Geomorphometry 2021

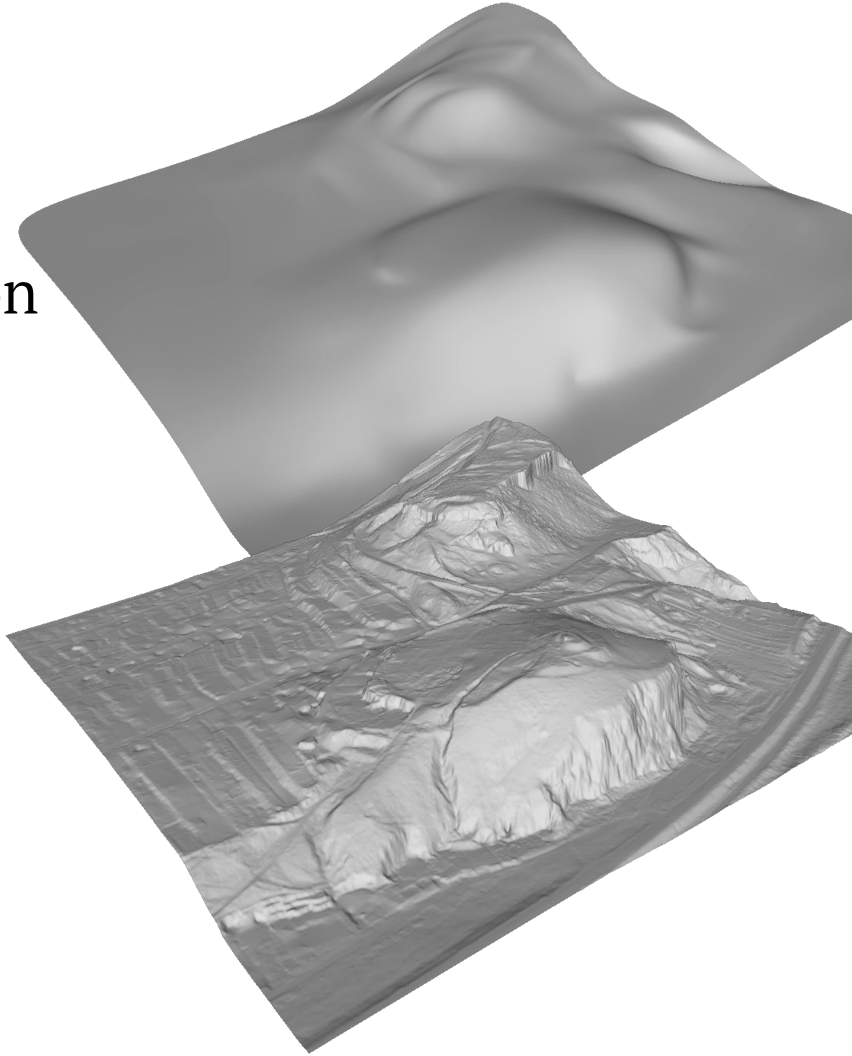
An optimization of triangular network and its use in DEM generalization for the land surface segmentation

Richard Feciskanin, Jozef Minár

Comenius University in Bratislava, Faculty of Natural Sciences
Department of Physical Geography and Geoinformatics

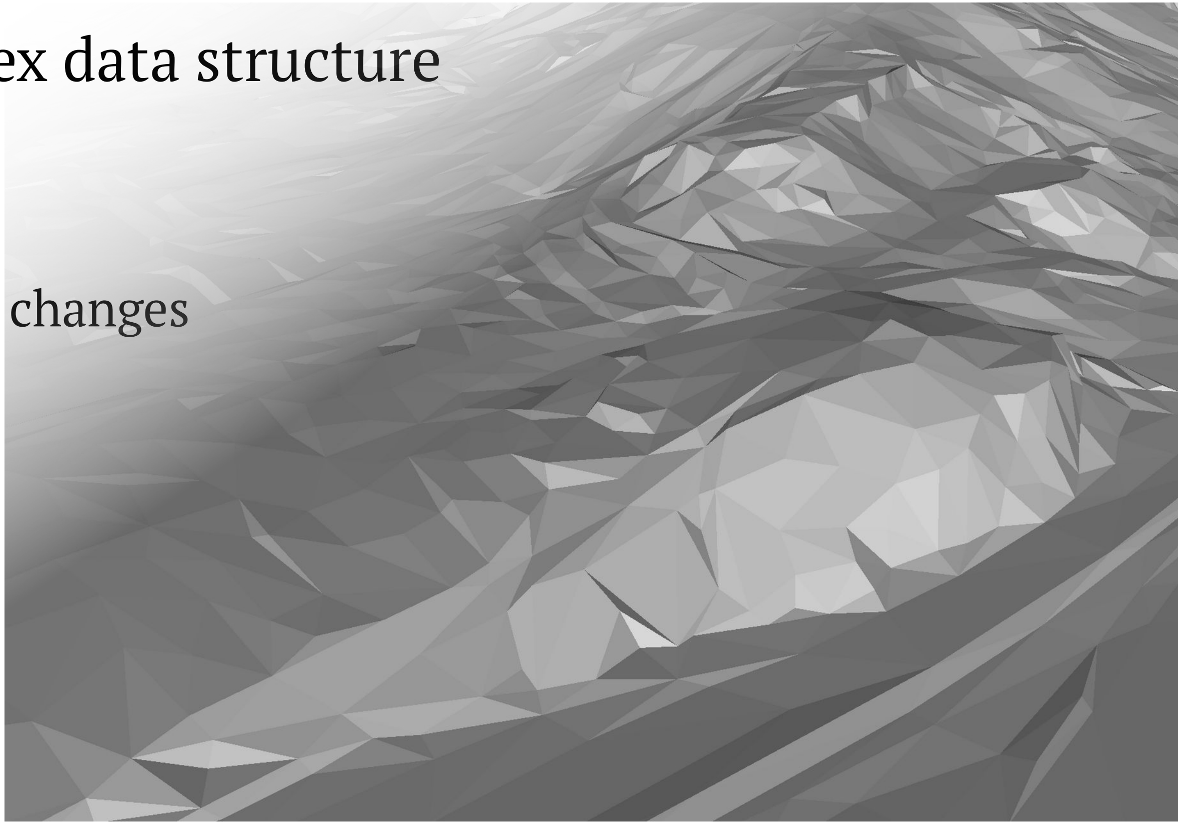
Motivation

- Geomorphological mapping / segmentation
  - Course analytic scale
  - Generalization is necessary
  - Finding appropriate levels
- Quality of generalization methods
  - Common methods limitation
  - Insufficient preservation of land surface shapes



Generalization methods working with TIN

- Irregular elements and complex data structure
  - ✓ Flexible structure
  - ✓ Effective for capturing shape changes
  - ✓ Suitable for simplification
  - ✗ Suitable for further analysis



Generalization methods working with TIN

- Classical methods for DEM: grid → TIN
  - Selection of relevant elements
  - Determination of deviations
- Polygonal simplification
  - TIN modifications instead of selection of vertices
  - Maximum shape fidelity
  - Advanced in computer graphics

Polygonal simplification / triangle optimization

Maintaining the characteristic shapes

⇩

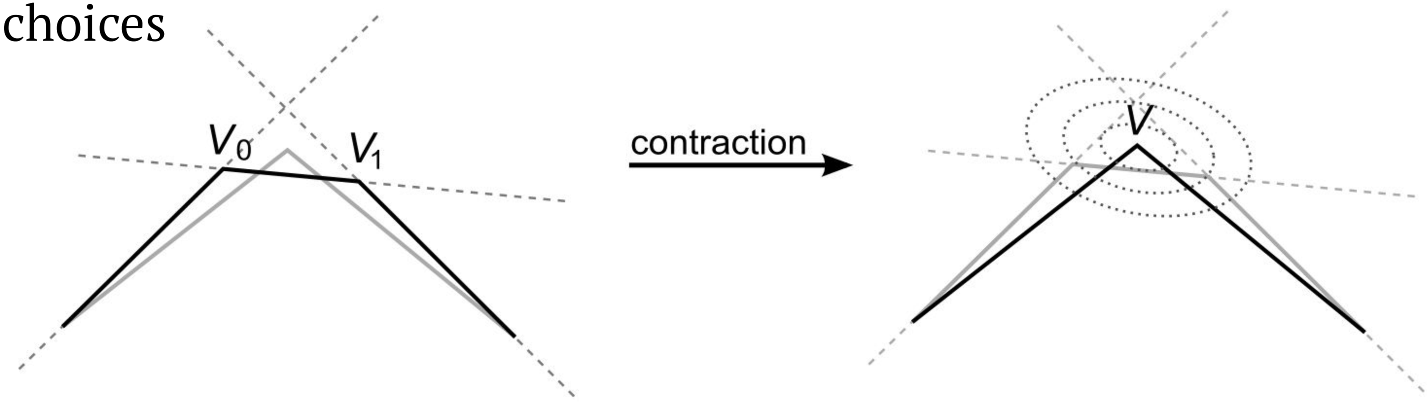
Triangle edges are located on the greatest surface changes

Triangle area represents homogeneous part

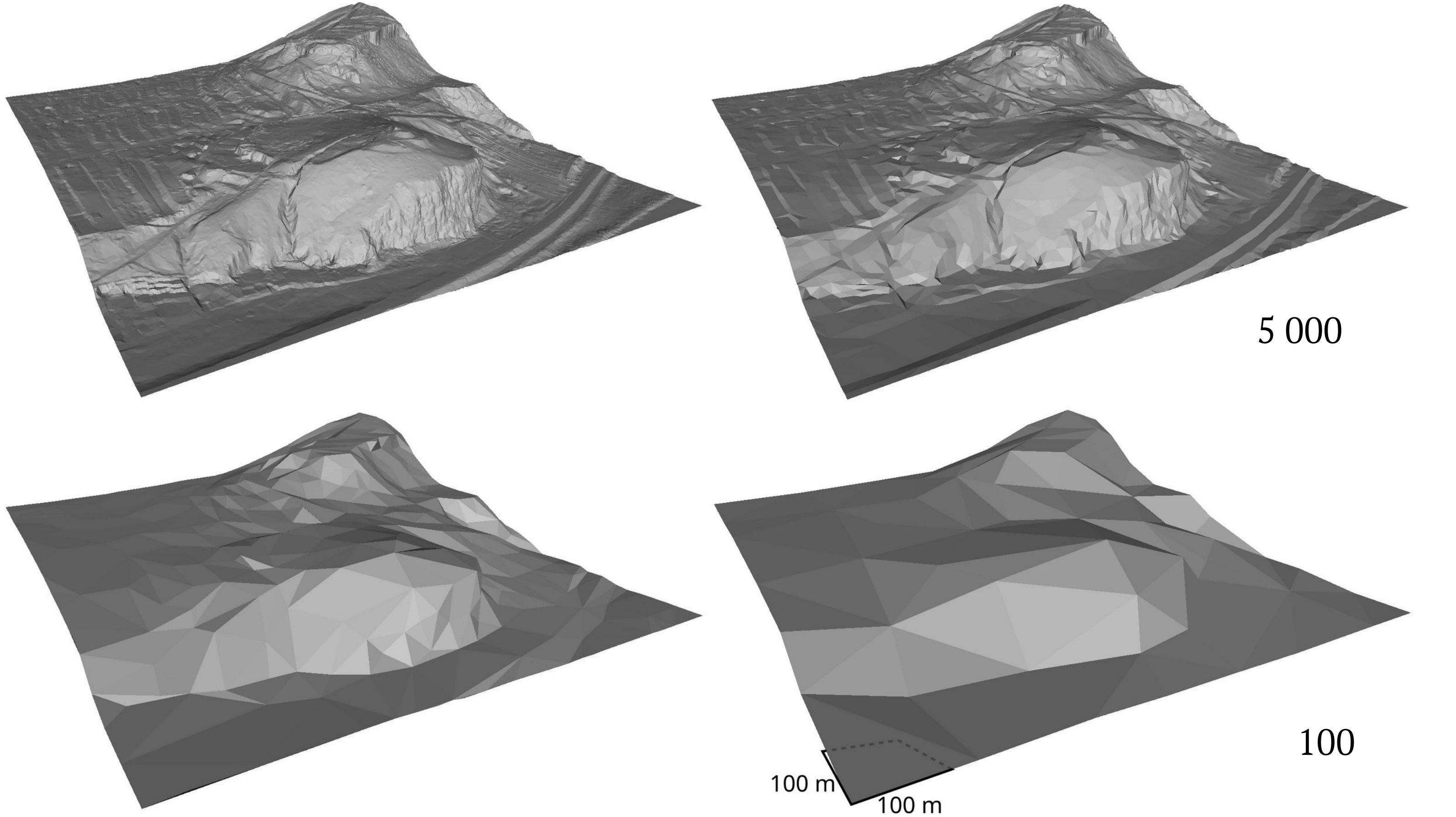
✓ Principle of maximizing internal homogeneity and external heterogeneity in land surface segmentation

Quadric error metric simplification (QEMS) method

- Decimation of a triangular network by edge contraction
- Minimization of the quadratic distance of a point to the planes of the surrounding triangles
  - In accordance with the theory of the optimal triangle
  - Without subjective choices



Quadric error metric simplification (QEMS) method



100 000

5 000

650

100

Comparison with conventional method

QEMS

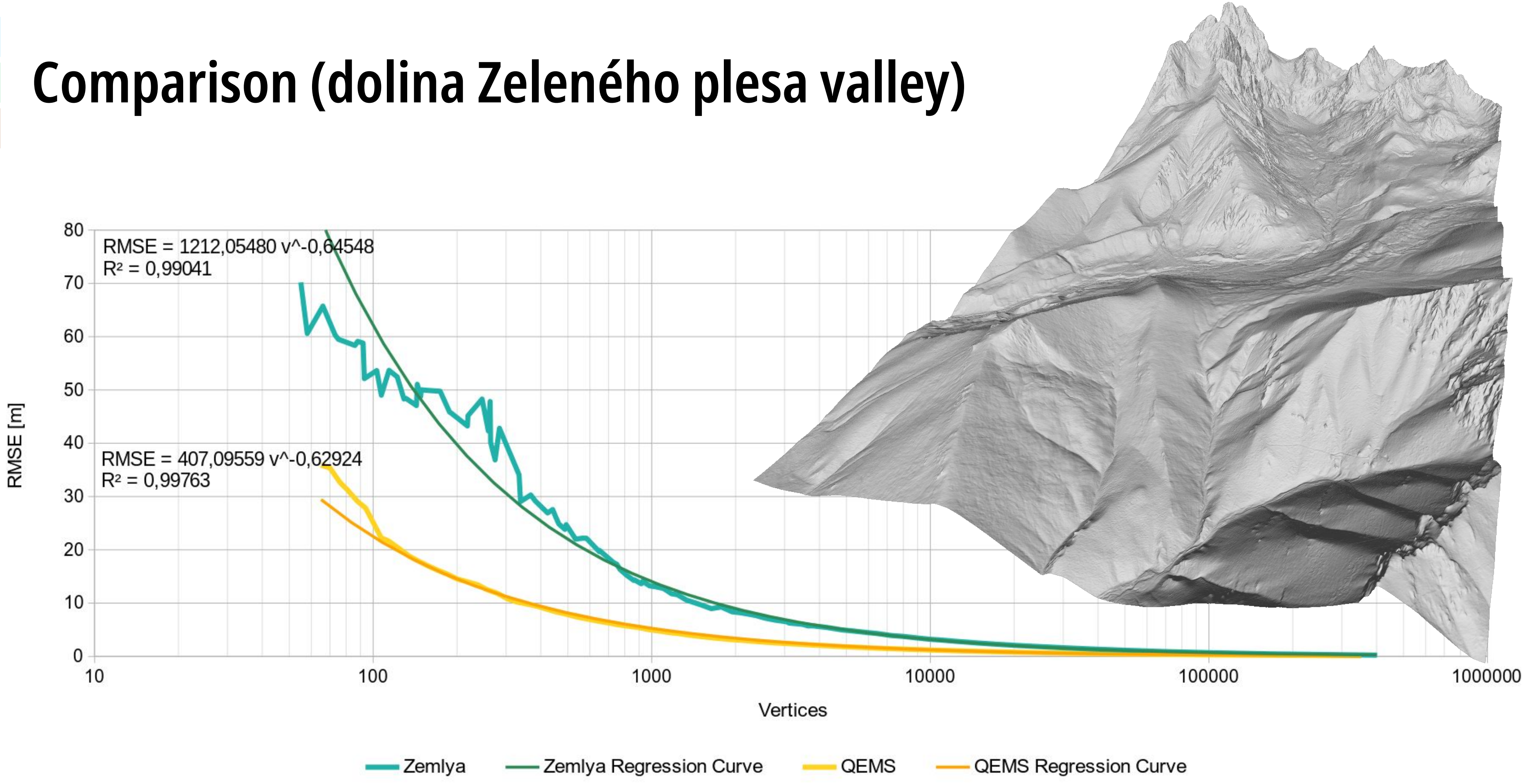
vs

maximum z-tolerance

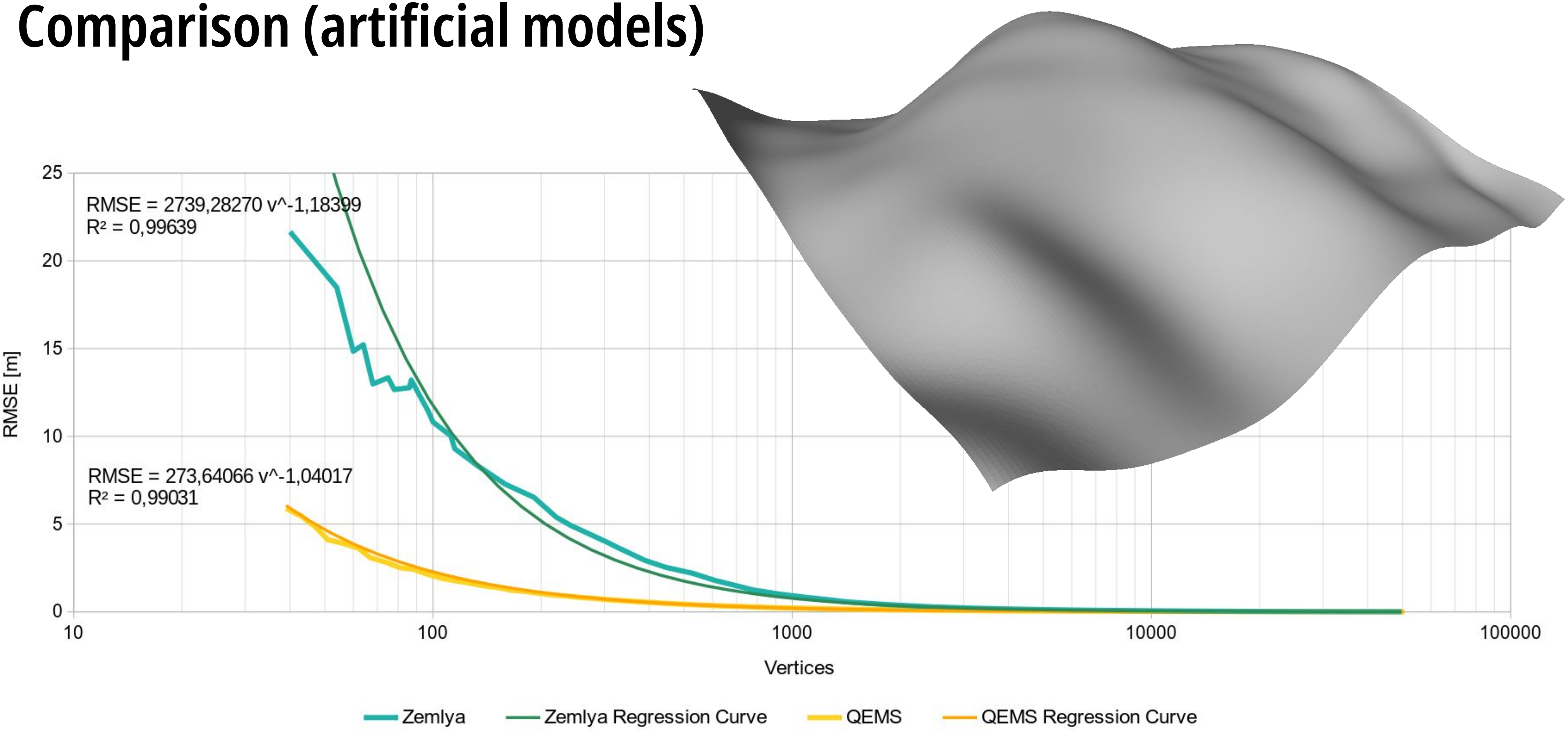
- Widespread approach to generalization
- *Zemlya* implementation was used

- RMSE of signed approximation error
  - Signed Euclidean distance (point to surface)
  - Random points on triangle planes (approx. 50 000)

Comparison (dolina Zeleného plesa valley)



Comparison (artificial models)

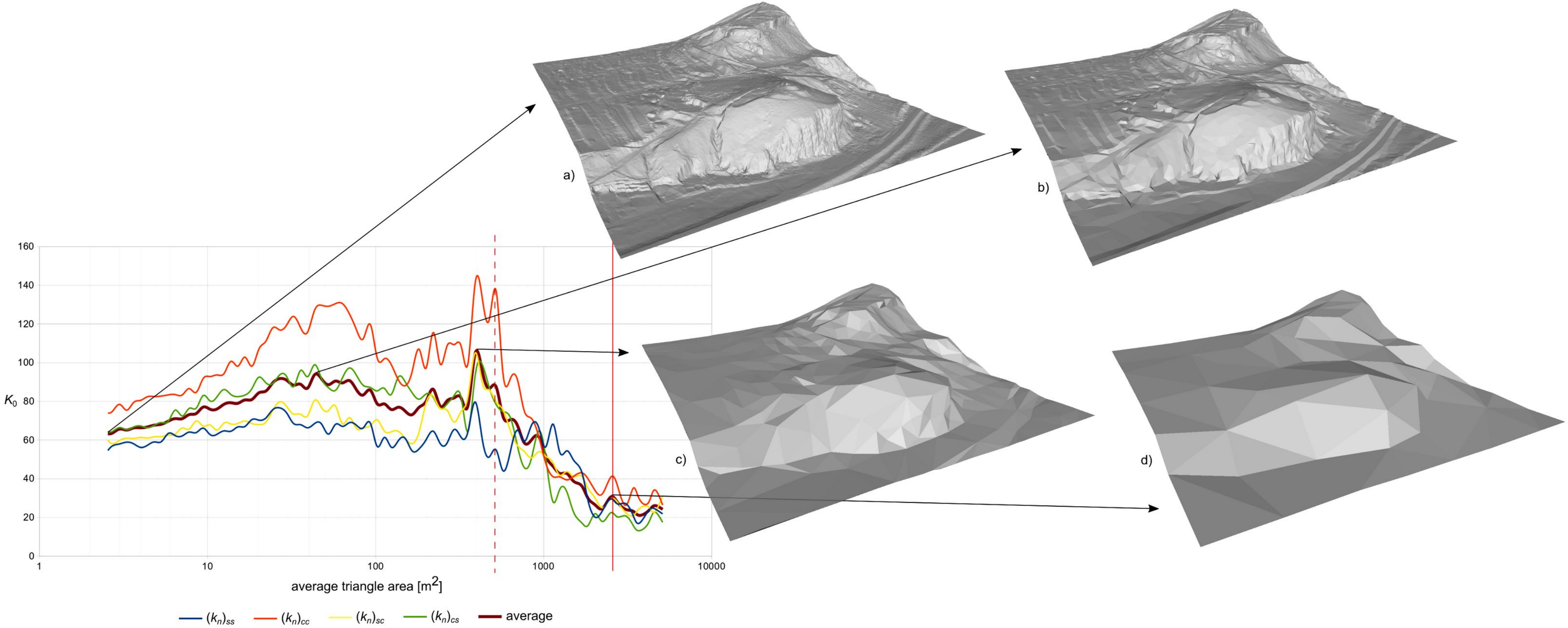


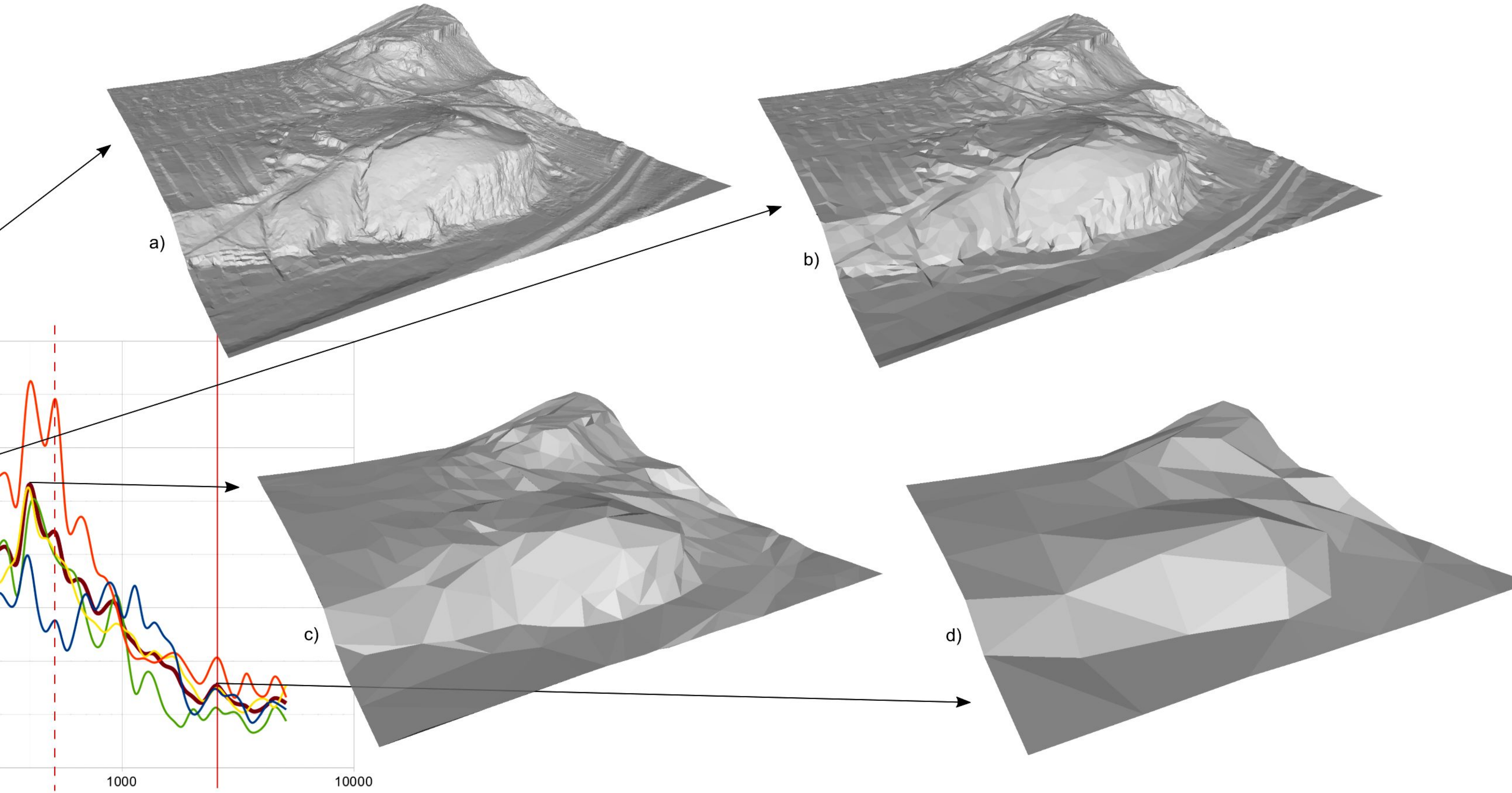
Suitability for segmentation

- Third order morphometric quantities
  - Affinity of second order quantities to constant values
- Calculation of values of curvature changes
  - $(k_n)_{ss}$ $(k_n)_{sc}$ $(k_n)_{cc}$ $(k_n)_{cs}$
  - Based on a third-order polynomial least-square fitting
- Concentration of data around zero
  - Quantile-based measure of kurtosis

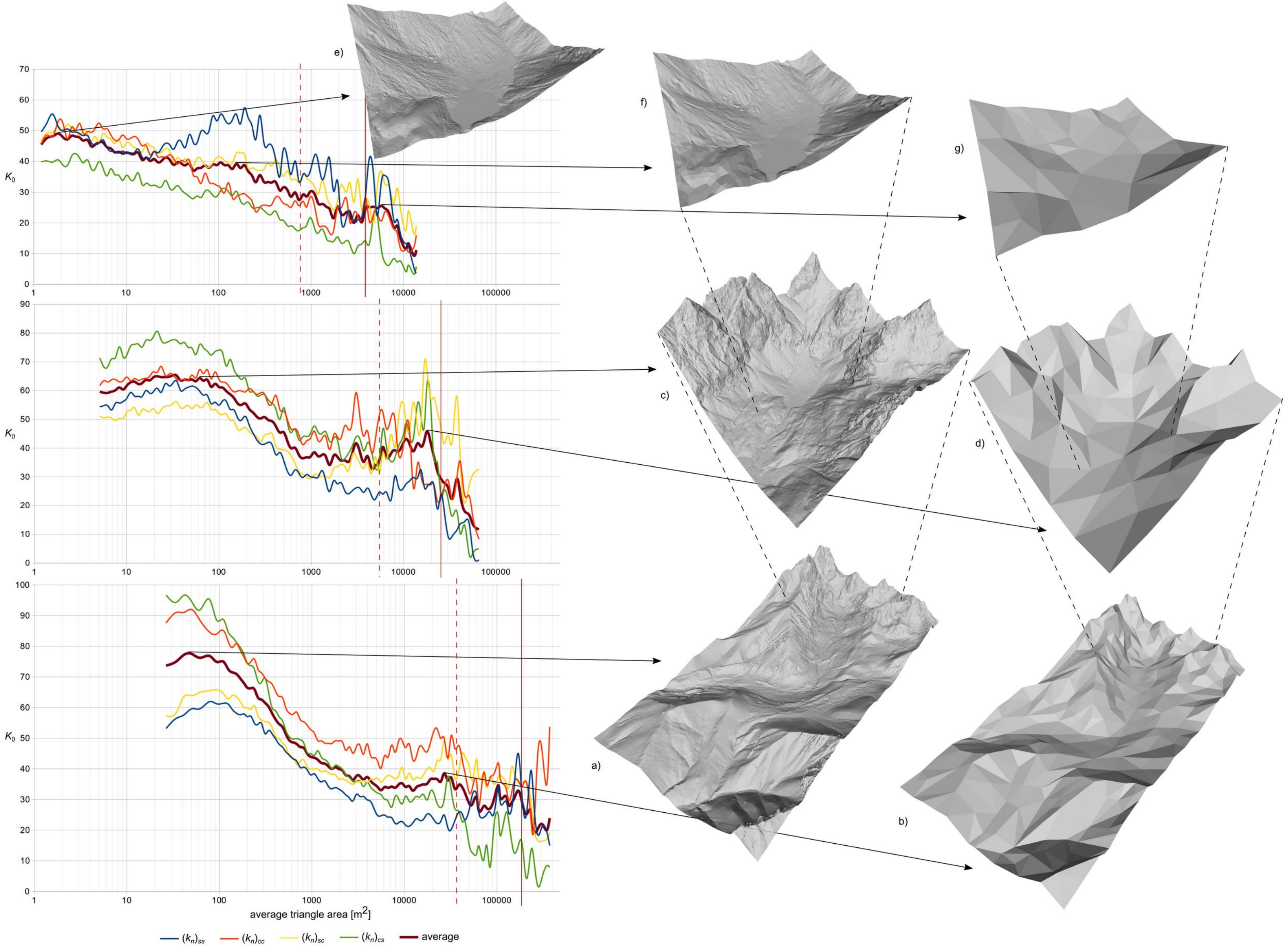
$$K_0 = \frac{\tilde{x}_{95} - \tilde{x}_5}{\tilde{x}_{0+5} - \tilde{x}_{0-5}}$$

K_0 curves (Slovinec/Sandberg)

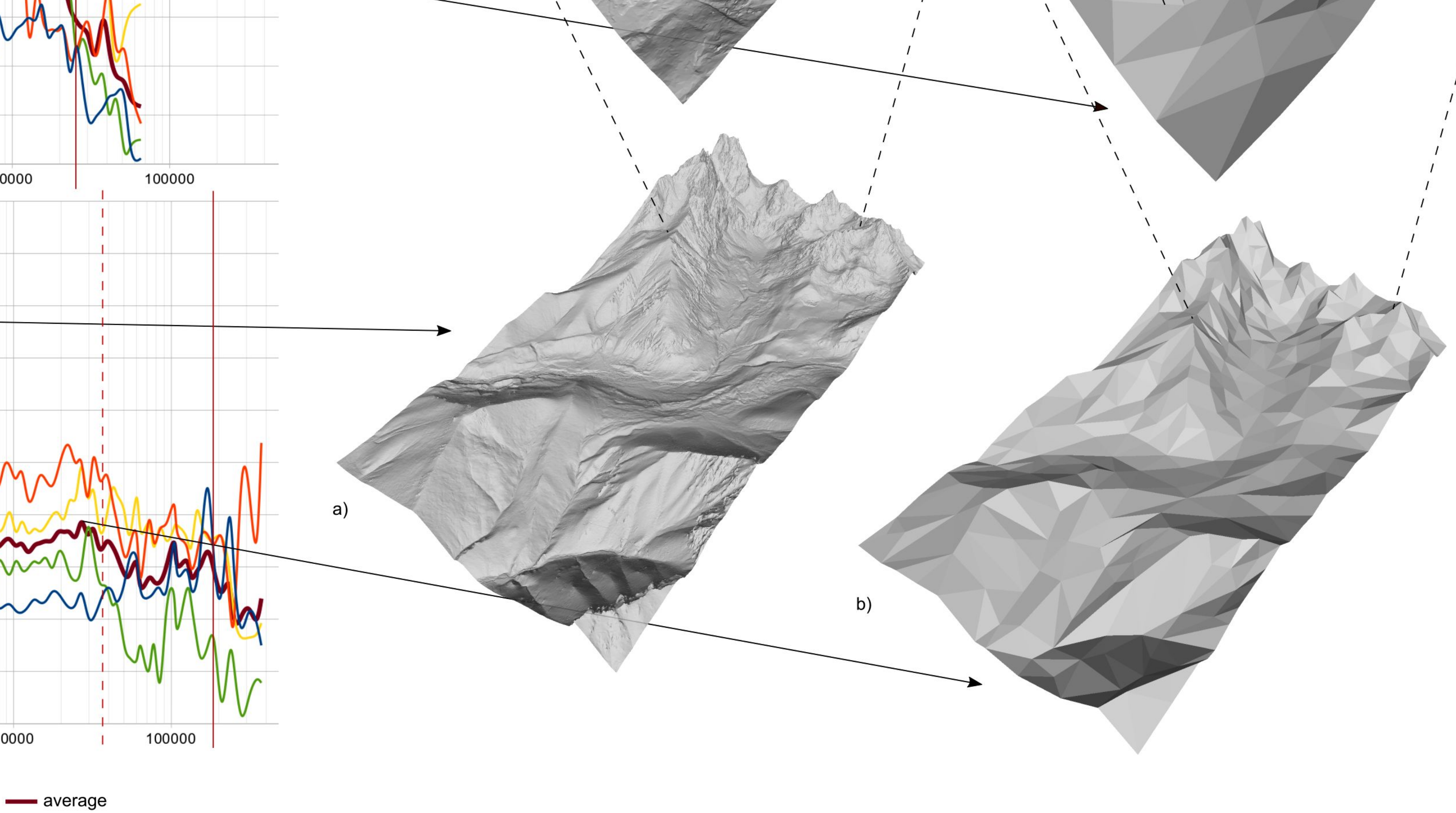


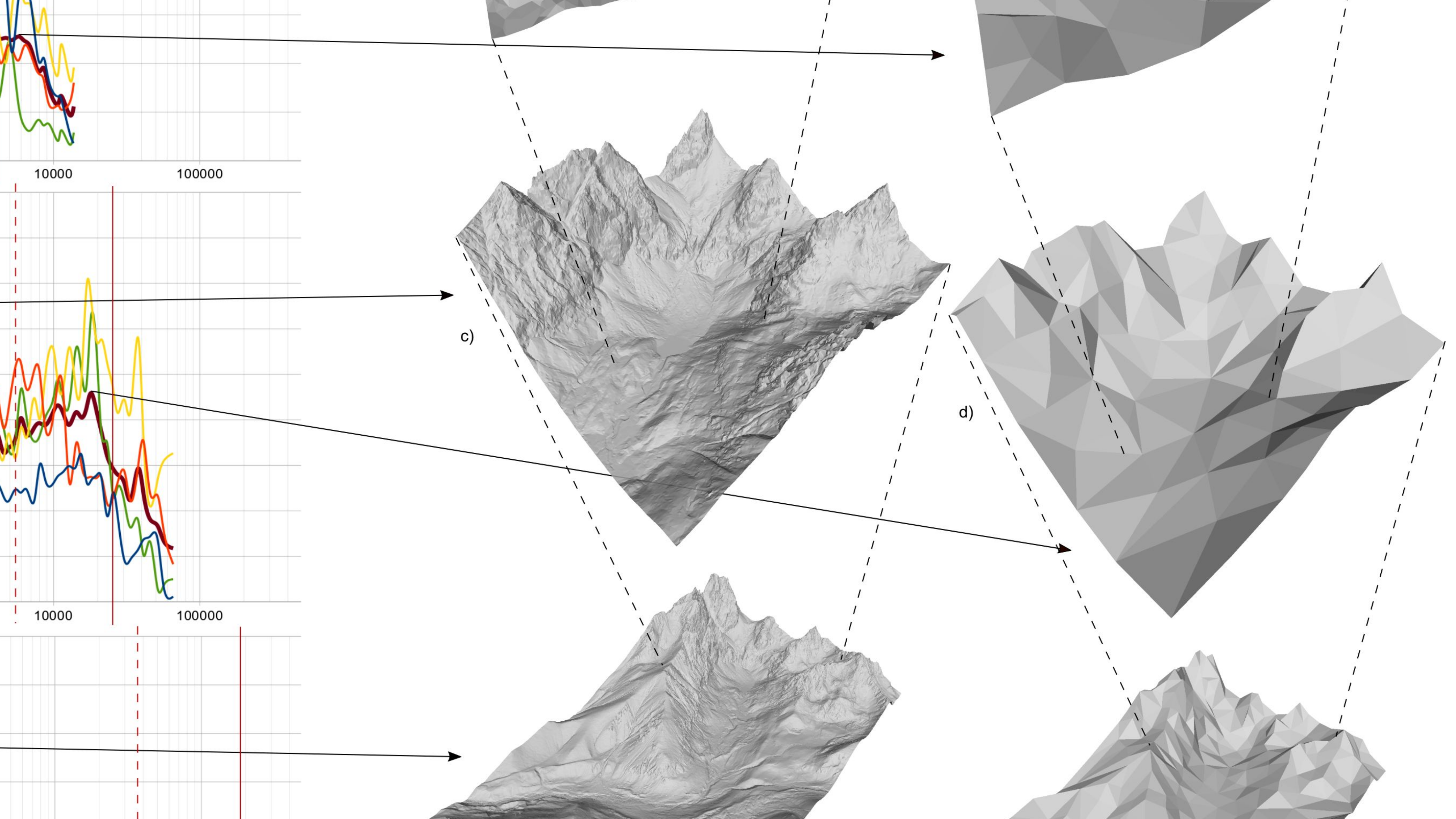

a)
b)
c)
d)
1000
10000

K_0 curves



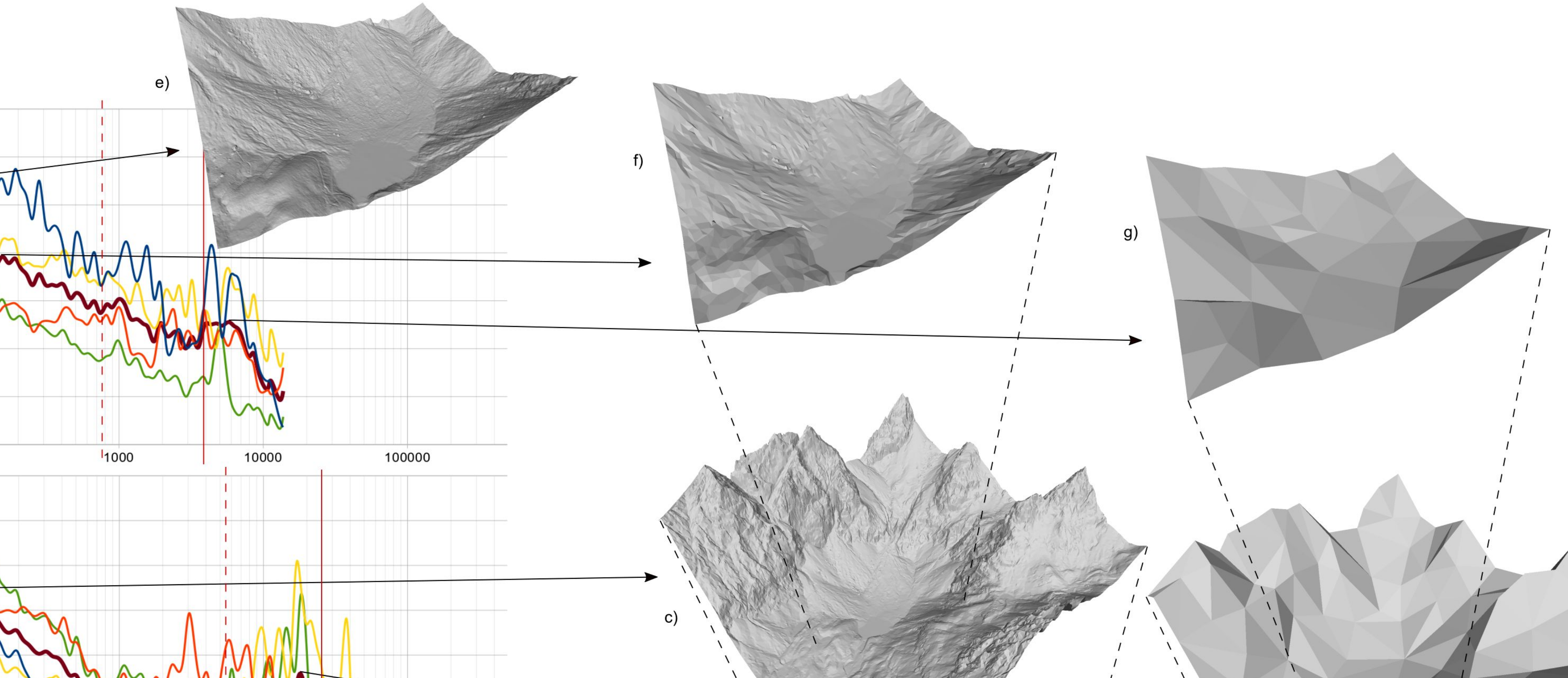
e)
f)
g)
c)
d)
a)
b)
K_0
average triangle area [m^2]
$(k_n)_{ss}$
$(k_n)_{cc}$
$(k_n)_{sc}$
$(k_n)_{cs}$
average


0000
100000
0000
100000
a)
b)
average

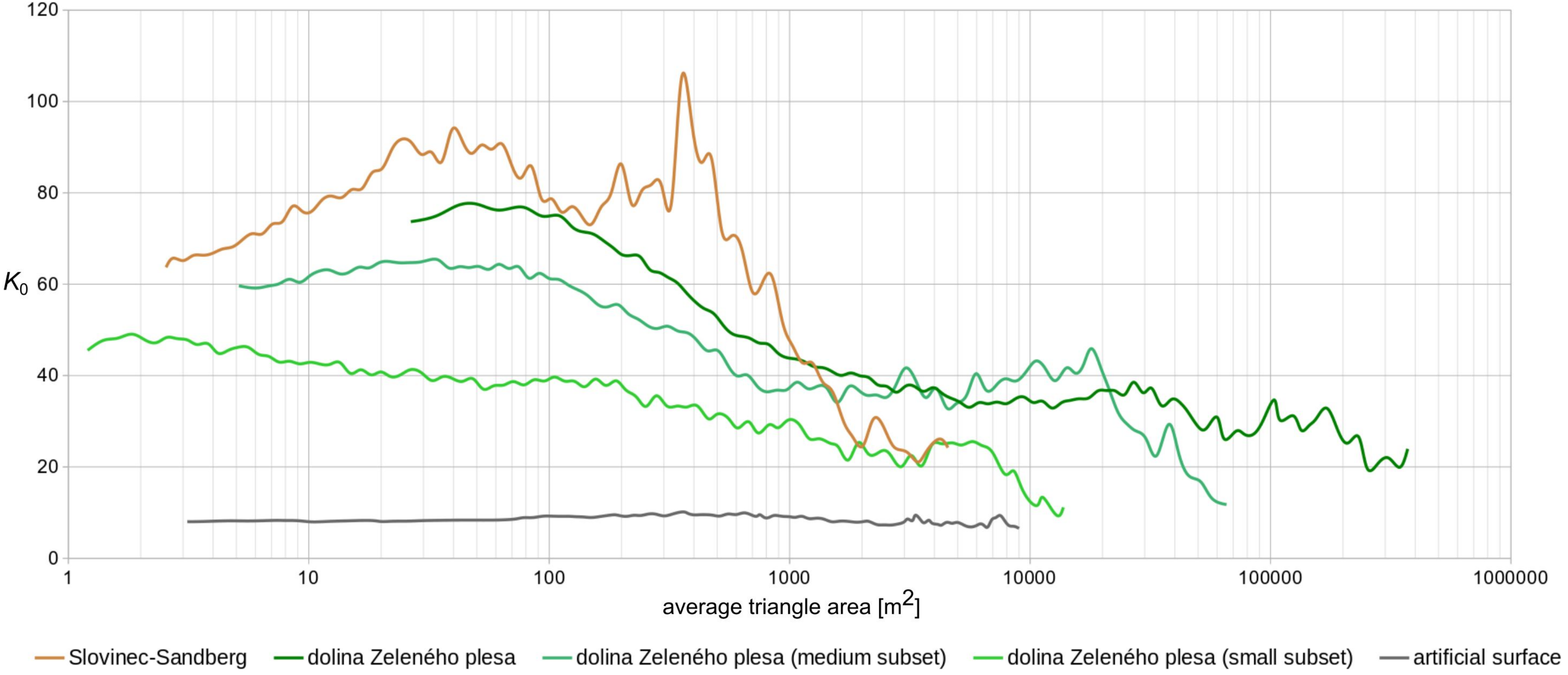


10000
100000
10000
100000
c)
d)

K_0 curves (Dolina Zeleného plesa valley)



K_0 comparison



Conclusions

- QEMS algorithm is well suited for land surface segmentation
  - Preserves important topographic features efficiently
- Local maximum of K_0 depict well the leading landforms in nested hierarchy
- The experiment of comparing K_0 values
  - Significant differences between natural and artificial surfaces
  - Can easily be interpreted in terms of the theory of elementary forms

Thank you

richard.feciskanin@uniba.sk

jozef.minar@uniba.sk