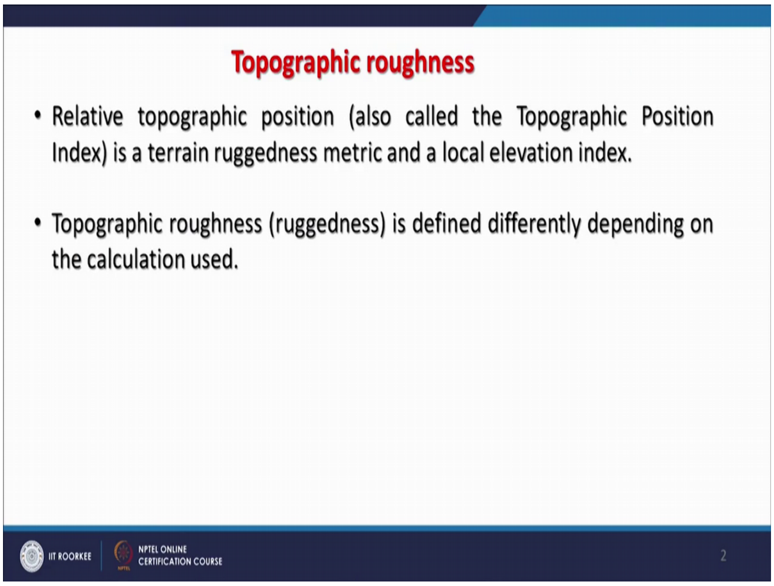
Digital Elevation Models and Applications
Dr. Arun K. Saraf
Department of Earth Sciences
Indian Institute of Technology, Roorkee

Lecture - 13
DEMs Derivatives – 3

Hello everyone and welcome to digital elevation models and application course and in the today’s topic which is the 14th topic of this course, in today’s topic, we will be discussing about few more derivatives of digital elevation models which we can drive. So, first one is that topographic roughness which is very important and also it is called topographic positional index. So, that can be used for determine the ruggedness of a terrain because otherwise a everything becomes subjective and invest through visual interpretations we may say that the terrain is a smooth or rugged.

But can we bring some quantities to it can be bring some index to it or indices to it and that is the approach here. So, we will be putting our digital elevation models and in for this analysis which is a basically relative topographic position or also called topographic position index and of course, the input is always here as usual is digital elevation model.

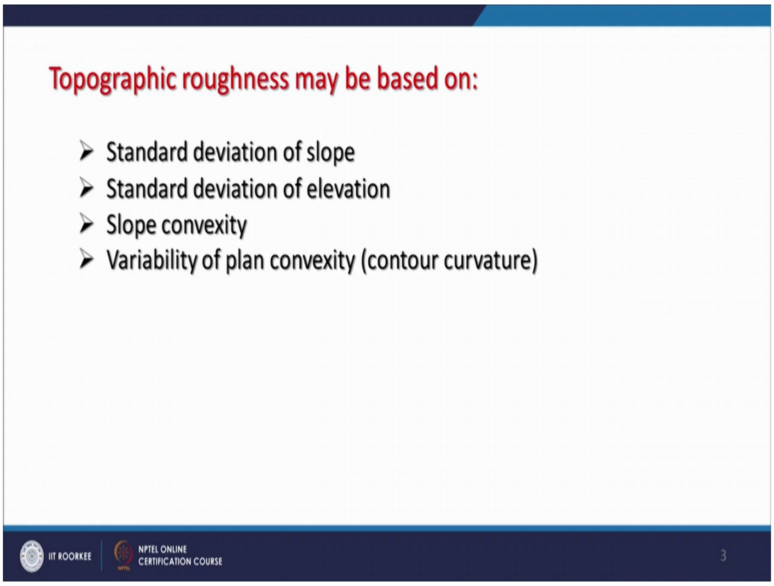
(Refer Slide Time: 01:30)



So, topographic roughness if we define that is ruggedness is defined differently depend in depending on the calculation used and mainly the main point would be here is the scale at which we will be determining the topographic positioning index.

So, TPI will depend on a scale that we will also discuss in detail. So, how basically it is depends the fundamentally behind this topographic position index is the slope and. So, how much it is deviating from a sloping surface that is standard deviation of slope and which may be based on our TPI or ruggedness by roughness may be based on standard deviation of elevations how elevations are changing.

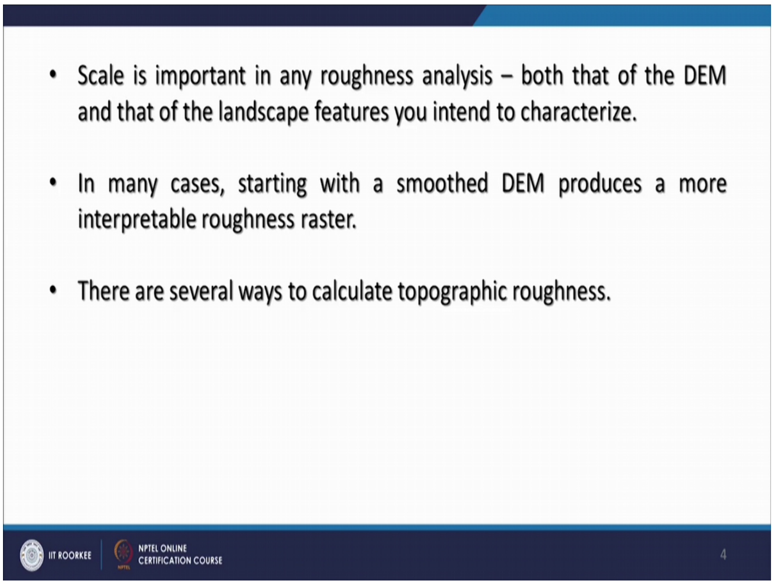
(Refer Slide Time: 02:23)



So, slope and elevation they are interlinked in here, then slope convexity whether slopes are convex concave that to we have also discussed and down slope or a cross slope and these parameters, we have discussed in previous discussion and forth in, this may be based on the variability of plan convexity that is contour curvature or some other measure of topographic texture.

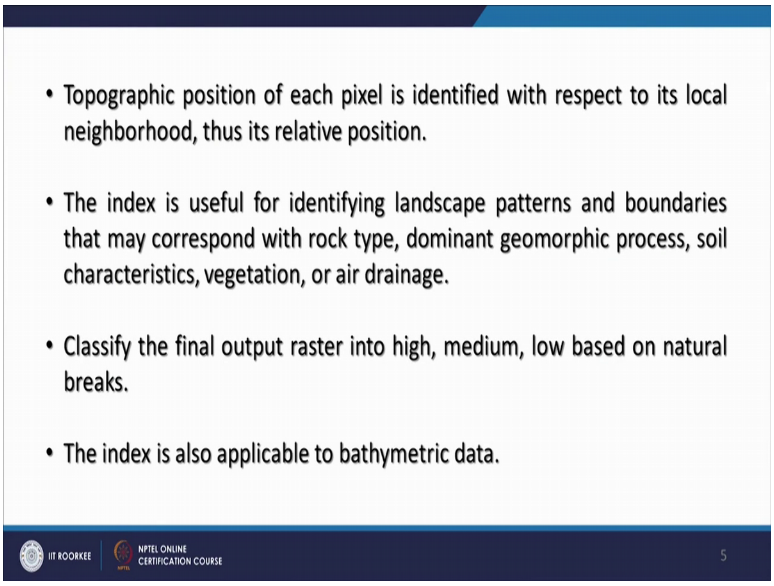
So, these will determine our topographic roughness or TPI. So, scale as I have mentioned earlier that is scale is an important.

(Refer Slide Time: 02:58)



In any roughness analysis both at the DEM at the landscape features, you intend to characterize. So, here the scale that is the resolution of digital elevation model will also play a very important role and. Secondly, at what is scaled we are analyzing this situation. So, we will see how the scale affects the TPI or topographic positioning index in many cases, they starting a smooth DEM produces a more interpretable roughness raster.

(Refer Slide Time: 03:39)



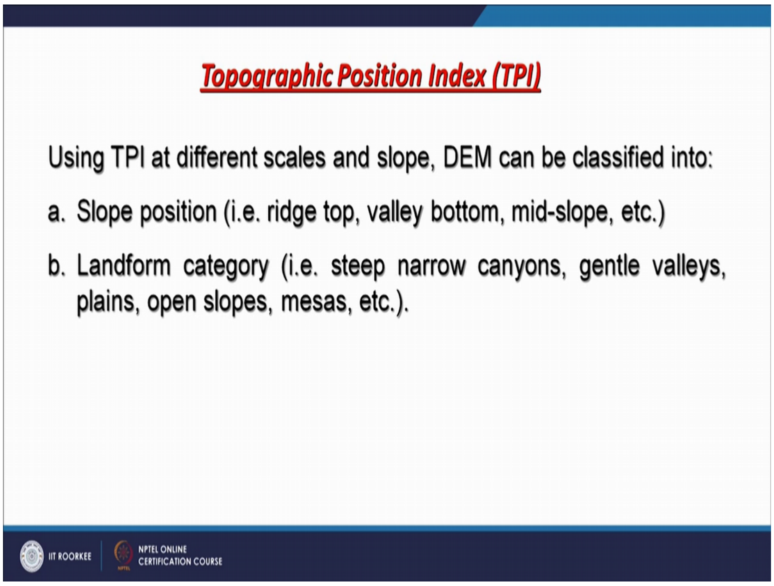
And then there are several ways to calculate and topographic roughness one the most popular one which we will also see here that how we can calculate TPI.

So, topographic position of each pixel is identified with respect to its local neighborhood and that is why it is in the beginning it is said that relative topographic position roughness. So, that that is because the calculation is basically based on the neighboring pixels what is their elevation and of course, the slope is determined based on that also.

So, the index is useful this TPI for identifying landscape patterns how landscape is there what are the different land landforms features which are present in a particular terrain or in a digital elevation model which has been subjected to TPI analysis boundaries and that may correspond with rock type dominate geographic processes soil characteristics vegetation or air drainage all these things can be used or can be identified based on this topographic positioning index and the final we can classify the output and we can create on output in sense of high medium or low based on natural breaks.

So, natural breaks like fault lines or some drainage lines or some geological features can also be incorporated and index is also applicable to mathematic data; that means, the data below the mean sea level underwater data if that digital elevation model is available then the same topographic index which can work for above mean sea level data can also work for below mean sea level data.

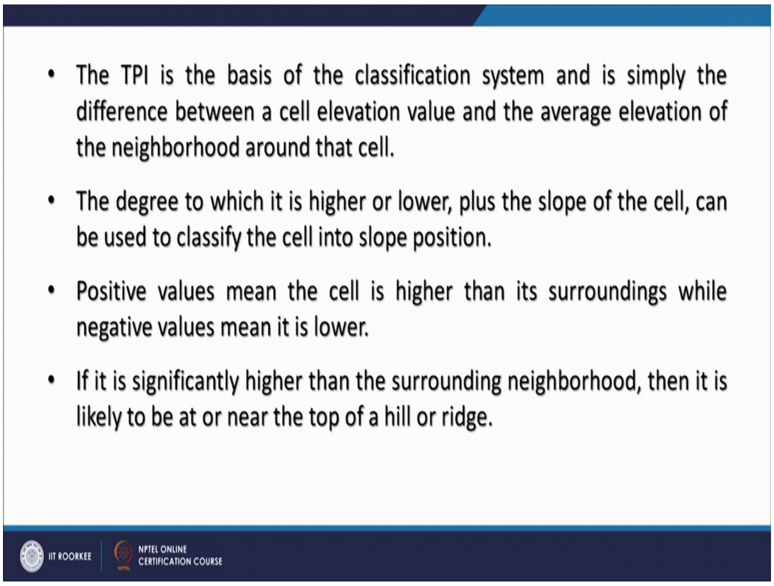
(Refer Slide Time: 05:36)



So, this TPI topographic position index a different scales and at different slope can be classified or based on that DEM can be classified for example, slope position sometime we say this is ridge top valley bottom or mid slope etcetera.

So, when we emphasize on slope where the slopes are positioned, then we can classify our digital elevation model based on ridge top valley bottom and mid slope etcetera when we bring the landform category then we can classify as a steep narrow canyons and gentle valleys plains open slopes mesas etcetera and this way as earlier I have mentioned that there are various ways of calculating topographic position index we will take one of the very popular example given by Janus to calculate this one. So, TPI basically is the basis of the classification system of landforms.

(Refer Slide Time: 06:36)

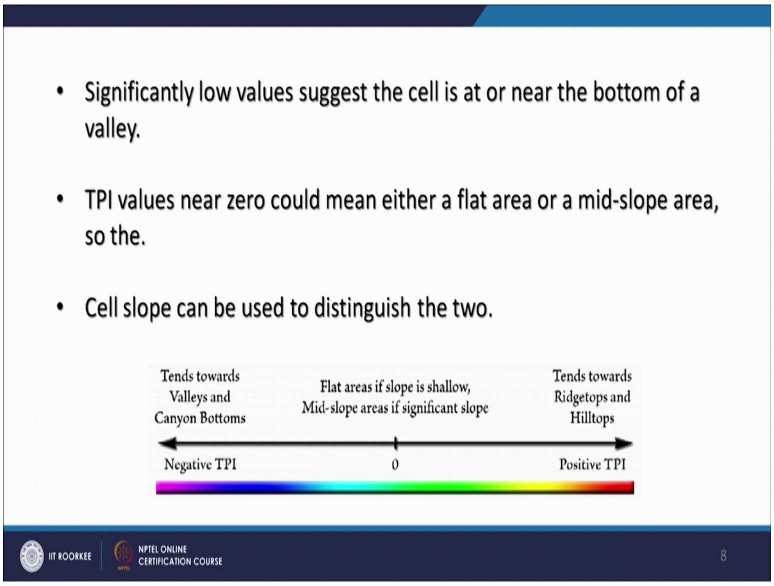


And is simply the difference between a cell elevation value and average elevation of neighborhood around that cell.

So, always for this calculation the neighboring cells values our elevation values are considered and degree to which it is higher or lower does the slope of the cell can be used to classify the cell into slope positions and these positive values means the cell is higher than its surroundings and vice versa when a while negative value will mean it is lower from surroundings and if it is significantly higher than the surrounding neighborhood, then it is likely to be near or at the top of or top of a hill or a ridge.

So, based on this if it is too high based on that we can say we can classify a landform as a hilltop or a ridge significantly low values suggest if a TPI values, we are getting very low value then probably we are at the near the bottom of a valley.

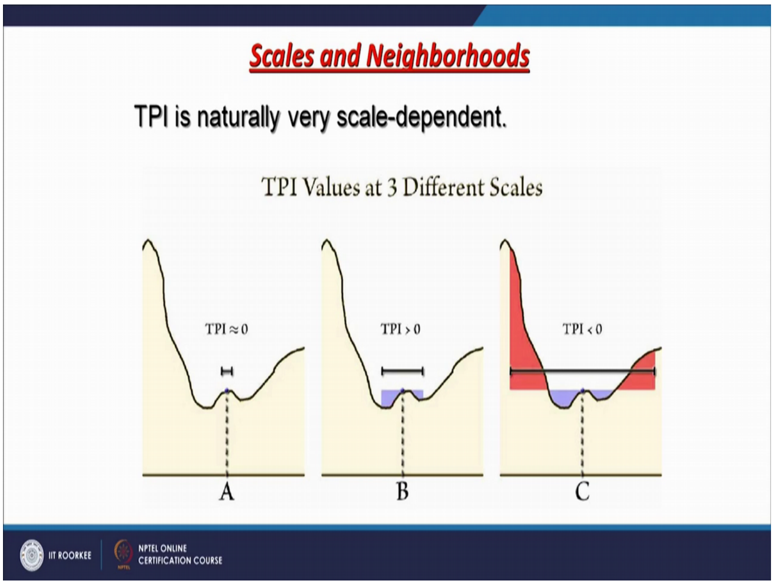
(Refer Slide Time: 07:53)



So, this is how the interpretation of a TPI map can be done and TPI values near 0 could mean either a flat area or a mid slope areas are present there and cell slopes can be used to distinguish the two whether it is flat or not here is the example is given here that what we are having in 0 values in the center. So, the flat areas if slope is shallow or mid slope areas if a if significant slopes are there then if we take towards the positive then trends and towards ridgetops and hill to hilltops when we are having positive TPI values very very high significantly high TPI value; that means, we are definitely on the ridge or hilltop whereas, significantly low and TPI value; that means, is a valley bottom canyon or in the maybe in the middle range also.

So, accordingly based on these TPI values we classify different landforms. So, TPI as have mentioned that is a naturally varies on the scale basically say scale dependent and because different neighborhood.

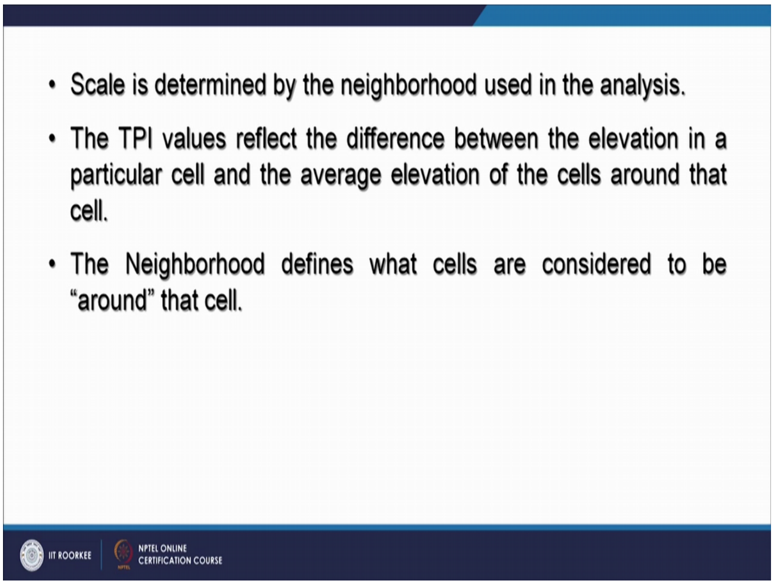
(Refer Slide Time: 09:10)



And the example here through this a schematic is that when like a if we get the TPI near 0 and then we are basically on the hilltop, but if TPI is greater than 0; however, the scale has changed this. this is nothing, but the scale bar and So, they say, this is a very large scale and therefore, your scale bar is very small here and if the TPI is equal to near about 0 then we are on the hilltop, but TPI is little greater than 0 when; however, the scale has changed. So, we are not really on the hilltop.

Now, we are in the valley bottom. So, it has given a completely different interpretation as scale has changed if a scale is further changed here like here it becomes further smaller scale bar becomes larger then we are encompassing these two things and completely the valley bottom has been incorporated when this TPI is less than 0. So, that is why it is said that TPI is naturally very scale dependent scale is determined because it is looking the neighborhood values which are used in the analysis TPI values reflects.

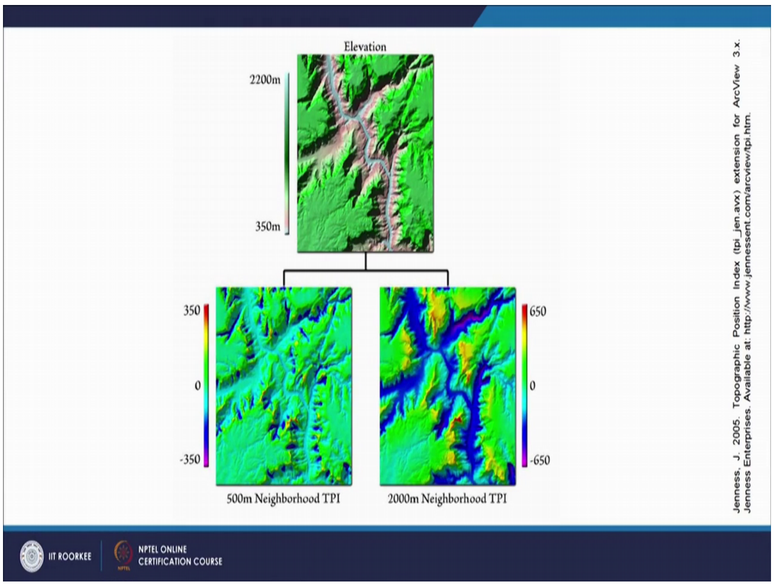
(Refer Slide Time: 10:30)



The difference between the elevation in a particular cell and the average elevation of cells surrounds that particular cell and neighborhood basically define that what cells are to be considered around that cell.

So, this they say a user can choose that while calculating the TPI, how big the search area should we and this is the example that.

(Refer Slide Time: 10:57)

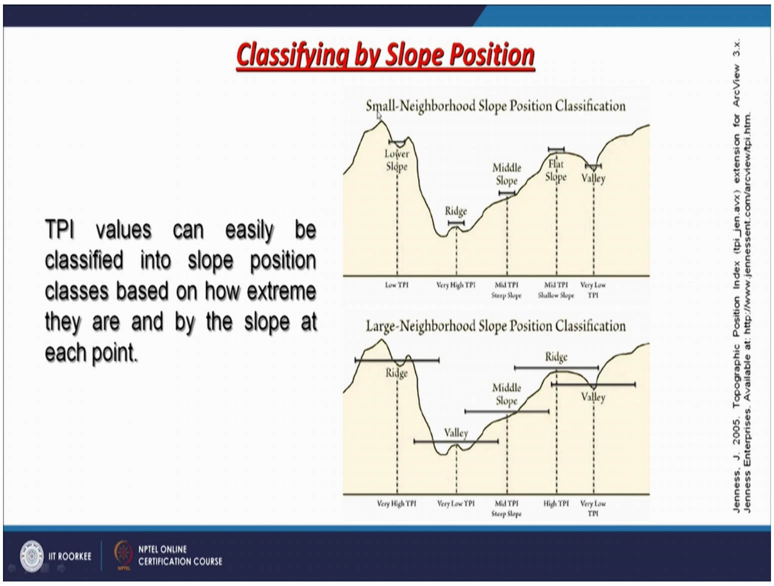


When we change the search area or neighborhood and in terms of here in this one is in terms of a scale then what happens. So, if the team the search is done based on the 500 meter in this particular example neighborhood TPI this is how a shaded relief model or a terrain will look like this and whereas, if the search area has increased four times it; that means, it becomes now 2000 meters, then the neighborhood or this TPI values will look like this or terrain will look like this and here this is this is the shaded relief model which is a input one here basically a digital elevation model, but shown here as a shaded relief model and these TPI values have completely changed.

So, if we see the legend here that the TPI when we are having a scale or the search area 500 meter then TPI values are not going much lower as compared to when we are keeping two hundred 2000 meter as a search area and TPI values are going much lower and much higher as. So, significantly lower here significantly higher significantly not that lower relatively and relatively not that higher here not that lower here, also it depends on what the search area, but generally a optimum value has to be found out and accordingly the search area should be chosen here.

So, TPI values can easily be classified into slope position classes based on how extreme they are and by the slope at each point.

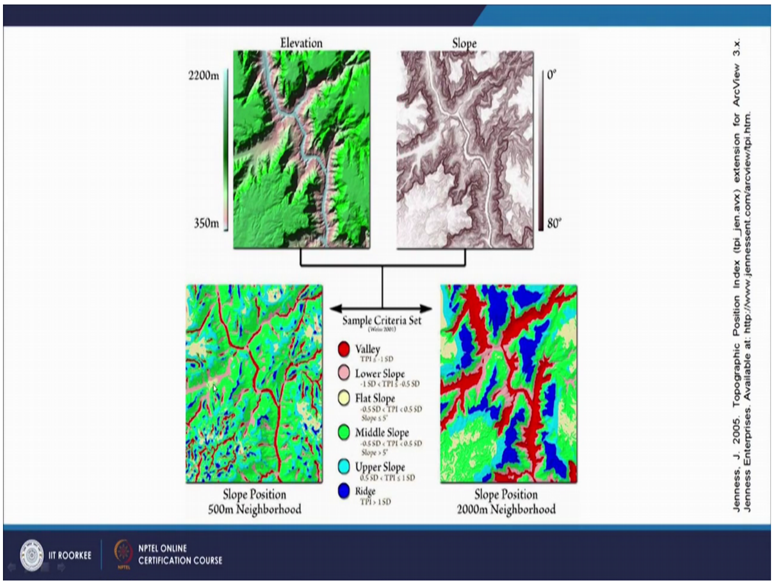
(Refer Slide Time: 12:48)



The two examples here given for a larger area we are different types of landforms are present, but different when we go for a small neighborhood and slope position classification is performed then only when a small neighborhood; that means, this is showing the length of the search area and then this area is defined as lower slope ridge middle slope flat and valley; however, when we go for larger neighborhood, when our search area increases then the same lower slope is defined here as a ridge the ridge here is defined as a valley and it is defined the middle slope remained middle slope this flat slope which was a layer determined based on the small search area is now have ridge valleys of course, here remind valley.

So, that is why the TPI values can easily be classified into slope position classes based on how extreme they are and by the slope of each point. So, the search area influences and the determination of our different kinds of landforms, here also one example is given here.

(Refer Slide Time: 14:08)



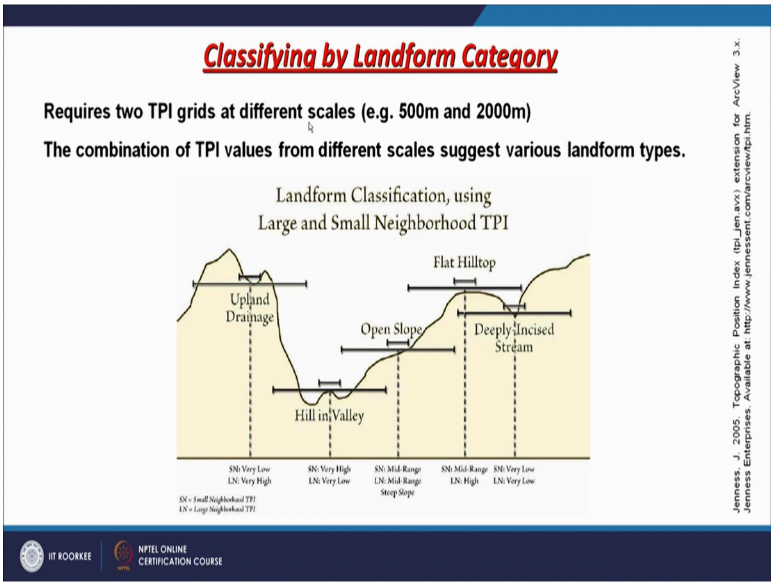
That when slope positions are in this example is 500 meter search area in this one is the 2000 meter search area now here like lower values where lower valleys were very is a very small part of this terrain had been classified lower value when this is a the TPI is just minus one standard deviation whereas here large area has been classified as valleys.

So, as we change from this thing; that means, the search area these things will change. So, these are the maps are they gone; that means, the digital elevation model is being represented at shaded relief model and this is the slope map derived from digital elevation model. So, depending on basically this is that is why we mentioned as a; this is a scale dependent. So, as we increased the search area the same the landform may be classified into different categories.

But basically it will depend on how rugged the terrain is if terrain is a not highly rugged undulated like Himalayan terrain which is highly rugged then these classification really will change quickly if you change the search area or scale in that case, but if it is a smoothly undulating terrain then probably while changing from say 500 meter to 2000 meter the classification of landforms or the area study area will not change that significantly. So, this basically depends on the of course, the terrain ruggedness how it is rugged.

So, by landform categories we can classify for which we requires two TPI grids at different scales for example, as we have been taken the example, when we are having a 500 meter and 2000 meter search area.

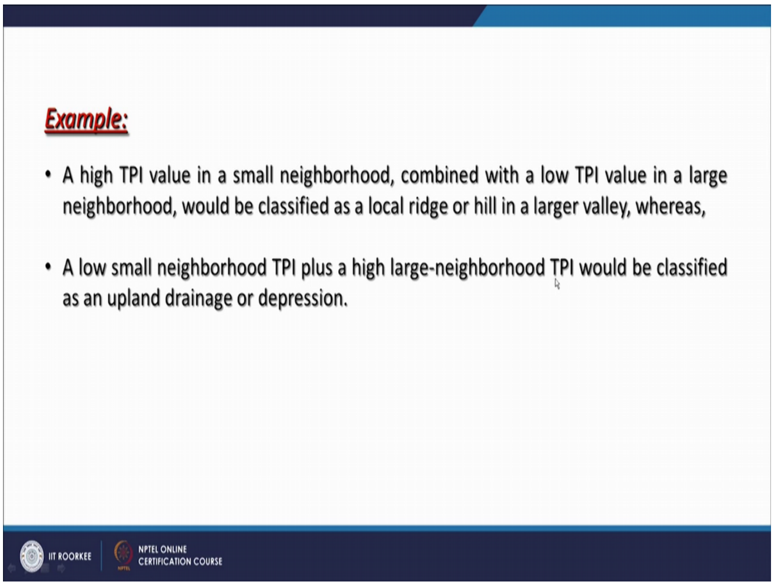
(Refer Slide Time: 16:20)



So, the combination of these TPI values from different scales will suggest various landform types as example here that the landform classification using large and small neighborhood TPI. So, when we combined different scales together then this is the situation that this we say, it is a upland drainage; that means, higher ground a drainage is there any re region, it is a very common thing and here is a hill in the valley means in a valley area there is a hello Hallock is there and open slopes are there flat hilltop there and deeply in size streams in the example.

So, it depends on again TPI here the small neighborhood TPI in this example is very low and this large neighborhood TPI is very high and that way it is classifying upland. So, classifying by landform category can give us a much better results because we are involving two TPIs which have been calculated based on two different scales in this example 500 scale and 2000 scale and an example here also.

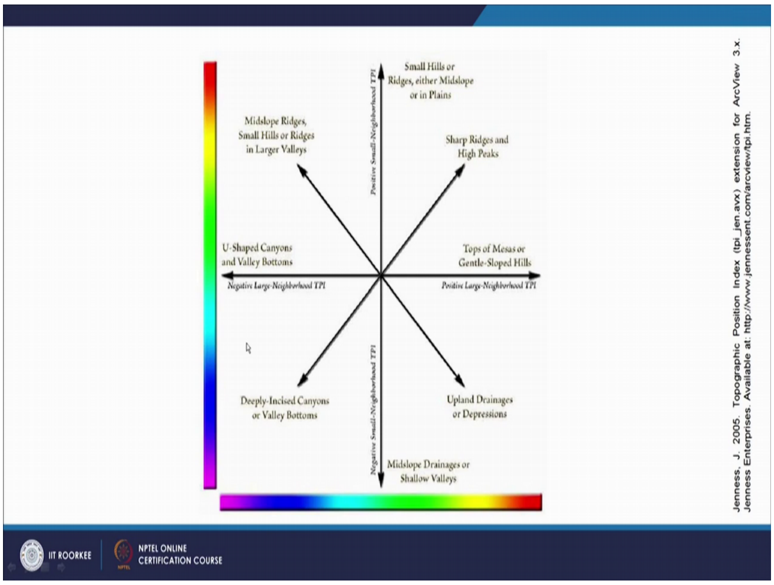
(Refer Slide Time: 17:38)



That a high TPI value in a small neighborhood combined with the low TPI as we have seen in the previous schematic with low TPI value in large neighborhood would be classified as a local ridge or a hill in the larger valleys areas as we have seen here like in this example.

But where we are having a small neighborhood TPI is very low and a large neighborhood TPI is very high similarly a low is small and neighborhood TPI plus a high large neighborhood TPI would be classified as an upland drainage or depression as we can see here that a upland drainage and a upland drainage in this example here.

(Refer Slide Time: 18:28)

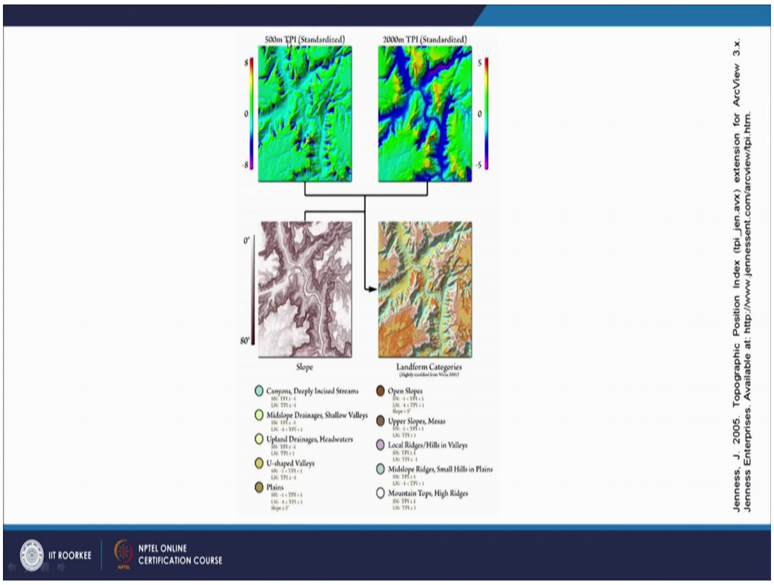


So, likewise we can classify the landforms based on the TPI and involving two TPIs of two different scales here if a another way of representing how things will be classified based on different TPI.

So, for example, if we can go on the right side this is positive large neighborhood TPI when the search area is large the scale is large the TPI value is positive then a slope will be gentle will be classified as gentle sloped hills or tops of mesa mesas mesa is a landform or a gentle sloped hills; however, if we go for a negative large neighborhood TPI that when the values are on the same large scale, but values are negative then we will have a u shaped canyons or valley bottom. So, just opposite landforms will be classified.

Similarly, for other two directions that when we go towards top or north that the positive is small neighborhood TPI, then we will classify as a small hills ridges either mid top or the plains opposite to this that the negative is small neighborhood TPI is mid slope drainage or shallow type and if we take the example here in the middle at that in this 45 degree angle then upland drainage drainages or depressions here is the mid slope small hills or ridges. So, likewise based on the TPI values based on the scales or combined in both we can classify our landforms and here is the final examples that here.

(Refer Slide Time: 20:21)



That TPI as 500 meter calculated and here it is 2000 meter and TPI.

So, different based on the slope we can classify and different landform categories as here shown the open slopes upper slopes mesa and a local ridges hills or in valleys mid slope ridges and mountaintops and what basically what we are getting here is that based on a simple digital elevation model and TPI calculations we can bring a landform classification very accurately rather than based on visual interpretations and maybe that may be due to human biasedness.

So, that may be avoided if we involved the digital basis that is the digital elevation models and calculating TPIs may be a first a two different scales and then combining and classifying that based on the landform categories. So, we can get a final product something like this. So, this brings to the end of this presentation.

Thank you very much.