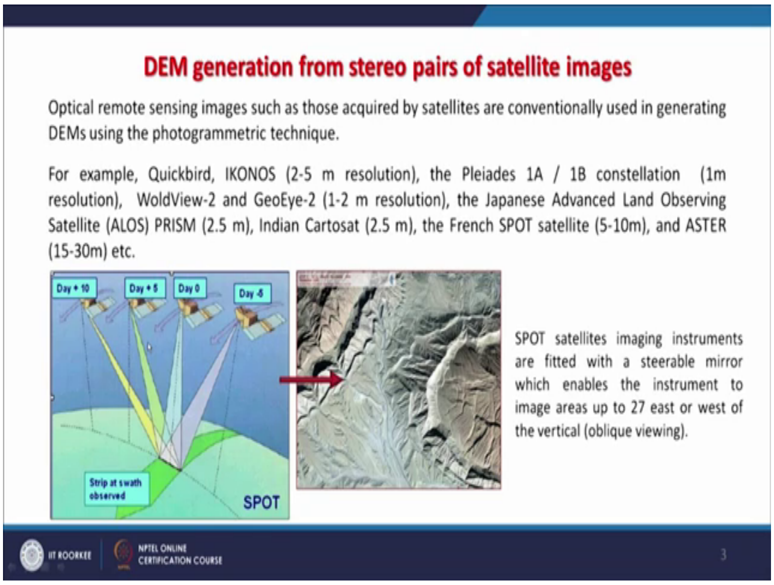

So, let us a go for first that is the optical remote sensing, and data images which can be acquired by the satellites as conventionally used in generating dms, and which imply the photogrammetric technique and for example, Quickbird, IKONOS 2.5, and Pleiades 1A 1B constellation 1meter resolution, WoldView GeoEye, Japanese this is alos and 2.5 Indian our Indian CARTOSAT 2.5, these are the resolutions and stereo data available for may data sets it is free. So, you can get a you can develop a digital elevation model even up to one-meter resolution.

In case of a spot which really this technology was first tested with the spot satellite data and what it was doing that, if you acquire the data of the same area with angles minimum two angles are requited, then you can imply the photometric technique; that means, the stereo images will be used and then, using these stereo pair one can generate digital elevation model.

So, this is one of the examples the problem, with this kind of a data acquisition, like in case of a spot the example is given, here that the same area is being covered 5 days before say day 0. So, 5days before it was possible to cover with an angle through a steering of a mirror of the sensor. So, 5 days before the settle the same area is being scanned on day 0, it is being scanned again 5 days after day 0, it is being same area is scanned and after 10 days same area.

So, now we are having a 2 data sets we may create a stereo pair, and then using implying photogrammetric techniques, we can develop a digital elevation model, the problem here was that say if you are working in a area, where clouds are a big problem. So, a suppose on day 0, you had a completely cloud free seen, but on day 5 that is plus day 5 you are having cloud cover and therefore, they were problem about a getting the data pairs or the image pairs for a stereo generation those both or all the should be completely cloud free, otherwise there will be a problem, because here we are using the optical images, which are which are not which is not possible in these images two penetrate through clouds.

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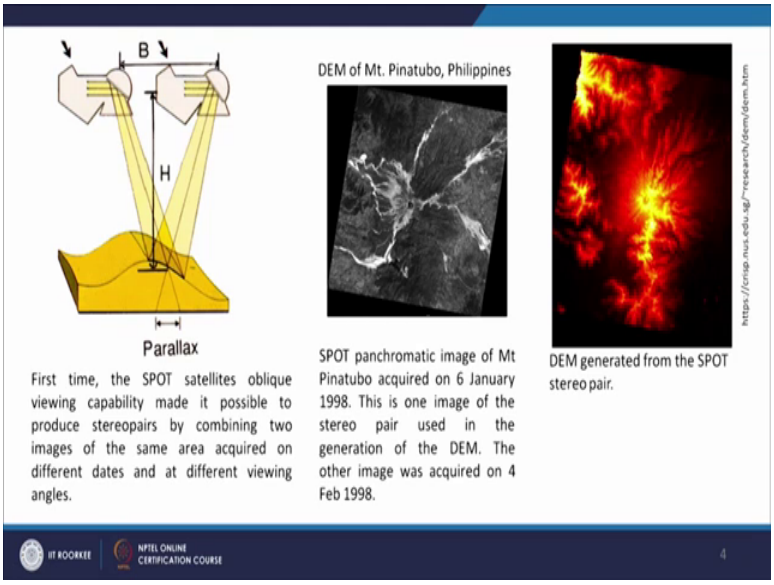

So, that was one of the limitations. So, this limitation was a sorted out later on in some other satellites, but especially in CARTOSATs. So, that example we will also see. So, here the parallax used to be developed using stereo pair data, and this as mentioned earlier it was started first started with the launching of a spot, and using such data pairs the here one example of mount pinatubo of a that image was acquired a data pair is required of a two different dates 6th January and then 4th February luckily, both were cloud free and then a digital elevation model of the same area was generated.

So, by this now here the resolution will depend on the resolution of optical images, if optical images are having resolution say 10 meter like in this case of a spot panchromatic, then your digital elevation model will also have a 10-meter resolution. So, it is a directly depending on the resolution of your original images, but later on technology improved and as given example, now that it is possible even to create a digital elevation model at 1-meter resolution employing same stereo pair based photogrammetric technique.

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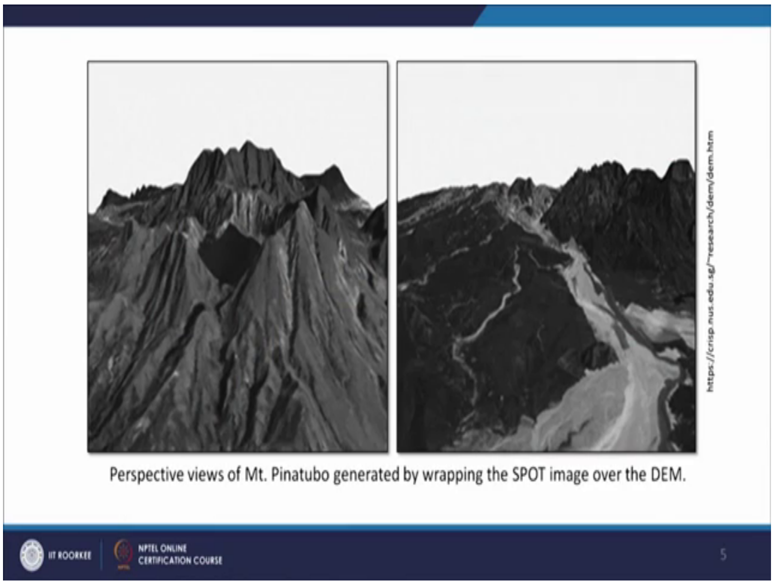

This is the 3D perspective view of the amount Pinatubo again generated with a spot images spot data pair, and the one image has been dragged over that data set. So, we can see the advantages of that the first images, where used to generate a digital elevation model and then one of the images, which was used to drap over digital elevation model and then you develop a 3D perspective.

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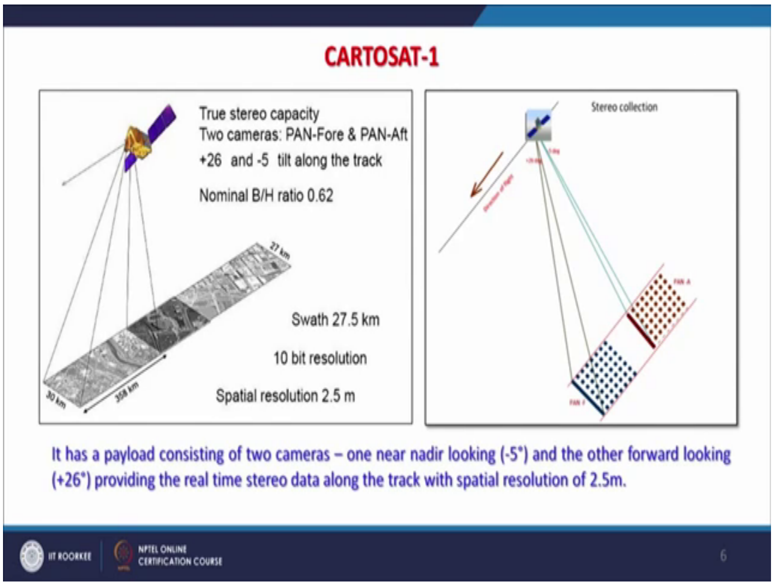

So, this can be done with any optical images, now as mentioned in the problem of clouds which was there with a spot or similar kind of satellites was dissolved in CARTOSAT of course, a the resolution improved to even 2.5-meter resolution instead of 10-meter resolutions, and simultaneously with two different angles the images were acquired and this was a very simple solution was found, that the satellite used to look in obliquely forward and backward as well.

So, it was acquiring data of a when it is flying over an area, then it is looking through a camera the backward as well as forward seen. So, this is what you see that a through stereo capacity simultaneously two different angles of the same area were covered two cameras, were there together one is called pan fore, and another one is pan aft and a they had a tilt angel of plus 26 degree that was looking forward and minus 5 tilt along the track.

So, this was the backward and then this ratio of a baseline B over height H ratio which must 0.62 of course, swath and other things were different, but a spatial resolution is important to note instead of like in a spot in case of his spot it was 10 meter, we could achieve 2.5 meter and the biggest problem of the clouds or metallurgical condition changes, where not there because when the 4 image or the 1 image is being acquired simultaneously the other image is also required.

So, it resolved two problems one is the cloud problem, another one is a spatial resolution. So, much improved spatial resolution data is available, I want to add one more information here, that a for large part of India the nrsc, which is part of isro organization has developed digital elevation models, which are available free of cost for some parts of Indian territory and slowly it is being updated or appended.

So, more areas are being covered using this CARTOSAT at DEM, and this can be downloaded through a google like product which is called Bhuvan. So, on Bhuvan CARTOSAT based digital elevation models at a relatively high resolutions may not be 2.5 around 5-meter resolution can be downloaded for many parts of India. So, that can be very useful, because the other global digital elevation models which are available today none of them are close to 5 meter.

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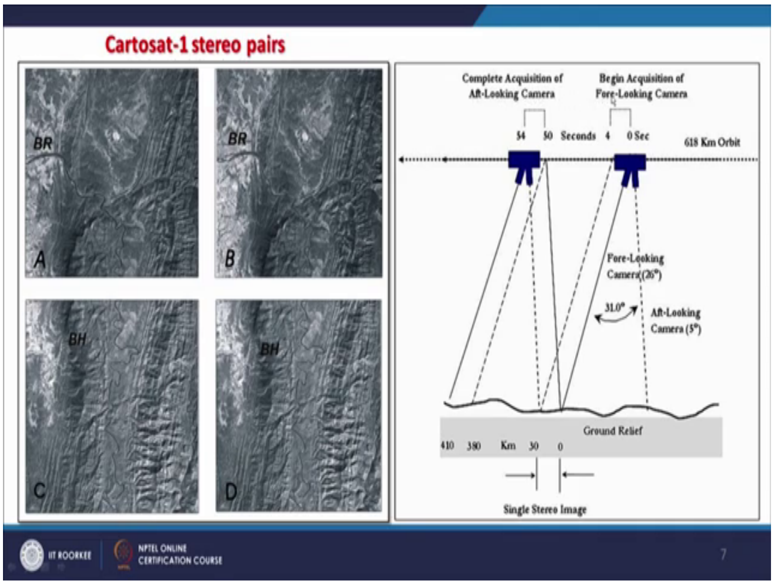

So, in that way it is quite good and these are the examples, this a camera four a pan aft a is the example is here, that they are covering the same area at the same time and this is how the images will look, when you see two images which I have been acquired the same time but you do not see usually much difference, but when you see through either used as a stereo products, and then use the photogrammetric technique, then definitely a digital elevation model can be prepared, using this and this is how this has been employed.

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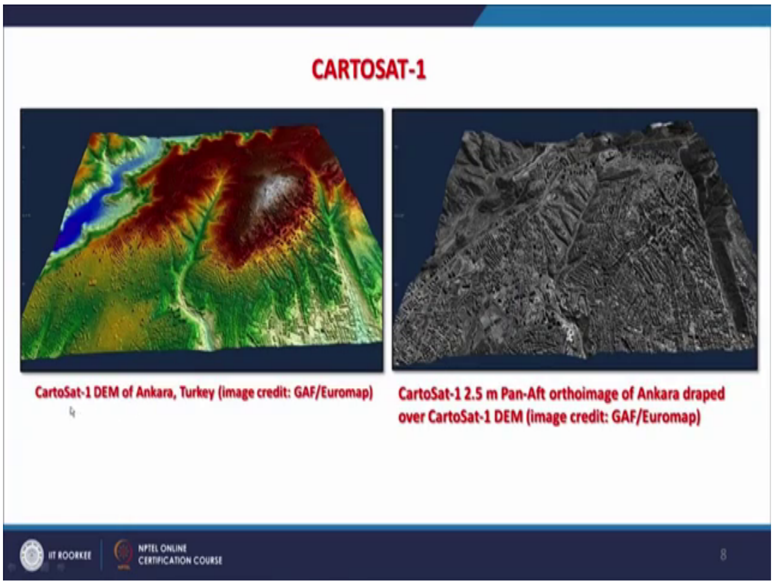

Further examples the draping another thing that this is the one example, of CARTOSAT DEM of a part of Ankara turkey, and here what we are seeing a first digital elevation model, was generated and over that the image has been this image has been draped, and this is what we see in a really a good a 3D at quite high resolution of at 2.5 meter, now because I have mentioned that there are many, now a days I can say many more than 2-3Digital elevation models are available the complete list, we will be seeing in subsequent lectures, but just to compare two DEMs or part of a Arunachal Pradesh and how they look.

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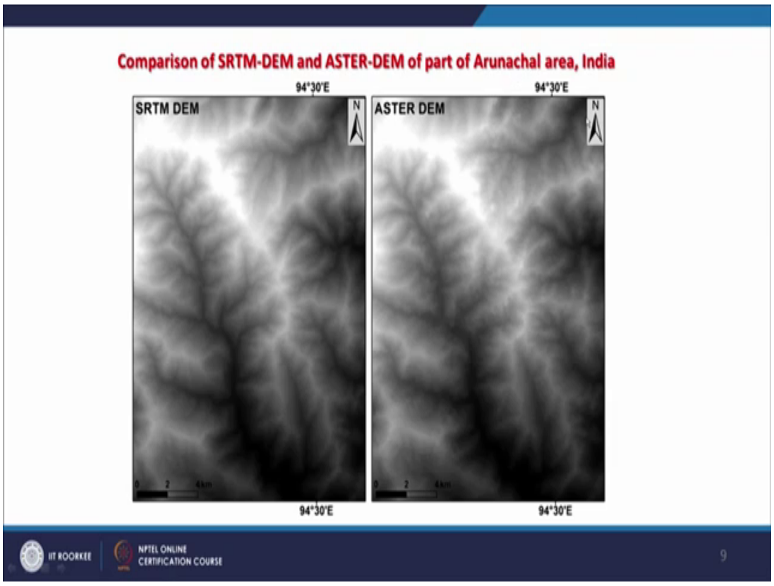

So, exactly the same area has been displayed here one is SRTM-DEM of the same resolution spatial resolution in both the cases it is 30 meter, and we hardly see any difference, but the important thing here to note that the technologies, which have been employed to generate these two DEMs are completely different, because in case of SRTM-DEM the INSAR technology has been employed which we are going to discuss very soon and in case of ASRTM-DEM stereo which we have just discussed briefly has been employed, but the product which has been generated are quite close or quite looks very similar at least at visual level .

So, but a we got further then we have found, that SRTM is not good for hilly terrain, because it implies the SAR interferometry technique and radar remote sensing is having some problems in a hilly terrain especially, like Himalayan which is highly rugged terrain, but a for plane areas SRTM is good in comparison to SRTM, ASRTM-DEM is good for hilly terrains, but it is not that good as for plane areas. So, if somebody is working for plane areas, then one should employ the SRTM, if a CARTOSAT DEM for that area at highly spatial resolution is not available, then SRTM can be employed or if somebody is working for hilly terrain, then it would be better to employ ASRTM-DEM.

This, I am telling based on certain comparative studies, which we have employed and a using also confirming with the point data, and which we are available for certain areas. So, by doing this comparison exercise we reach to this conclusion that SRTM is good for plane areas ASRTM-DEM is good for hilly regions, another technique which INSAR or SAR interferometry technique which is one of the very powerful technique.

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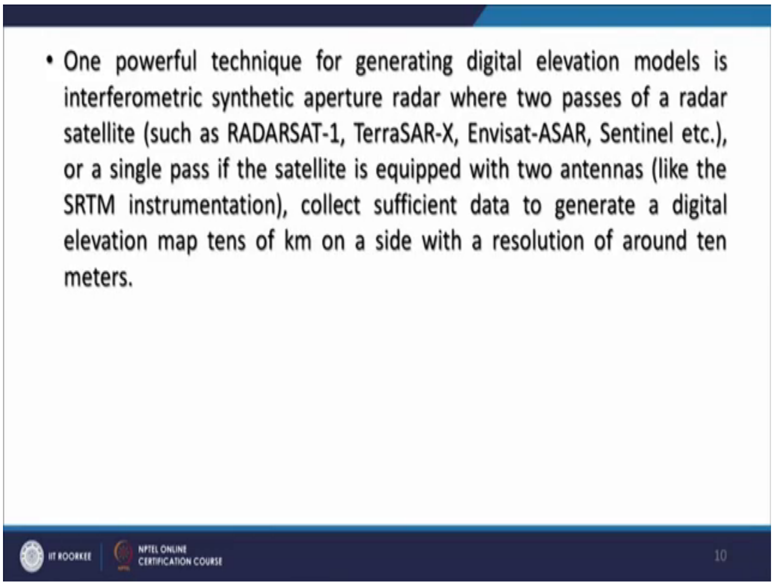

Now, has been established and not only for generating digital elevation models, because the advantage with radar remote sensing is that even in a cloudy conditions, it can acquire the data, second is that a it is not a only day time, because you do need the solar energy to acquire the data the energy, which required to acquire the data is sent by the satellite itself.

So, therefore the data can be acquired in any weather condition one, and also day and night any time of the day. So, that is one of the biggest advantage is with radar data, and when we go for interferometry; that means, we require a pair of the same area covered with again two different angles. So, this two passes and the examples are first started with the like ers later on radarset-1, terrasar-x, nvsatsr that was the name of the sensor on nvsat satellite then sentinel, which is a currently operational and this data is available.

So, that a when we get the two images or a pair, then it can be used to generate elevation map which is say a may be at very high resolution, around 10 meter or so and the advantage is that a now a days this data is available free and products are coming these are based on global product, global DEMs are coming which have been generated using, these data sets especially in like sentinel or others.

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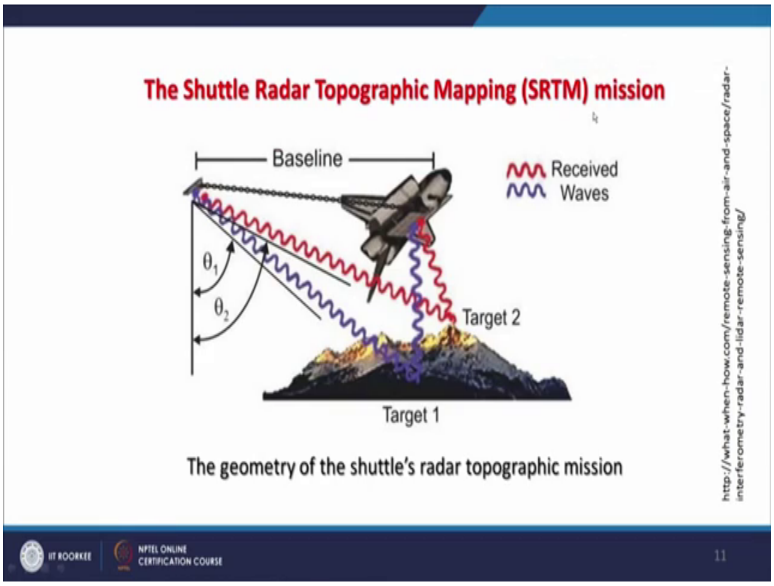

So, the first example of a SRTM, INSAR and or INSAR technology based was example, I have already taken that this was a mission, it was a not really a satellite, but it was a mission and roughly in 10 days time the 80 percent of the globe was covered, and a the technology which was employed here, through because in radar interferometry or SAR interferometry the base line is a big issue.

So, there is a long shaft base was used to acquire the data from two different angles, and this mission lasted about 10 days and the 80 percent of the globe was covered with two different angles data as you can see theta1, theta 2 and then this was processed through photogrammetric techniques and a glue digital elevation model at different resolution 90-meter, 30 meter were generated for almost all parts of the globe except a for polar regions.

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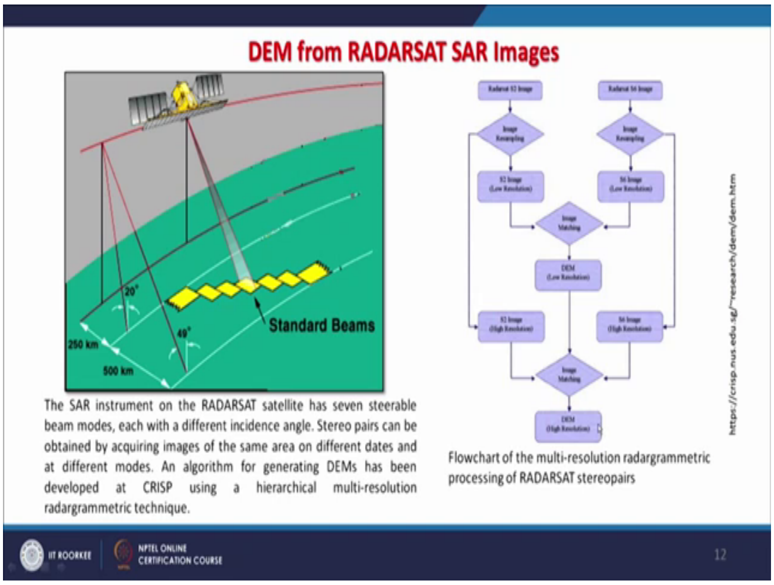

One example from RADARSAT that DEM, can also be generated employing same SAR interferometry technique. So, RADARSAT had the capability of a steerable beam with a 7 steerable beams and it used to a acquire data in that manner stereo pair, where made finally and then you process the data and ultimately finally, you get the digital elevation model, at the same resolution as the data was being acquired.

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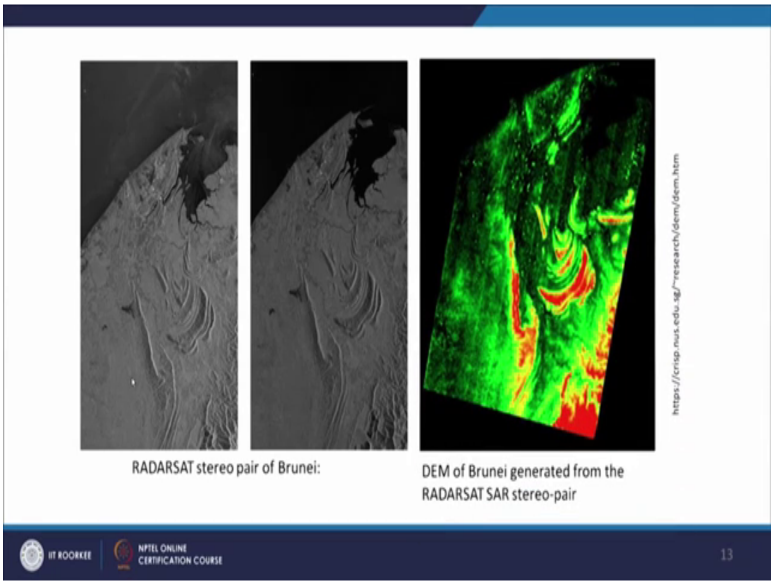

The example here again the stereo pair of this data and this is the digital elevation model, or Brunei generated from RADARSAT employing SAR interferometry technique, another example here which is one of the other satellite is coming, which is ALOS

PALSAR. So, what we are seeing in the top left image, is it true color land sat image just for visualization and for the same area.

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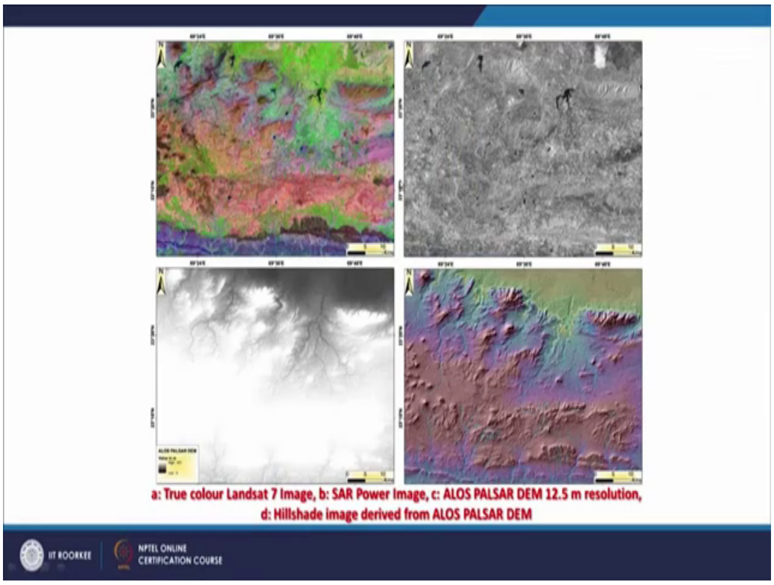

We are now seeing this ALOS PALSAR image, and which is having this a resolution, using this ALOS PALSAR data pair a digital elevation model on the bottom left, is shown here with a which was generated at 12.5-meter resolution of a region of a Kutch region of Gujarat India and a shadow relief modal generated from this ALOS PALSAR DEM is also shown here.

So, you can compare that, this is the optical image from landsat this is power image or radar image from ALOS PALSAR, and data pair of ALOS PALSAR has been used to generate a digital elevation modal at 12.5 meter and then finally, hillshade is generated you can use this data for various purposes, but just one product which is very common looks nice as also been shown in this example. So, various options are available, to generate digital elevation models even using SAR interferometry and radar technology.

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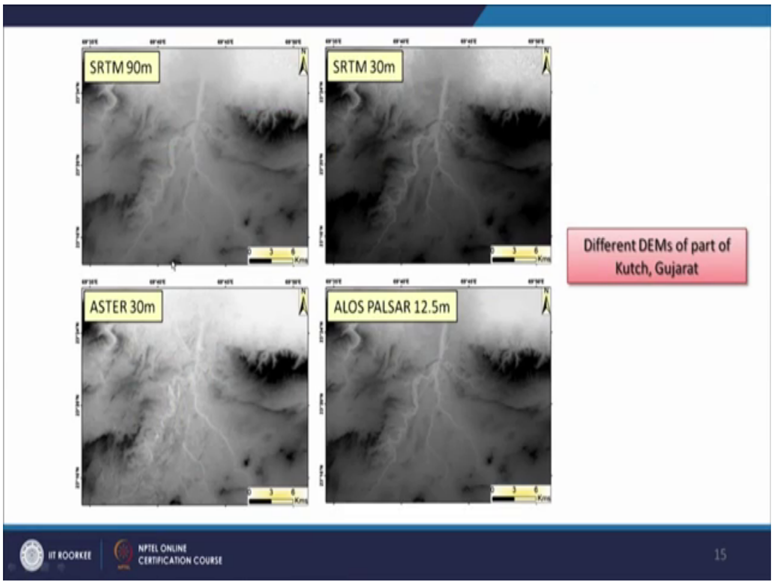

One more comparison is here, that this is a SRTM at 90 meter, and this is SRTM at 30 meter again ASRTM-DEM at 30 meter, which you can compare 30-meter, 30 meter, but a still SRTM is also a quite comparable and then also PALSAR 12.5 meter. So, when we compare this 90 meter to 12.5 meter definitely, there are there is a difference and finer details in this 12.5 meter can be seen as those may not be visible at a relatively low-resolution image, and this is again the same part which is the Kutch region of Gujarat.

So, if a options are available, that if you are having for the same area multiple digital elevation models are available one can do first comparative study, and then asses which one is the most accurate by employing some point observations or getting data from differential GPS or already collected data by some other organization, then you can use the data input, data point, data and compare against the data which has been generated or elevation models, which has been generated employing and different techniques and then one can use further for various analysis.

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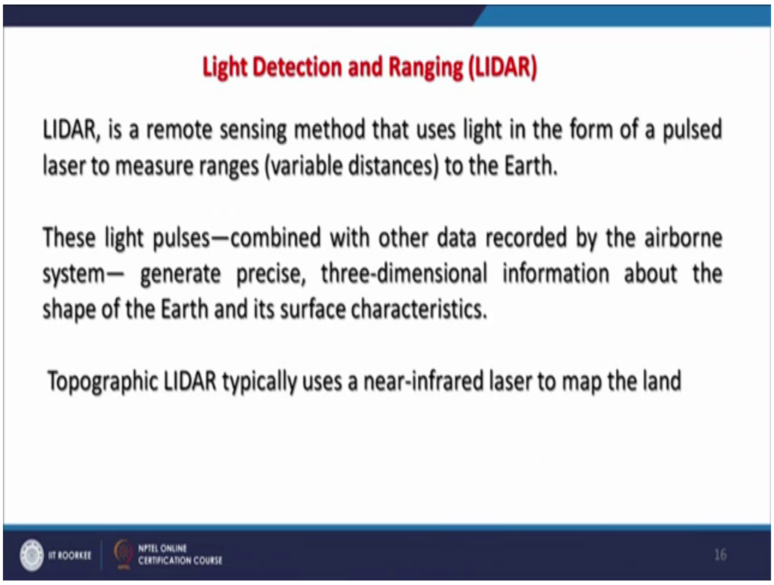

Now, another example is from LIDAR, which is LIDAR is a light detection and ranging technique, I am not going to in detail of how LIDAR really works, but LIDAR generates the DSM the digital surface model. So, again LIDAR is a remote sensing technique, and here instead of working in micro wave region it sends the light visible light in form of pulse laser to measure the ranges or distance to the earth.

Now, these lights pulses combined with other data recorded by airborne system, which generate precise 3Dimensional information and; that means, this data can be used also to generate a digital elevation model and this is what we do.

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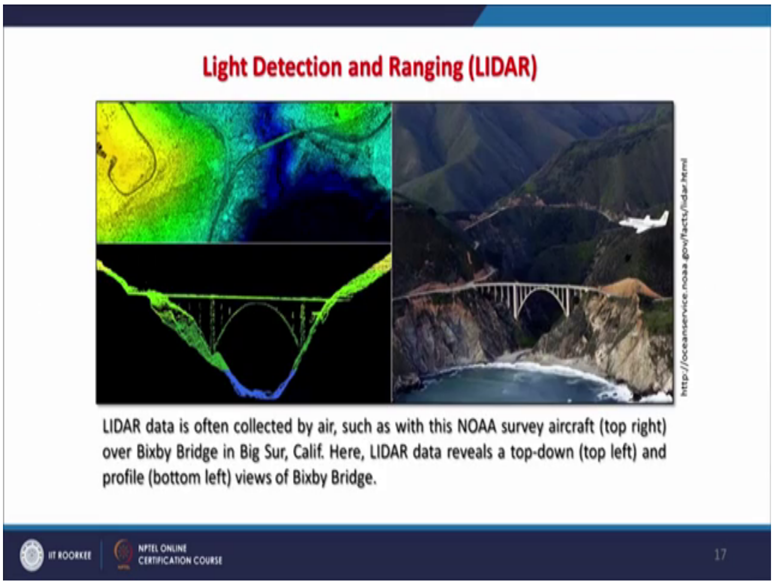

So, this is the example here, what we see this is the real photograph of that area and but what you are seeing, that by this is from the top and this is the profile view. So, both the things are here can be seen and this is how a LIDAR image will look like.

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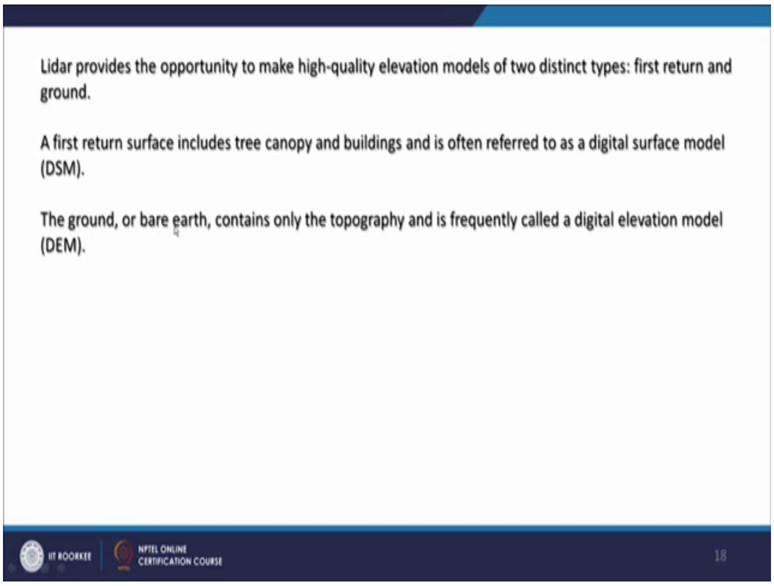

So, here LIDAR data is of 10 collected by air crafts and of course thus satellite LIDAR, LIDAR based on some satellites a still not a very ready one, but air borne LIDAR is very common, also radar provides opportunity to generate very high quality digital elevation models at a very high resolution, because a ground waste so we can generate much more higher elevation modules, as I have said that the this a this generates the DSM. So, first return surface which includes tree canopy and buildings, it is of 10 referred as a digital surface model.

So, in the example which we have seen here with the LIDAR, it is showing the DSM not really a digital elevation model, but later the ground of bare earth contains only topography and which we call as a digital elevation model. So, when we compare with the LIDAR DEM with the same resolution corresponding at the same area with say USGS 10-meter resolution.

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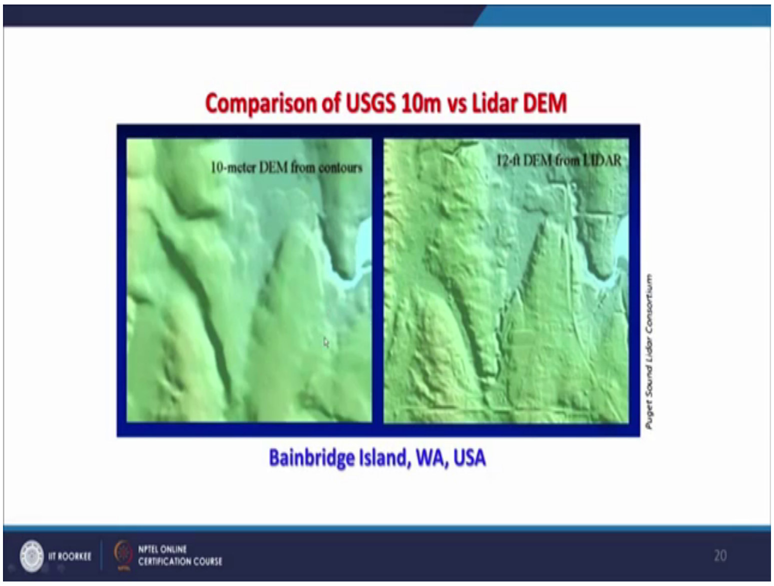

Because, LIDAR has generated a surface model rather than the elevation model and therefore, you see lot of differences, but there are techniques are available by which you can remove this canopy and buildings from the surface and a bare digital elevation model can also be generated.

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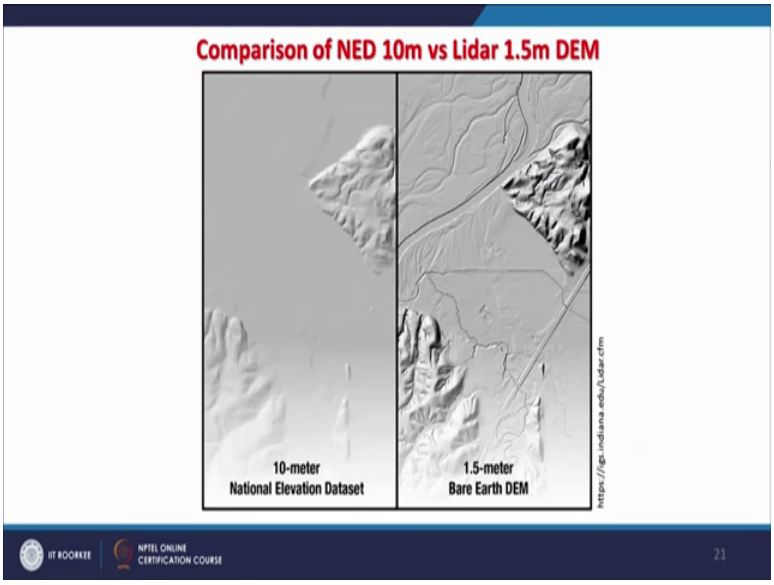

So, all kinds of options now a days are available to generate digital elevation model, one more example we see here, which is a national elevation data of us at 10-meter resolution versus LIDAR of 1.5-meter resolution. So, see is a 1.5-meter resolution, this is bare earth, this is not DSM this is really a DEM with comparing DEM of 10-meter resolution of course, there is a huge difference between the resolution spatial resolution and therefore, you are seeing much detailed information which is missing in 10-meter resolution we know very well that, if resolution improves then the details will more details will be available for us. So, that it depends on basically, what is the requirement project, requirement the work requirement and a depending on that one should choose the spatial resolution of a digital elevation model.

The first choice of course, is available through the free digital elevation models, but if it is not sufficient for requirement of a project, may be some constructions sites may be a dam site or a for landslide studies for route alignments any civil engineering problems, or a looking for some other things then at a digital elevations models at higher resolutions for a small area can also be generated as we have seen various techniques that either you use the ground survey techniques or use the stereo pair data of very high resolutions a CARTOSAT 2.5 meter, 4meter, 5meter resolution or may be some other INSAR technology and some other technologies can be employed and therefore, digital elevation models, almost at desire spatial resolution are now possible to generate. So, this brings to the end of this presentation.

Thank you very much.