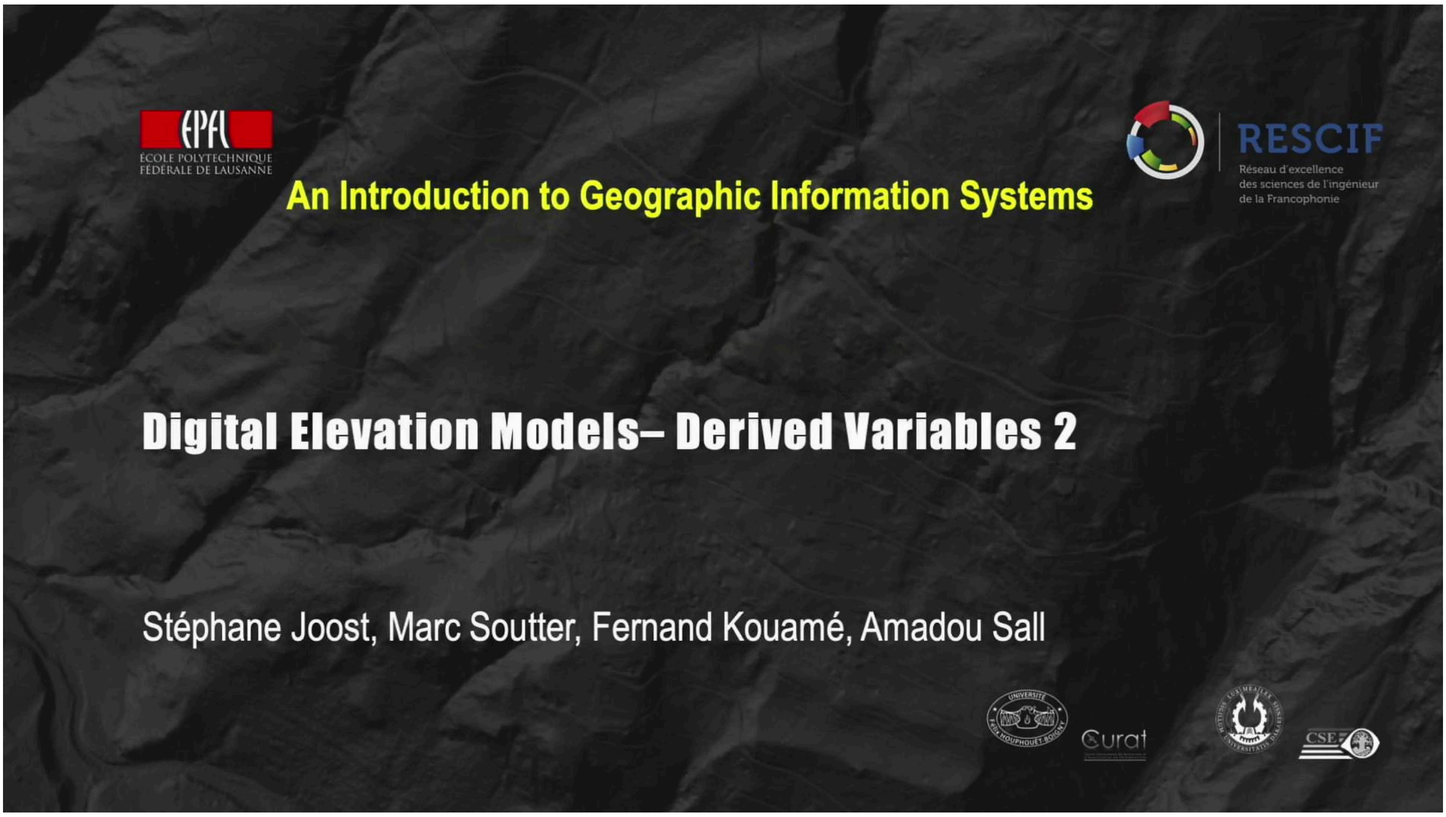
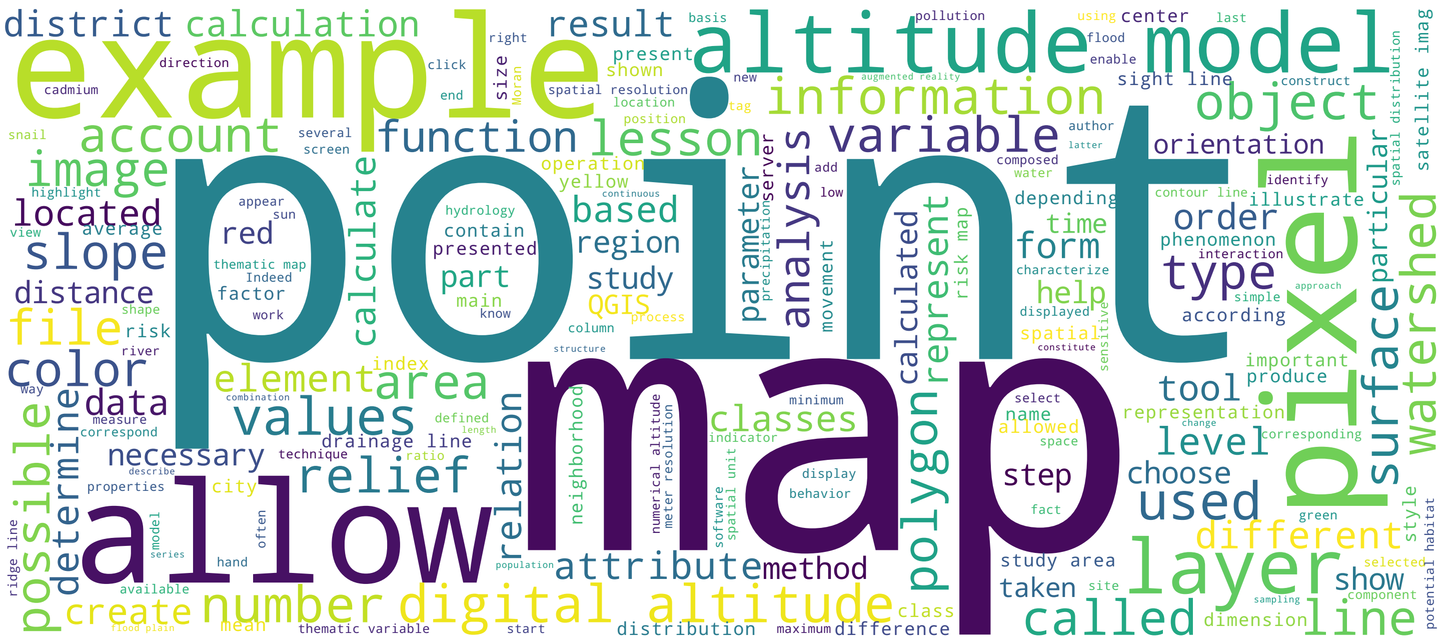
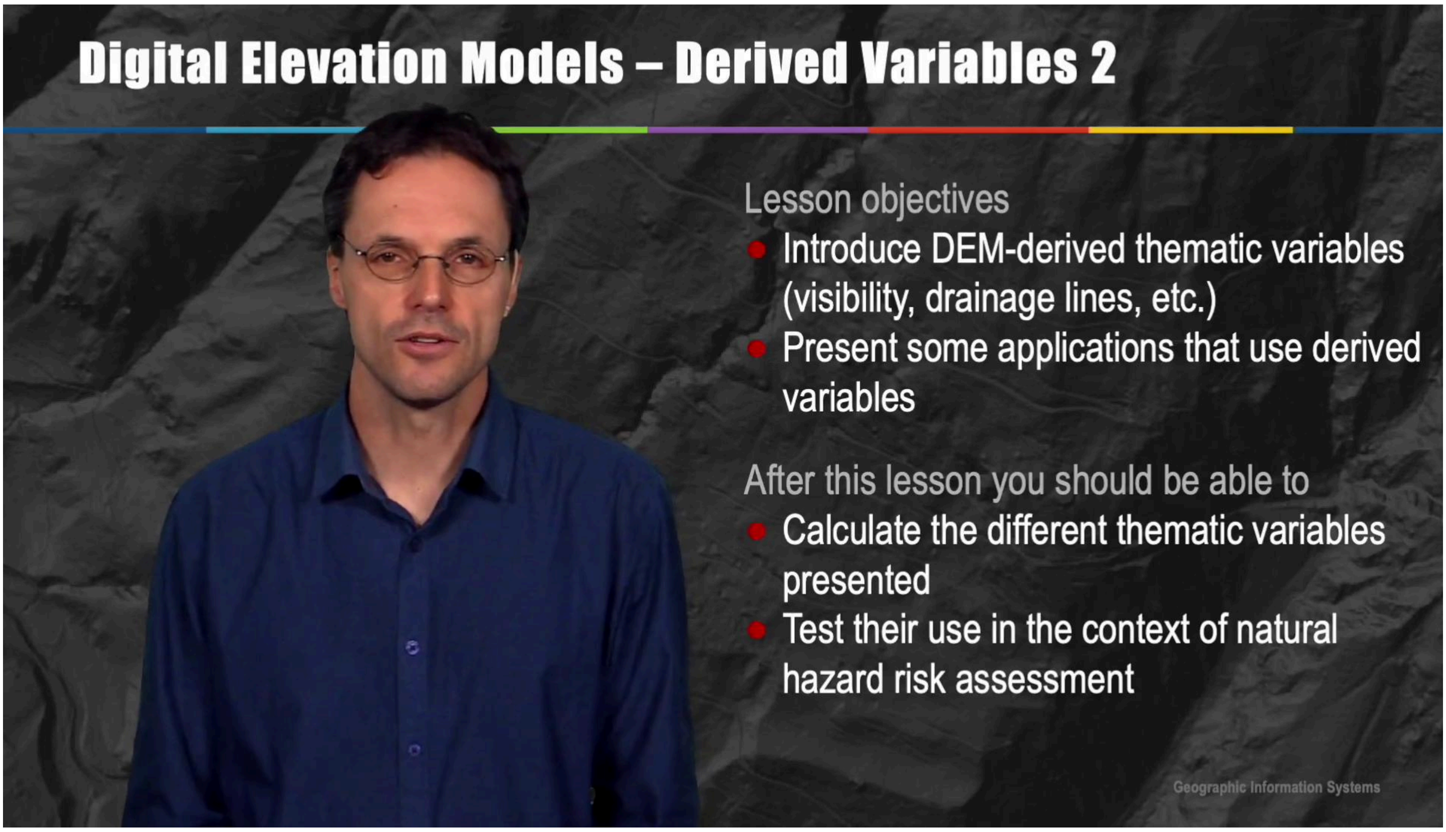




Search MOOC

Video

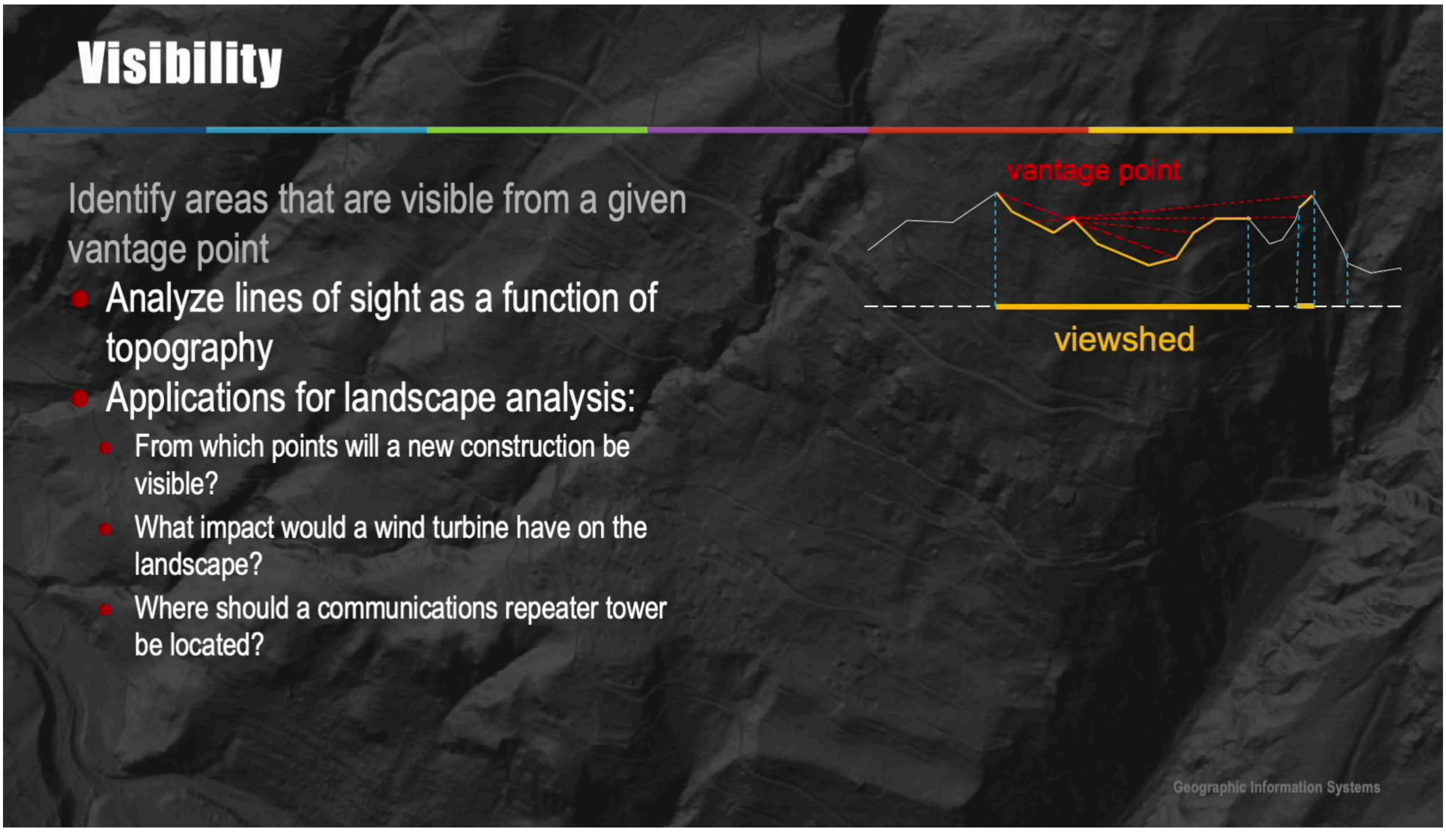


Welcome to this lesson which will focus on the derivatives of the digital altitude model that are the flow lines and delimitation of the watersheds that are important for hydrological studies. After presenting the derived variables frequently used in the previous lesson, the main purpose of this final lesson dedicated to the digital altitude model is to present a series of other thematic variables mentioned by Amadou Sall earlier. Indeed, the altitude is a primary variable which allows to determine the zones, which due to their topographical characteristics like the slope, the curvature or the orientation, are wanted or on the contrary avoided. But there are remarkable properties of numerical altitude models that allow to produce other variables and you will learn how to calculate them here and how it possible to use them in practical applications related to the assessment of natural hazards.

Notes

Summary

0m 30s

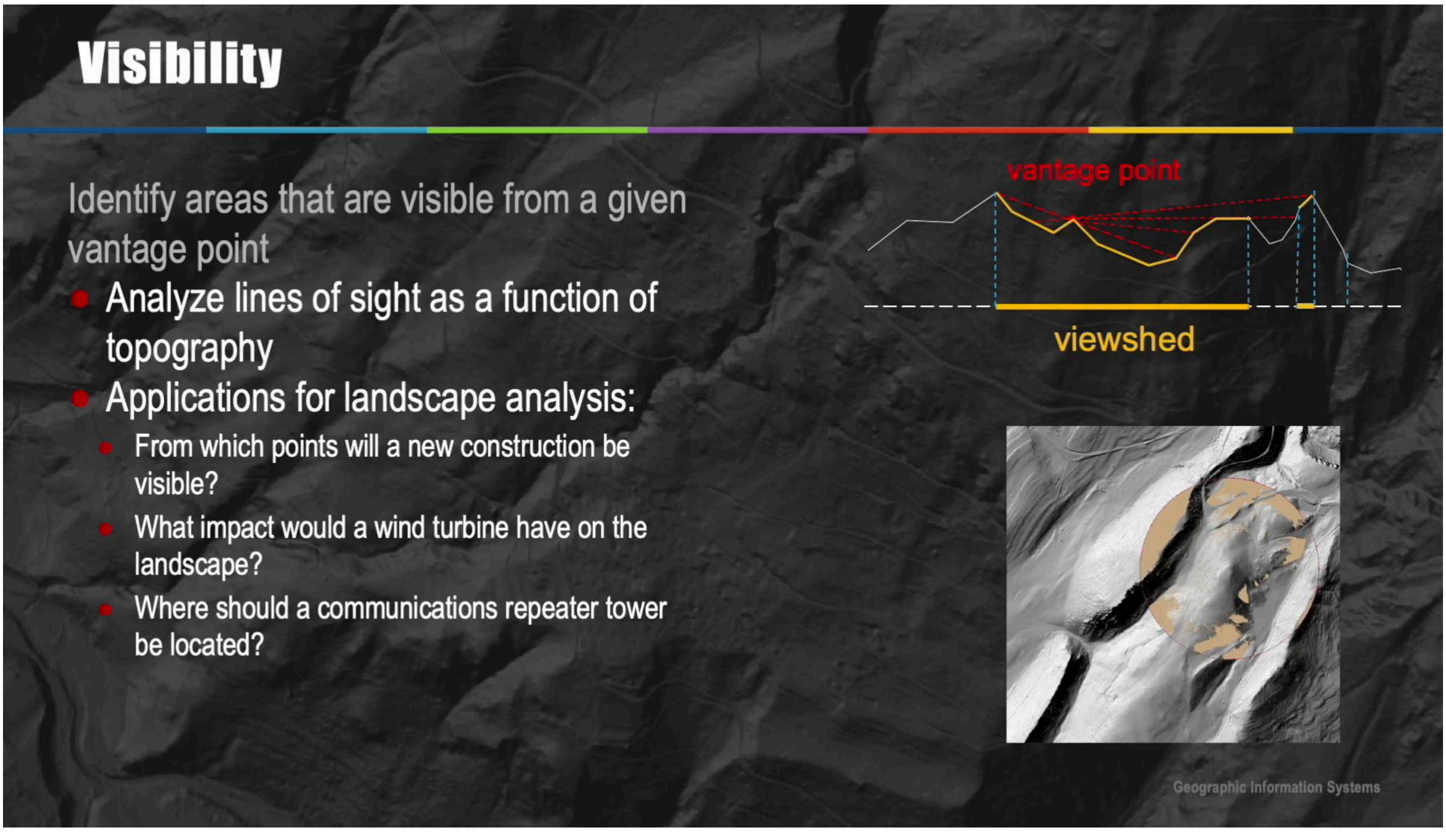


We will address first the analysis based on the exploitation of sight lines such as the analysis of visibility, the shadow cast and projected shadow or the calculation of the sunshine rate. And then we will introduce variables related to hydrology like the drainage lines or the watershed limits. And finally, we will show how some of these indicators can be used to assess natural hazards and the roles they can have in the public health field. Different approaches exploit what is called sight lines on a digital altitude model. A sight line is a straight line that connects two points and which is composed of all the pixels that are located on its path. The first approach, shown here, is called visibility analysis and it determines the visible areas from a given perspective shown here in red. The technique is based on the analysis of all the sight lines, that is to say in all the directions in relation to the relief. And it allows to identify clearly a visibility area shown in yellow on the illustration and an invisible area which is left blank and this from the point of view. This function is frequently used in landscape impact analysis.

Notes

Summary

1m 32s

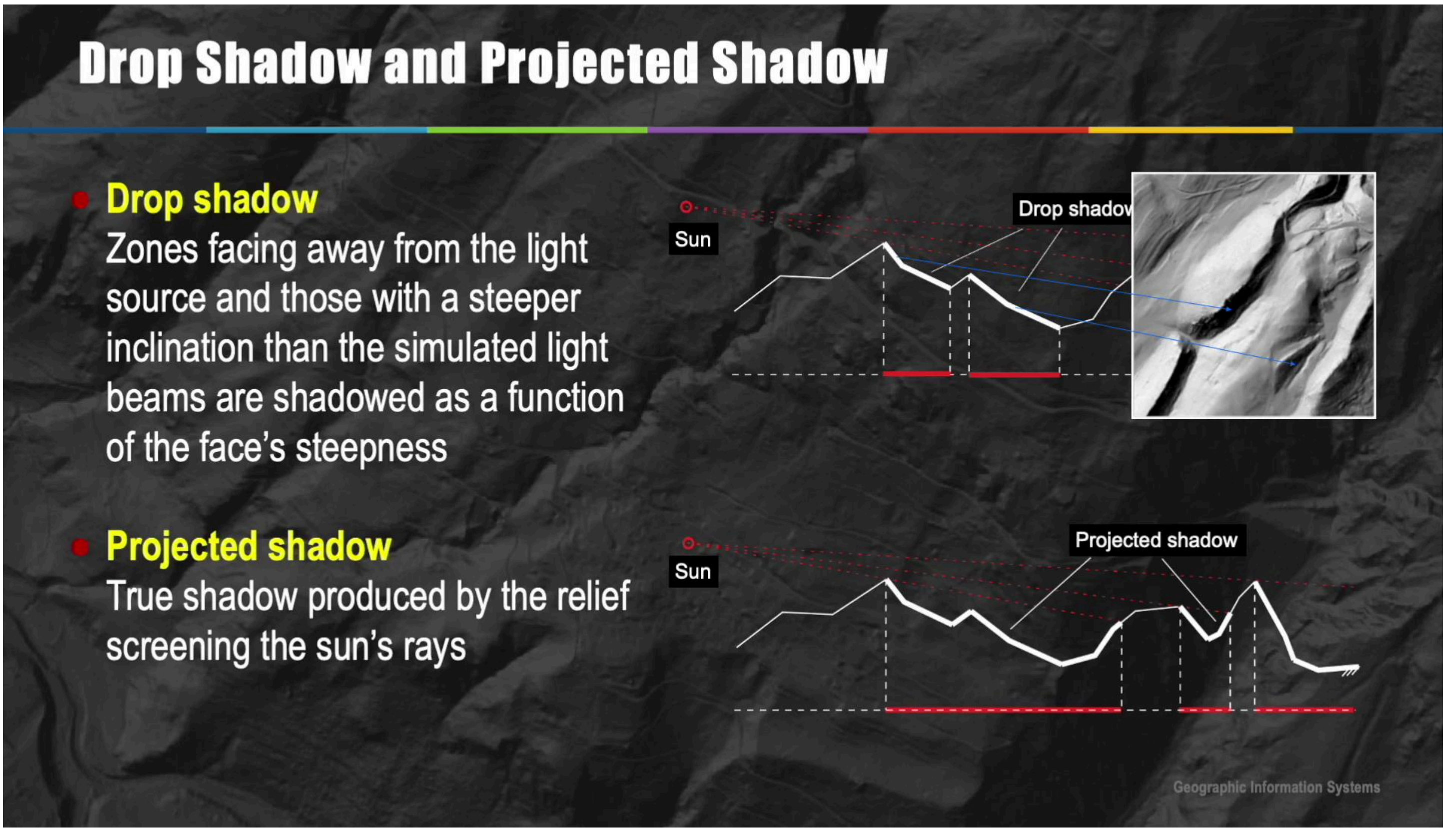


When it comes to implementing a new building for example and identifying what appears in the visual field from the latter. And in the opposite direction, a visibility analysis allows to realize the visual impact that a wind turbine will have, for example, from which point will the wind turbine be visible. This type of analysis is also used to evaluate the reception areas of an antenna for the mobile telephony. In the figure at the bottom right, the transmitter is placed in the center of the circle whose radius corresponds to the power of the installation. The brown areas are not in the field of vision and the reception risks being low or null.

Notes

Summary

2m 48s

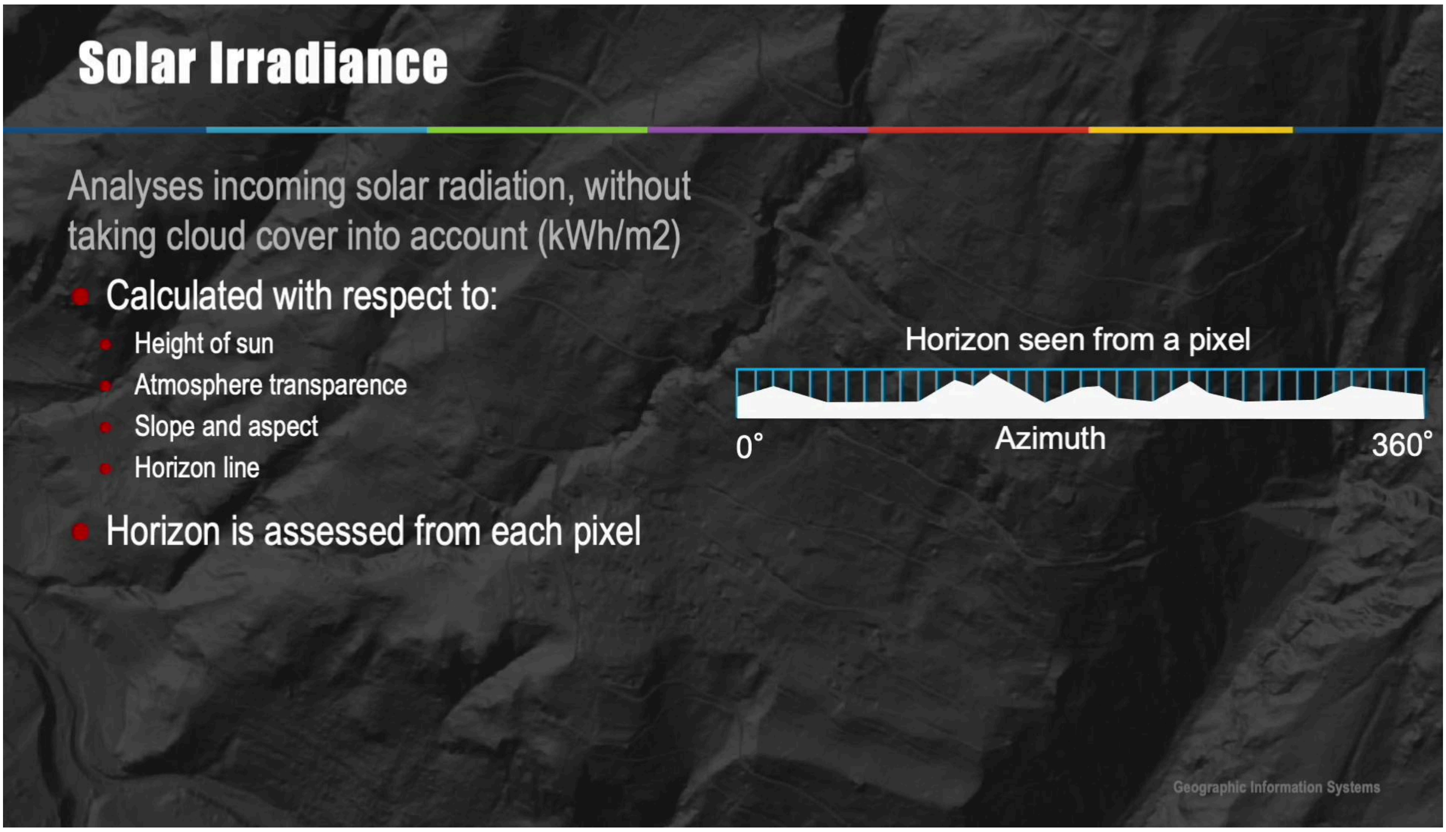


The shadow of the digital ground models allows to represent the altitude information in one form offering the perception of the relief. The technique implemented is the calculation of the sight line in one of the given reactions from the position of the light source. Depending on the intensity of the slope, we often simply color in grey the orientation areas that are opposite to those of the sun and the zones presenting an inclination greater than those of the sun rays. This is called the cast shadow. Now, if we determine the actual shade produced by the relief which is shielding the sun rays, this is then called a projected shadow. The analysis of the potential radiation, that is to say the received sunlight without taking into account a possible cloud cover, is based on a similar approach to that used for the calculation of the shading. It takes into account the cast shadows.

Notes

Summary

3m 28s

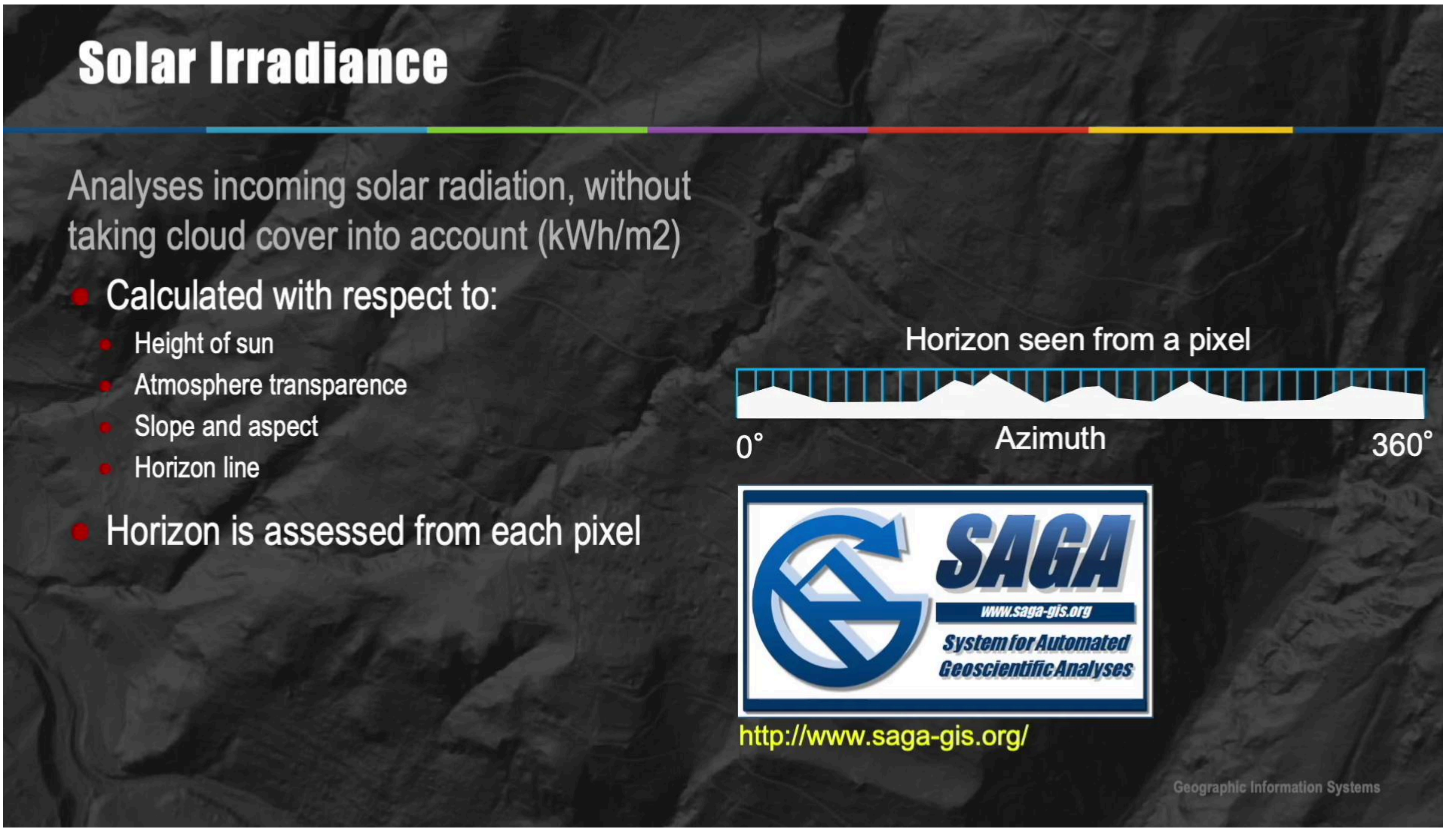


Each mesh corresponding to a point in the digital altitude model receives a sunlight which depends on the altitude of the sun, the transparency of the atmosphere, the slope and the orientation as well as the skyline. The result is given in kWh / m². The technique is based on the definition in any pixel of the grid of a horizon on 360 degrees similar to the one shown here on the right.

Notes

Summary

4m 21s

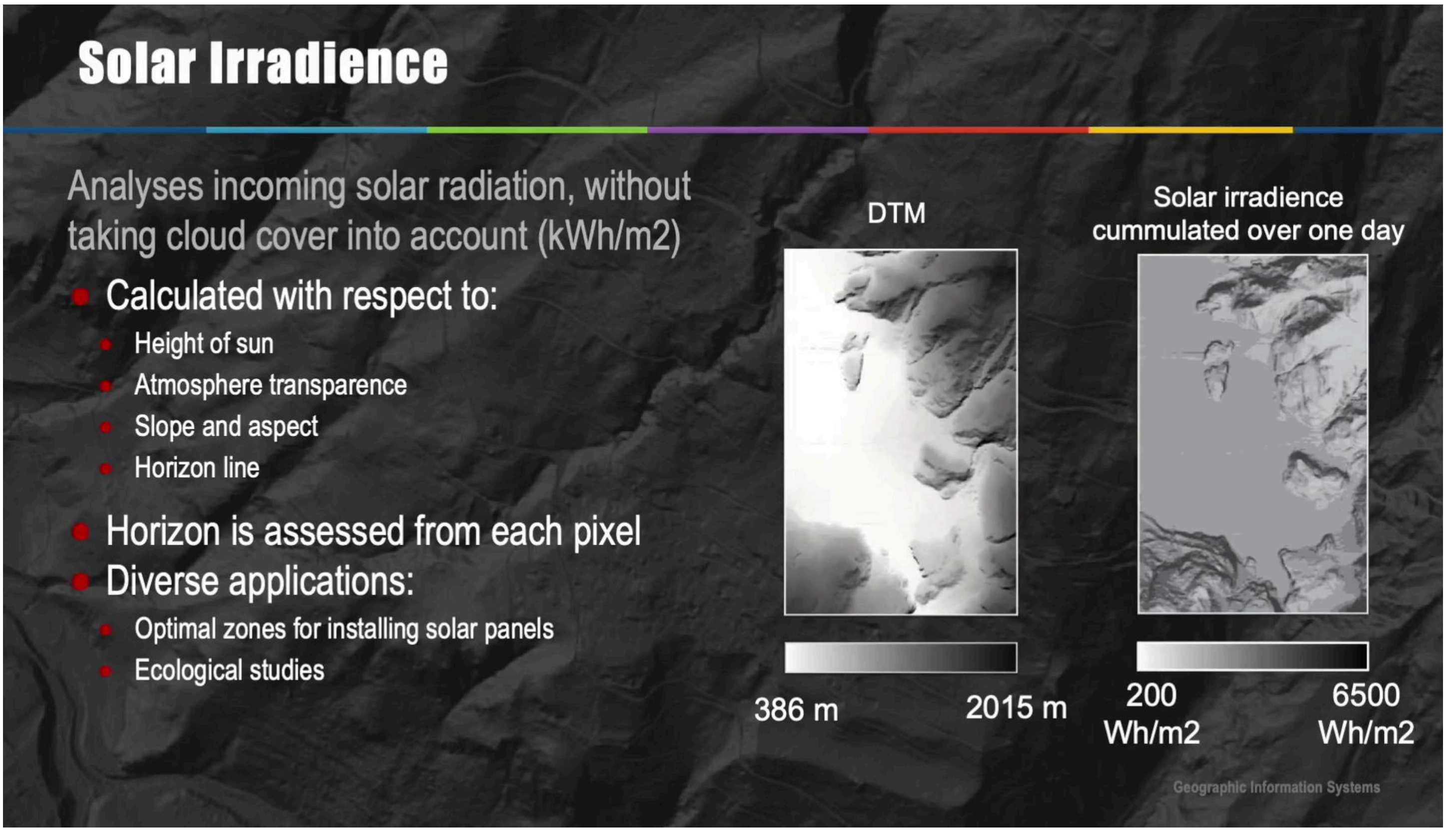


And on this basis, specific algorithms available in the free SAGA software for example, allow to calculate for each pixel, the potential energy received from the sun for a specific period of time. Indeed, for a given geographical location, it is necessary to know at what point of the horizon and at what time the sun rises and what will be the trajectory wave of the rays in the sky before it sets.

Notes

Summary

4m 50s

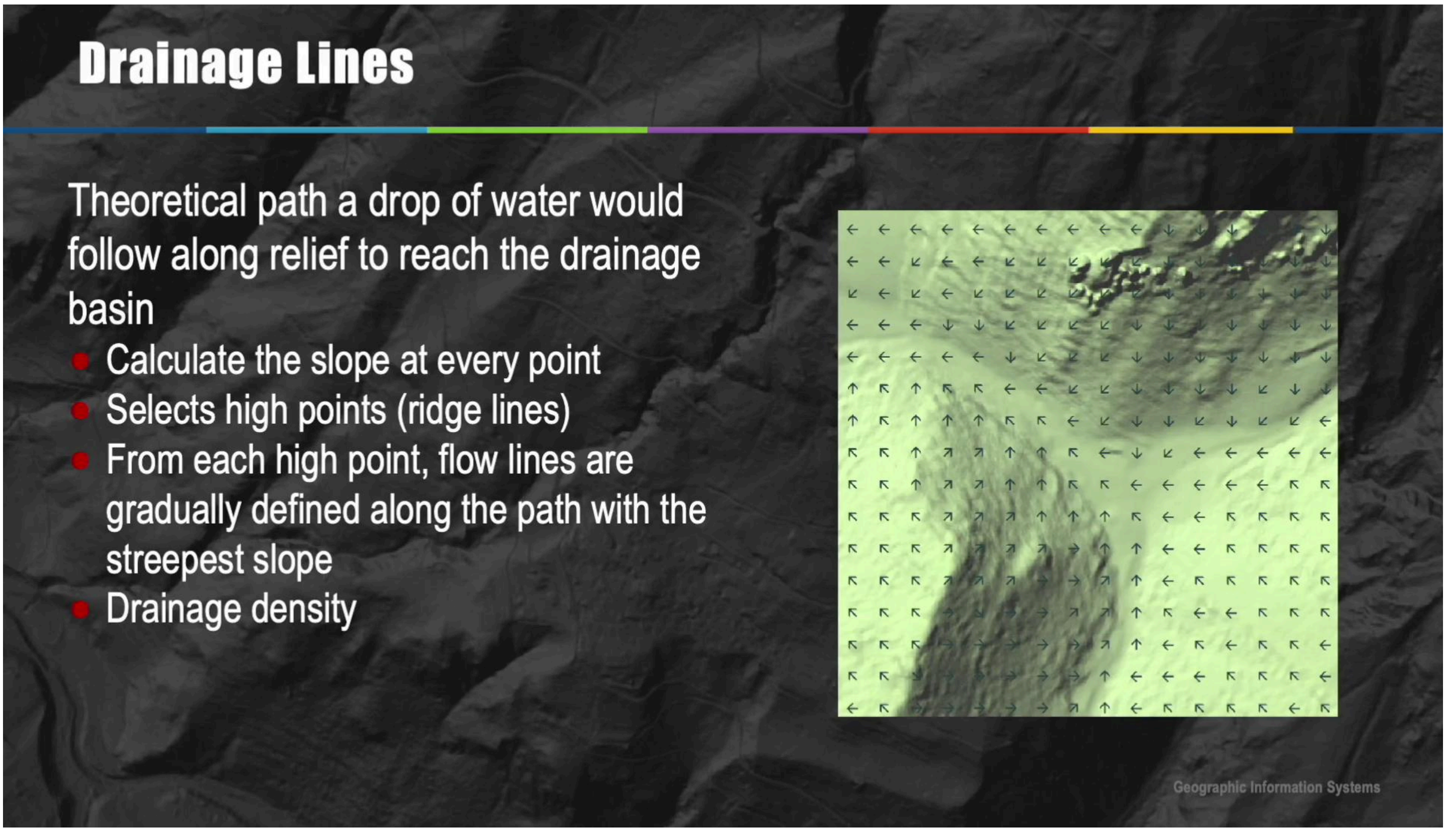


These algorithms allow to calculate grids whose pixels express the potential radiative energy of the sun received on the relief. Here we have a numerical altitude model on the left at 25 meters of resolution on which we based ourselves to construct the line map that shows the potential solar energy accumulated during a day.

Notes

Summary

5m 12s

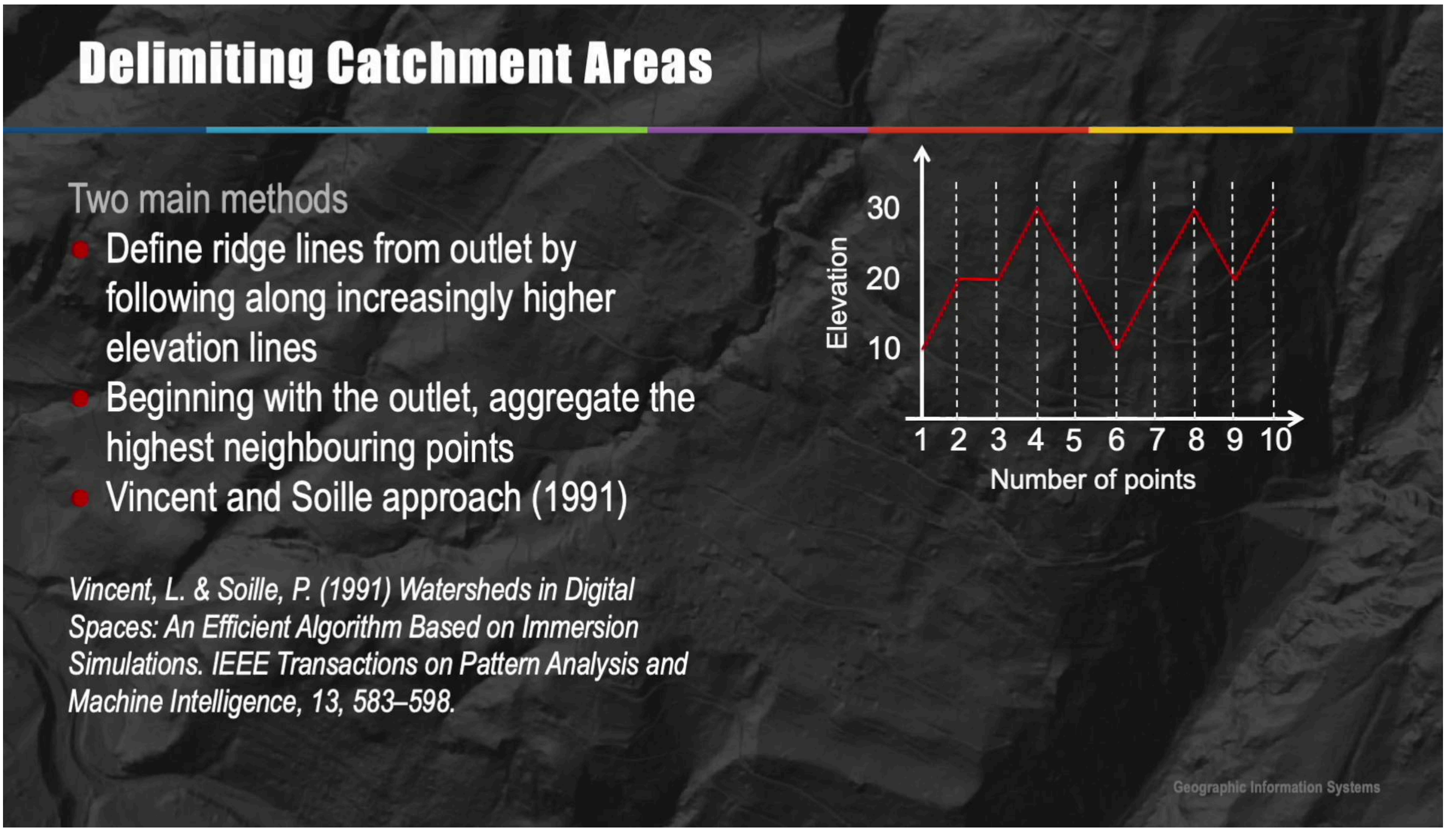


Let's move on now to the thematic variables related to hydrology. We will start by the drainage lines. A drainage line is the theoretical path a drop of water falling on the relief is supposed to follow until the watershed outlet. We will assume for the calculations that the surface of the ground is smooth and impermeable. So first, the slope is determined for each pixel of the digital altitude model. And then we will go from each high point of the watershed, so the points that belong to the ridge lines. And the flow lines are determined step by step according to the line of greatest slope. And of all the lines thus drawn, we deduce what is called the drainage density.

Notes

Summary

5m 41s

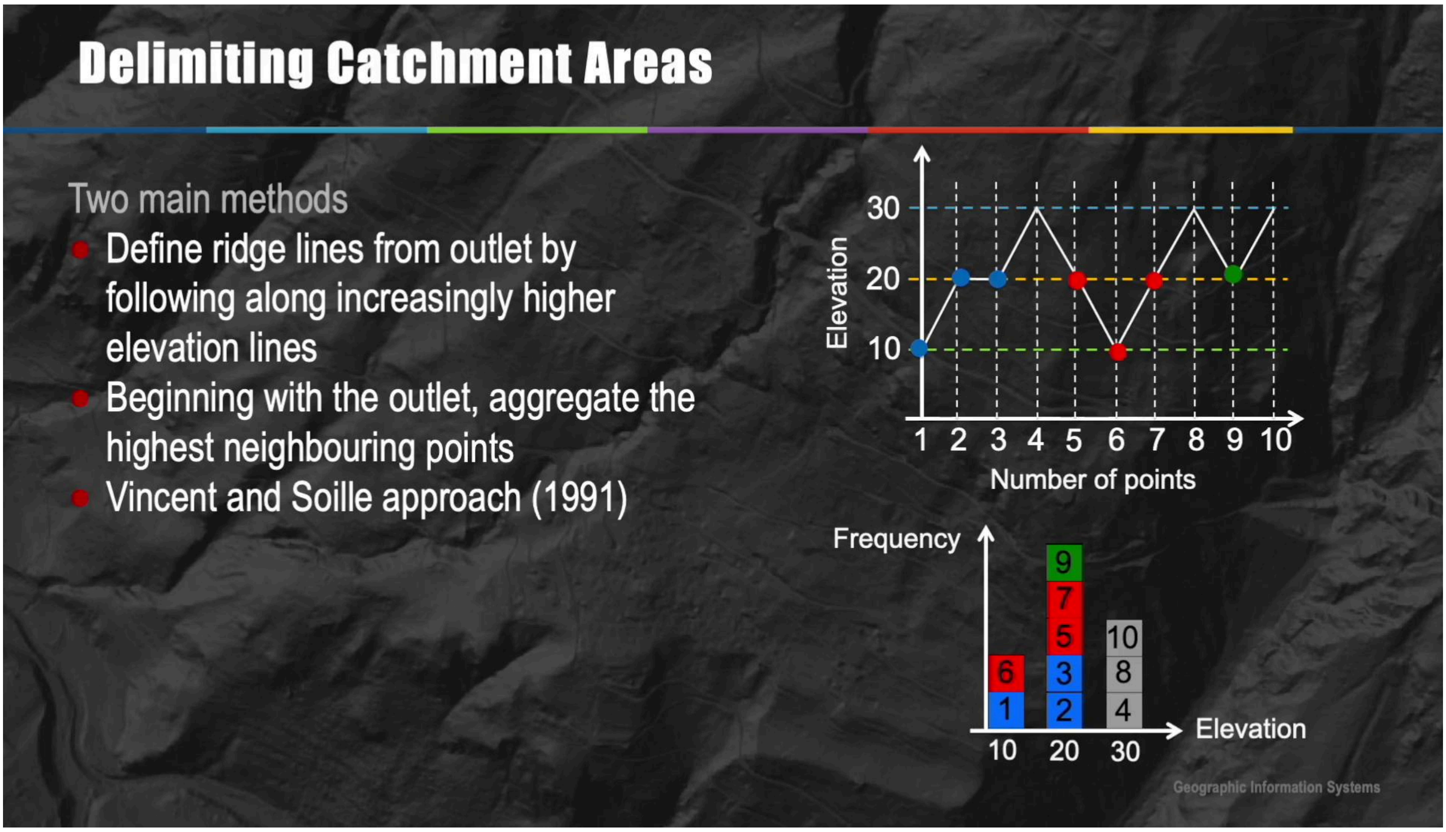


This parameter, the drainage density, is used in hydrology. It is the total length of water courses of a watershed per surface unit. And we have established numerous correlations between this parameter and the average flow of the river or the average precipitation or the production of sediment. Several approaches are possible to automatically determine the watersheds with the help of a numerical altitude model. They divide into two categories. The first seeks to determine the ridge lines from an outlet following step by step the increasingly high altitude points. And the second category builds the watershed also from the outlet, but by aggregating the highest neighboring points. And step by step, the watershed limits are reached. If the principle seems simple and logical too, the results are often imperfect and this because of local minima or errors which are due to the shape of a horse saddle that forms a neck on a ridge in particular. So a method proposed by Vincent and Soille in 1991 helps to avoid these problems. And we describe here the principles with the help of a simple digital altitude model with one dimension and containing ten altitude points.

Notes

Summary

6m 26s

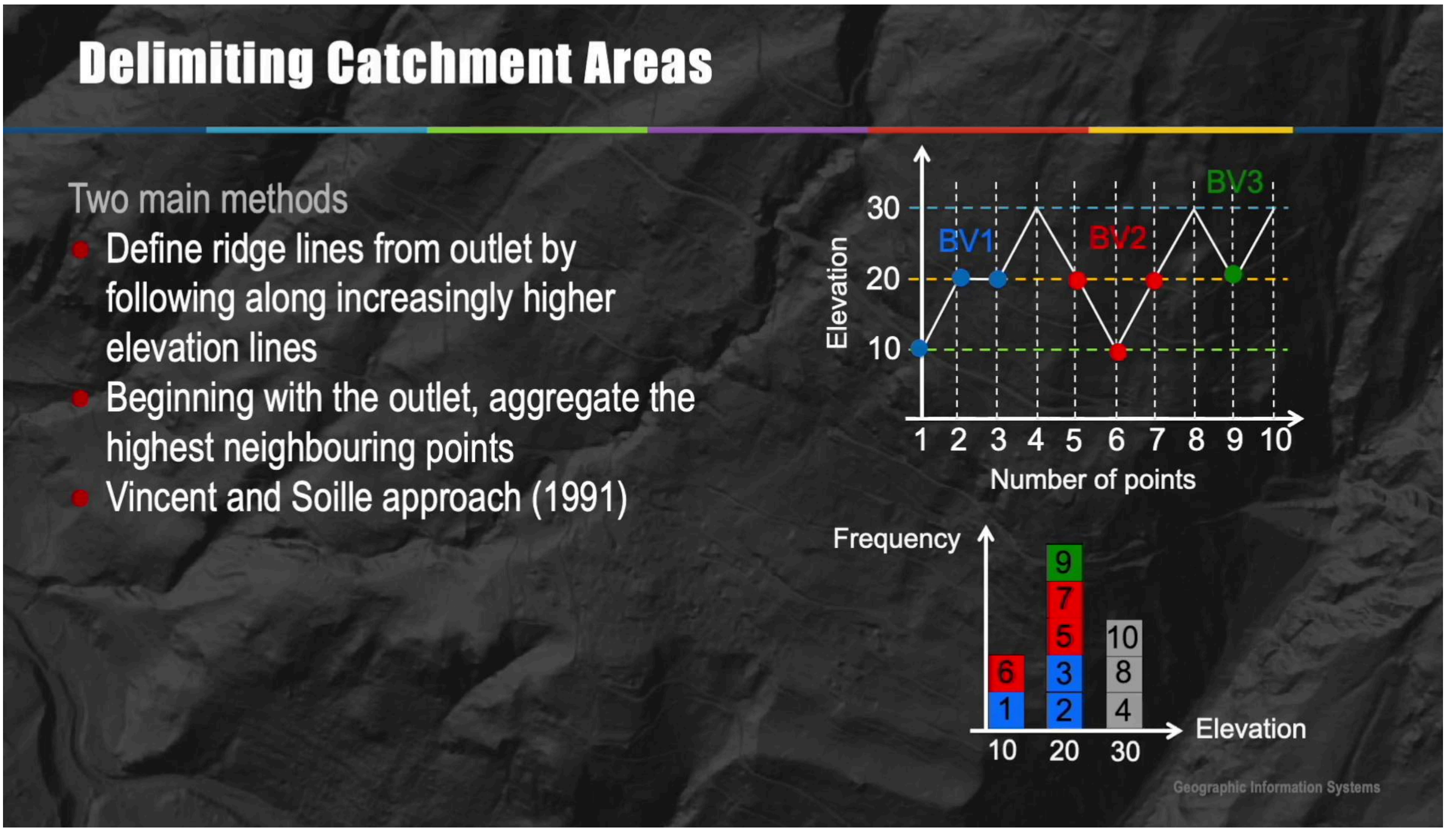


Firstly, the points or the pixels are numbered from 1 to N depending on their initial order from an edge so as to identify them. We then construct a diagram with the altitude on the x-axis. In parallel, we establish the altitude-frequency diagram noting for each point its identification number. And in our case, two pixels are part of the altitude class number 1, in a green, five are part of the second class, these are the orange dots and finally three are part of the highest class, these are the blue dots. The algorithm identifies, to begin with, the pixels with the lowest altitude. If they are isolated, they each form the germ of a separate watershed In our example, the pixel 1 presents a minimum value. It forms the first point of the blue watershed. The second low point, number 6, also of a minimum value, is then selected. As it is not adjacent to point 1, it forms the starting point of a second watershed, the red one. If no other pixel is located at the same altitude, we raise the altitude level until we find a new point. As point 2 is adjacent to a pixel that is already assigned to the blue watershed, it is assigned to it. And we carry on like that until the end of the process, so until all the pixels are assigned to a watershed.

Notes

Summary

7m 47s

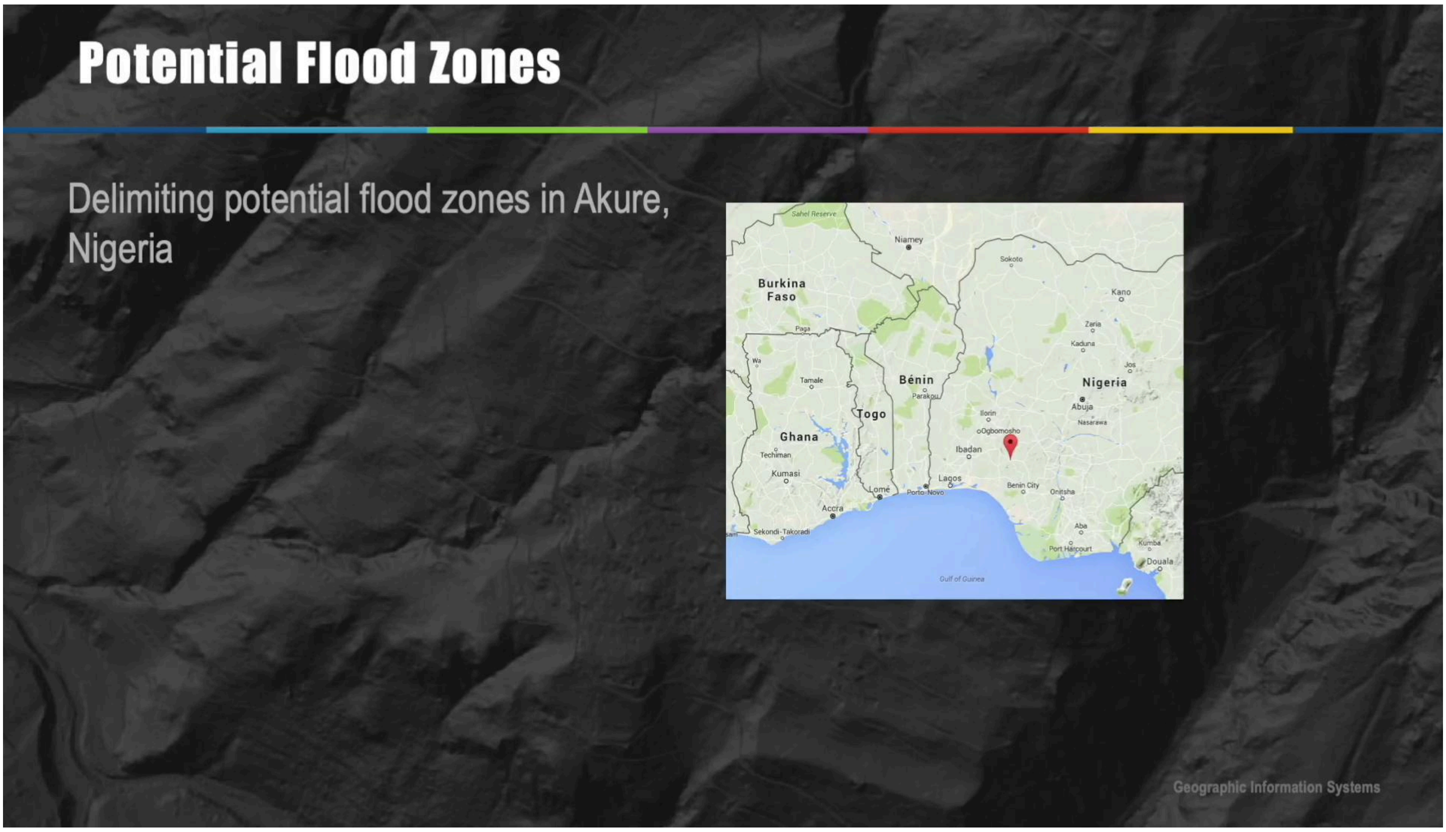


The system works as if the relief was gradually filled with water by a water table that rises until it is all flooded. The two watersheds that are joined form the ridge line that separates them.

Notes

Summary

9m 12s

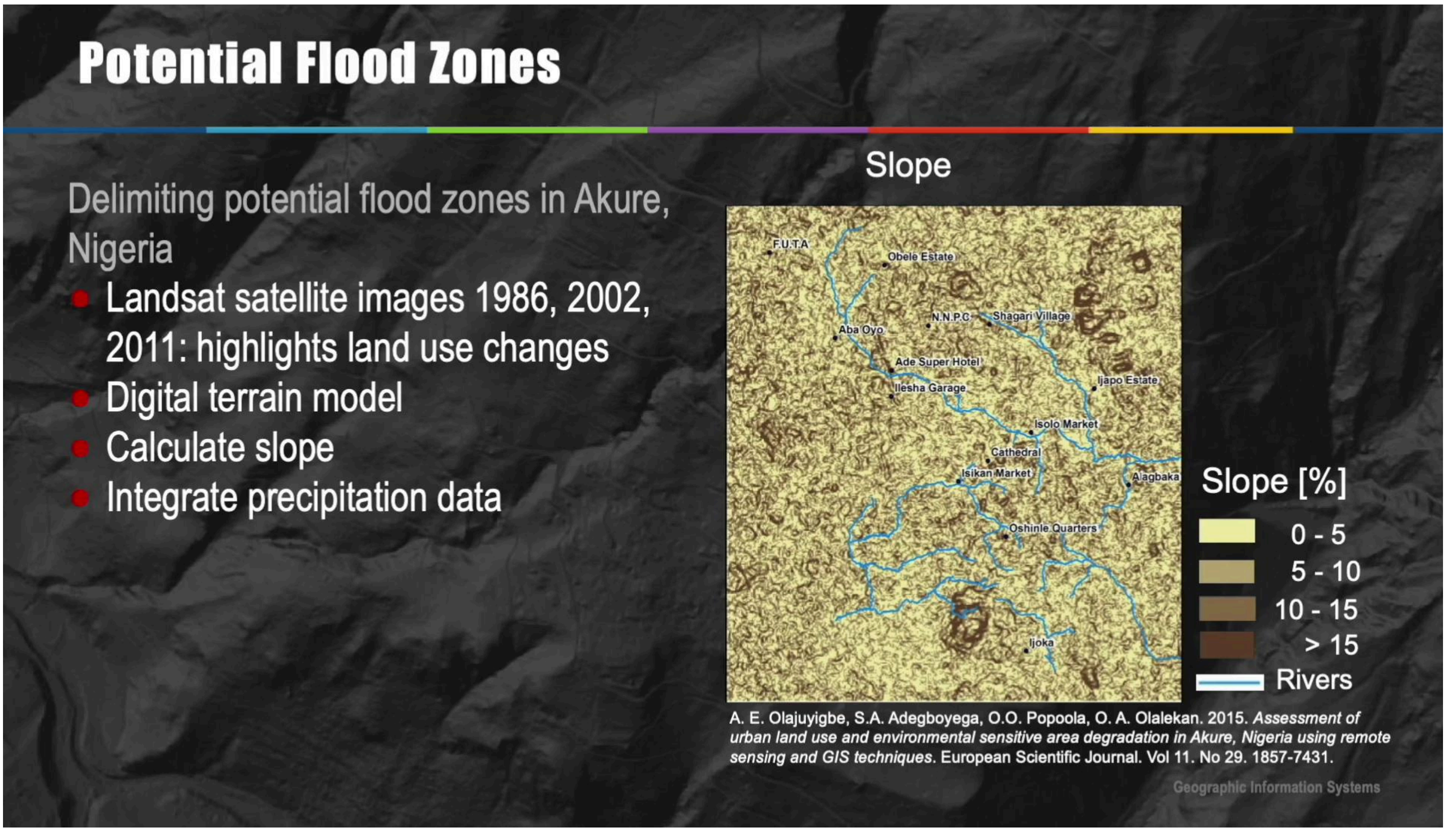


We now propose to you to illustrate the use of thematic variables derived from digital altitude models and presented in this lesson. We have chosen examples that demonstrate the utility of these variables in real cases. And each example is from a free access scientific publication and contains all the details of the methodology applied. The first example chosen concerns the identification of flood plains in Akure, a Nigerian town of about 495,000 inhabitants. This city has experienced a significant growth because of its central role in the administration and the local economy. Akure experiences a rainy season which lasts about seven months, from April to October, with average annual precipitations of 1,500 mm / m².

Notes

Summary

9m 33s

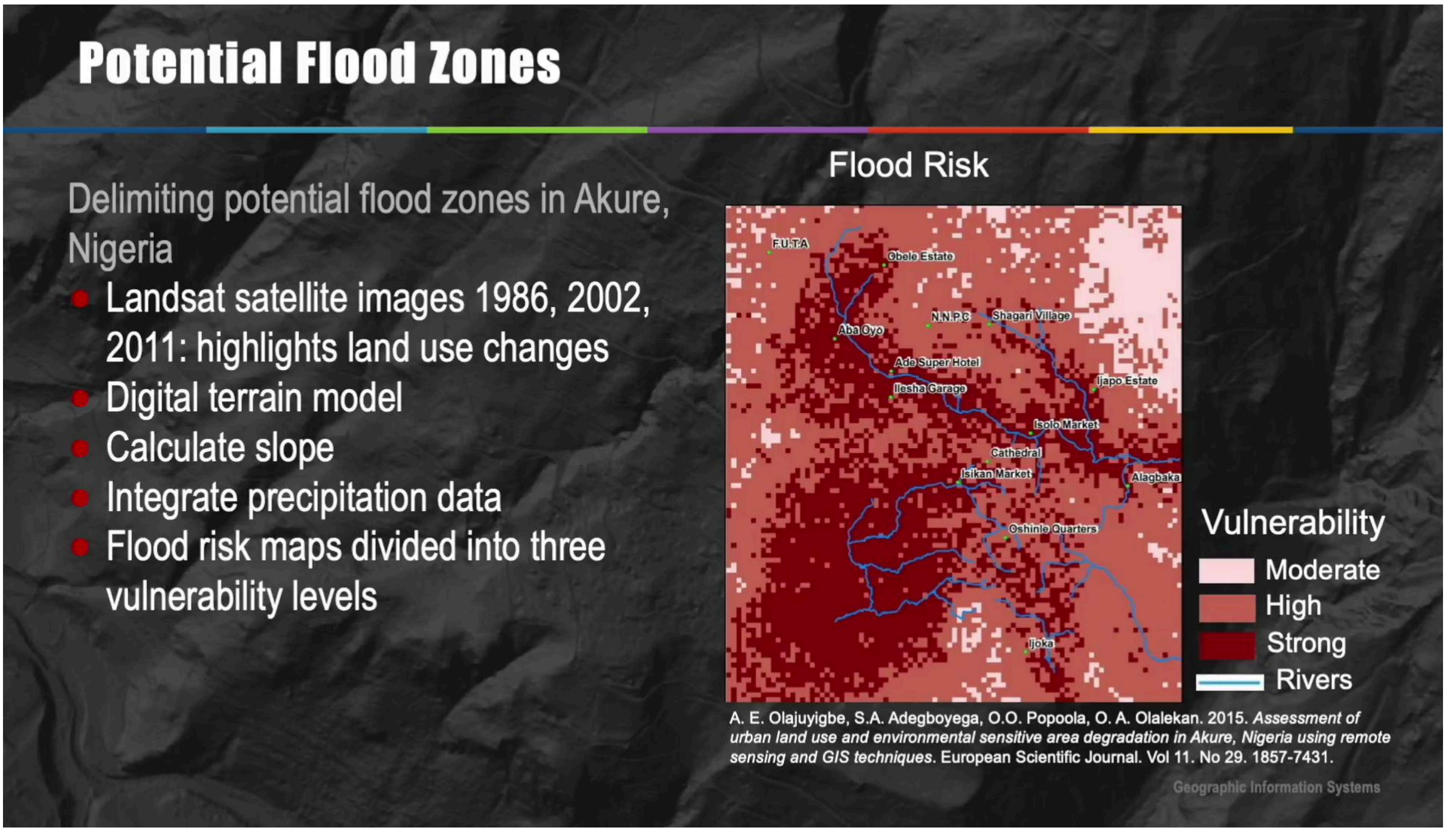


And because of the increasing demand for building land, the city was forced to precisely define the flood plains in order to find constructible areas. And in this study, we first classified Landsat satellite images to highlight the changes that have taken place in land use in urban areas and for the studied period, so between 2002 and 2011. And this has allowed to notice that there was an increase in built-up areas and a decrease in riverside vegetation which caused a reduction of the soil absorption potential. The scientists then used a digital ground model, the SRTM, or Shuttle Radar Topography Mission of NASA at 90 meter spatial resolution. With the help of the digital altitude model, we calculated the slope, which allowed to identify the drainage lines. The authors then integrated the average annual precipitation data collected in different points in the study area.

Notes

Summary

10m 22s

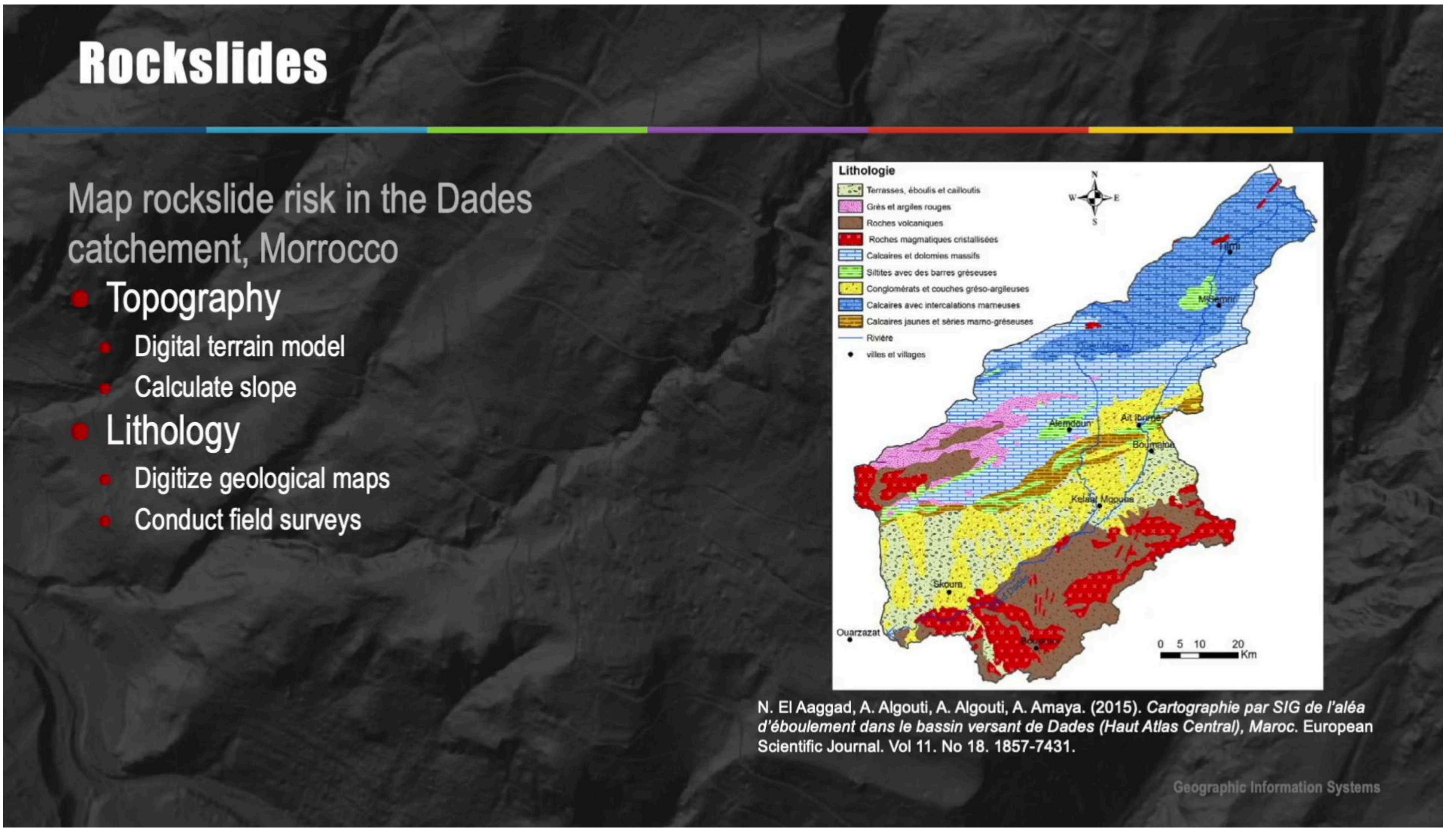


The different layers of information used, so the land use, the drainage lines and precipitations were weighted according to their probability to contribute to a flood, then combined using a multi-criteria approach to create a risk map, so a flooding vulnerability map in three classes.

Notes

Summary

11m 22s

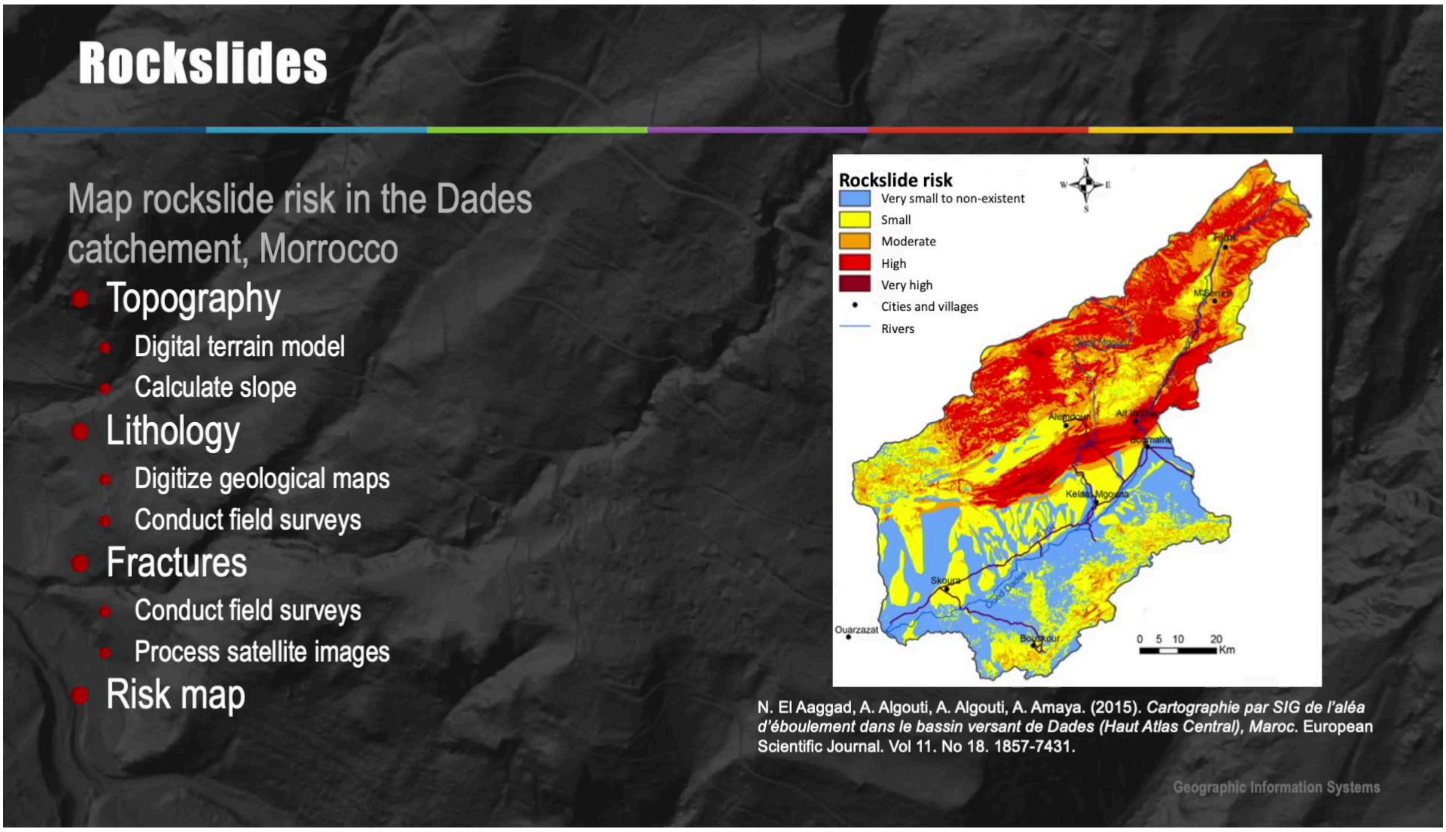


The second example is devoted to rockslides. It is located in the watershed of Dades in Morocco, it is an unstable area and it is sensitive to landslides. The goal here was to create a risk map of rockslides. To achieve this, various criteria have been taken into account. With the digital altitude model SRTM at 90 meters spatial resolution, we first calculated the slope to observe that 30% of the study area presents steep to very steep slopes. In addition, the upstream area is very steep and damaged, hence its unstable nature. The authors also digitized geological maps in order to take into account the lithology. Indeed, the various rock types and structures are an important information to characterize the risk of movements on the hillside. The geological layers most sensitive to movement are limestones and massive dolomites which are represented in light blue on the map, but also the marl limestones which are shown in dark blue as well as the conglomerates and the sandstone-clay layers that are shown in yellow. It shows that 50% of the region is composed of layers most sensitive to movements.

Notes

Summary

11m 42s

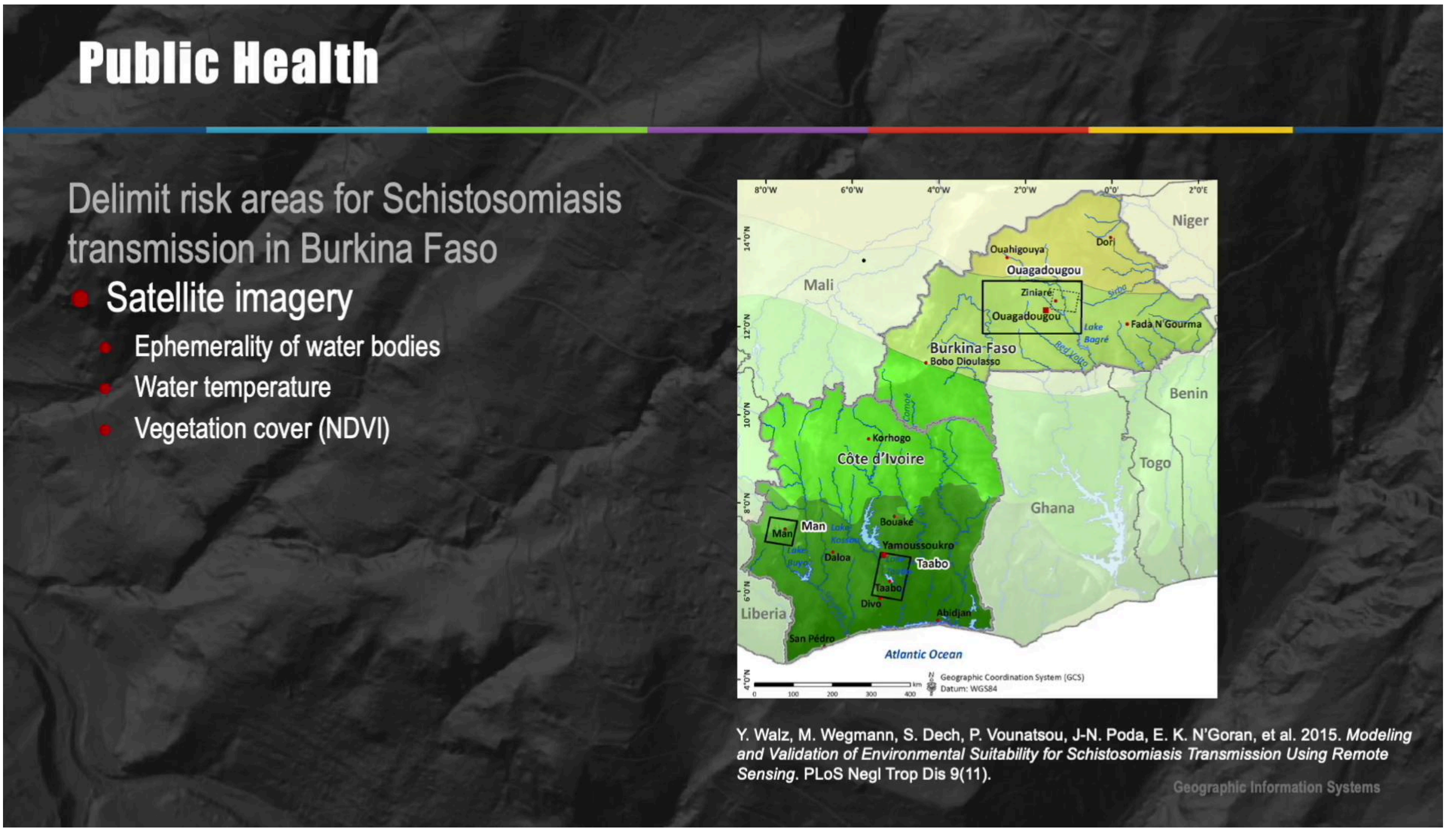


As the stability of rock slopes is essentially controlled by the density of tectonic fractures and by their orientation, another information layer was created from land surveys and a Landsat satellite image to locate them. This is an important criterion since the High Atlas is in a tectonic uplift phase and that the faults represent a destabilizing factor of the slopes. The slope, sensitivity to movement and fracturing characteristics have been combined to generate a risk map. Each factor was broken down into five qualitative classes ranging from very low to very high. The resulting risk map expresses for each pixel a combination of qualitative classes provided by three factors. This map shows five classes of hazards ranging from very low risk to very high risk. The result mainly shows that 25% of the watershed surface is subject to a high risk.

Notes

Summary

12m 59s

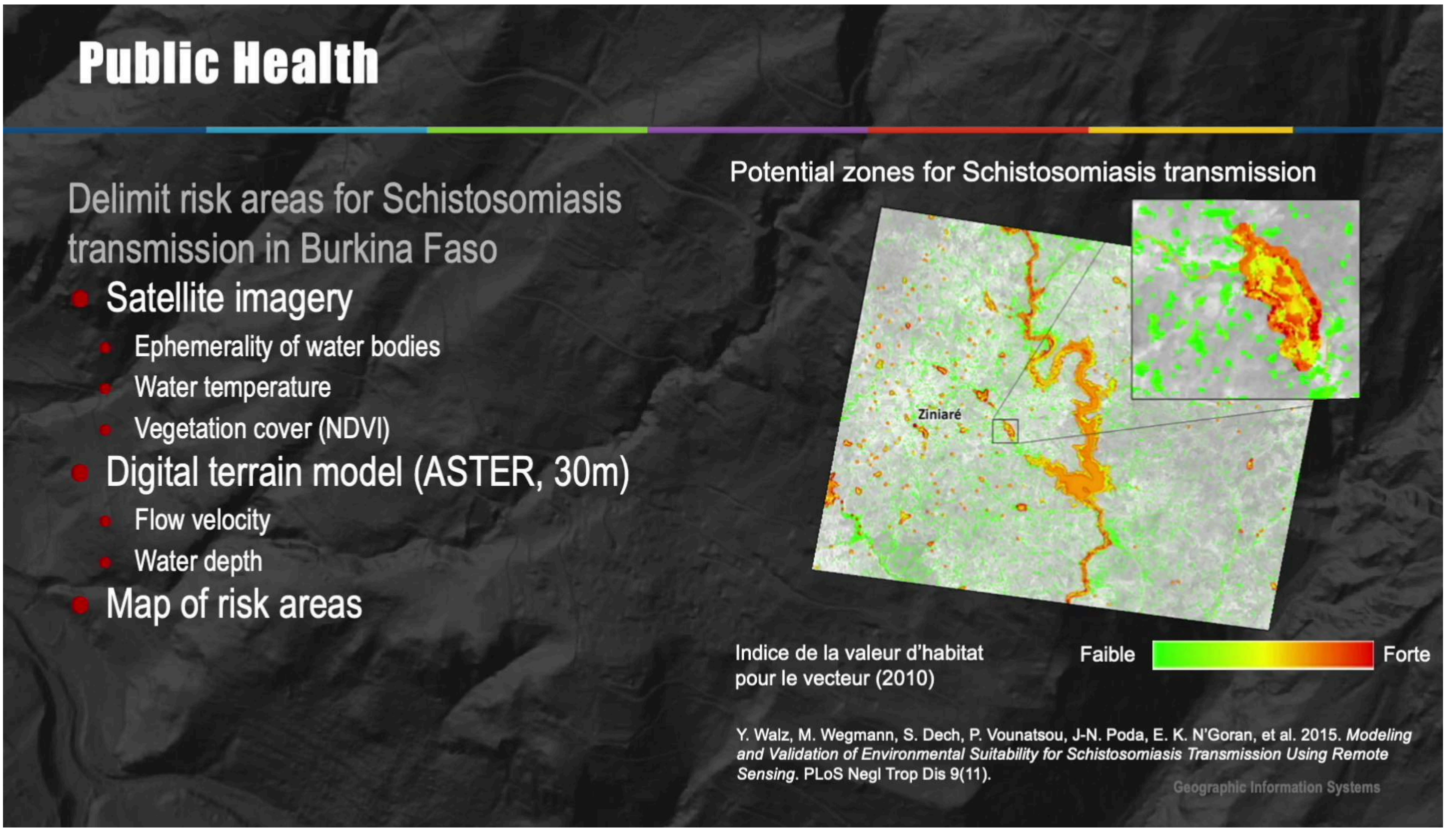


We conclude with an example from the public health field which illustrates the range of applications for which a digital altitude model can provide valuable services. This is a study on schistosomiasis, published in PLoS Neglected Tropical Diseases in 2015. Schistosomiasis is a water-related disease most prevalent in sub-saharian Africa. It is carried by freshwater snails that act as intermediate hosts. And the purpose of the study presented here is to define the potential habitat of this vector to identify areas at risk for the transmission of the disease and this in a region of the Burkina Faso near Ouagadougou. So, several environmental variables were taken into account to delimitate the potential habitat of this snail. There is firstly the persistence of the water stagnating in small depressions on the surface of the earth and this is a factor that is calculated from RapidEye satellite images at 6.5 meter resolution and Landsat images also at 30 meter resolution, images that were taken at different times. And there is also the water temperature influencing the mortality of the snail and which has been derived from the thermal band of the satellite images.

Notes

Summary

14m 07s



The vegetation cover was also analyzed since the vegetation affects the metabolism of the snails. And finally, the water depth and the current speed were calculated from the digital altitude model ASTER at 30 meter resolution as well as from derivative slope maps. An additive multi-criteria function finally allowed to weight and combine environmental variables to develop a potential habitat index. And this index allows to estimate the risk for a specific area to be favorable to the transmission of the schitosomiase, the redder the shade of the pixel, the higher the risk. Such a map is likely to support prevention and control measures also to limit the spread of the disease.

Notes

Summary

15m 22s