Object, element, element class
raster GIS = field model

Spatial objects

Geometric dimension of **raster objects in raster GIS**

- **dimensionless** - 0-D - points (value 13)
- **one dimensional** - 1-D – line objects (value 2)
- **two dimensional** - 2-D – surface objects of finite size (value 1, 15, 3)
- **three dimensional** - 3-D - solids of finite volume with finite surface area (polyhedrons)

Object, element, element class

raster GIS = field model

Choice of data creator - but the object will always be areal

1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

1	1
1	1

1

6
6
6
6
6
6

6

areal object

Object, element, element class
raster GIS = field model

Descriptive data in raster GIS

Descriptive properties = attributes

- they specify individual elements - they define dimensionally or qualitatively properties
- **feature class** = (*family house*) expressed as a field value **in the raster layer**
- for **each its attribute listed in a new raster layer**

Object, element, element class

raster GIS = field model

Descriptive data in raster GIS

56	153	153	153	153
56	56	153	153	153
56	56	153	153	153
56	56	56	153	153
56	56	56	153	153
56	56	56	153	153
56	56	56	153	153

Attribute (nominal value)

Owner (= text string, expressed as owner ID)

- ID = 56
- ID 153

For this type of data , the field model is usually disadvantageous

Object, element, element class

raster GIS = field model

Descriptive data in raster GIS

Attribute - nominal boolean value

***connection to the public water supply* = boolean yes = 1, no = 0**

0	1	1	1	1
0	0	1	1	1
0	0	1	1	1
0	0	0	1	1
0	0	0	1	1
0	0	0	1	1
0	0	0	1	1

Object, element, element class

raster GIS = field model

Descriptive data in raster GIS

Attribute - ordinal value

area - I can code the values

The year the houses were completed

Code: code value

0. area outside buildings

1. *1990*
2. *1995*
3. *1997*
4. *2002*

1	1	0	3	3	0	0
1	1	0	3	3	0	0
1	1	0	0	3	3	0
1	1	0	0	0	3	0
1	1	0	0	0	0	0
0	0	0	5	5	0	0
0	0	0	5	5	5	0
0	0	0	0	5	5	0
0	0	0	0	0	5	0
0	0	0	4	4	0	0
0	0	0	4	4	4	0
0	0	0	0	4	4	0

Object, element, element class

raster GIS = field model

Descriptive data in GIS

Attribute - interval value - I have to code the values

last fix = date, if a raster GIS is required, it is advantageous to divide it into interval values of the attribute:

1	1	1	1
3	1	1	1
3	1	1	1
3	2	2	2
3	2	2	2
3	2	2	2
2	2	2	2

Code meaning attribute

1 until 31.12.1979

2 1.1. 1980 – 31.12. 1990

3 after 1.1. 1991

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

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 relief 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."*

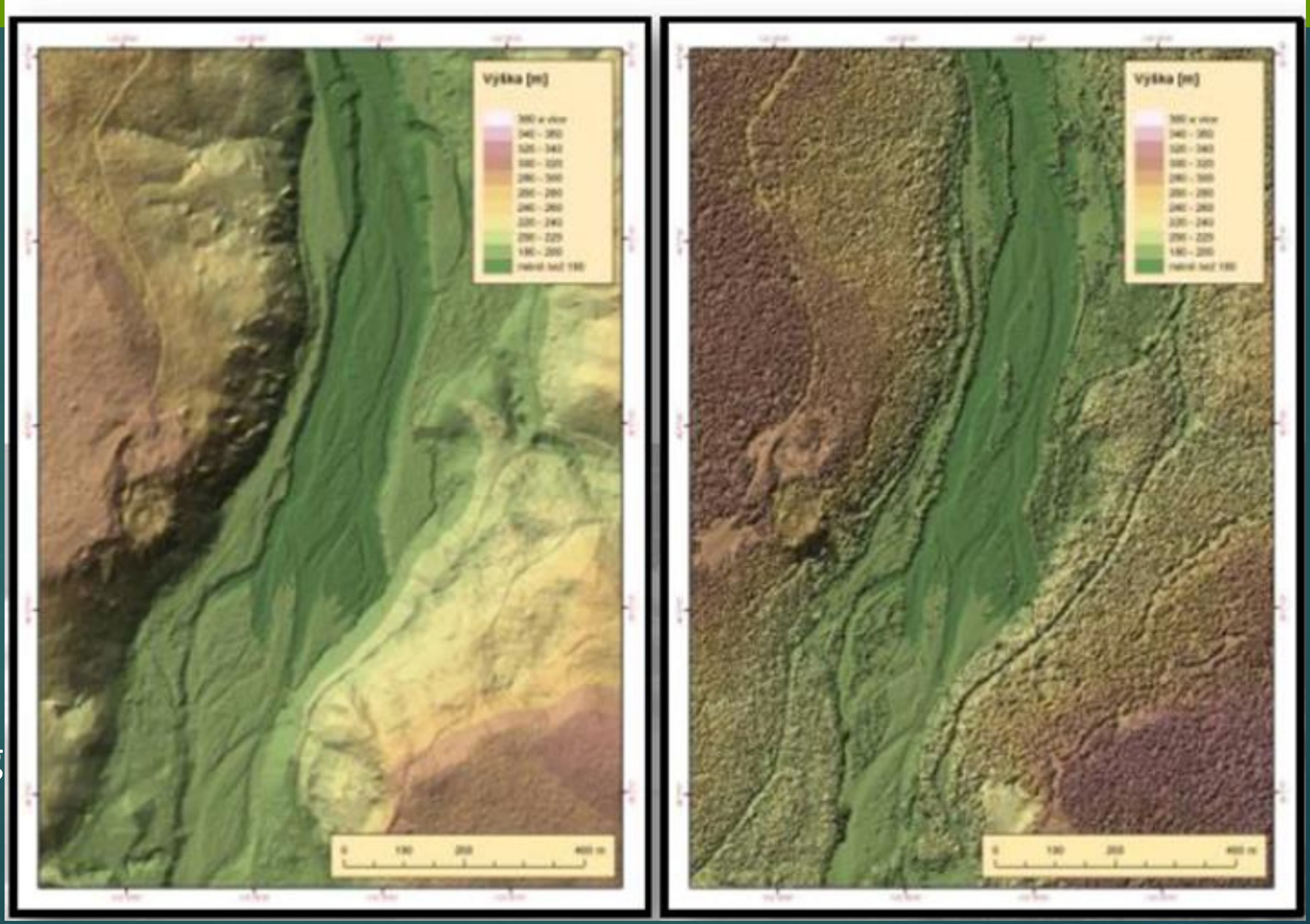
Representation of spatial objects
Digital terrain models

LIDAR data:

Mount St. _ Helen -

source : laser scanning

vegetation removed and building objects



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

Digital relief model Czech Republic 4th generation (DMR 4G)

represents display natural or human activities adjusted of the earth surface in digital shape

in form height **discrete points** in **regular grid (5 x 5 m)** of points

with full medium by mistake height

0.3 m in the open terrain

1 m in the field forested .

Representation of spatial objects
Digital terrain models

- **Digital relief model Czech Republic of the 5th generation (DMR 5G)**

represents display natural or human activities

adjusted of the earth surface in **digital** shape in form height **discrete** points in **irregular triangular network (TIN)** points

with full medium by mistake heights :

0.18 m in the open terrain and

0.3 m in terrain forested .

Representation of spatial objects
Digital terrain models

Digital surface model Czech Republic 1st generation (DMP 1G)

represents display area including buildings and plants cover in form

irregular triangular networks height points (TIN)

with full medium by mistake height

0.4 m for **exactly defined objects (** buildings)

0.7 m for objects **exactly unbounded** (forests and others elements vegetable cover)

Representation of spatial objects
Digital terrain models

Digital relief model

Supplied in **2.5 D** , i.e.

at the point (X,Y) is the value of the height attribute Z :

$$Z = f(X,Y)$$

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. Profile
   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**

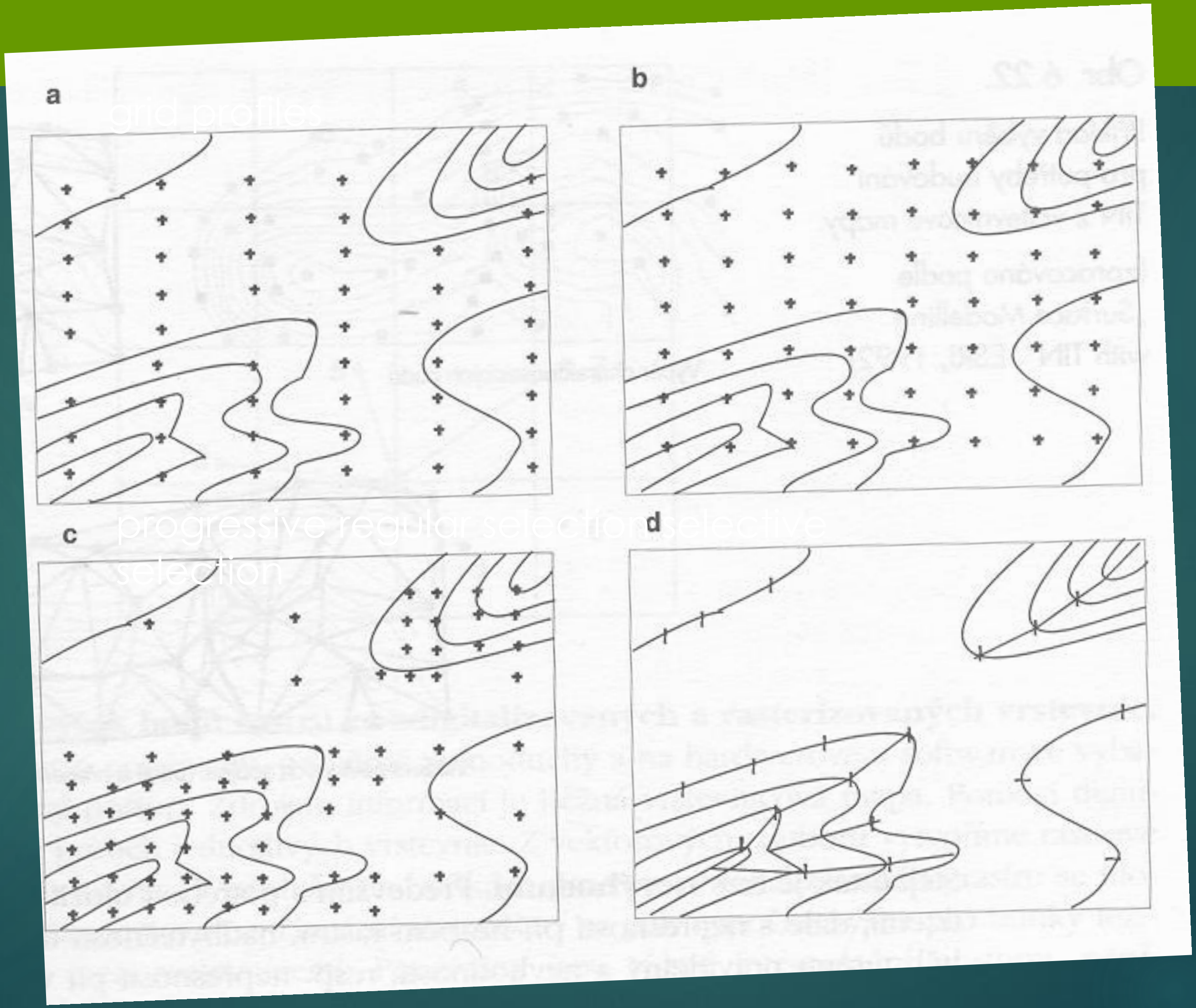
Origin:

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

Types of selection of grid points for creating contours



Representation of spatial objects
Digital terrain models

Grid model:

Advantages

- Can be used for different scales
- A simple data model
- Output from partner processing. give

Grid model :

No disadvantages

- For detailed data, large volume of data
- Suppresses extreme values
- Rugged terrains require detailed resolution

Representation of spatial objects
Digital terrain models

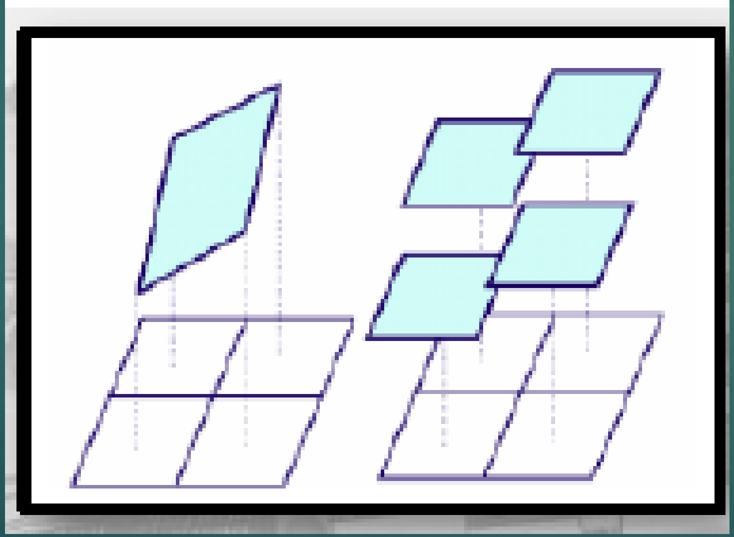
2. Pointed – with a regular structure

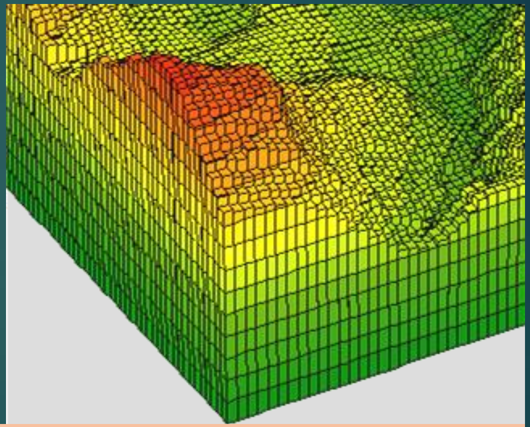
Lattice models – _

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

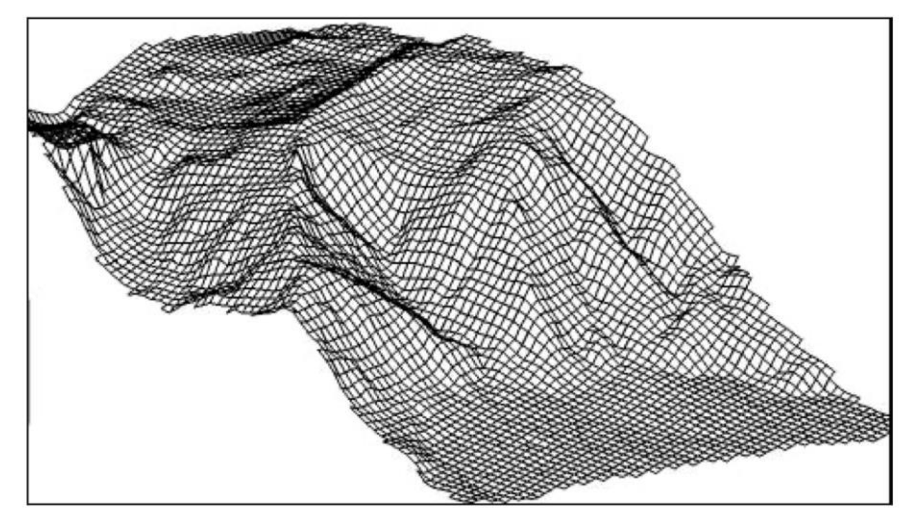
Representation of spatial objects
Digital terrain models

2. Pointed – with a regular structure

lattice

The height is given in the center of the cell

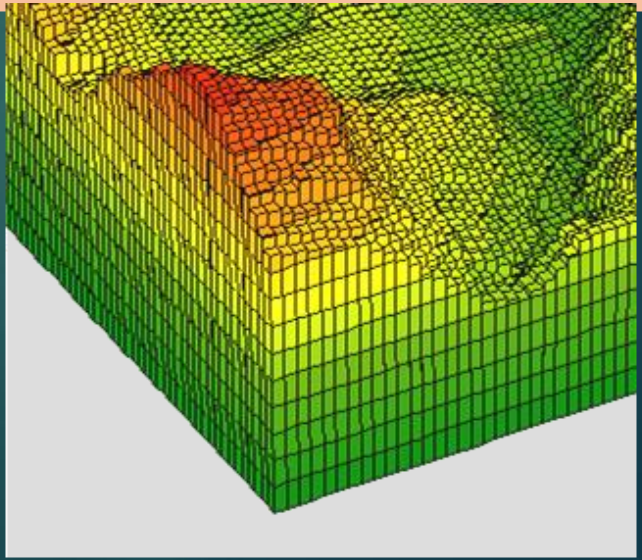
Areas follow each other



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



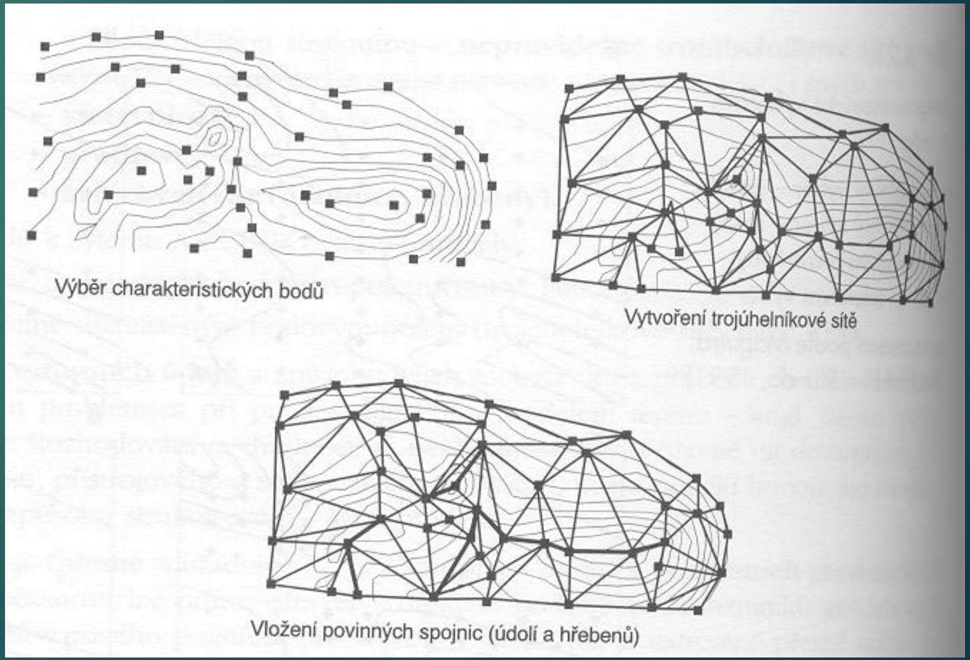
Representation of spatial objects
Digital terrain models

2. Pointed - with an irregular structure

Triangular model (TIN = triangulated irregular network)

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

TIN structures are used



Representation of spatial objects
Digital terrain models

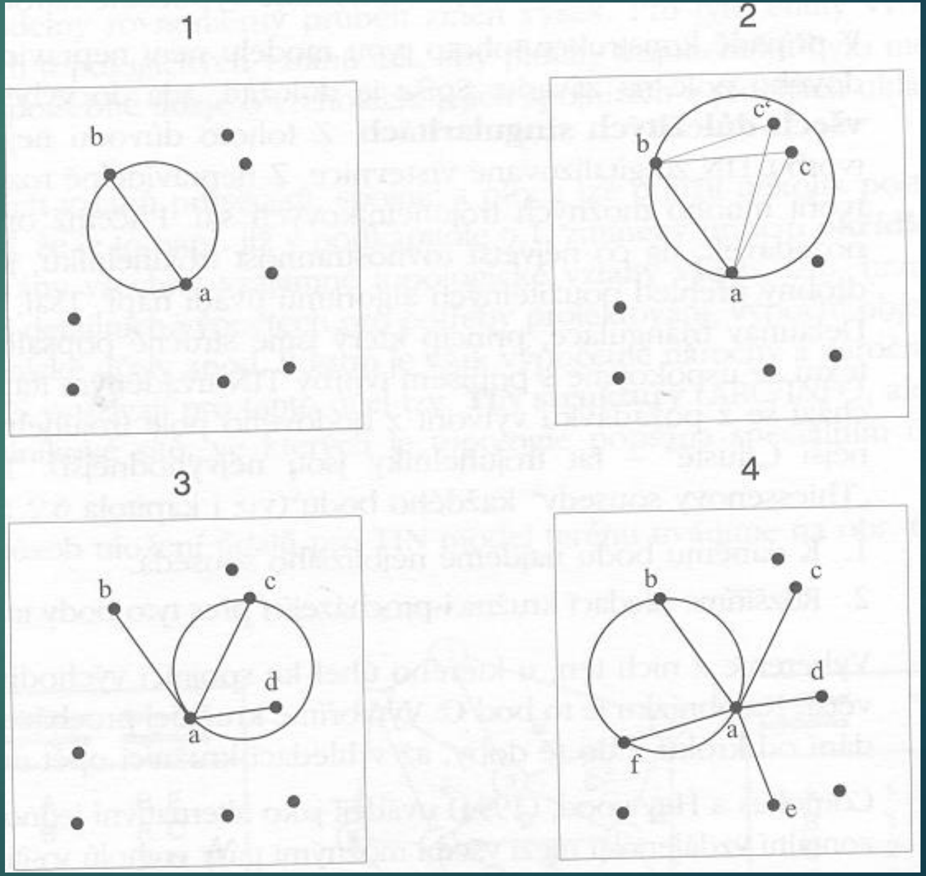
How to create a TIN using the selection method when I create from the given points the smallest triangles

= **Delauney** triangles:

1. Any points ***a* , *b*** – construct a circle
2. Point *c* – circle above triangle ***abc*** does not contain ***c´***
3. Circular assembly. between ***ac*** contains only ***d***
4. Connect ***e***
5. Connect ***f***

The triangles should be as similar as possible

equilateral triangle



Representation of spatial objects
Digital terrain models

TIN consists of:

- **Nodes** - (X,Y,Z) – height values are stored in them

  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 - see next semester)

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

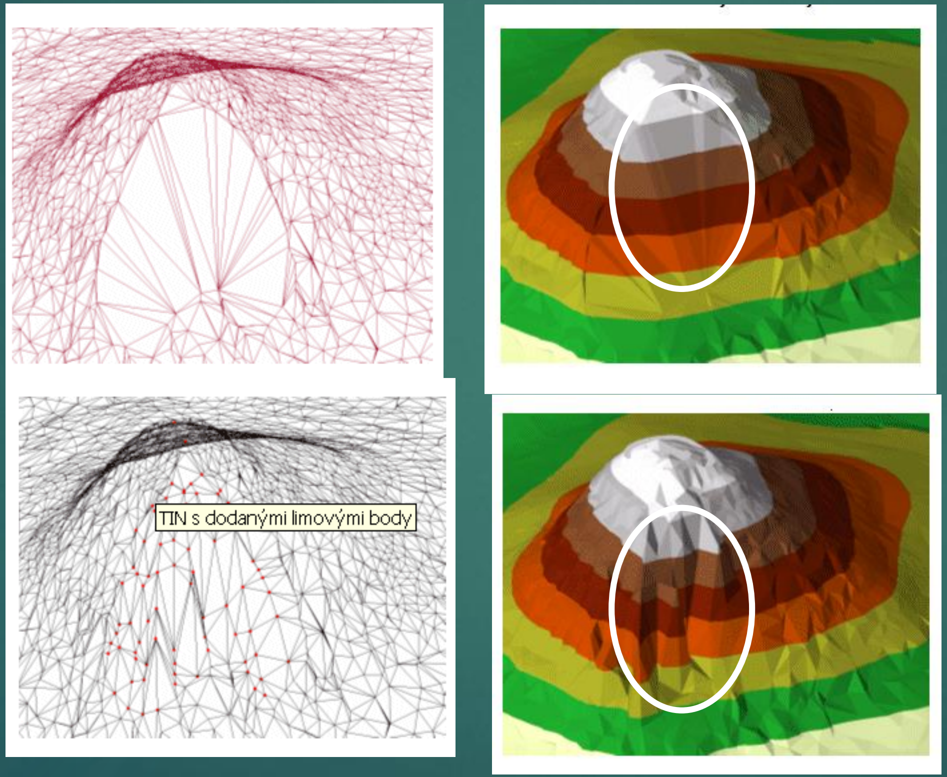
4. Finding the skeleton of the terrain - valleys, ridges

Manipulation of digital terrain models

Improvements to the model in TIN format using breakpoints

model without breakpoints

breakpoints model



Geographical Information Systems and Computers Cartography , Christopher B. Jones, Singapore; Algorithmic Foundations of Geography Information Systems, Marc van Kreveld , Springer ; Generalization in Digital Cartography , Robert B. McMaster , Washington

Manipulation of digital terrain models

Conversion of grid to TIN (into a regular triangular mesh)

Method

1. which grid points to keep/cancel - assignment of importance (the height of the grid point is compared with the interpolated height - from the 8 neighbors of the investigated point - **the points with the biggest difference are kept**

2. first **triangulation from only 4 corner points of the grid** and still refined to a sufficient approximation of the grid surface

3. Finding **significant terrain shapes** - peaks, depressions, saddle points, ridge valleys. It is then completed in the TIN form.

4. points are canceled by leaps and bounds (e.g. Lee's heuristic omission)

Geographical Information Systems and Computer Cartography , Christopher B. Jones , Singapore ; Algorithmic Foundations of Geography Information Systems , Marc van Kreveld , Springer ; Generalization in Digital Cartography , Robert B. McMaster , Washington

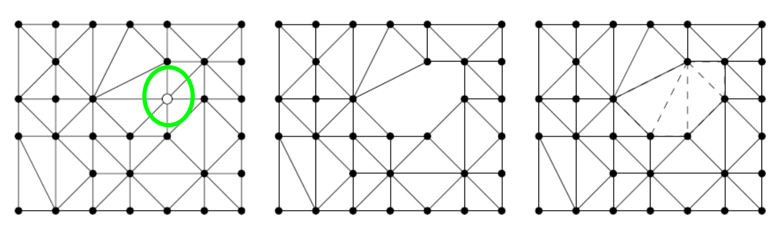
Manipulation of digital terrain models

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

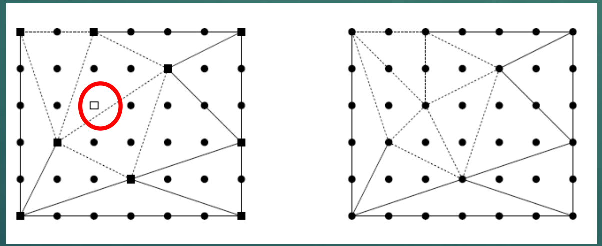
Lee's Lee 's drop heuristic method _ _

1) Regular triangulation - initially only grid

the peak that we omit (gradually they test all)



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



the peak with the least error

Lee, J .: Comparison of existing methods for building triangular irregular network models of terrain from grid digital elevation models . *International _ J. of Geographical Inf . Syst* ., 5(3): 267-285, July - Sept.1991

Representation of spatial objects
Digital terrain models

TIN model:

Advantages

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

TIN model:

No 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

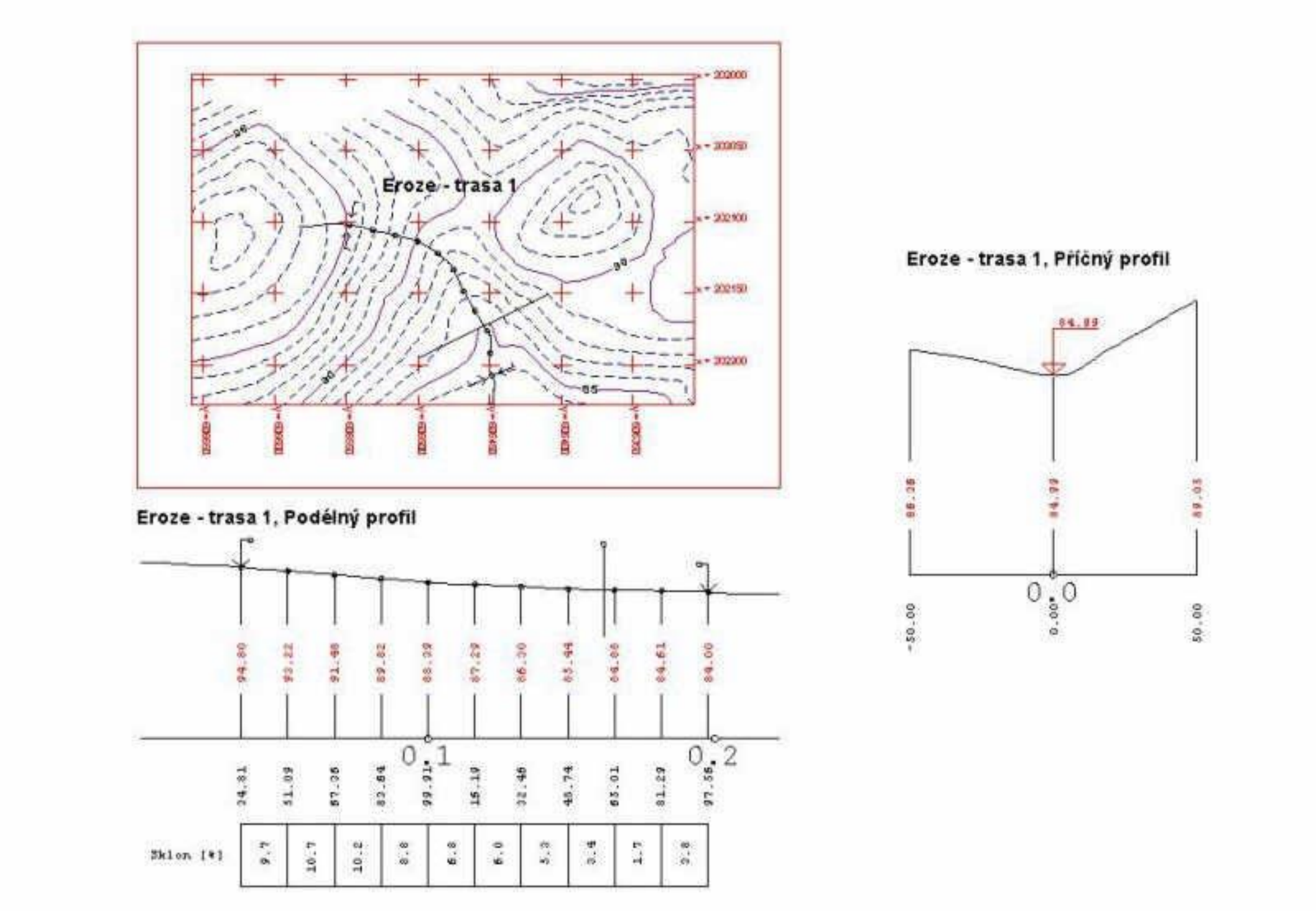
Mostly for printed maps

Profile

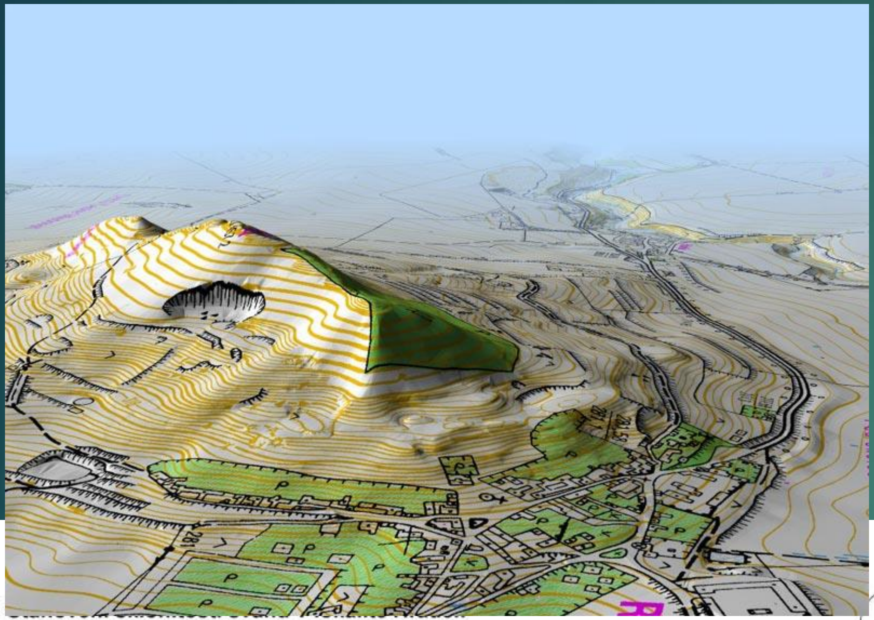
Mostly ro engineering applications:

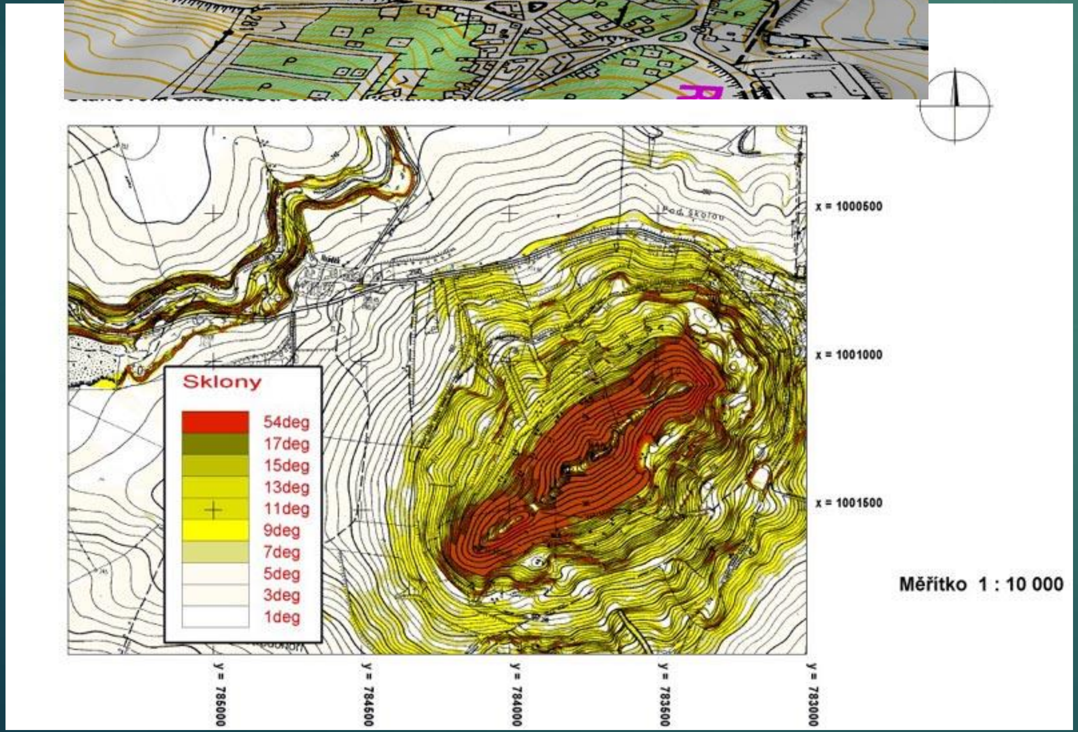
profiles for laying

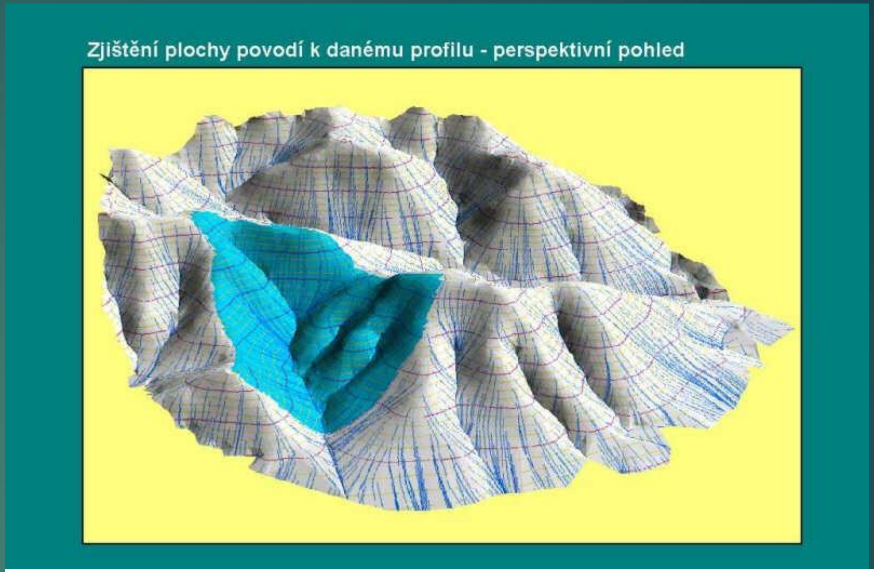
water pipes , etc.

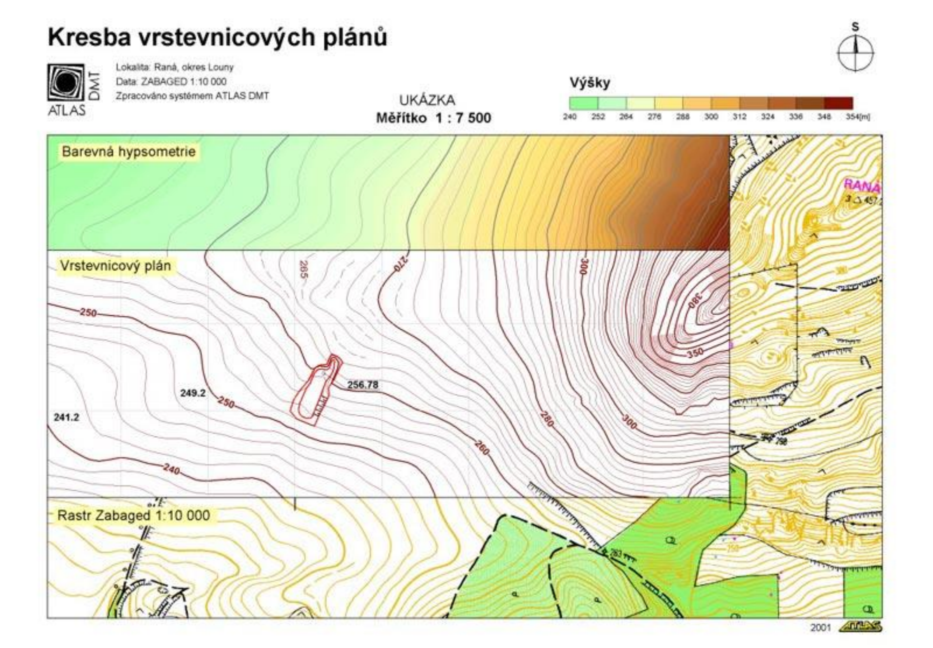


3. Line contour models









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 the map base
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 record
- Not suitable for large differences in slopes in a small area

Manipulation of digital terrain models

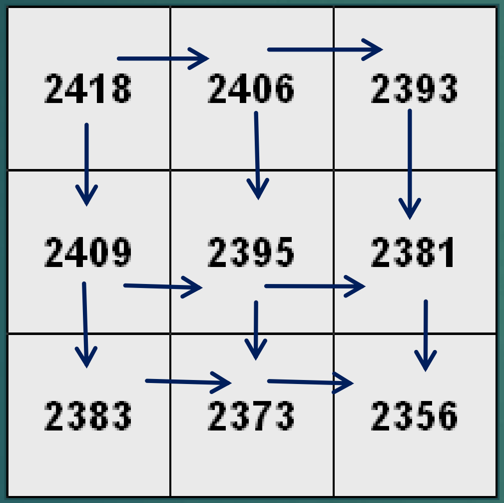
Finding the skeleton to determine the flow

- the peaks will connect to create ridges that **theoretically** divide the territory into individual watersheds , the **actual boundaries** should be adjusted based on impermeable geological layers
- depression will connect for valleys

Manipulation of digital terrain models

Creating a slope map

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



depression

top

height values than in the center pixel

arrows show the direction of the slope

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

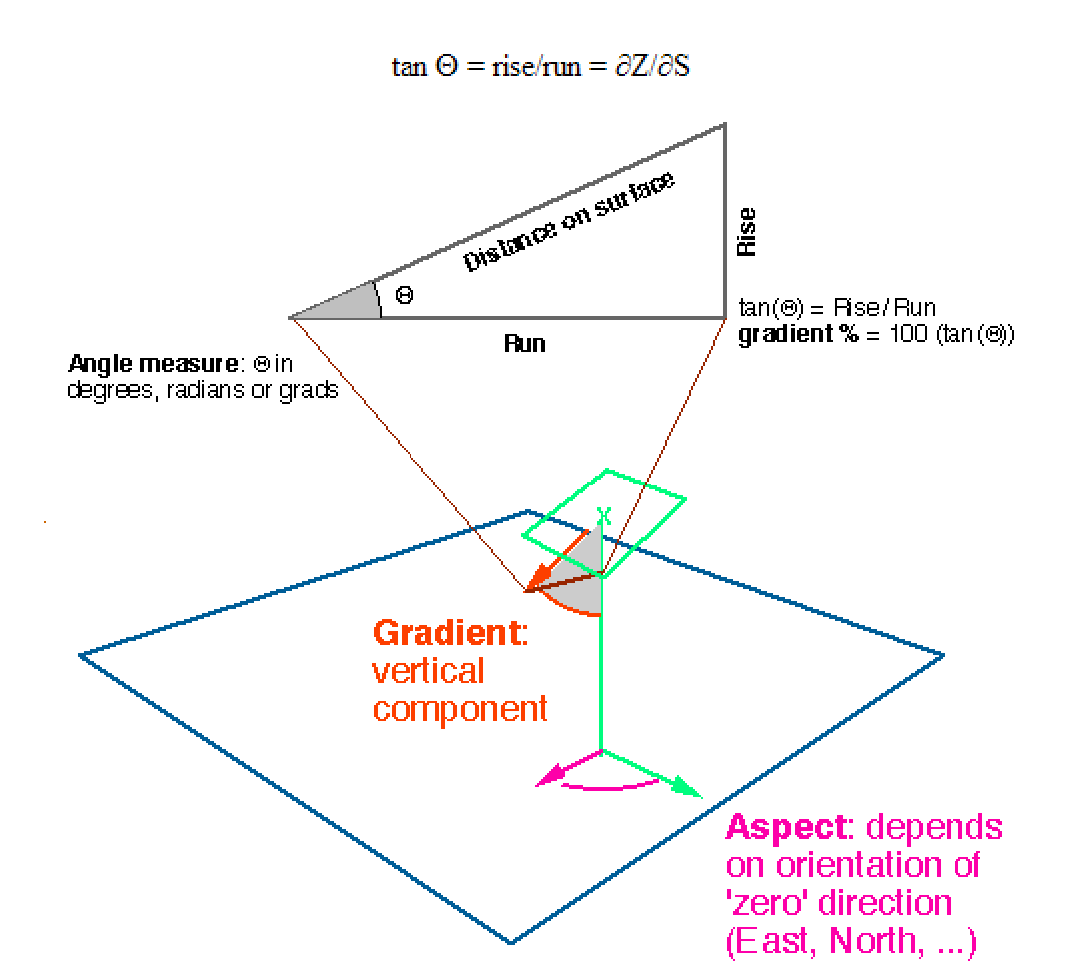
Manipulation of digital terrain models

Derivation of other parameters – general methods derived from geomorphology:

- **tilt** = tangent of the plane of the surface at any point - displayed as an oriented line of length equal to the magnitude of the slope
- **gradient** = **maximum** height change ratio

  (%)

- **orientation (aspect)** (orientation of the slopes to the cardinal points) = azimuth orientation of this max. height change – to the north (degrees)



Manipulation of digital terrain models

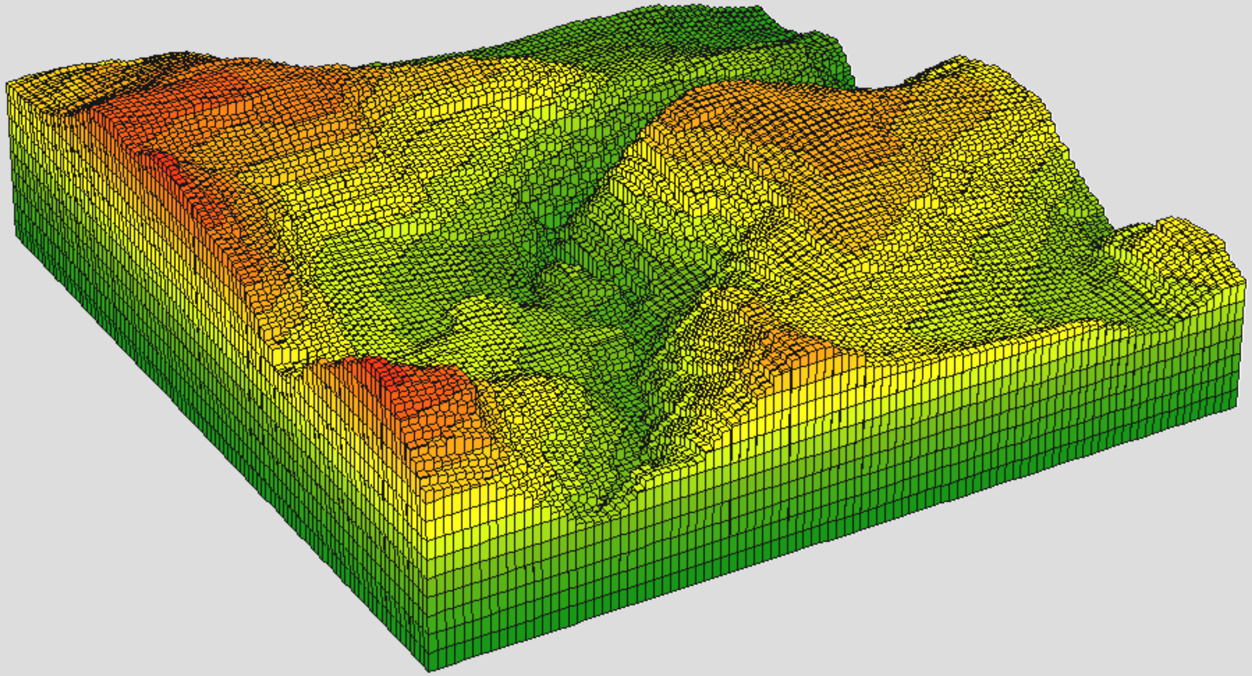
Summary of other DMT parameters. cont .:

- contour line
- horizontal sections = sections in contour lines
- vertical sections – to determine height conditions, e.g. for linear constructions
- ridge = connecting points with local maxima of heights
- Valley = connecting points with local minima of heights

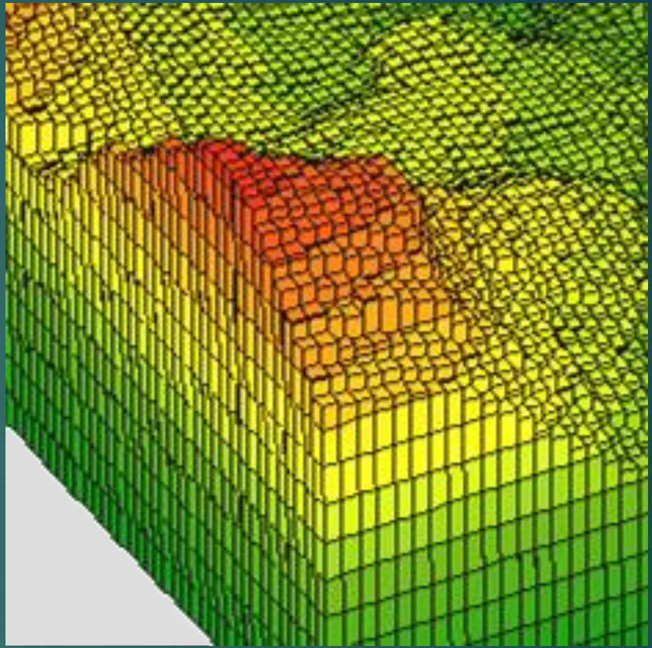
Handling digital terrain models

application for determining erosion

Elevation raster model



(berry)



DTM is a set of interconnected "prisms"

colors indicate heights