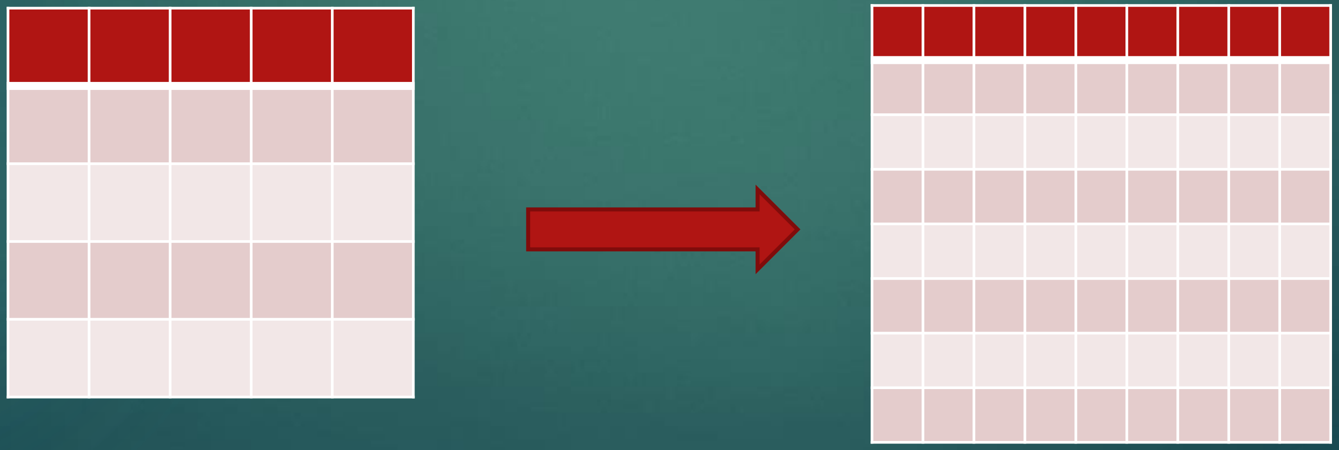
155GISE – Lecture 6
Raster data analysis

Re -sampling

Resampling

raster transformation, i.e. changing the pixel size or resolution of a raster GIS

- <u>it is necessary to assign new pixel values to the newly created pixels!!!!</u>



Manipulation of resampling data

Raster GIS

Resizing the raster for a raster representation = **resampling** the raster will necessitate the creation of new attribute (digital) values stored in the newly created pixels - there are different approaches

Inserting digital values into the newly created pixels:

1. smaller pixels are created - attribute values from larger pixels are taken over

2. larger pixels are created - mostly calculation methods are used (i.e. not assignment) - some original attribute values in pixels may be omitted

Conversion of representations

Conversion from raster to vector

point elements – 1 pixel = 1 point

line elements - guiding the line with a raster template

a line consisting of **one** pixel (column, row) or **all the** pixels through which the line passes

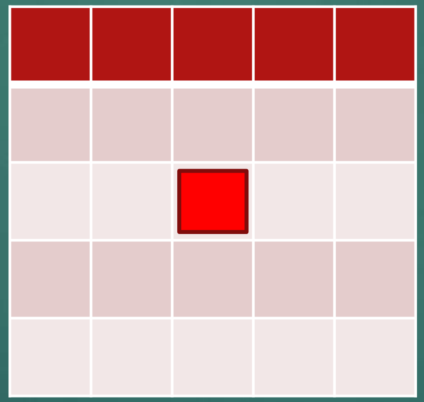
surface elements - drawing a line on the border between two different surfaces - follows a raster structure, or the curve is smoothed

pixels included in the area , whose area more than half lies in the given area

Conversion of representations

Conversion from raster to vector

point elements – 1 pixel = 1 point



Conversion of representations

Conversion from raster to vector

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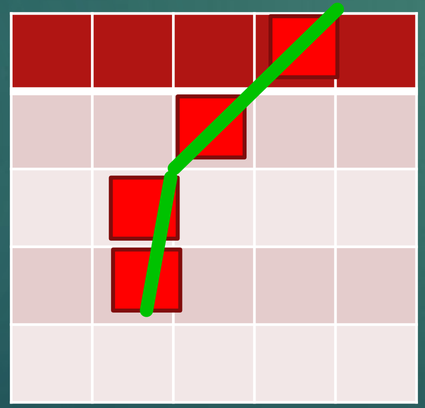
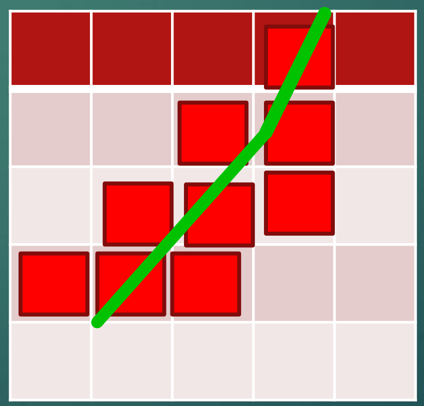
a line consisting of **one** pixel (column, row) or **all the** pixels through which the line passes

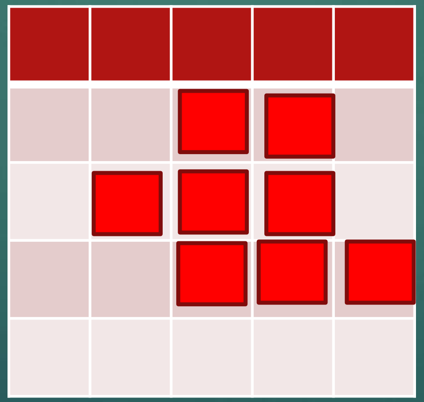




Conversion of representations

Conversion from raster to vector

surface elements - drawing a line on the border between two different surfaces - follows a raster structure, or the curve is smoothed

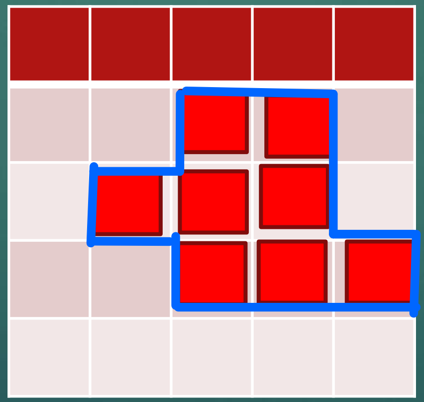


Conversion of representations

Vector to raster conversion

for surface elements – one option: line management on the boundary between two different surfaces – follows the raster structure

therefore the areas of all **pixels are included in the area**

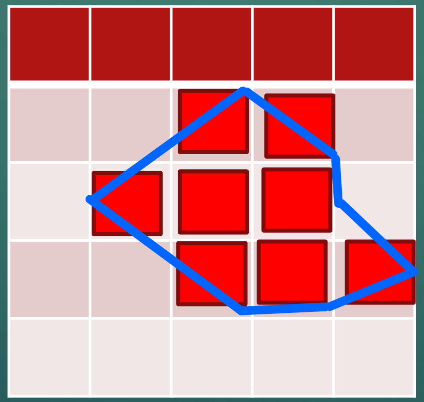


Conversion of representations

Vector to raster conversion :

surface elements - the second option: drawing a line on the border between two different surfaces - with a smoothed fracture line

the area includes **pixels** whose area is more than half in the given area, sometimes the line is led diagonally across one or 2 cells



Analysis of Spatial Data

Analysis using geometric and non-geometric data

Usually two parts:

1) data selection
2) their analysis

This task can only be done in GIS, because the analyzes take place in space

Selection, classification and measurement functions

selection functions - according to existing properties

classification - classification into classes - the class of watercourses divided into classes according to the orders of watercourses

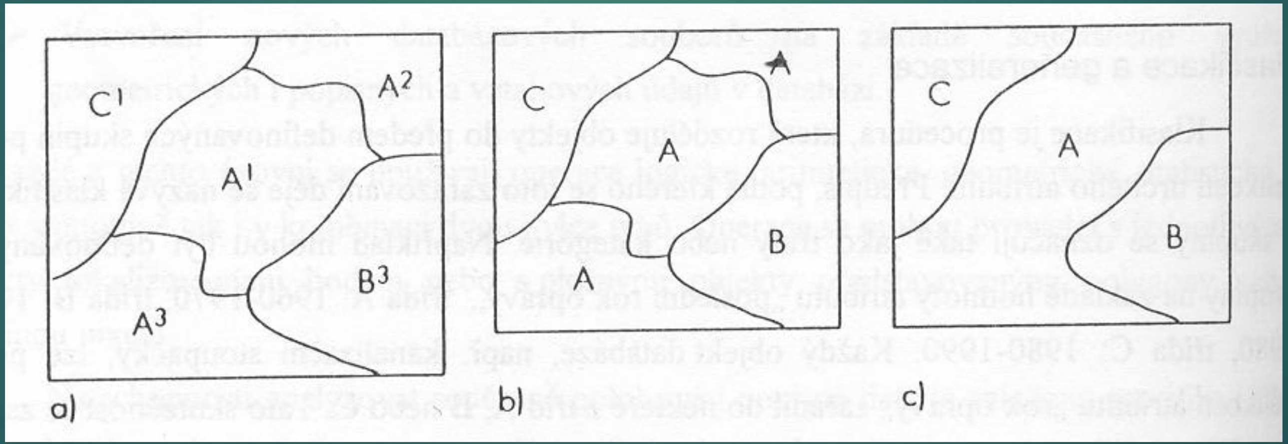
reclassification and subsequent generalization / merge / delete of internal boundaries

Analysis of Spatial Data

Selection, **classification** and measurement functions

reclassification and subsequent connection (merge , dissolve)

original classes — new classes — dropping boundaries



Reclassification : creation class A from classes A 1 , A 2 , A 3

The same classes are separated by the boundary = topological error

spatial connection / merge , dissolve
I will remove the topological error

Analysis of Spatial Data

Selection, **classification** and measurement functions for raster GIS

Classification function

Calculation of a new layer for the one quantity/attribute

It is necessary to enter:

1. the size of the neighborhood within the grid
2. the type of function applied to the surrounding territory

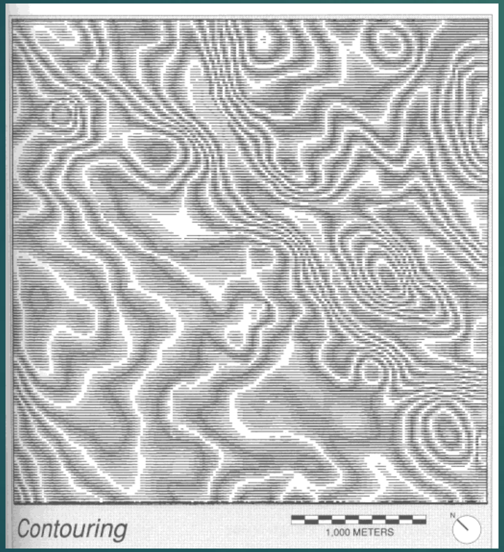
- local classification
- local maximum, l. minimum, l. sum, local difference
- local product, local ratio, loc. square root
- local sin, local arcsin , local cos, local arccos , arctg

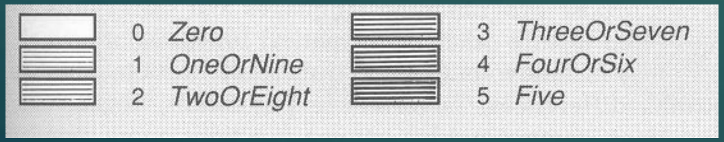
Analysis of Spatial Data

Reclassification and connection for **raster** GIS

Calculation of a new layer for the progress of one quantity/attribute

Example of local quotient, product and difference for determining deviations from contour lines





Altitude Data (NV) :
220 - 229 m above sea level
230 – 239 m above sea level
240 – 249 m above sea level

1) **local quotient**: **P= NV/10** (8-bit data positive integers: 220 → 22
222 → 22
223 → 22
224 → 22
225 → 23

2) **local product** N=P*10: 22 *10= 220

3) **local difference** R= NV - N: 221 – 220= 1
R = NV - N: 225 – 230 = 5 (8-bit data is taken as an absolute value, not a negative number)

Analysis of Spatial Data

Selection, classification and **measurement** functions

measuring function – measurement of distances, lengths and areas

The user can make a selection:

surfaces **greater** than , **less** than

of line objects **longer** than , **shorter** than

Overlay function - raster **data**

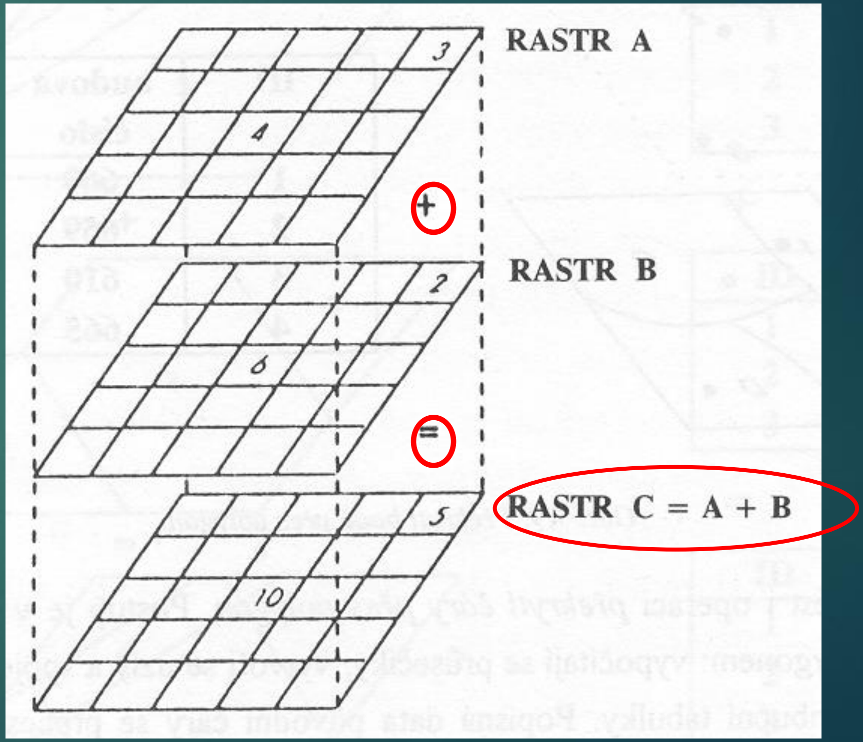
Overlay function for raster GIS = **map algebra problem**

overlap of 2 area classes in
vector GIS - frequent formation of **slivers**

overlay function - easier in **raster GIS**

Here is an example for the sum, that is, the classic one overlap

This role can be extended to use other operators.
The principle is the same, these are calculations between corresponding pixels



Analysis of Spatial Data
Raster GIS

connectivity functions

They are cumulative functions , they express topological relations

Raster GIS:

describe the relationships between pixels /cells

- attribute value in one pixel – the sum of all values above it in the raster

– this site is called *a test site* (see runoff from the watershed based on slope directions

Analysis of Spatial Data

Connectivity function

Proximity

can be used for both **vector** and **raster** data

- the most common connecting function – **envelope (buffer) zones (buffers) are created**

surfaces around geometric objects

points

linear

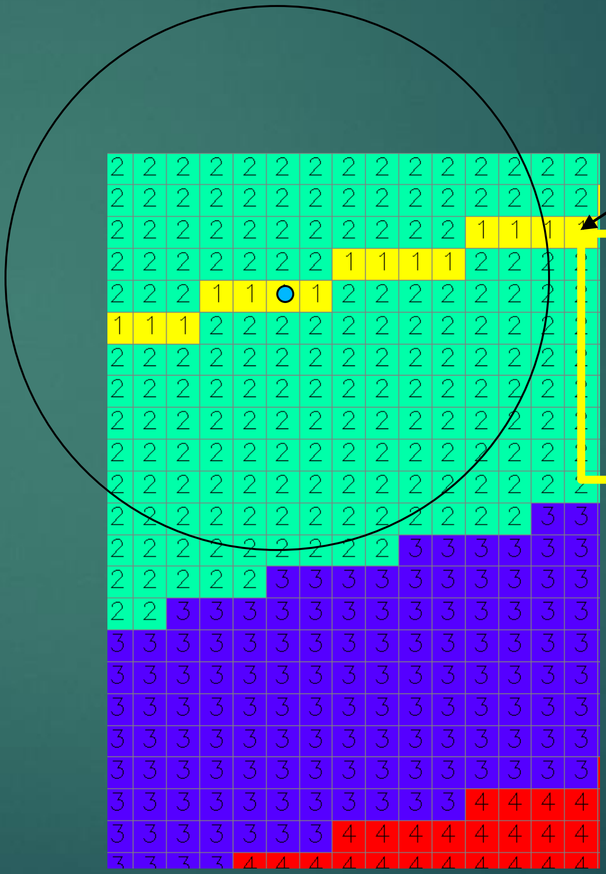
surface - internal, external, both proximity

Analysis of Spatial Data

Connectivity function

Proximity – raster data

Distances are measured from cell center to cell center



road

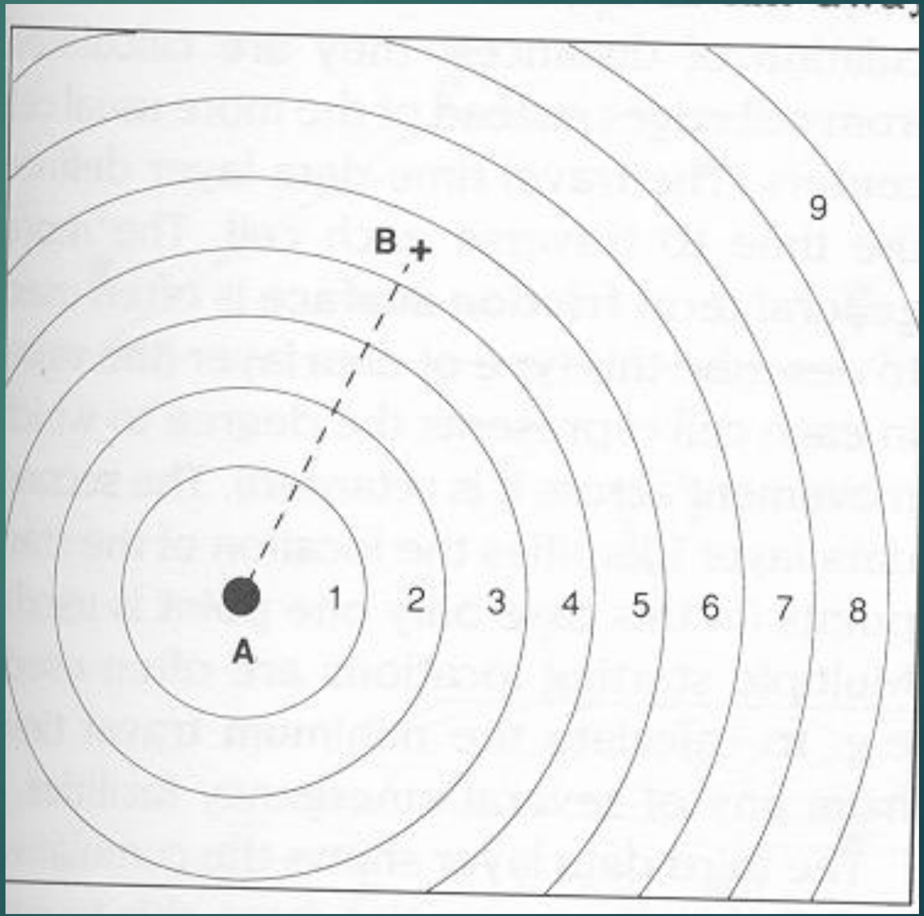
Protective belt (buffer):
cat 2: 0- <250m
8 x 30=240m
for a 30m grid

Protective belt
cat. 3 : 250-500m
(8+9) x 30 = 510m

Analysis of Spatial Data
Connectivity function in **vector** GIS

Spread function

in raster, it is often displayed as vector **isolines**



Analysis of Spatial Data

Connectivity function in **raster** GIS

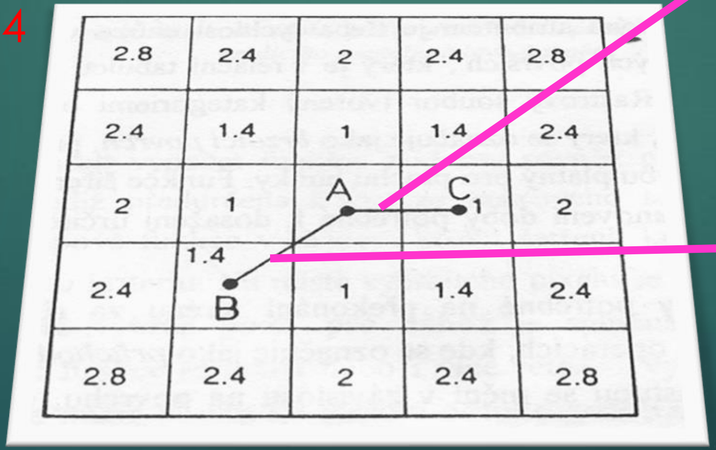
Propagation function

for determining the travel time between two points in the grid (and gradually from A to **all directions**)

Travel time from A to C = 1

Travel time from A to B = 1.4

In **raster** GIS - it can also work with attributes whose distribution is irregular in area



AC length =1 unit = 1 cell

Length AB=1.4 units (cells

Comparison of vector and raster representation

Vector representation (vector GIS):

Advantages

- good representation of the structure of objects
- compactness of the structure
- quality graphics, drawing accuracy
- simple search, editing and generalization
- high accuracy
- suitability for modeling individual objects
- almost unlimited positioning accuracy
- small amount of data
- exact transformation of coordinate systems

Comparison of vector and raster representation

Vector representation (vector GIS):

Disadvantages :

- complicated data structure – various geometric types, division into classes and their attributes
- demanding calculations, specialized software and hardware
- problems in analytical calculations
- unsuitable for continuous surfaces with variable behavior values of phenomena = classes within individual surfaces
- laborious when accurately describing some shapes - a large number of vertex points

Comparison of vector and raster representation

Raster representation - raster GIS

Advantages :

- simple data structure – matrix dig . values
- simple creation of user superstructures - work with matrices
- simple combination with other raster data
- simple performance of analytical operations = algebraic calculations between corresponding cells/pixels
- relative hardware and software simplicity

Comparison of vector and raster representation

Raster representation - Raster GIS:

Disadvantages:

- large volume of stored data
- inaccuracy in the calculation – lengths, areas with a less detailed grid, the smallest area unit is a cell
- low output quality with a large grid cell
- less visual quality of raster outputs
- not very suitable for network analysis
- only approximate geometry and topology modeling
- coordinate transformations lead to inaccuracies in position or attribute

Representation of spatial objects
Digital terrain models

Raster models suitable for phenomena continuously changing in space :
terrain height, temperature, pressure, etc.

Height is stored as a simple attribute:

1) in the regular model
for a given pixel in the raster – a regular model
(= digital value expressed e.g. by color)
or for grid – in the node

2) in an irregular – e.g. triangular model
the digital value at the top of the triangle

Representation of spatial objects
Digital terrain models

- Digital elevation model - DEM
  - altimetric data about the territory - is a general term containing various ways of expressing the terrain or surface

- Digital surface model - DSM (digital surface model)

"A digital surface model is a digital representation of the topographical area it contains buildings, bridges, vegetation, or other man-made built objects that are firmly connected to the relief."

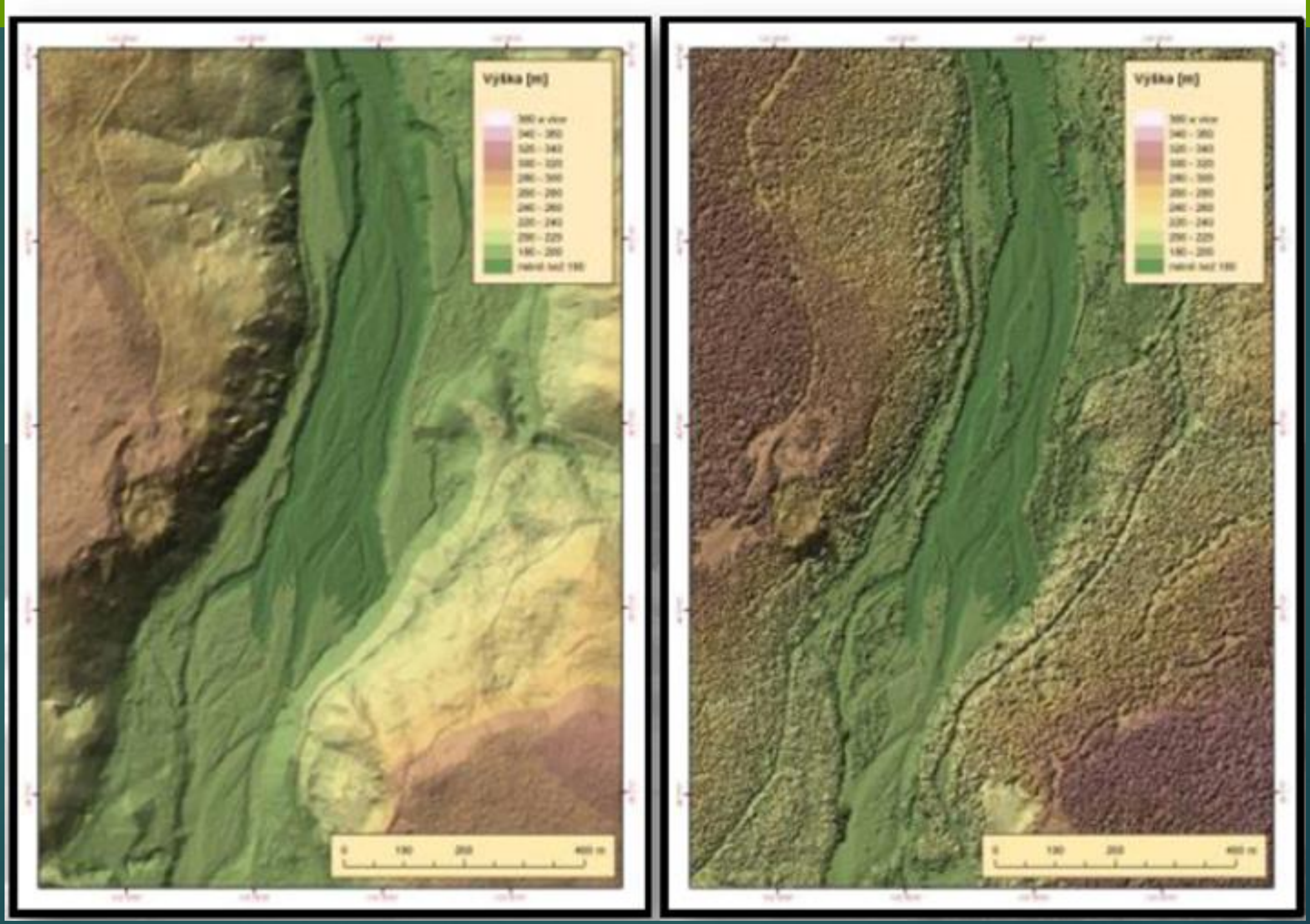
- Digital terrain model - DTM (digital terrain model)

1. *"A digital relief model (DTM) is a digital representation of a topographic surface ."*
2. *"The DTM does not contain buildings, bridges, vegetation, or other man-made built objects that are firmly connected to the terrain."*

Representation of spatial objects
Digital terrain models

LIDAR data:

source : laser scanning



vegetation and buildings removed

with vegetation and buildings

Representation of spatial objects
Digital terrain models

Digital surface model

Combination of 2.5D and 3D

2.5 D terrain

3D objects (three-dimensional)

Representation of spatial objects
Digital Terrain Models - Types

1. **mathematically defined areas** - in practice it is impossible
2. **point images**

   1. *Points with a **regular** structure*

      1. raster (the value applies to the entire pixel),
      2. grid (value is in knots),
      3. lattice (the height is stored in the center of the pixel and applies only to this point and can be further interpolated in the model).

   2. *Point with **an irregular** structure* - TIN (triangulated irregular network = irregular triangular mesh)

3. **linear images**

   1. Contour lines
   2. Profiles
   3. Critical lines – valleys, ridges

Representation of spatial objects
Digital terrain models

2. Point model – with a regular structure

Grid model

It is based on a raster model, where the height is constant throughout **the entire area of the cell**

Origin:

1. by calculation from TIN or contour lines - interpolation
2. interferometrically from a satellite model from SRTM radar data
3. from other satellite processing - ASTER, SPOT satellites

Representation of spatial objects
Digital terrain models

Grid model:

Advantages

- Can be used for different scales
- A simple data model
- Output from satelite data processing

Grid model :

Disadvantages

- For detailed data, large volume of data
- Suppresses extreme values
- Rugged terrain requires detailed resolution

Representation of spatial objects
Digital terrain models

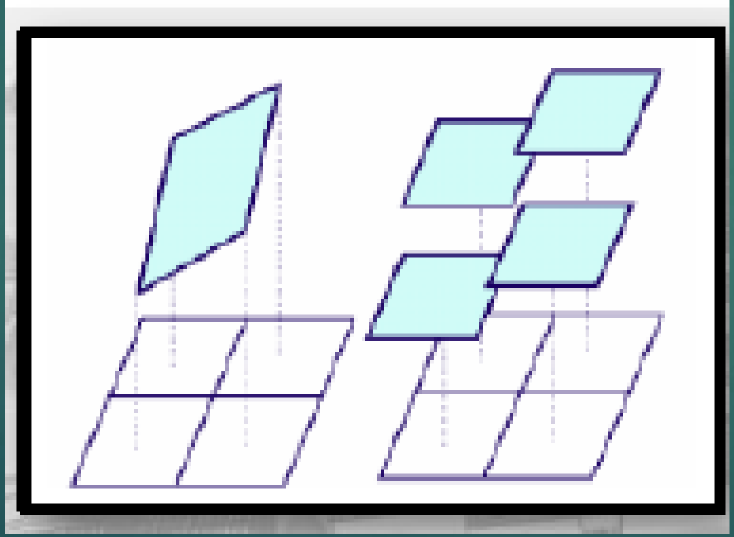
2. Pointed – with a regular structure

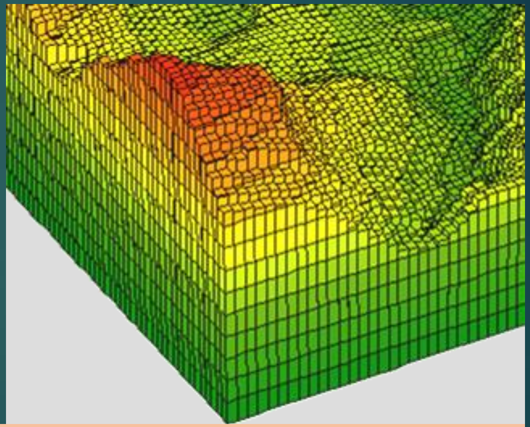
Lattice models – _

division of the area into irregular areas of different sizes - mostly triangular/quadrangular, they use non-linear transformation

lattice :

raster:





element represents the average height

Surfaces do not connect to each other at the edges

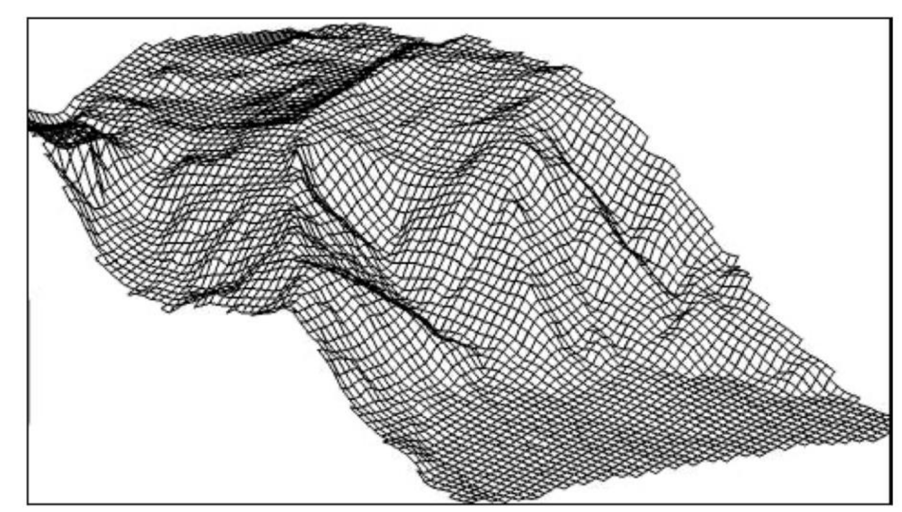
Representation of spatial objects
Digital terrain models

2. Pointed – with a regular structure

lattice

The height is given in the center of the cell

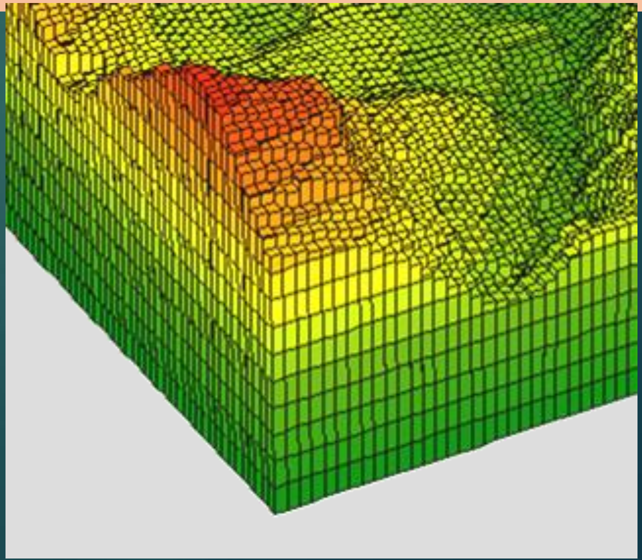
Areas follow each other



raster

element represents the average height (the value is also in the center of the cell)

Surfaces do not connect to each other at the edges



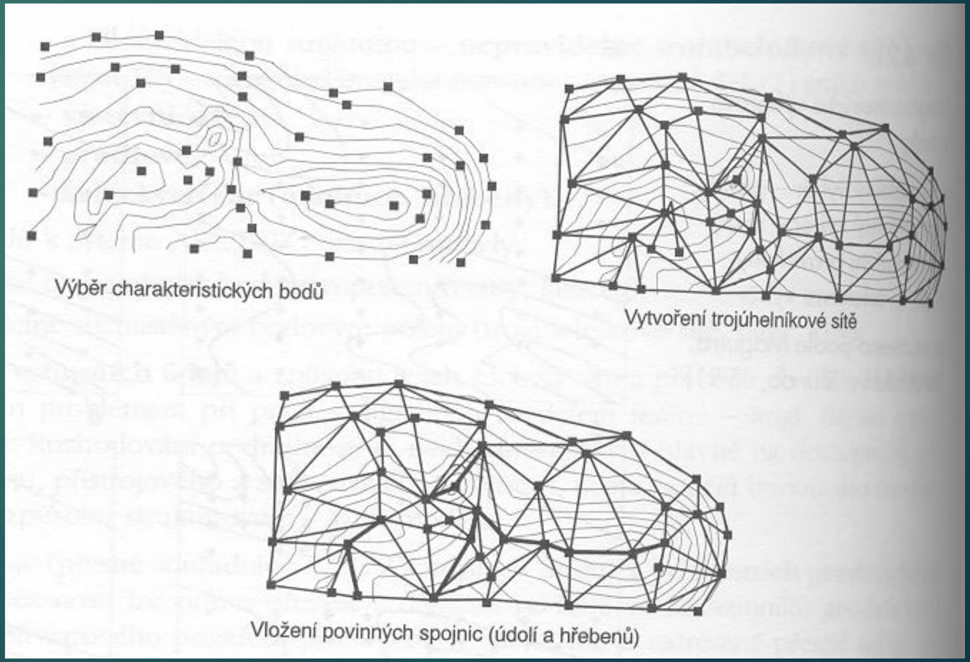
Representation of spatial objects
Digital terrain models

2. Pointed - with an irregular structure

Triangular model (TIN = triangulated irregular network)

The boundaries of the division are drawn by **singularities** and **lines** where significant changes occur

Delaunay triangulation



Representation of spatial objects
Digital terrain models

TIN consists of:

- **Nodes** - (X,Y,Z) – height values are stored in themselves
  therefore, triangles have any orientation of their surface
- **Edges** – connect the points after Delauney triangulation
- **Triangles** – given by 3 edges

Manipulation of digital terrain models

1. Creating a model from source data:

    a. geodetic measured points
    b. contour line - vector data
    c. TIN model – values stored in nodes, sides of triangles connect to each other
    d. photogrammetry, remote sensing data - raster data, cells do not connect to each other in height

2. Raster model editing - smoothing using map algebra methods (map algebra)

3. Conversion from TIN to grid (regular networks of points) – for use in models of erosion, surface water runoff, etc.

4. Finding the skeleton of the terrain - valleys, ridges

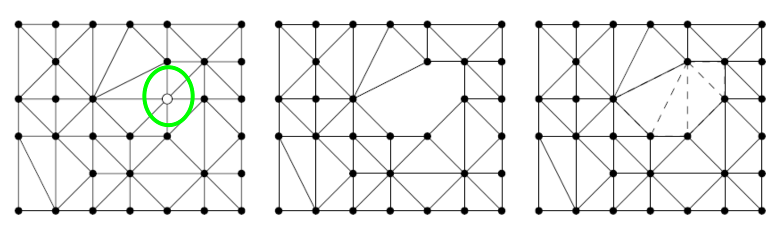
Manipulation of digital terrain models

Conversion of grid to TIN (into an irregular triangular mesh) - (there is a significantly lower number of points in the TIN)

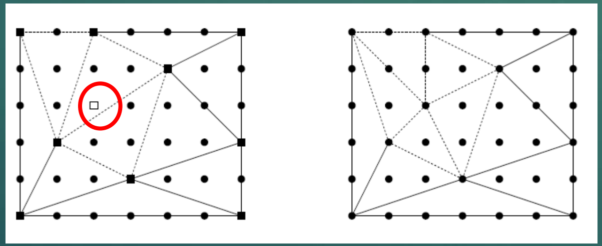
Lee's drop heuristic method

1) Regular triangulation - initially only grid

the peak that we omit (gradually all are tested)



2) the error when omitting individual vertices and their edges is assessed, then checking which error is the smallest, and that peak is omitted



the peak with the least error

Representation of spatial objects
Digital terrain models

TIN model:

Advantages

- The most suitable replacement of the terrain, it best corresponds to the actual shape of the terrain - with well-chosen sampling

TIN model:

Disadvantages

- It requires a large amount of source data (either a contour, or a dense network of measured points, or raster data)
- Difficult to use in normal raster GIS - cannot perform normal numerical analysis tasks with additional raster data

Representation of spatial objects
Digital terrain models - **line models**

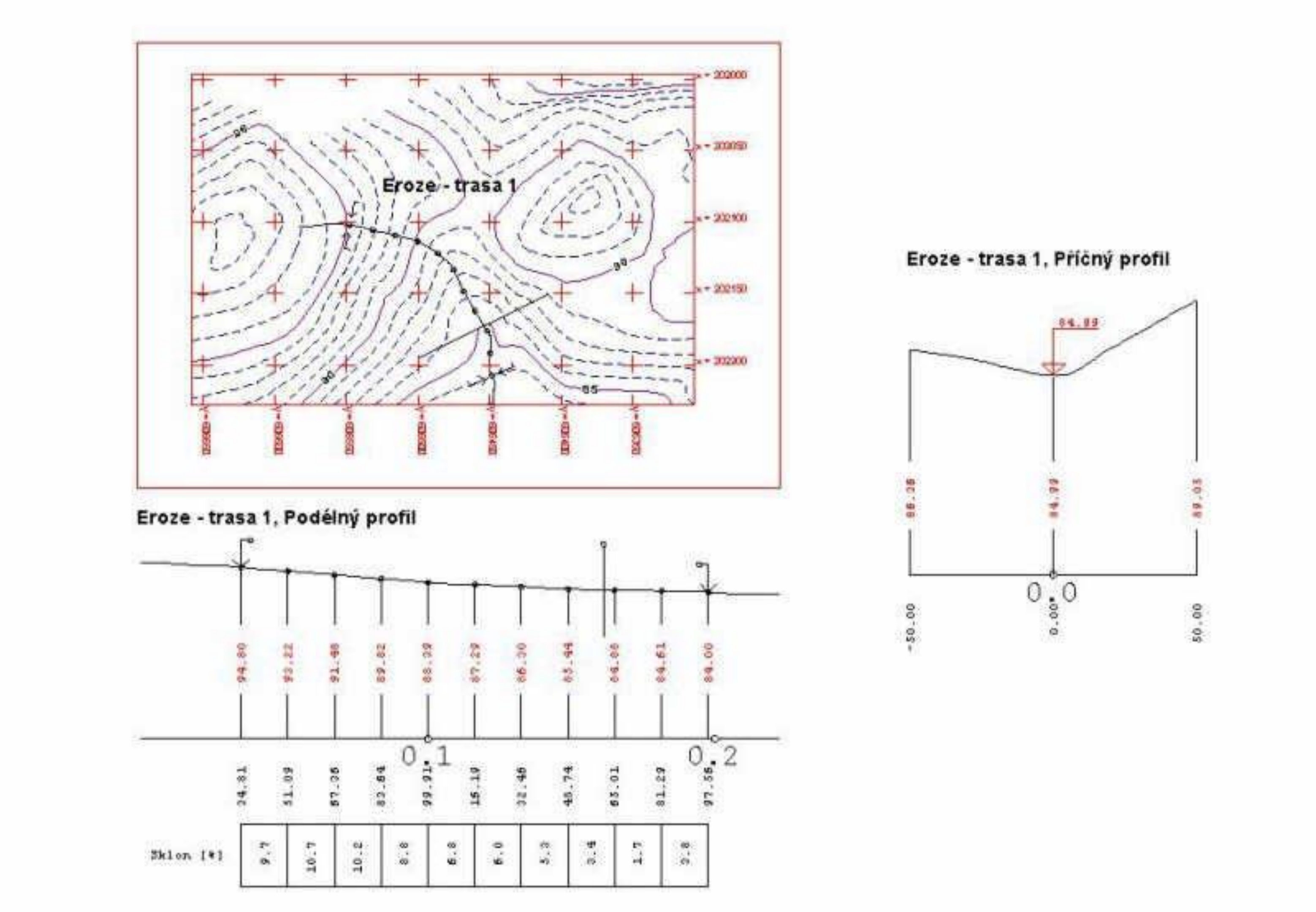
3. Line models

Contour lines

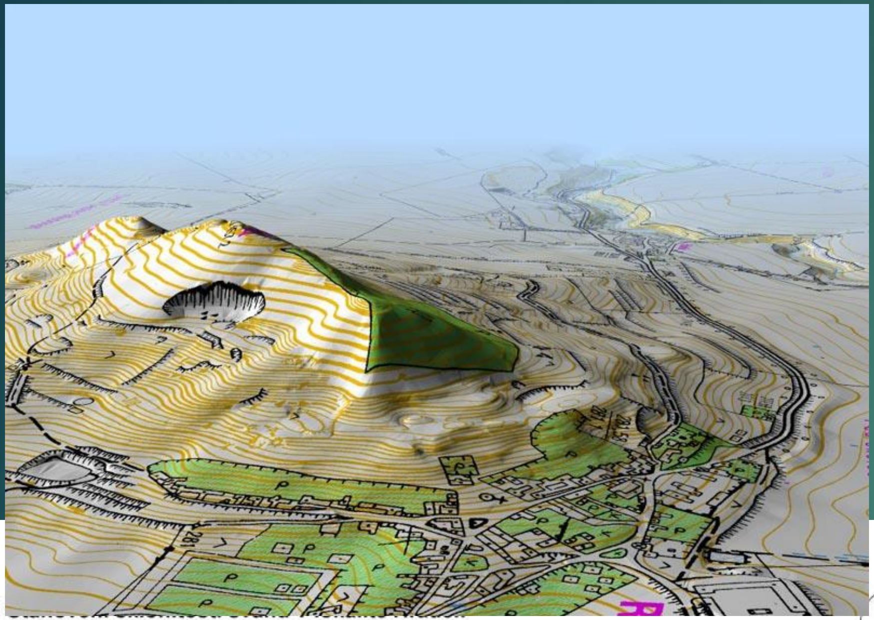
Mostly for printed maps

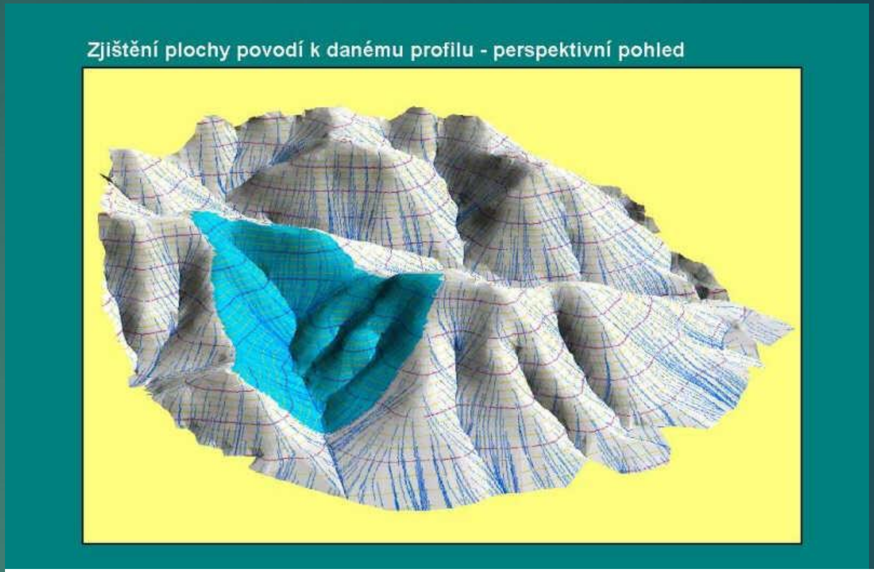
Profiles

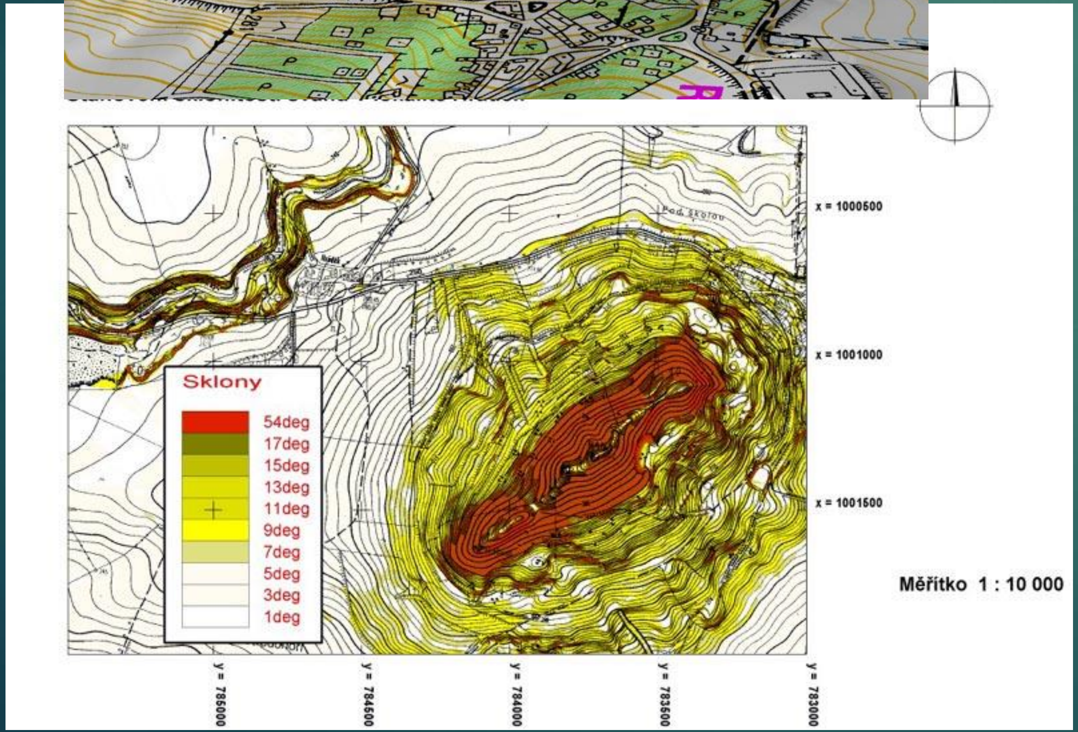
Mostly for engineering applications

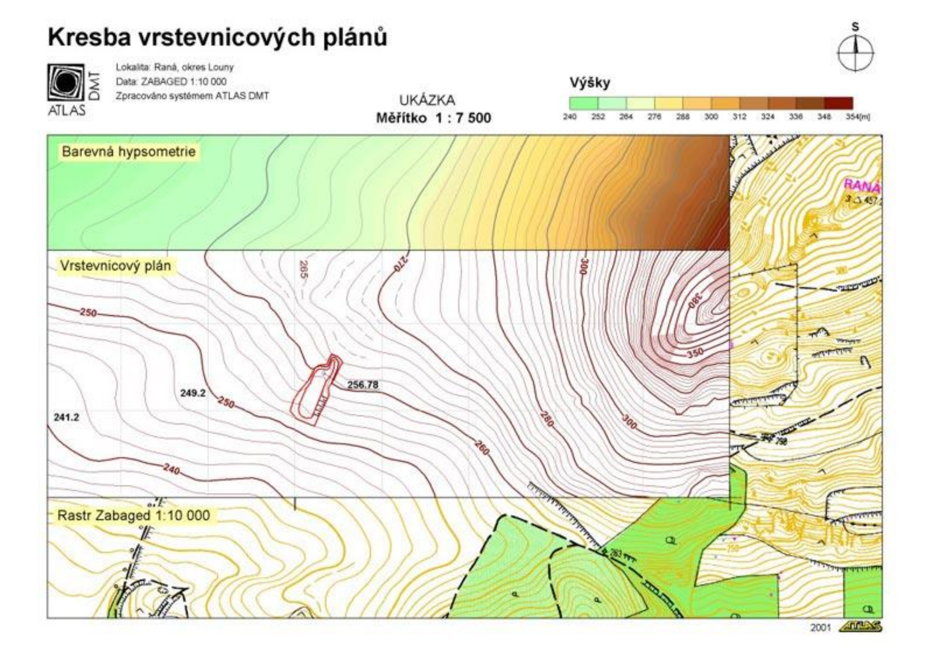


3. Line contour models









Representation of spatial objects
Digital **Contour Terrain Models**

Contour lines : the possibilities of obtaining them

1. by interpolation from point measurements
2. from photogrammetric evaluation
3. digitization from maps
4. by deriving from GRID or TIN

Representation of spatial objects

Digital terrain models - **contours**

contour line :

benefits

- A simple data model - a line
- Easy to perceive
- Easy accessibility from maps

contour line :

disadvantages

- Inappropriate anomaly sites
- Not suitable for large differences in slopes in a small area

Manipulation of digital terrain models

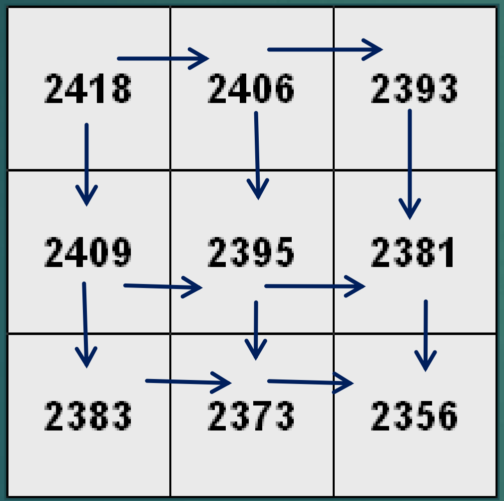
Finding the skeleton to determine the flow

- peaks connect to create ridges that **theoretically** divide the territory into individual watersheds
- depression connect for valleys

Manipulation of digital terrain models

Creating a slope map

the cells show the **heights** – **slope** , **depression** and **peak** can be determined



arrows show the direction of the slope

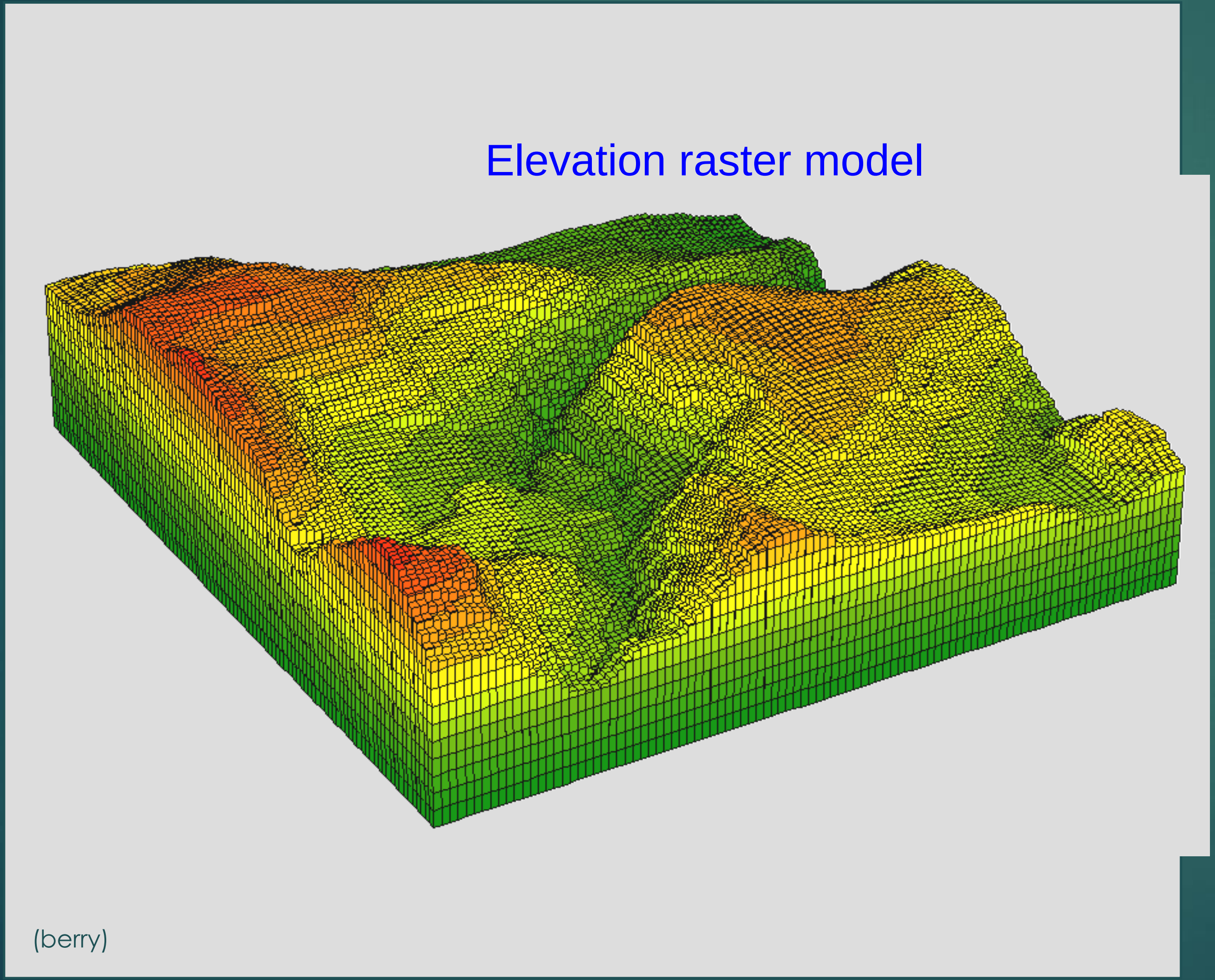
depression

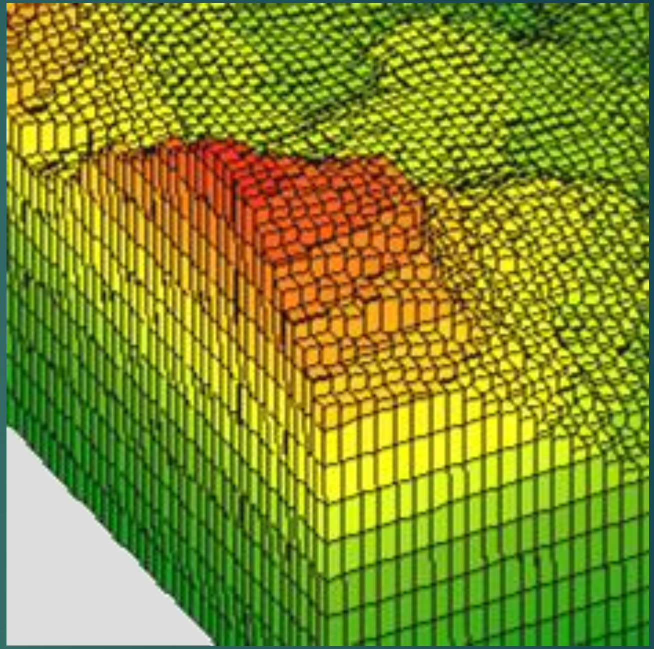
top

height values - center pixel

The arrows show the slope according to the height values of the individual cells

Handling digital terrain models
application for determining erosion





DTM is a set of interconnected „blocks"