Digital Elevation Models and Applications

Dr. Arun K. Saraf
Department of Earth Sciences
Indian Institute of Technology, Roorkee

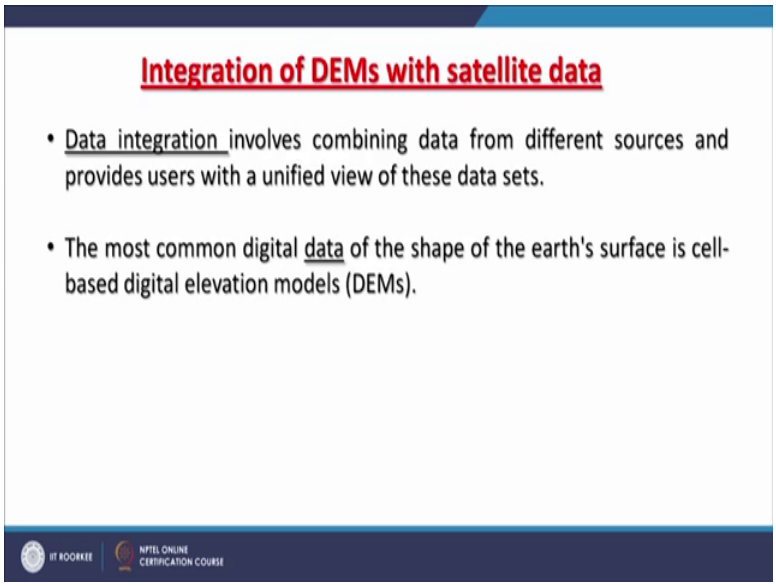
Lecture – 07
Integration of DEMs with Satellite Data

Hello everyone and welcome to the 7th lecture of digital elevation models and applications. And in this lecture, we are going to discuss about how to integrate digital elevation models with satellite data. One thing is common between these DEMs and satellite data that both are raster and therefore, it is a easy to integrate these 2 different types of rasters.

We have seen little differences which exist between DEM and satellite data, but while integrating them these minor differences will not create should not create much problem on this. So, when we go for integration of satellite data what basically integration here means that involves combining data from different sources and provides user by the unified view of these data sets. So, you know that digital elevation model represents the elevations an a and a or terrain conditions.

But the satellite data are representing only the surface part of it. So, when we you know integrate these 2 then we really get a 3D perfective view or a fly through view and other views we can achieve by integrating which we will be seeing some examples here and the most

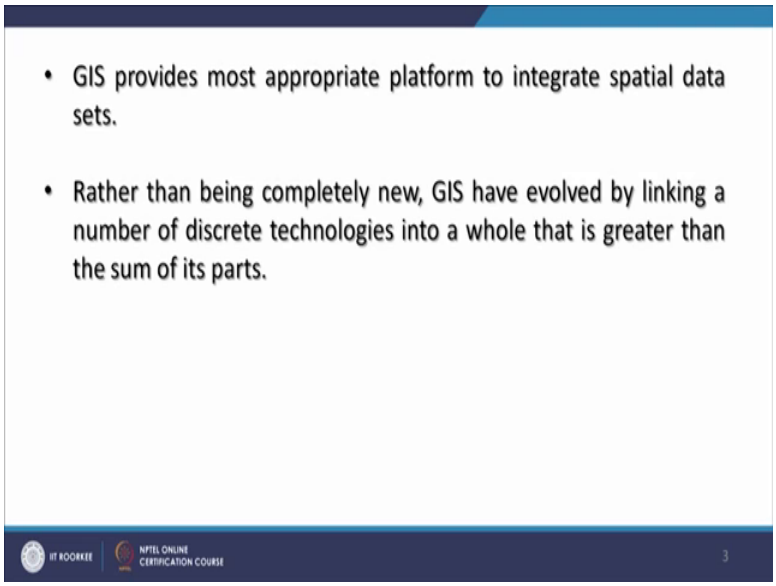
(Refer Slide Time: 01:41)



Common digital data of the shape of the Earth surface is cell based digital elevation models which we use. So, it is not very easy to integrate like for example, a surface like tin which is triangulated irregular network, but it is easy because as I have mentioned that satellite data and DEMs both are raster. And these a satellites which are geostationary and polar orbiting satellites also provide radiance or data images which are highly useful for integration purposes and GIS technology or many digital image processing tools also can allow us to integrate a such data sets.

So, GIS also provides most appropriate platform to integrate a special data sets and a rather.

(Refer Slide Time: 02:30)

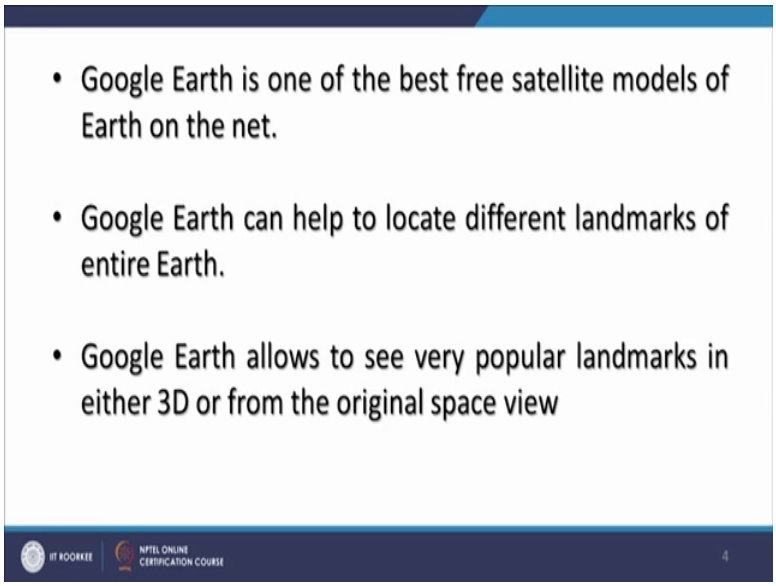


Than being completely new GIS has evolved by linking a number of discrete technologies into a whole that is greater than the sum of it is parts. So, different technologies if they are lying in isolation cannot be used a in integrated manner where GIS allows a integration, that is the one of the biggest strength of GIS that it allows the data to be integrated. And the, this platform which is available can also allow us to do the modeling and a, which is otherwise not possible by other means.

So, one of the best example of this a custom design GIS which provide the 3D perspective view and fly 3 view or data integration that is digital elevation model and satellite data is Google Earth as you know that on Google Earth the 2 basic kinds of data are being used, one is the what we see in the front satellite images of different resolutions when we zoom in we get higher and higher spatial resolution satellite images otherwise in the normal background what we are getting is landsat ETM images of about 30 meter resolutions and a in the background which the information which is coming about the elevation is coming from SRTM DEM of entire globe.

So, this a Google Earth has done the complete integration of these 2 data sets one is the satellite images and another one DEM SRTM DEM and therefore, and this is a custom design GIS software and therefore, we can very easily see the 3D perspective view and fly 3 view. And a Google Earth can also help to locate different landmarks of entire Earth not only that Google Earth is also having now Google Moon and Google Mars.

(Refer Slide Time: 04:26)

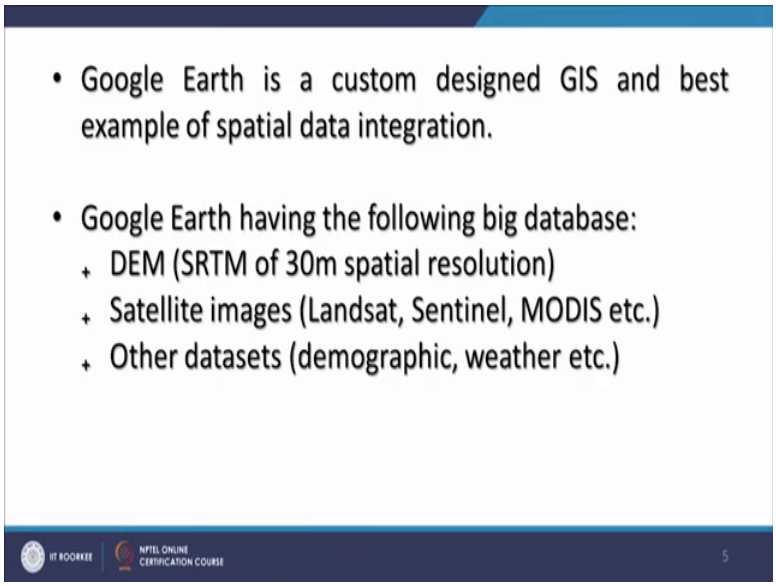


So, beautiful geomorphic features land forms of Google Mars. On Google Mars through satellite images or through Google Mars we can see which are very rear to see even on the surface of the Earth, reason is that the surface of the Mars is completely free from atmosphere there is no atmosphere on Mars.

So, the images which we get through the satellite which are orbiting Mars are very clear without much atmosphere distortions and therefore, we see beautiful land forms, but when this a 3D part has been added that is the digital elevation model of Mars has been added in Google Mars, then these land forms can be study as easily as for the Earth surface as well. And Google Earth also allows to, see very popular landmarks either in 3D or from, original space view for example, a very famous landmark which is the Mount Everest. So, Mount Everest can be seen through Google Earth in a very many different ways and with many different angles and that too in the 3D.

Google Earth as I have already mentioned is a custom design GIS and a best example of spatial data integration and especially it is the best example of satellite data and DEM integration Google Earth having the following big databases which I have already mentioned.

(Refer Slide Time: 06:16)



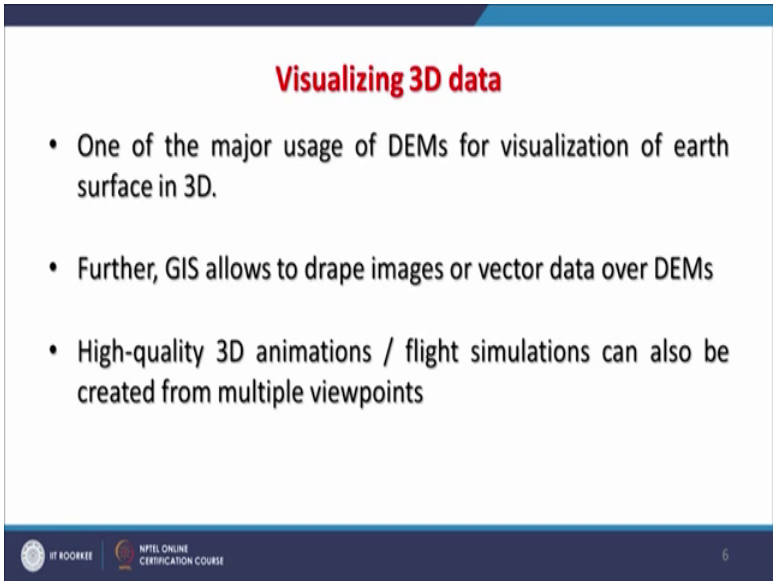
That a it is having a SRTM 30-meter spatial resolution data of entire globe and satellite images especially landsat in the background then sentinel and sometime modis data has also be in use for those areas where high resolution, relatively high resolution landsat images and sentinel images were not available some other data sets like demographic weather these are the additional layers.

Which you can overly over the Google Earth data are also available. Even Google Earth also allow users to add their own layers or own data sets, but the basic thing which we are discussing here is the integration of spatial data in that to digital elevation model and satellite images. So, when you want to visualize data in 3D basically the elevation value which is present in the cell of a digital elevation model be assign that to be treat that value as a hide value or z value and a do some vertical and add some vertical aggregation because you know the a scale vertical scale and horizontal scale are completely different in a digital elevation model.

So, because here least count may be a 1 meter in case of height whereas, a you may be having a 30-meter resolution data. So, that is why we add the vertical aggregation and then in a small screen we start seeing things in 3D, but when we overlay with or drape a satellite image over that then really it becomes a 3D perspective view otherwise it is a wear terrain surface

Which we see without satellite data in 3D. So, one of the major usage of DEMs for visualization of Earth surface in 3D or any part of the Earth in 3D and

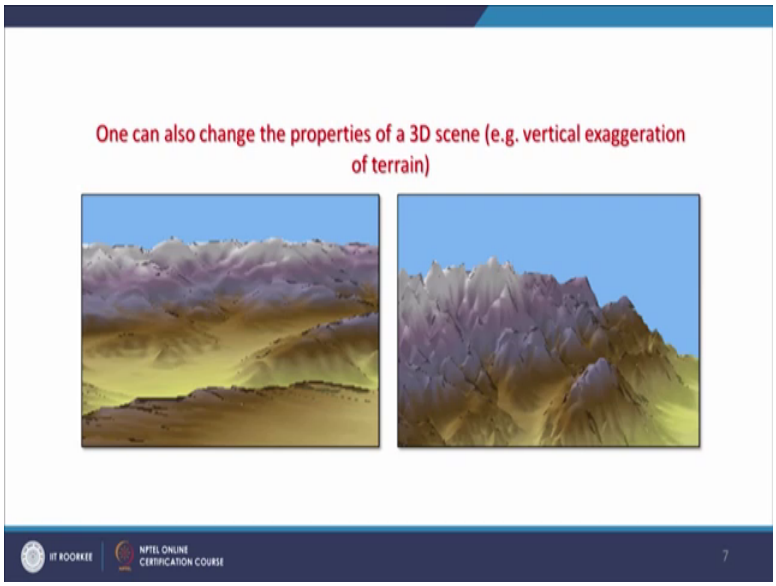
(Refer Slide Time: 08:13).



Further GIS or some digital image processing tools will also allow to drape images or vector data over DEMs, but a when we drape the images then only it becomes a true 3D perspective view. And high quality 3D animations flight simulations can also be created from multiple view points, and a these flight simulations are very, very useful sometimes especially for defense purposes or purposes or a training purposes for pilots and a say little older a story when we India had this Kargil war and during that time that terrain we knew that the terrain is very difficult and on war footings 3D perspective view of Kargil area where presented on GIS platforms to the pilots who were suppose to fly in that area.

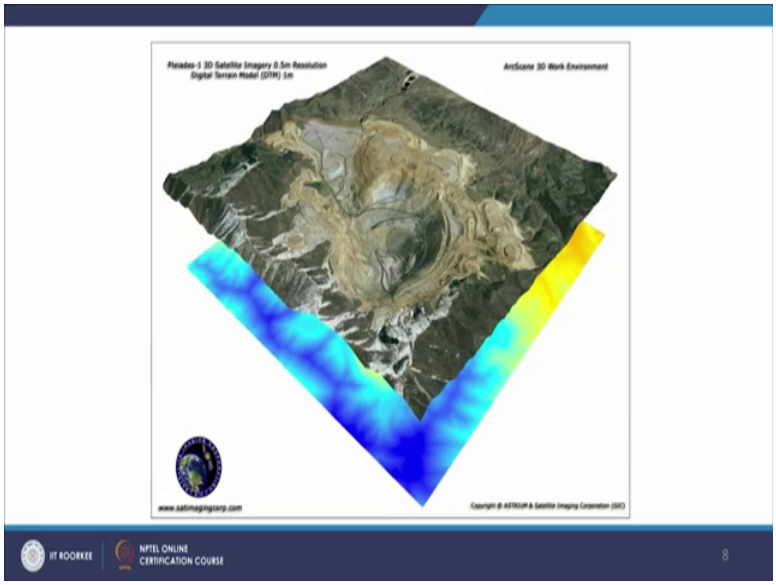
And then they were trained on the systems. So, that they are aware what kind of a terrain difficulties they will encounter. So, these the 3D perspective view flight simulations can

(Refer Slide Time: 09:30)



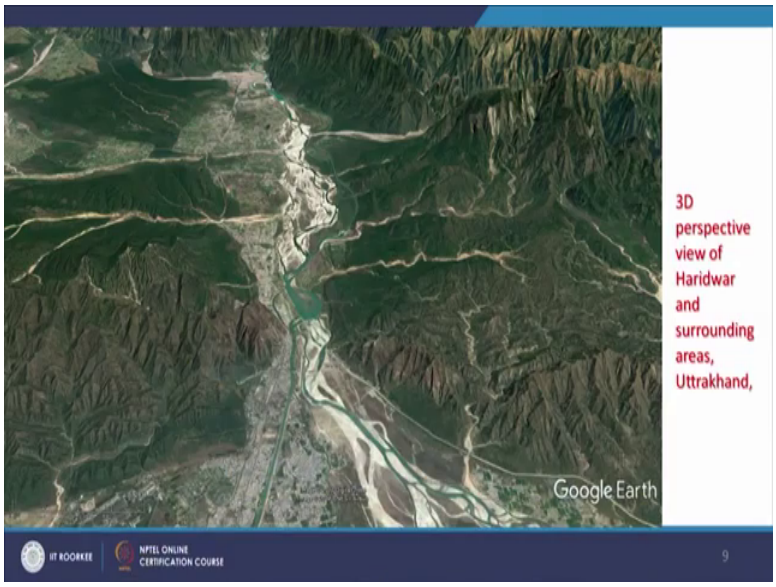
Really help pilots to train themselves. And a this is one example what we see here that a you can change this these properties in a 3D and that is this is what I was mentioning about the vertical exaggeration of a terrain. So, if you increase the vertical exaggeration then you start seeing things in a much more with much more height and a, but a one has to be very careful while a increasing vertical exaggeration, because it should not give a wrong perception of the terrain condition. So, it has to be judiciously chosen the vertical exaggeration otherwise a it may give a very wrong a perception about the terrain conditions. And this is one example here that in the background

(Refer Slide Time: 10:15)



What we are seeing a digital elevation model and top of this an image satellite image has been draped here and this has been this product has been created on a easy product which is arch scene 3D and a this having a very high resolution high spatial resolution satellite image from Plegados of one 3D satellite image of having 0.5 meter that 0.5-meter spatial resolution and a digital elevation model at 1-meter resolution. So, it depending on the requirements and availability of data sets one can create such 3D products.

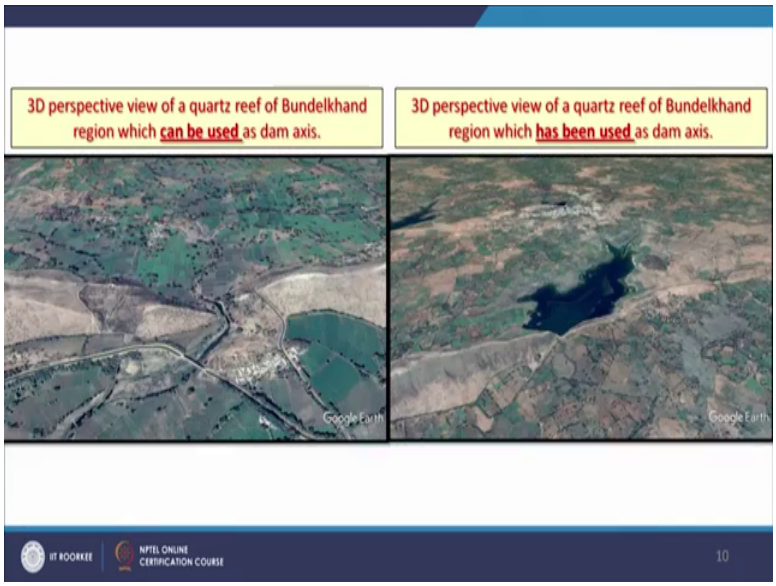
(Refer Slide Time: 11:01)



This is a one example from Google Earth which anyone can create for areas, but if a areas are having a rugged terrain like Himalaya then these 3D perspective view looks very good and convincing as well. This is the example near Haridwar which is located here the Ganges a river is coming down and then these are the Shivalik ranges.

Which you see and then for later on you find lesser Himalaya and the doon valley as well. So, while looking such thing terrain in 3D with a satellite data the interpretation becomes very easy one can make a load of interpretations about a geology about a structural features, geomorphology and many other things which may be required for different purposes.

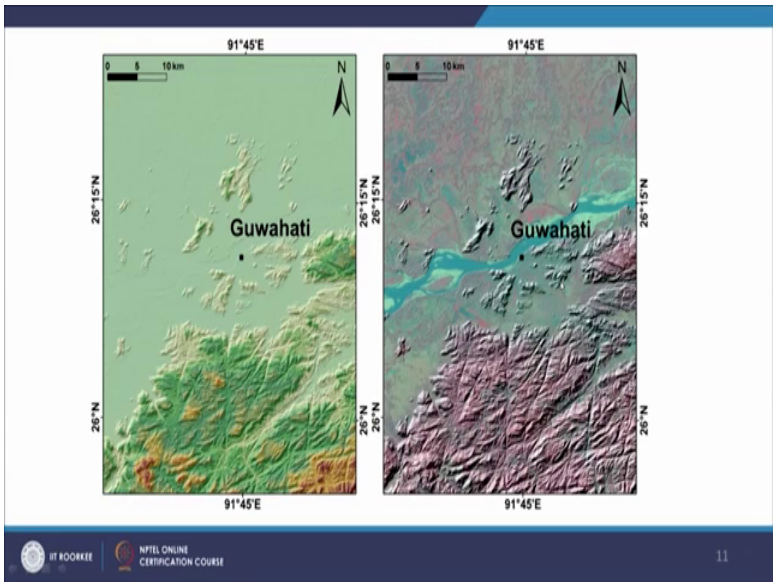
(Refer Slide Time: 12:00).



One more example here is that the 3D perspective view of quartz reef of Bundelkhand region which can be used for dam axis. So, this is the quartz reef it is very easy in a Google Earth to see a river is just a crossing this if just for from ground water recharge point of view of water resources point of view it is mentioned here that this ridge after seeing in 3D perspective view it is very easy to assess that if a this area is plugged then this can be used as a and then there will be an Phistream and there will be a reservoir and that can be used as a groundwater recharges texture, as one example here where this these quartz reef.

Which are running for 100 of miles in a Bundelkhand grenade which is having problems about the water. So, if a this has been blocked and a dam has been created and this is what the reservoir you are seeing in the Phistream. So, just looking a 3D perspective that 2 in Google Earth one can really use the data immediately without much processing for even such projects which are of very highly importance.

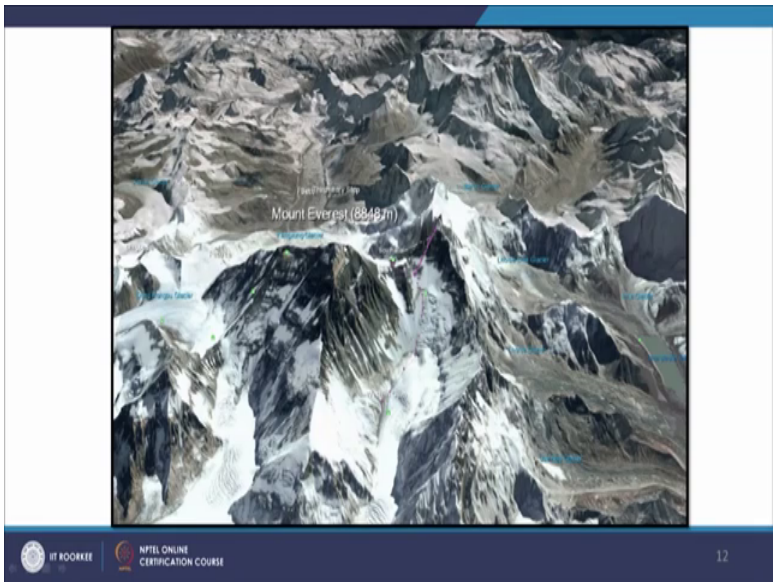
(Refer Slide Time: 13:22)



Now, there is another example of this is Guwahati region and what we are seeing a digital elevation model along with a satellite data and draped over it, and the instead of having some other view this is a shaded relief model over which a the satellite a data has been draped.

And one can see a you know lot of details which is otherwise impossible to see only with a shaded relief model of the same region. So, the input data are digital elevation model and satellite images sometimes you can instead of directly using digital elevation model you can create a product like shaded relief model and then later on use as a satellite image as a draped image over it and then you can see things in a much more better manner it, depending on the area and what resolution you are working and for what purpose one is working for. So, 3D perspective view or a these views where you combined or integrate 2 different data sets and a little none conventional way is also Possible.

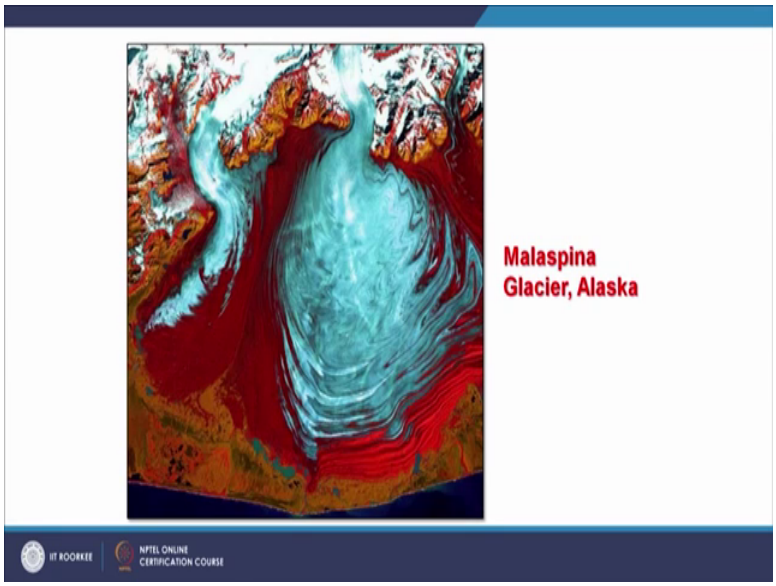
(Refer Slide Time: 14:37)



Now as I was mentioning about the Mount Everest. So, those this is very helpful for climbers to understand the terrain conditions before they start climbing such a peaks and a what they can plan everything.

And they can have a feeling of the terrain conditions and they can even on this Google Earth one can rotate the views and they all these 3D perspective and a create a proper vertical exaggerated 3D perspective view and can have a better training before they go or start climbing. So, this is one of the examples of data integration of digital elevation model as well as a your satellite data.

(Refer Slide Time: 15:26).



Another very good example of studying landforms and that too about a glacier which is very famous glacier is Malaspina in glacier in Alaska and this is a simple satellite image.

(Refer Slide Time: 15:40)

But this is the 3D perspective view. So, lot of features or lot of things which probably one cannot understand by just looking the satellite image, but if one goes for a 3D perspective view integrating with the digital elevation model of a may be about a relatively high resolution then everything become very clear.

So, all different types of glacier features landforms can now very easily identify on identified on these a 3D perspective view and moraines and lateral moraine and moraine terminal moraine all these things can be very easily identified including the lakes and the downstream area and they are main glaciated part crevices, all those features can be identified quite easily once we integrate the data digital elevation model and satellite images. There are some other applications where we can integrate and this is one of the examples because here if you see this a image on the left side which is our IRS 1D list 3.

(Refer Slide Time: 16:55)

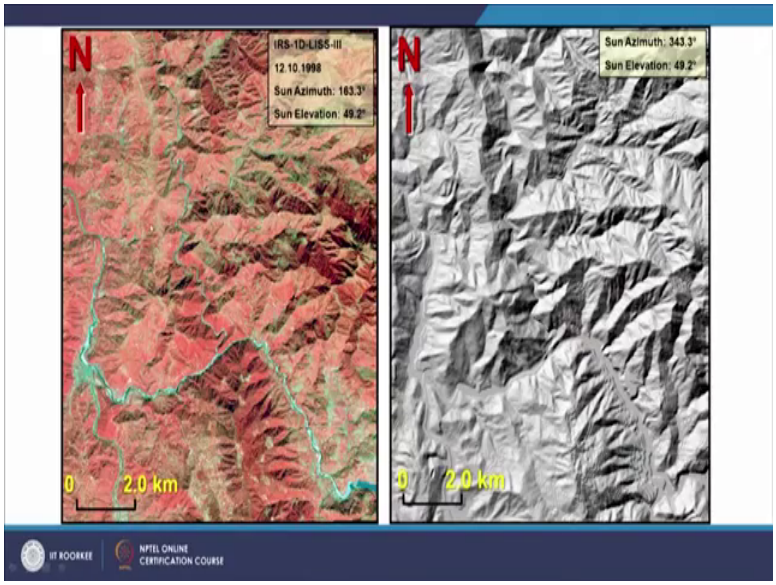


Image and a the in the center the image is having the Bhagirathi river which is tributary of angels and what we perceive here that it is flowing on the ridge and this is because of a phenomena which is called false topographic perception phenomena. And a this happens because of the illumination angle and view viewers position and the satellite position.

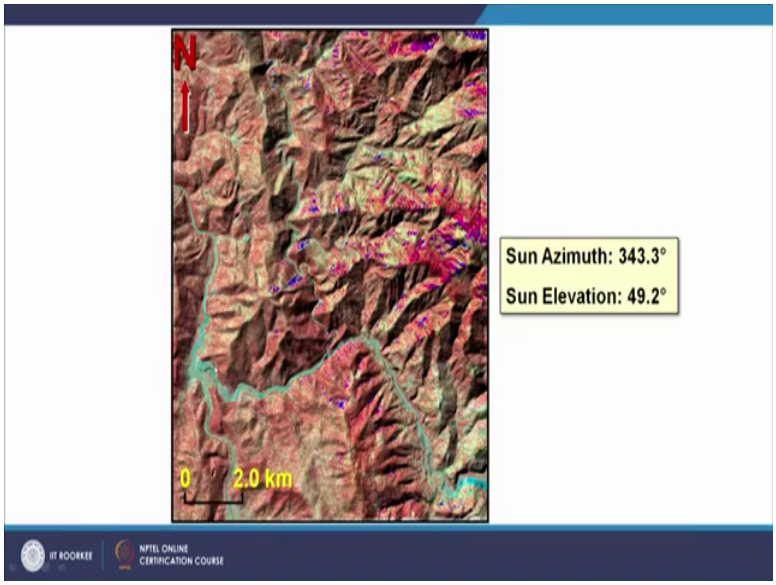
So, when this combination is there; that means, when the view the illumination is from south east quadrant, basically in the morning hours and a viewer is always in the you know and the southern hemisphere north is upward and a satellite has taken image from northern view.

Then we see this false topographic perception phenomena or in short, we call as a FTPP. And the fact of this that the one perceives ridges as valleys and vice versa and this is what we are seeing in this particular image that Bhagirathi river seems to be flowing on

the on the ridge geomorphologically or topographically it is not possible, but this is what one perceives in the images of hilly terrain, but implying this digital elevation model and then a product which is shaded relief model or hill shade of a opposite illumination angel.

Which is on the right side as you can see that if we add 163 plus 180 degree then it becomes 343.3 degree and that is the illumination is now in the north west direction and once this is there then the viewer and the illumination source are in opposite hemisphere and then FTPP has gone, but this is a just a shaded relief model. So, implying this shaded relief model with a transformation, some color transformation techniques in digital image processing we can remove this FTPP from this satellite image as soon here. And this is what we are seeing that now this Bhagirathi river has gone inside the valley instead it was a in this original image it was seems to be flowing on the ridge because of effect of FTPP.

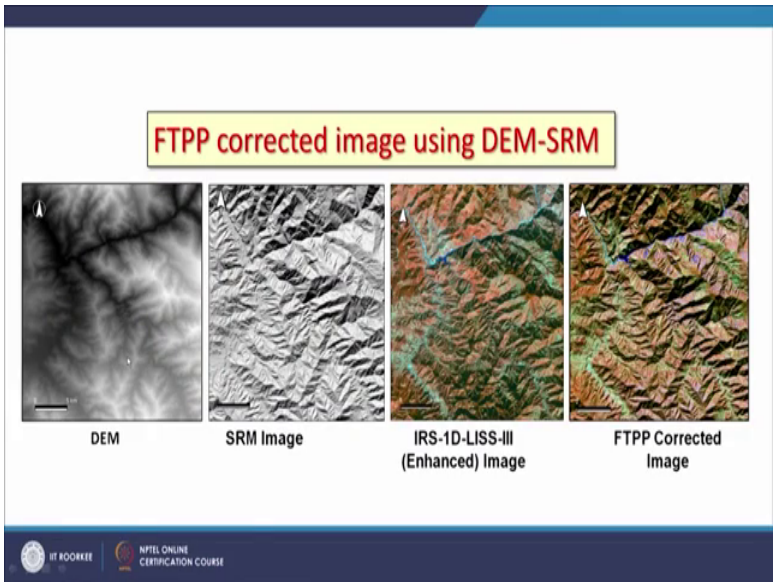
(Refer Slide Time: 19:23)



So, implying this is another way of integrating your satellite data and digital elevation model, but digital elevation model using that first a opposite angle shaded relief model was created and then through color transformation techniques then this FTPP has been removed very successfully.

So, there are various such examples can be given about the integration of remote sensing data with digital image and digital elevation models. So, here one more example is here

(Refer Slide Time: 19:58)



This is simple digital elevation model this is the shaded relief model which is having opposite illuminations source as compare to the satellite image and therefore, in the satellite image you are seeing river is flowing on the ridge this is because of the fact of FTPP. Here we have taking care while illuminating the digital elevation model and creating shaded relief model, in which it is illumination source in north west direction in case of this satellite image it is in the south east quadrant and a therefore, it is suffering from FTPP whereas, this shade SRM shaded relief model is not suffering from FTPP.

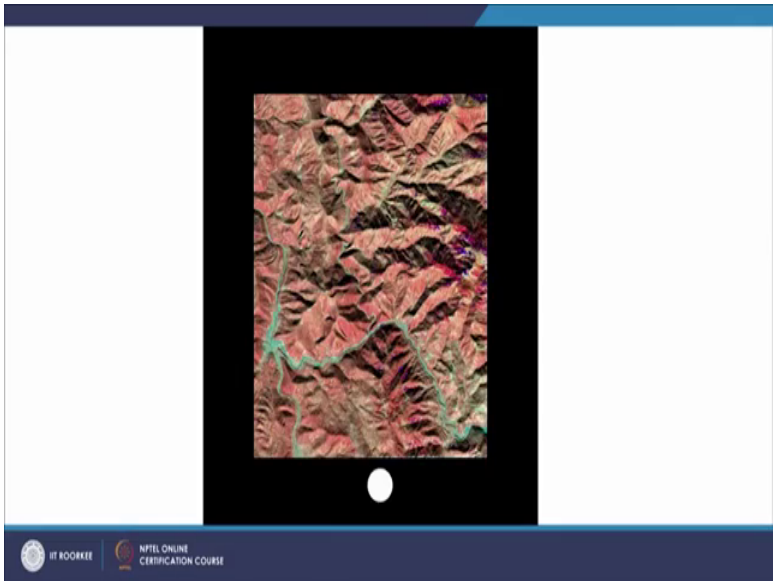
Because illumination source and viewer are in the opposite hemisphere. When we integrate these 2 through a color transformation technique then what we see that the this river this is again Bhagirathi river has gone in the valley which is giving a correct perspective view of the terrain.

So, if a somebody is making image interpretation just simply based on this satellite image this is suffering from FTPP, then he is bound to make lot of wrong interpretations about the terrain and geomorphic features. So, it is a it is always good that one first should remove the FTPP may be implying this SRM based a correction technique and then if make the interpretations then those interpretations are going to be highly reliable.

One can further use a the same technique and can create a animations which are simulated animations and 1 or 2 examples I am going to show you here is a one example

here; that here 8 such scenarios have been created where which includes that north direction.

(Refer Slide Time: 21:48)



And north east direction, then each direction, south east direction, south direction and south west direction, west direction and North West direction and with eight different illuminated shaded relief models, one single satellite image and over all these 8 different illuminated hill shades or shaded relief models the satellite image has been draped and what you see here? That a the phenomena which I was talking that is the first topographic perception phenomena.

When this, the solar illumination from the southern hemisphere then we see this effect of FTPP, but once a this solar illumination goes in the northern hemisphere and the viewer always assume himself in the southern hemisphere then FTPP is not seen. As you can see here that once it reaches a in the northern hemisphere direction in that in the upper half then FTPP is not seen. Whereas, once it goes the illumination source this is the showing the position of the sun when it goes in the southern half of the image then we start seeing FTPP.

So, this FTPP phenomena was also resolve or understood very easily while integrating DEM with a satellite data. So, not only it gives the 3D perspective view not only this integration gives you the flight simulation and other things, but also it can resolve many other problems which one might be facing in the field of a image processing remote

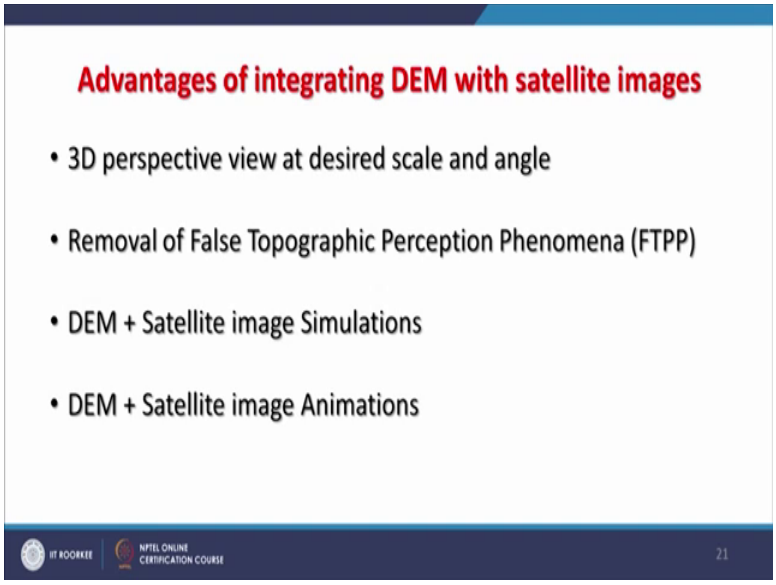
sensing or may be in GIS. One more example here is at a at every 5-degree interval there is a shaded relief model which has been created and each of these model the same satellite image has been draped. So, when you see the darkest image at that time the sun elevation has been kept at 5 degree from horizon. And a in the previous example the sun azimuth was being changed and or in the simulation had 8 images having 8 different sun azimuth angle, but here this is the what we are doing in this animation we are playing with sun elevation angle.

So, in the early morning what we see the sun is sun appears from the horizon and therefore, the terrain looks very dark, but when in the afternoon or in the noon when sun goes about overhead then we see the terrain very bright, or fully having full light and minimum size of the shadows. This is what it is depicting, but the same time it also convey to us that a you know in the morning hours between say 9:30 to 10:30 when these a sun synchronous satellites start taking images generally the sun elevation angle is a relatively low and therefore, we see large shadows and these shadows are basically creating the effect of FTPP.

So, this say simulation also depict or explains how FTPP effects when sun elevations changes. So, this is again important animation example in which shaded relief model or digital elevation model has been use along with the satellite data to understand this a FTPP phenomena in a better manner. So, this brings to the last few slides of this presentation.

What are the advantages with a integrating the DEM with satellite images? As we have seen that they provides the 3D perspective view

(Refer Slide Time: 25:59)



At desired scale and angle. And also, removal of false topographic perception phenomena I have demonstrated through many images and their integration with DEM and shaded relief model and a, this a DEM and satellite images simulations are also possible with different sun azimuth angle with different sun elevation angle.

Basically, using digital elevation model the when we create a shaded relief model then at our desired sun azimuth and elevation we can create a shaded relief model, and that model we can integrate with satellite data to create new products with otherwise impossible to create. So, that is the another advantage of integrating DEM and not directly, but creating a shaded relief model from DEM and integrating with satellite images and DEM and satellite image animations are also possible here. So, this brings to the end of this presentation.

Thank you very much.