EUFAR - EUropean Facility for Airborne Research

Education & Training

Hands-on practice: Digital Surface and Terrain Models

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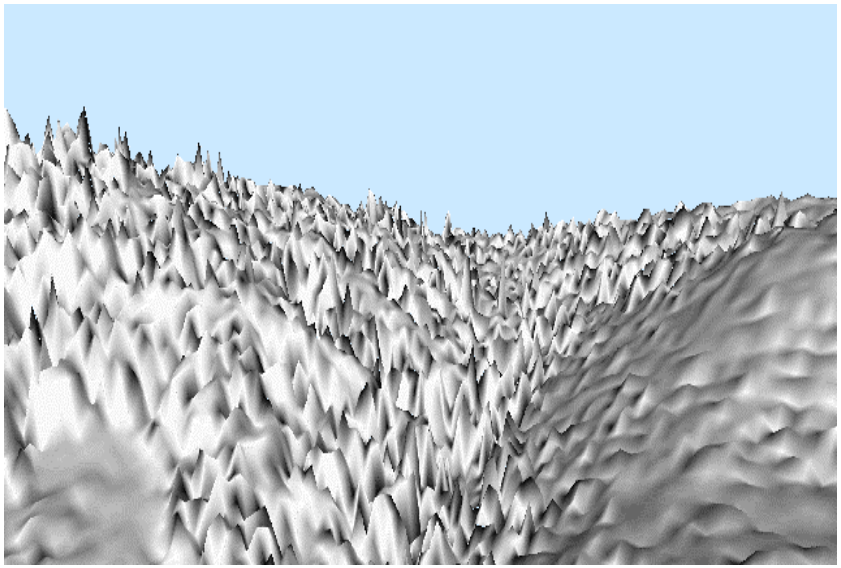
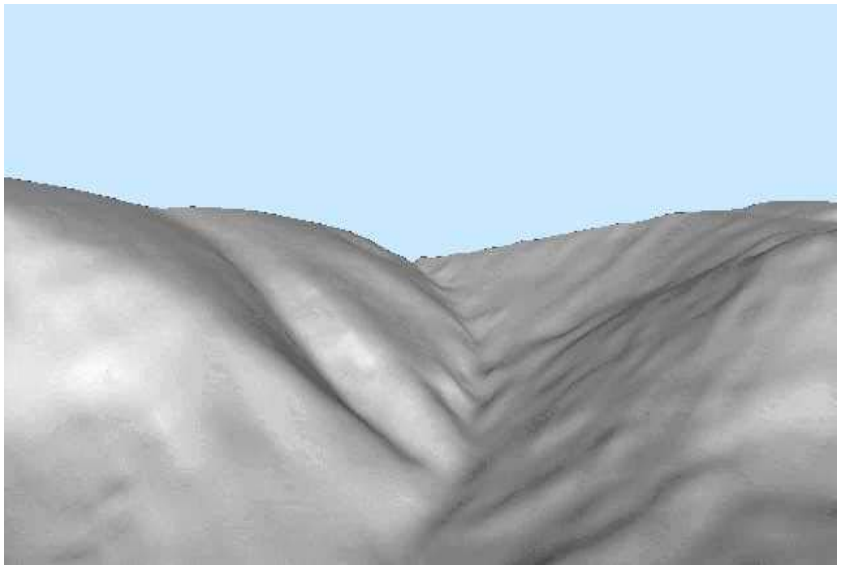
ADDRESSS training course, 19-28 August 2010, Balaton Limnological Research Institute , Hungary

Digital Surface and Terrain Models



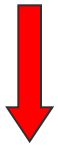
DSM



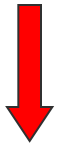
DTM

DTM derivation using ALS point clouds

- **ALS point cloud** (combiend from all ALS flight strips)

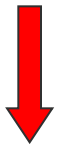


- **Selection of the Last Echo points**



- **Filtering / Classification**

  (Seperation of terrain and off-terrain points; e.g. using robust filtering)



- **Computation of the DTM using all points classified as „terrain“**

DTM Filter Algorithms

Different Methods (Selection):

- Slope based morphological Filter (Vosselmann, TU Delft)
- Progressive TIN-Densification (Axelsson, TerraScan)
- Hierarchic Robust Interpolation (Kraus/Pfeifer/Briese, SCOP++)

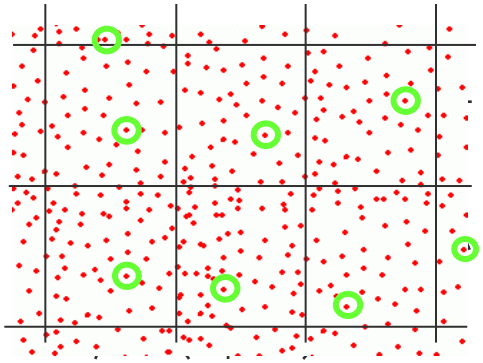
•Morphological Filter:

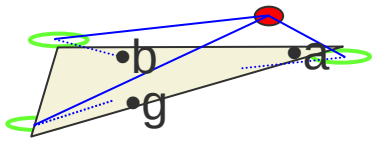
•Height difference between terrain points

•P_0 is a terrain point, if: Z_0-Z_i < $f(\ d_h(P_0,P_i)\ )$

•for all P_i in a certain neighbourhood of P_0

- **Progressive TIN-Densification**
- Classification by mesh refinement
- Triangulation of "confident" terrain points
- Test: Points vs. TIN
- If accepted: insertion of further points into the TIN





Hierarchic Robust Interpolation

- Interpolation
  - Surface *f* (x,y) through the Points
  - Filtering of random measurement errors
- Robust
  - Residuals (Surface vs. Point)
  - Weight functions for the points:
    Points above/below the surface get a low/high weight
- Hierarchic
  - From rough to fine (e.g. 5m → 3m → 1m)
  - Data pyramids

I.P.F., TU Vienna, SCOP++, http://www.ipf.tuwien.ac.at/eurosdr/index.htm

Robust Filtering I

Measurements are affected by random errors, whose influence on the DTM should be minimized.

Filtering using Least-Squares-Interpolation (aka **Kriging)**

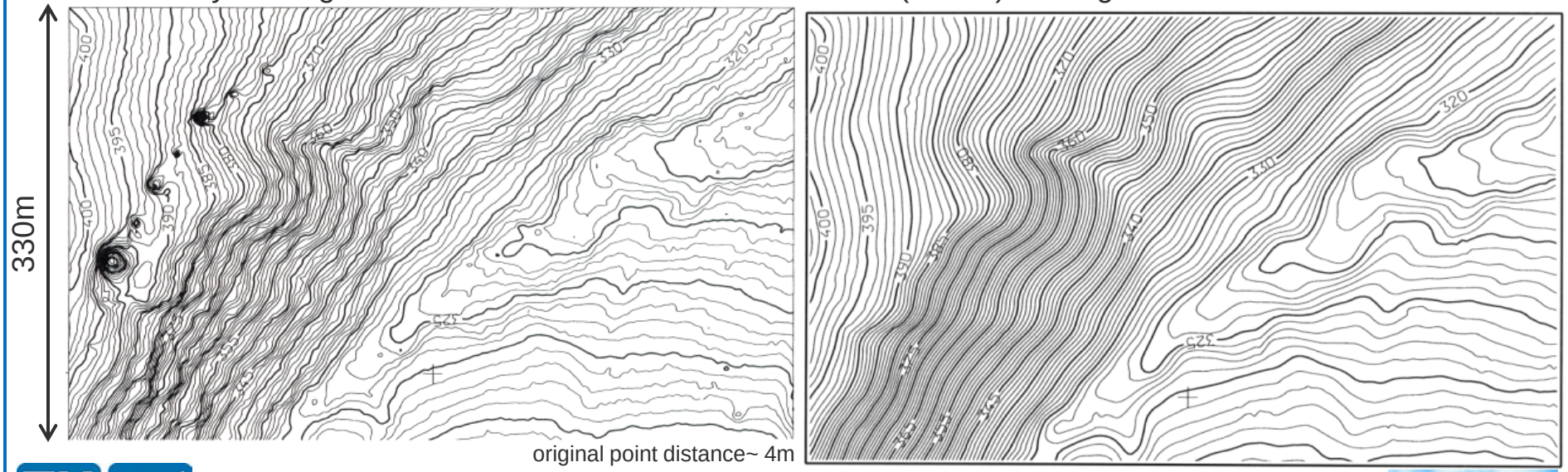
→ Minimization of the **random** errors

→ Terrain models with realistic geomorphology

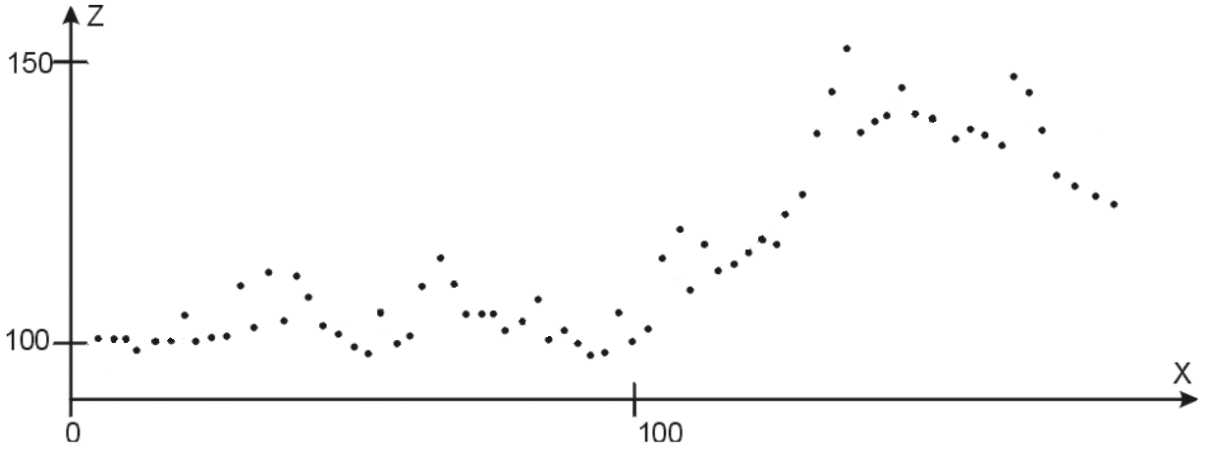
robust Filtering → elimination of gross (and partly also systematic) **errors**

Without any filtering

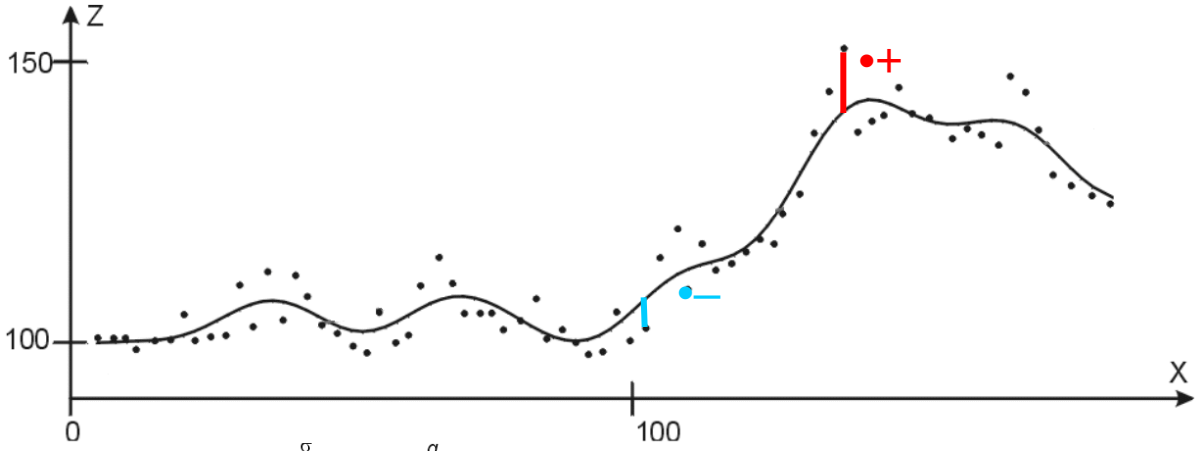
With (robust) filtering



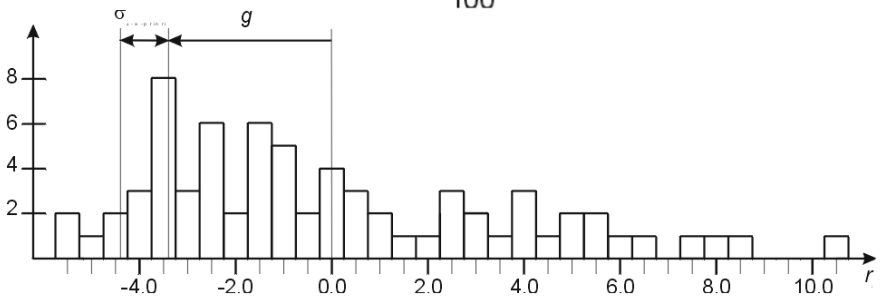
Robust Filtering II



Robust Filtering II



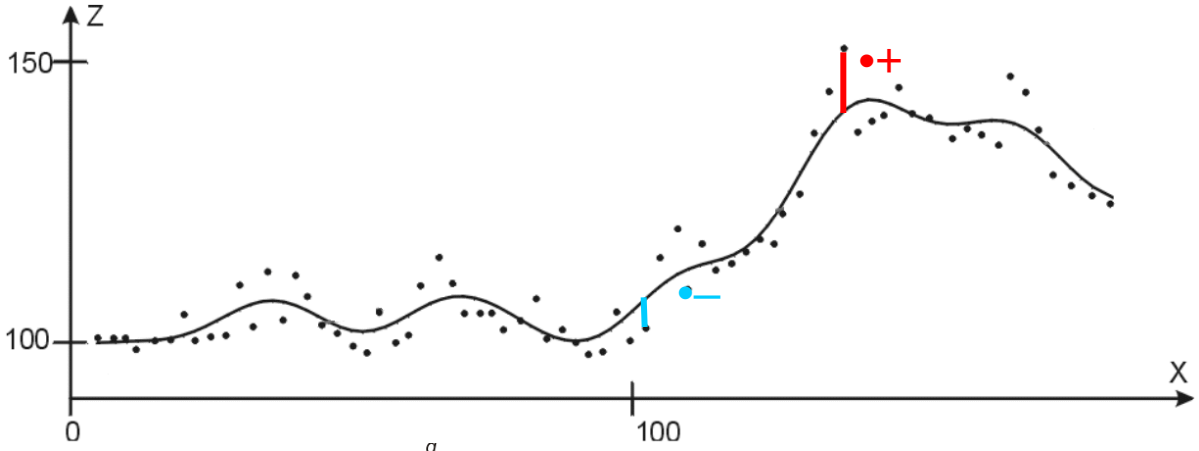
All points gets the same weight 1



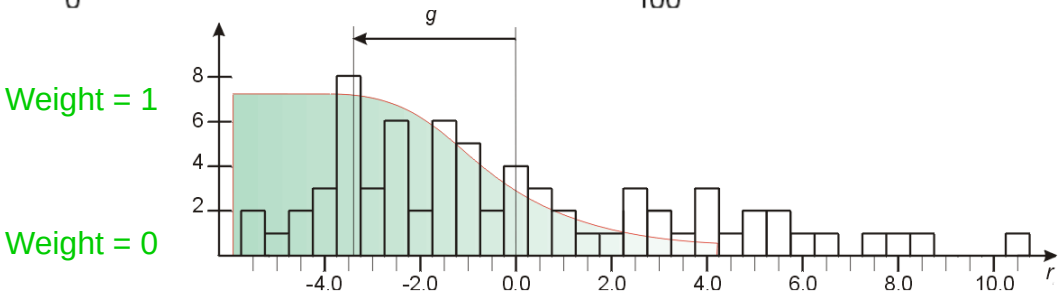
Histogram of the residuals

→ Choice of the weighting function

Robust Filtering II



All points gets the same weight 1

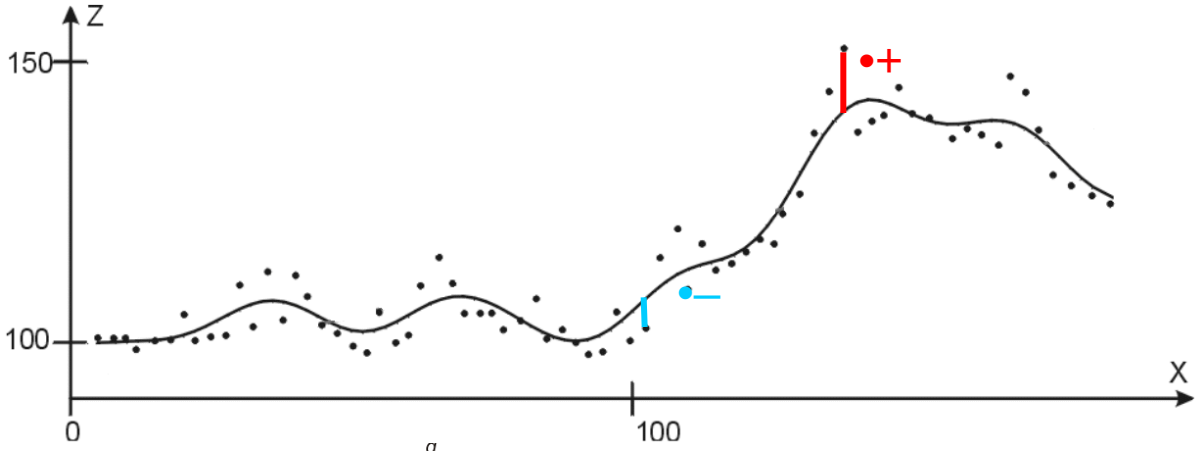


Histogram of the residuals

→Choice of the weighting function

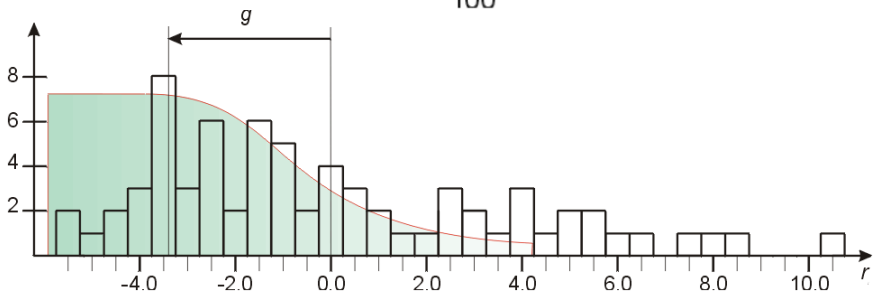
Emphasizing the lower points

Robust Filtering II

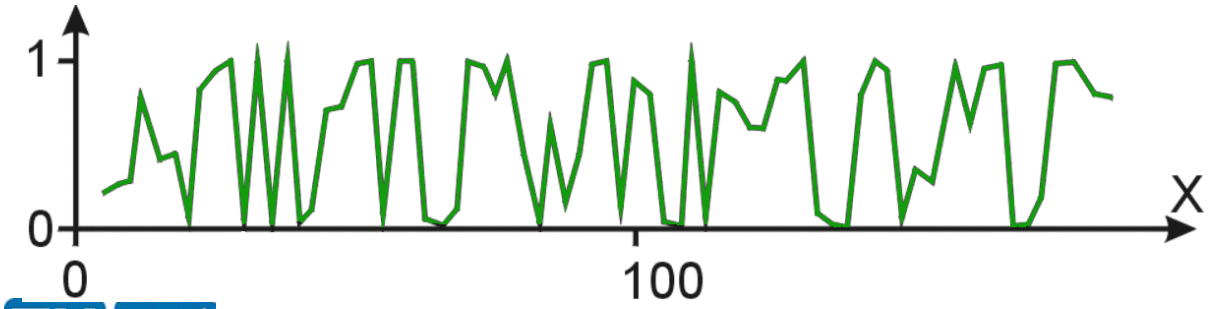


Weight = 1

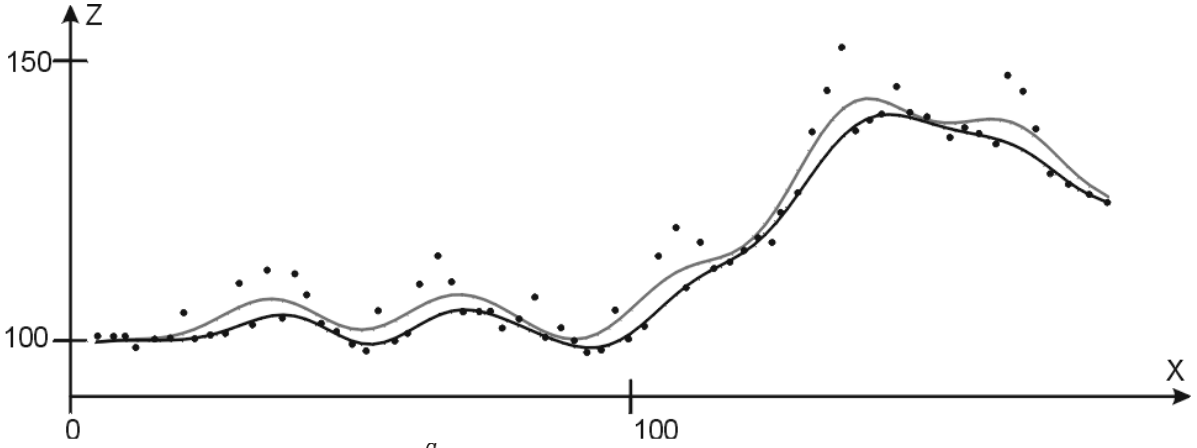
Weight = 0

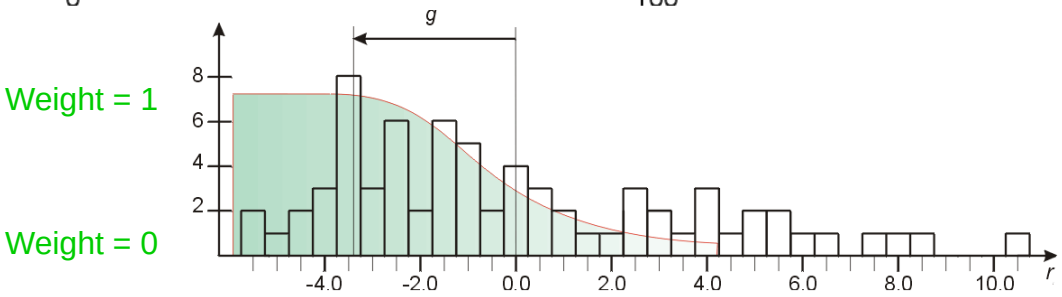


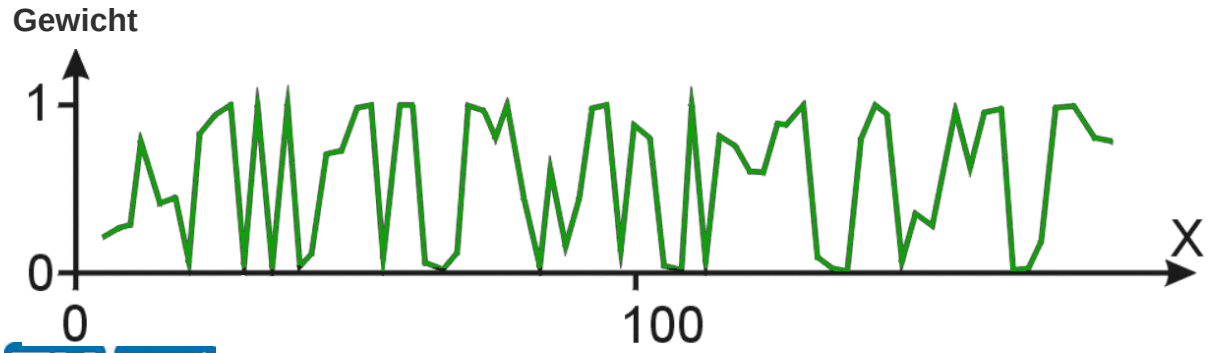
Weight



Robust Filtering II

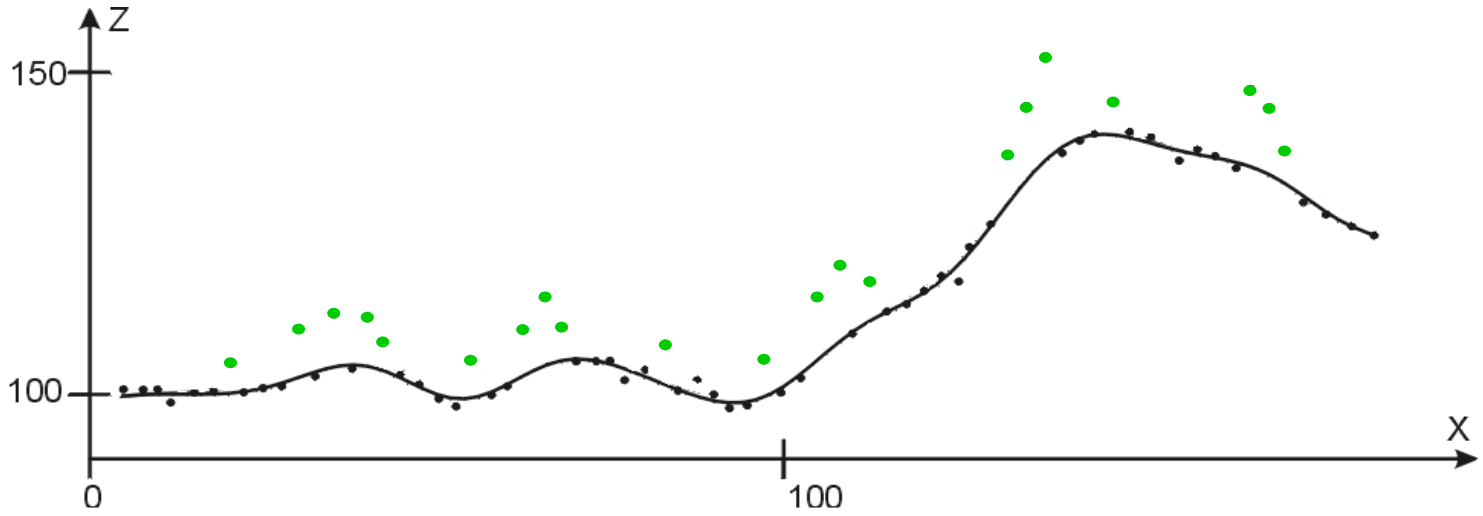






Every point acts with its own individual weight.

Robust Filtering II



Side result of the filtering: **Classification** of the points on the **terrain** and **Off-terrain** (vegetation, buildings, etc.)

BRIESE C., PFEIFER N., DORNINGER P. Applications of the Robust Interpolation for DTM determination. Symposium der ISPRS-Comm. III, Graz, 9 - 13 September 2002. Volume XXXIV / 3A, pp. 55 - 61.

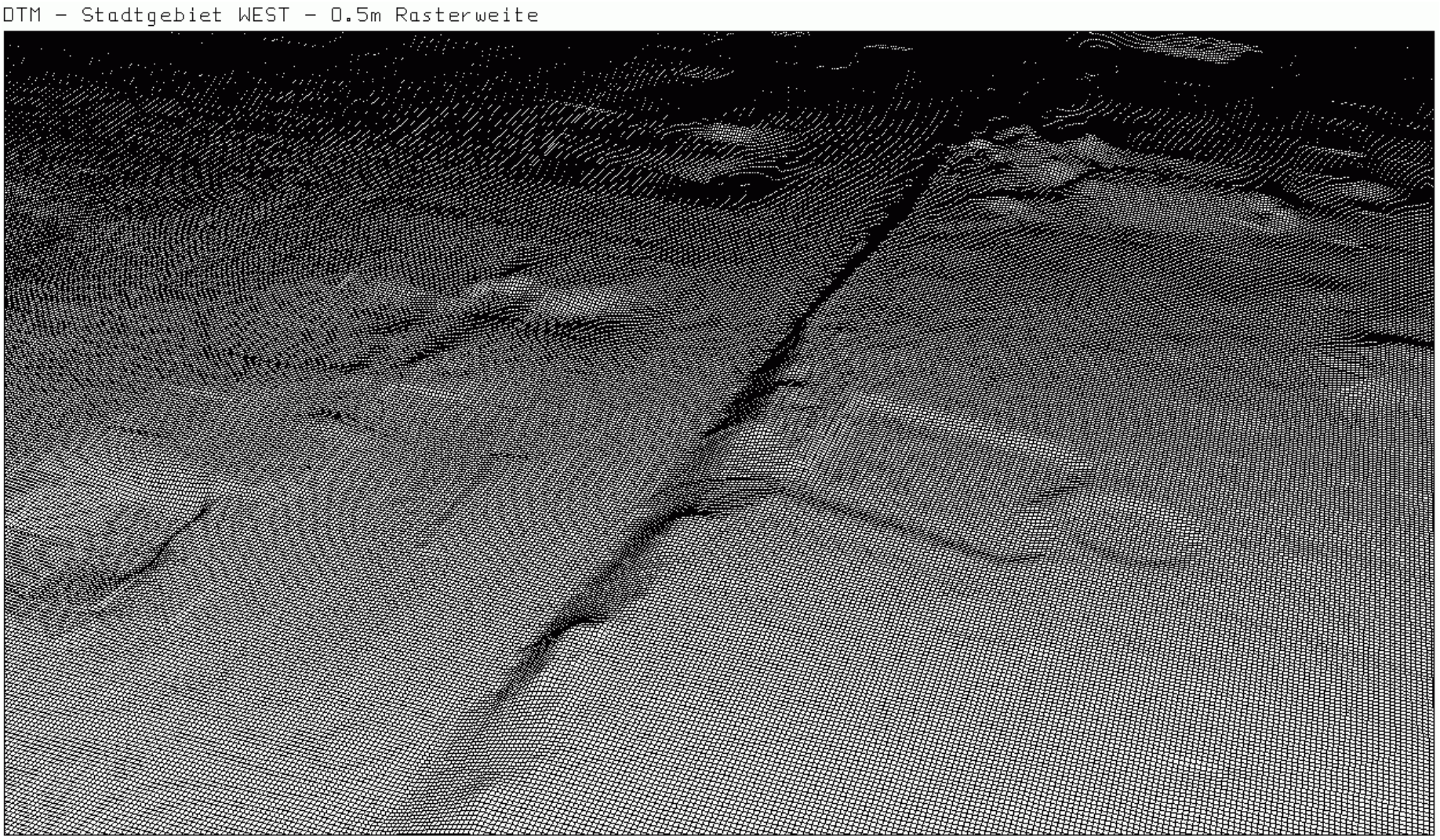
BRIESE C., PFEIFER N., STADLER P., Derivation of Digital Terrain Models in the SCOP++ Environment. Proceedings of OEEPE Workshop on Airborne Laserscanning and Interferometric SAR for Detailed Digital Terrain Models, Stockholm, Sweden, 2001.

KRAUS K., PFEIFER N., Determination of terrain models in wooded areas with airborne laser scanner data. ISPRS Journal, 53, 1998, 193-203

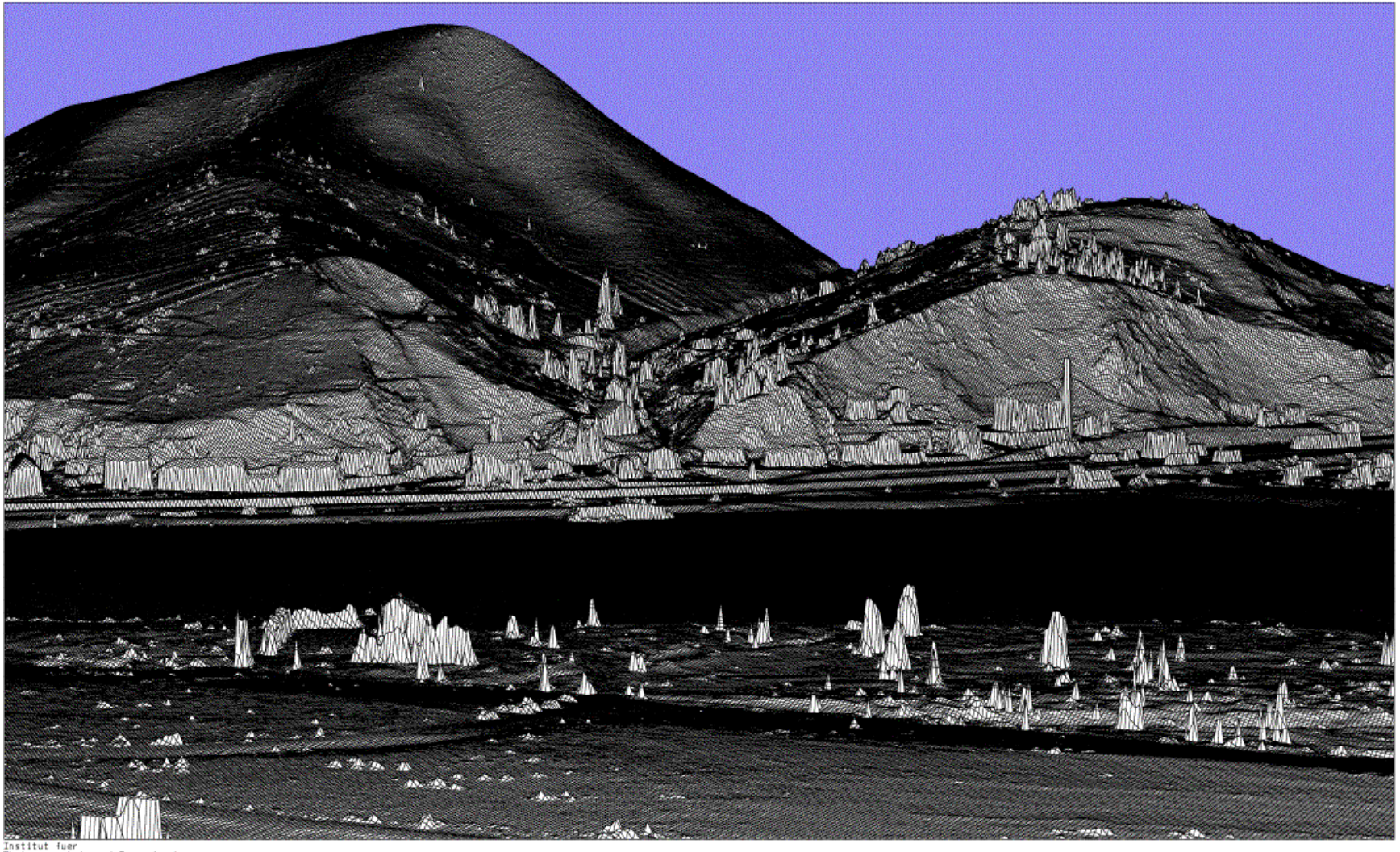
Weitere Informationen (EuroSDR Distance Learning Course): www.ipf.tuwien.ac.at/eurosdr/index.htm

George Sithole, George Vosselman
ISPRS TEST ON EXTRACTING DEMs FROM POINT CLOUDS: A comparison of existing automatic filters
http://www.itc.nl/isprswgiii-3/filtertest/

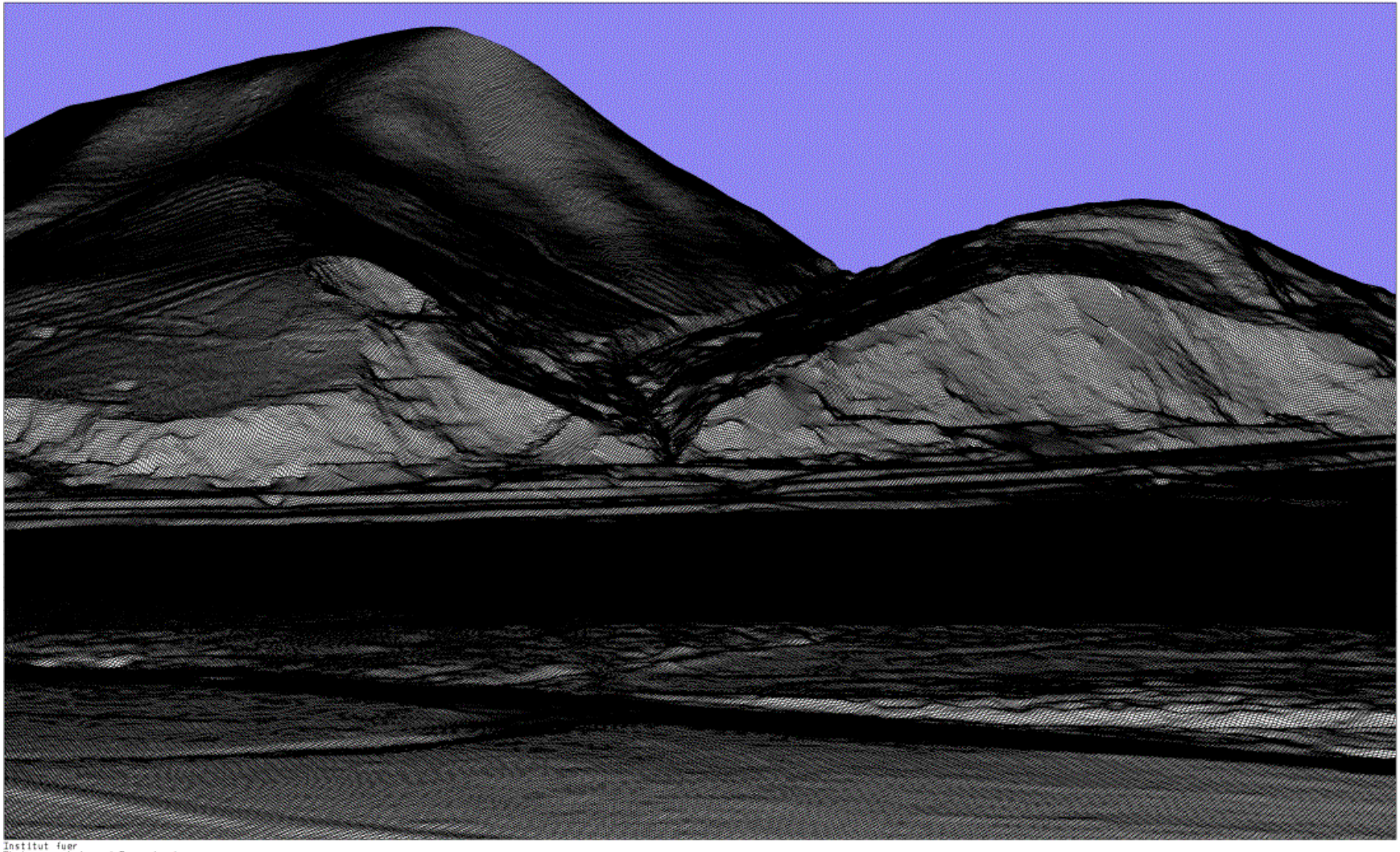
Hierarchic Robust Interpolation



From DSM to DTM – example 1

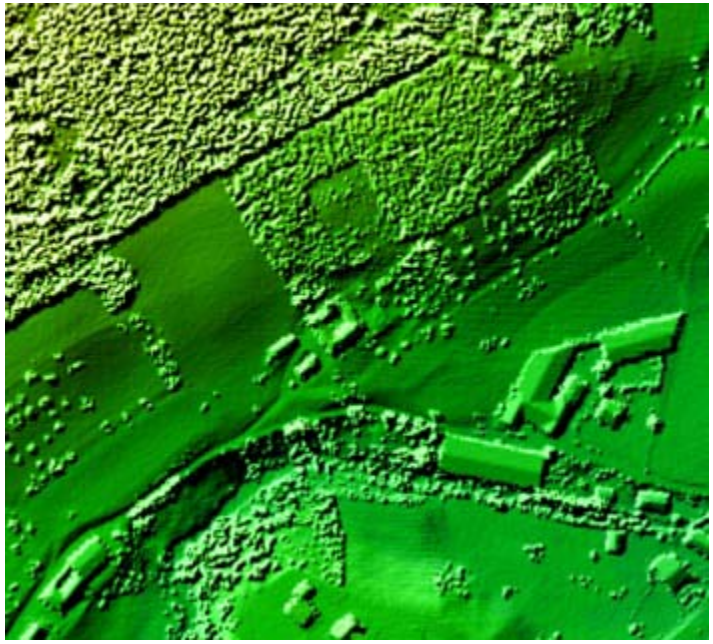


From DSM to DTM – example 1

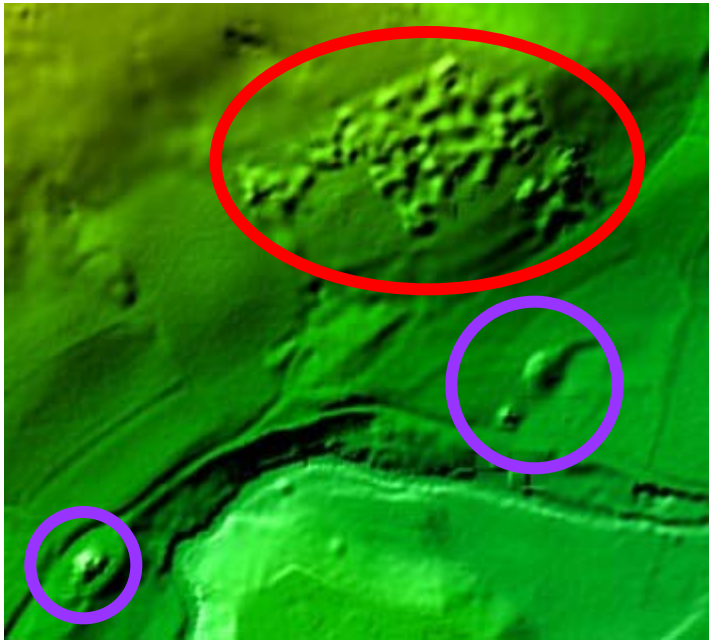


DTM: potential improvement

DSM



DTM

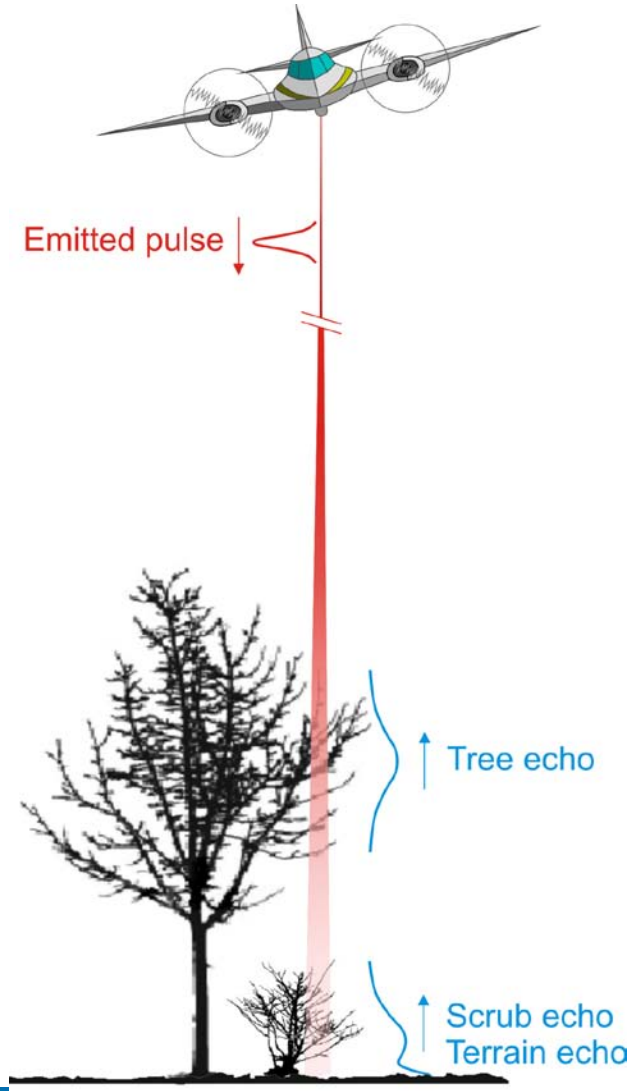


At **low vegetation** and at **(large) buildings** the DTM derived by robust filtering can be wrong.

→ **Possible automatic solution:**

Full-Wave-Form laser data (number of echos, echo width)

Improved DTM Generation based on Full-Waveform (FWF) Attributes per Echo



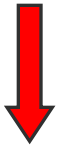
Echo Attributes:

- Distance R_i
- Amplitude A_i
- Echo width EW_i
- Cross section σ_i

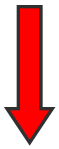
Improved DTM Determination by FWF-ALS Attributes

- **ALS Point Cloud** (points from all strips)

- **Selection of the Last Echo Points**



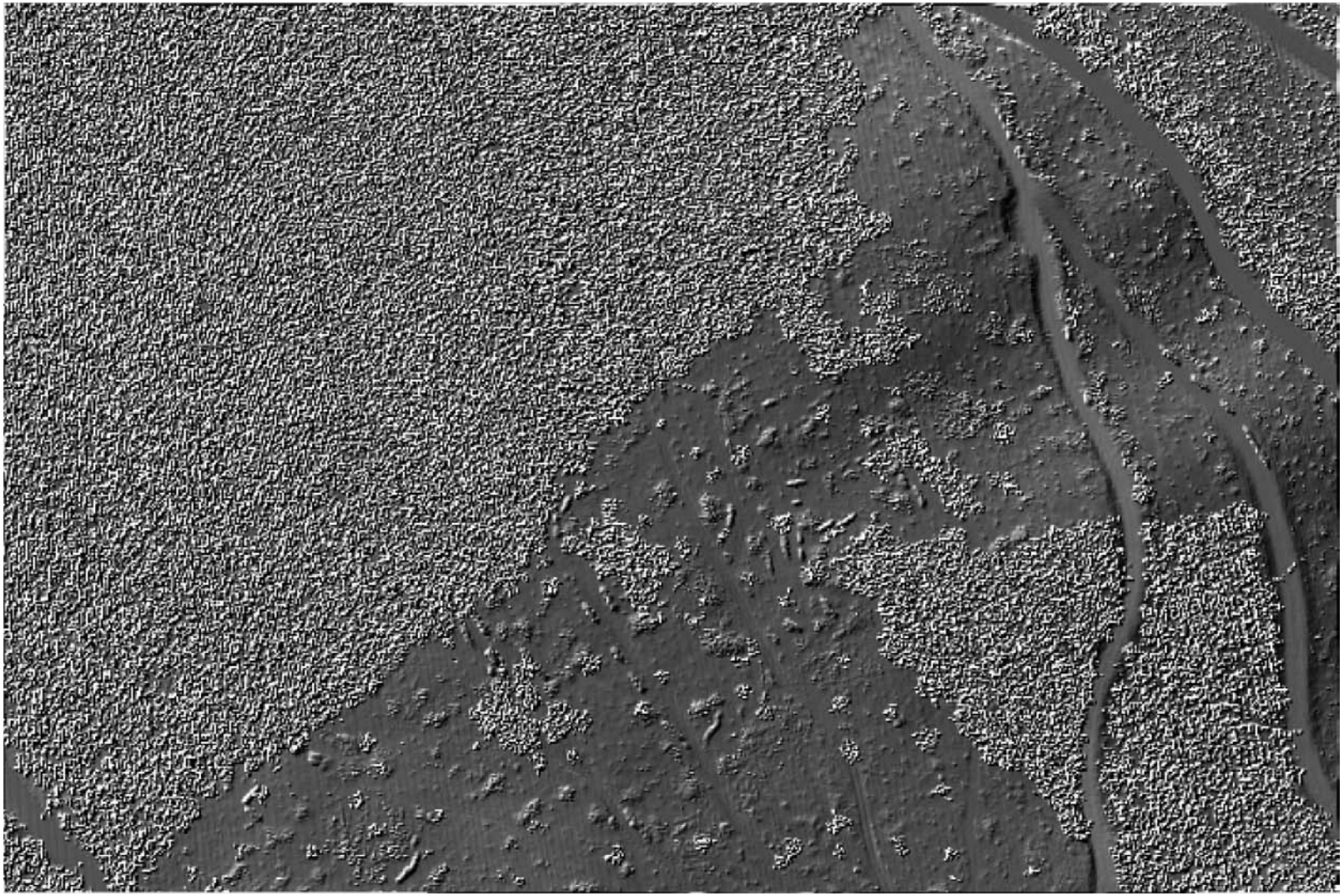
- **Pre-Filtering / Pre-Classification based on the FWF Attributes**
  (Elimination of potential vegetation echoes)



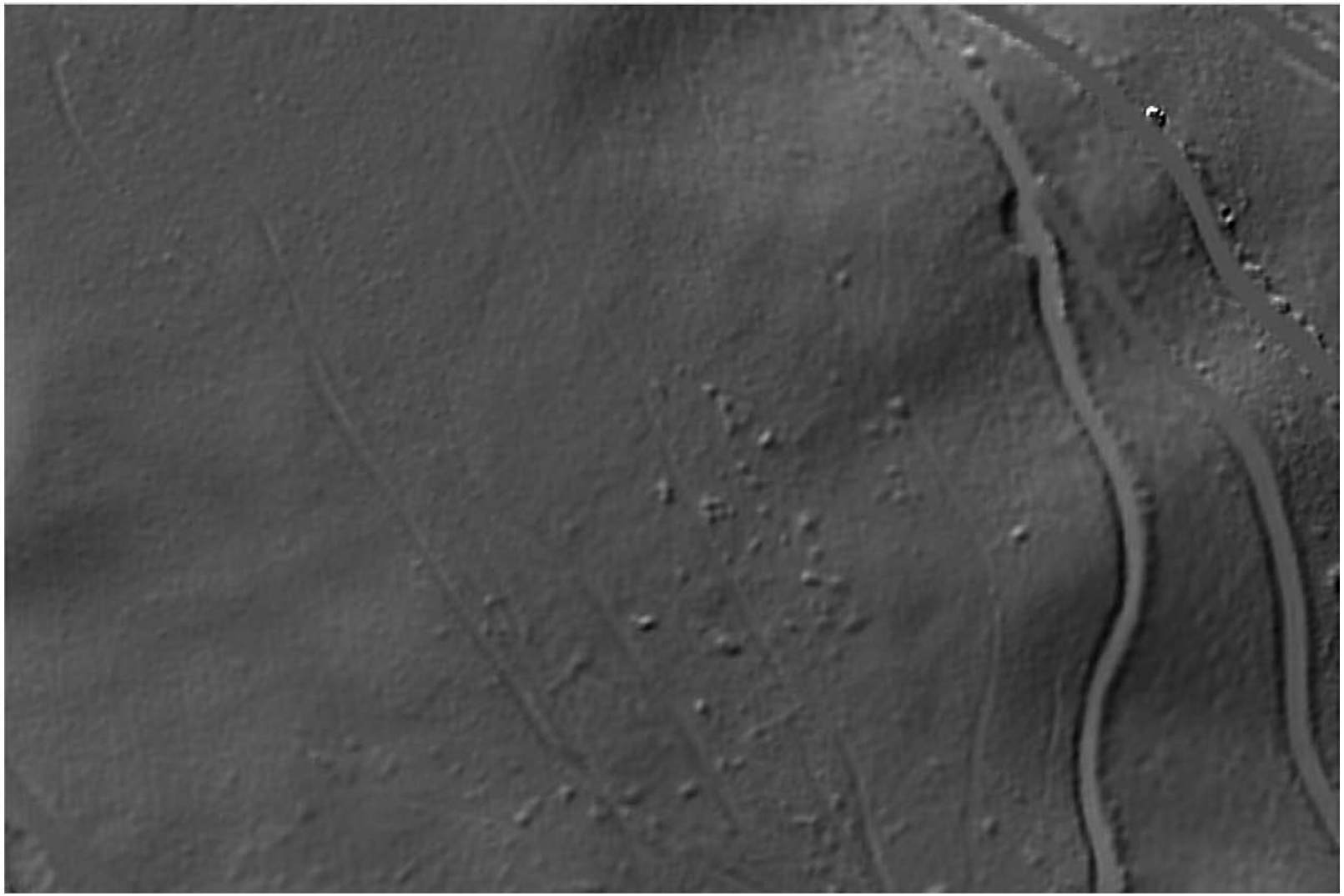
- **Filtering / Classification**
  (Separation of Terrain and Off-Terrain Points)

- **Determination of the DTM based on the classified terrain points**

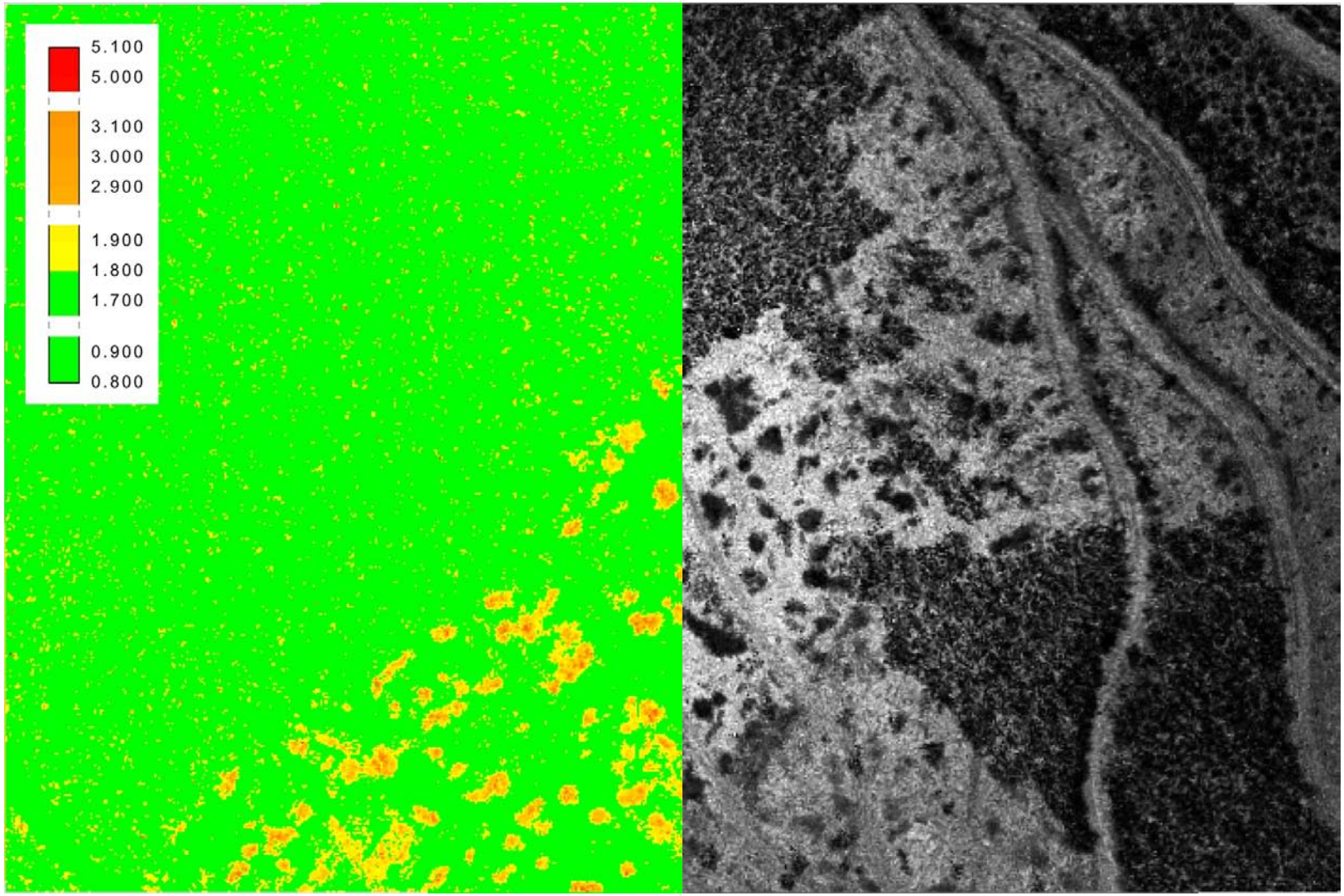
ALS Leithagebirge – DSM (first echo)



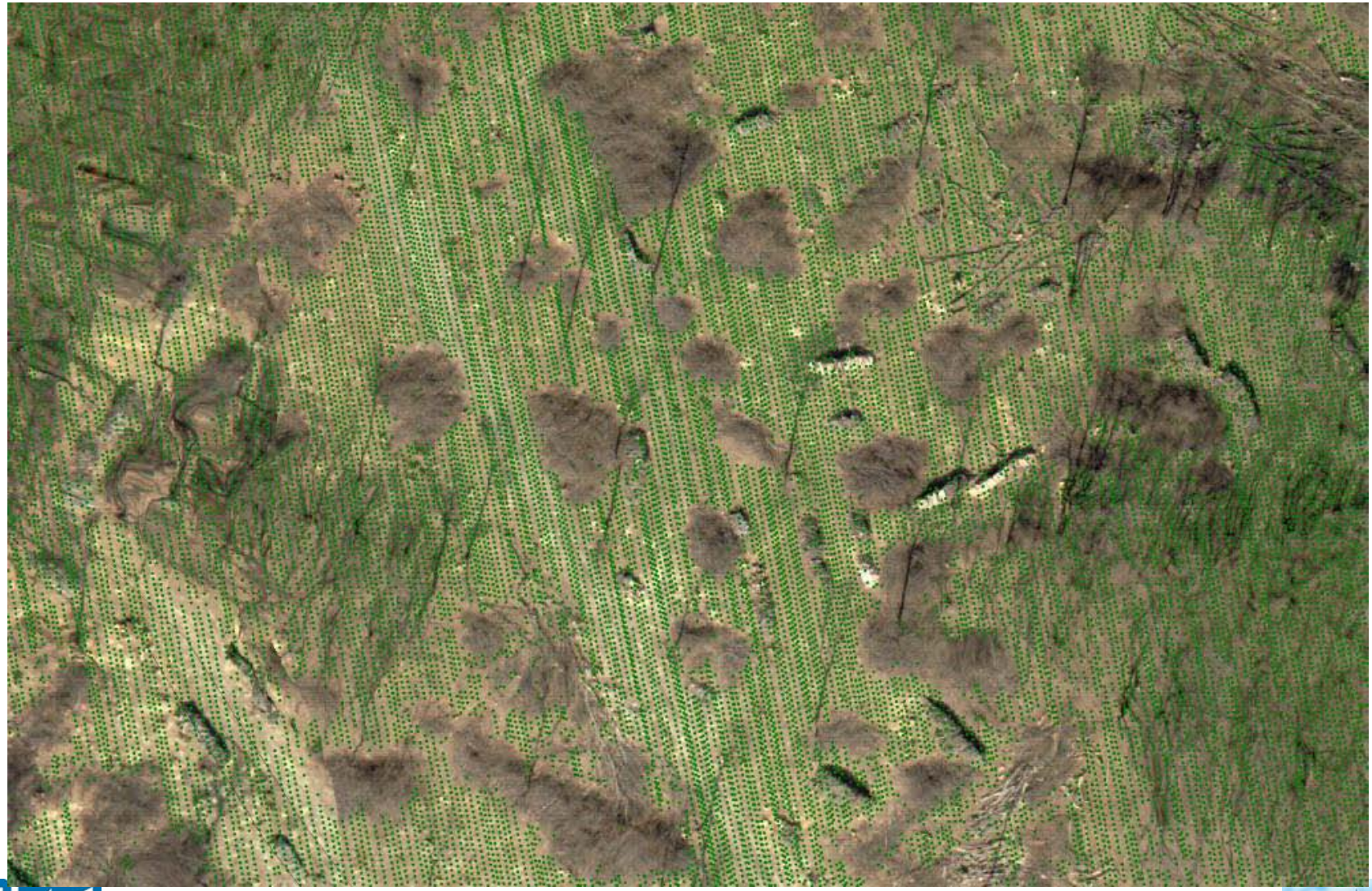
ALS Leithagebirge – DTM (last echo - SCOP++)



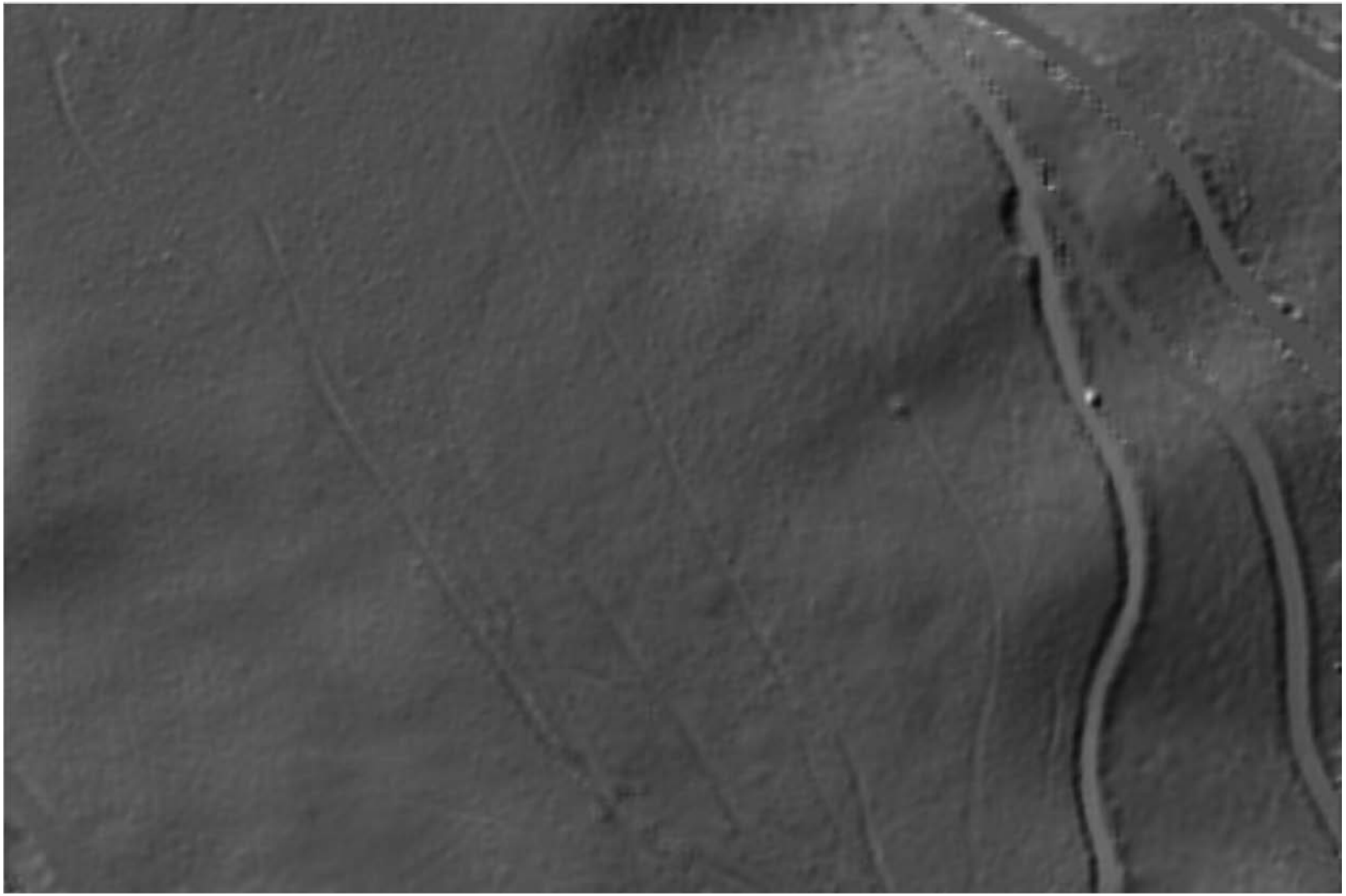
ALS Leithagebirge – Echo width and Amplitude



ALS Leithagebirge – Result of the Pre-Classification



Improved DTM Determination based on a pre-classification step utilising the Echo width information



Summary: Improved DTM determination with FWF ALS

- **Additional Information available by FWF ALS data**

  Per echo: distance, amplitude, echo width, cross-section

- **Interesting results in order to detect last echoes reflected by low vegetation**

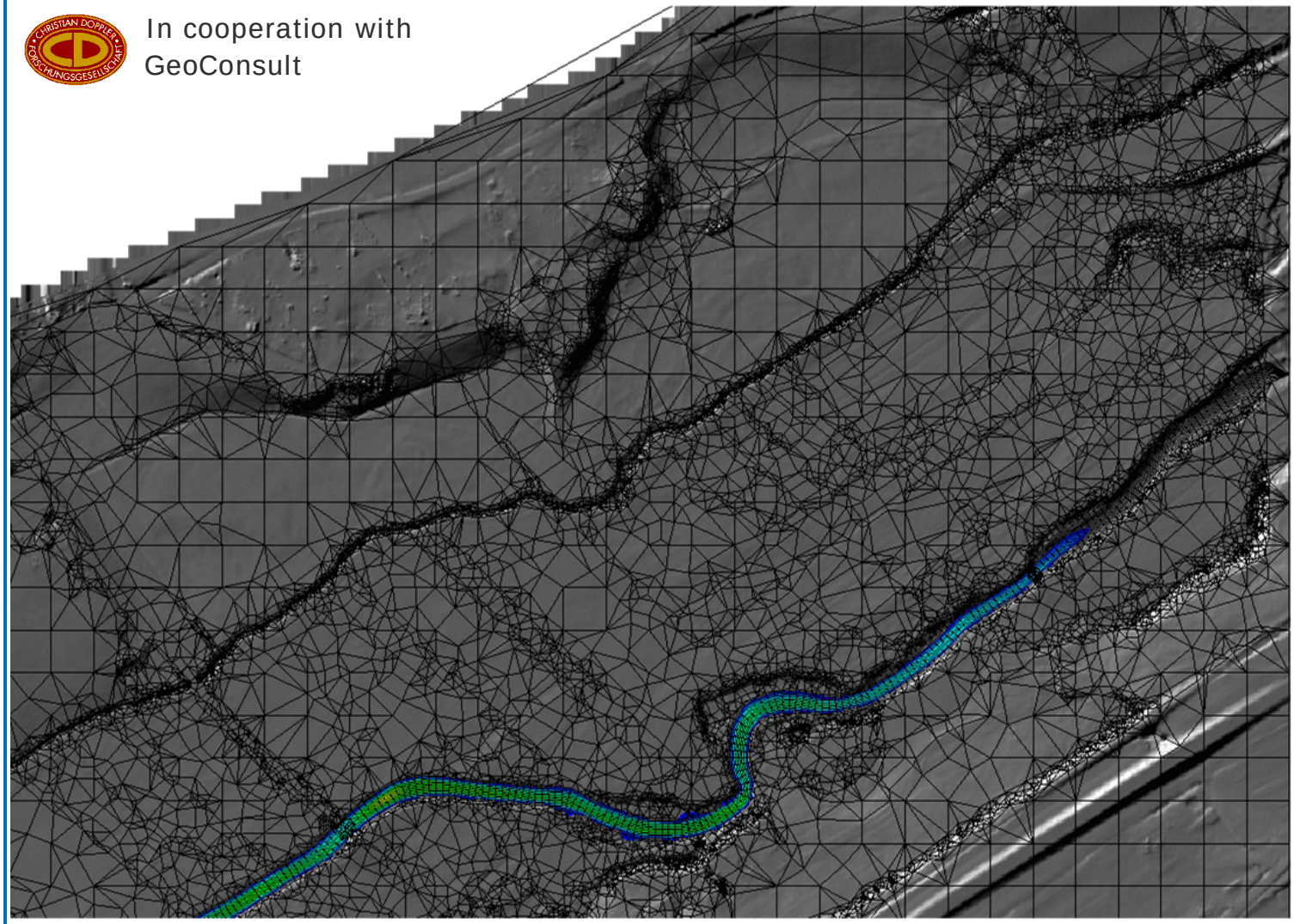
- **Further studies are still necessary:**
  - Analysis of the influence of the footprint size, the incidence angle, …
  - Analysis of the accuracy and reliability of the FWF attributes (distance, echo width, amplitude, …)
  - Comparison of different sensors

- **Extension of the Filtering and Classification Methods**
  - additionally to the typically purely geometric criteria – additional FWF echo attributes are available and should be integrated into the classification process
  - however, a large area based detailed analysis of the advantages of the FWF attributes is necessary in the future

DTM: Flood risk modelling

Simulations of flood risks:

In cooperation with
GeoConsult



DTM: The need for data reduction

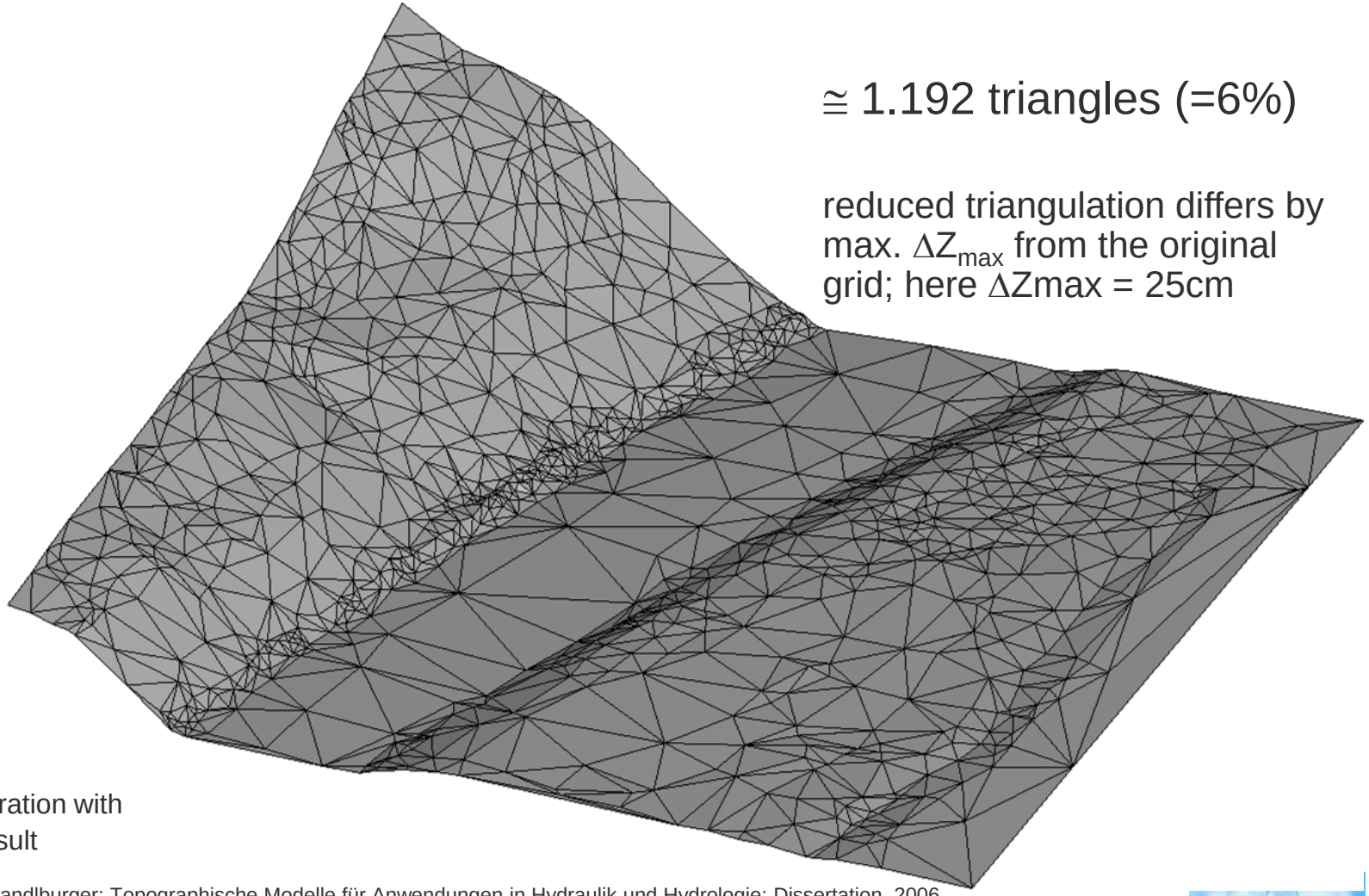
original grid points, triangulated

≅ 32.768 triangles

In cooperation with
GeoConsult

DTM: The need for data reduction

reduced grid points, triangulated



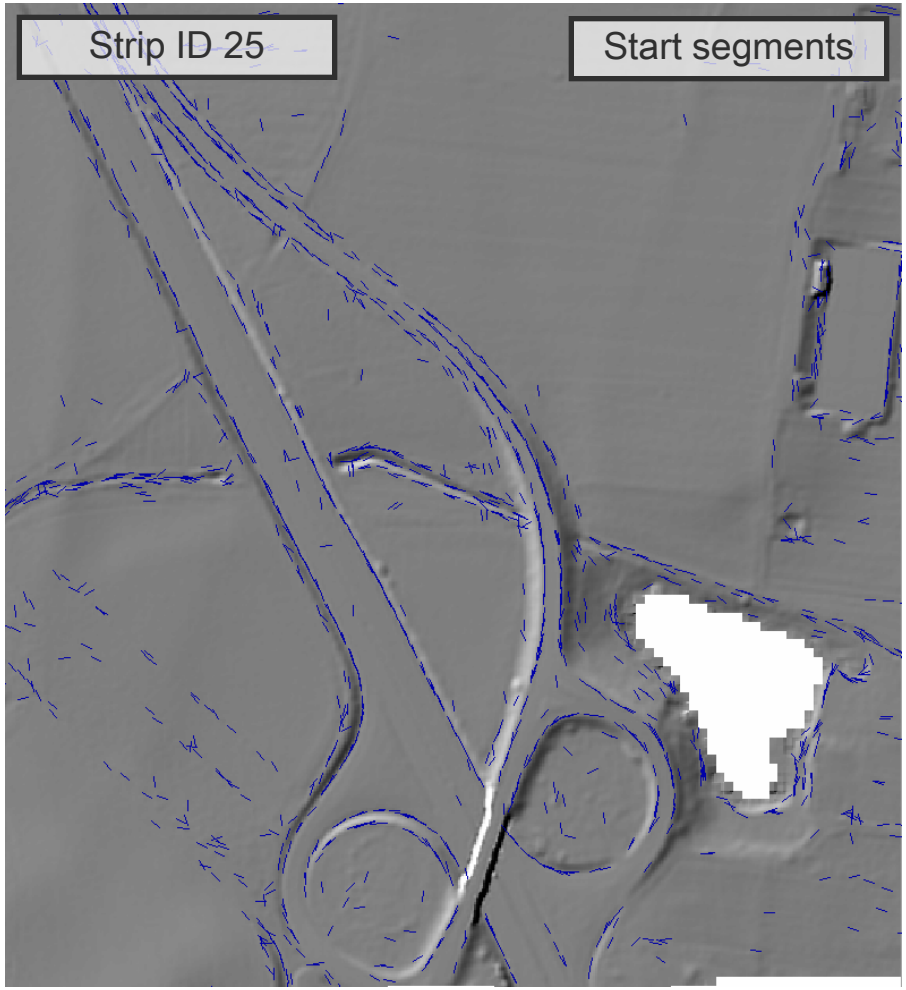
≅ 1.192 triangles (=6%)

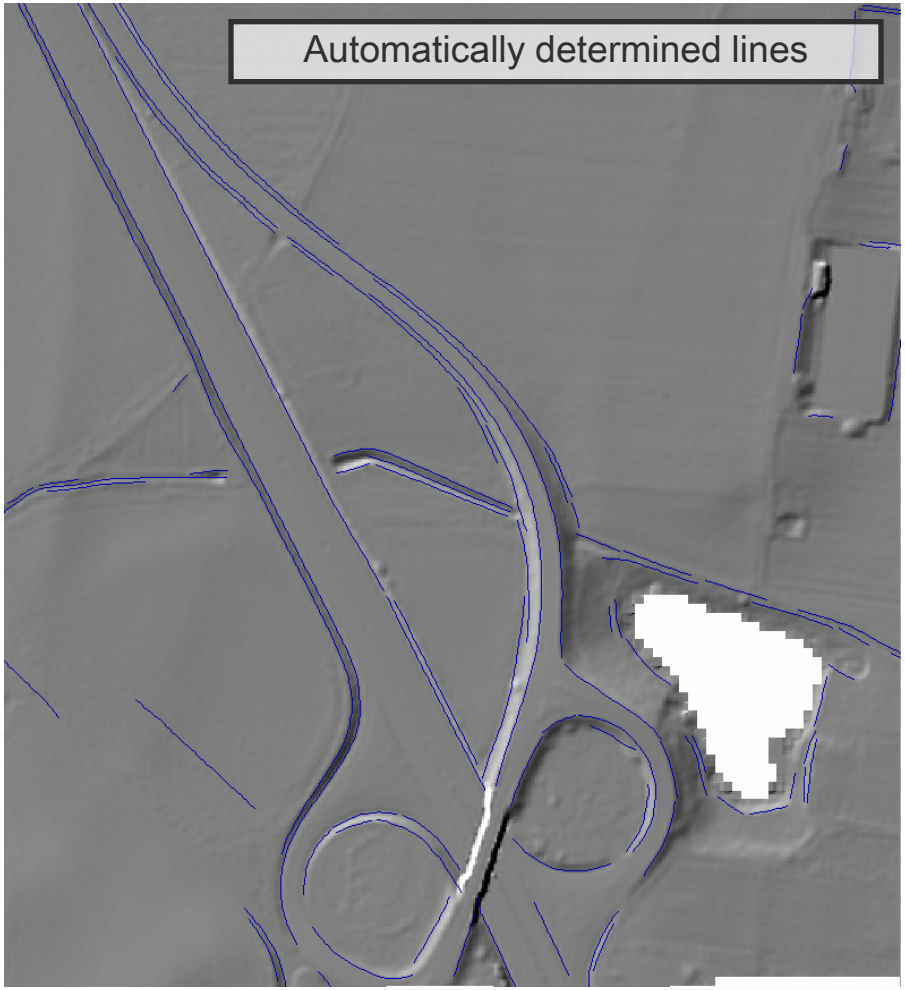
reduced triangulation differs by max. ΔZ_{max} from the original grid; here ΔZmax = 25cm

In cooperation with
GeoConsult

G. Mandlburger: Topographische Modelle für Anwendungen in Hydraulik und Hydrologie; Dissertation, 2006.

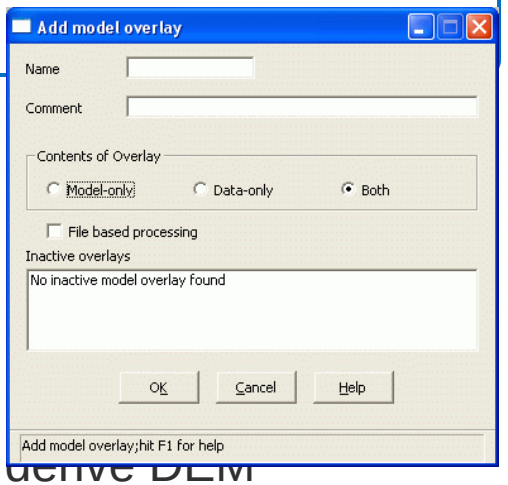
Automatic estimation of Structure Lines



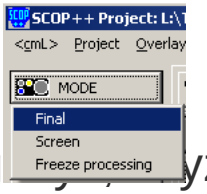


I.P.F.-software STREX

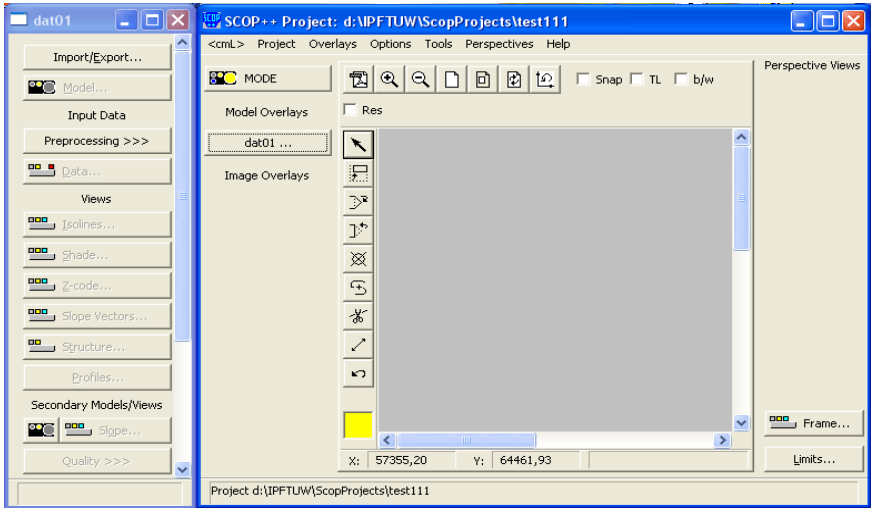
SCOP++: First steps



- Start SCOP++ using the icon
- Create a new project: Project → New
- First: Select MODE FINAL
- Add model overlay



  - both: input are „original data“ (e.g. [illegible]yz) → derive DEM
  - model only: input is a DEM → create visualizations (e.g. shading, zcoding, ...) and analysis (e.g. difference modells) can be determined.
- Import data
- Analysis
  - shading
  - z-code
  - difference model
  - …



Hands-on-practice - documents

- "CB_DxM_ADDRESSS.pdf" – ppt presentation
- "SCOP++ brief instruction.pdf" – short SCOP++ introduction
- "SCOP++_ALS_DSM_DTM.pdf" – SCOP++ - DSM and DTM generation
- "Tasks_Hands-on practice_ALS_DSM_DTM.pdf" – Tasks
- "Data_usage_restrictions.pdf" and "readme.txt" – Data usage restrictions