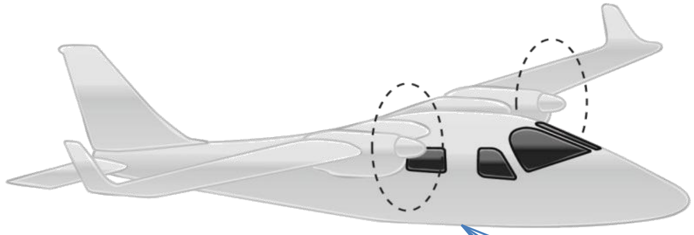


GREENSURVEY

AIRBORNE HYDRO MAPPING

AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

AirborneHydroMapping

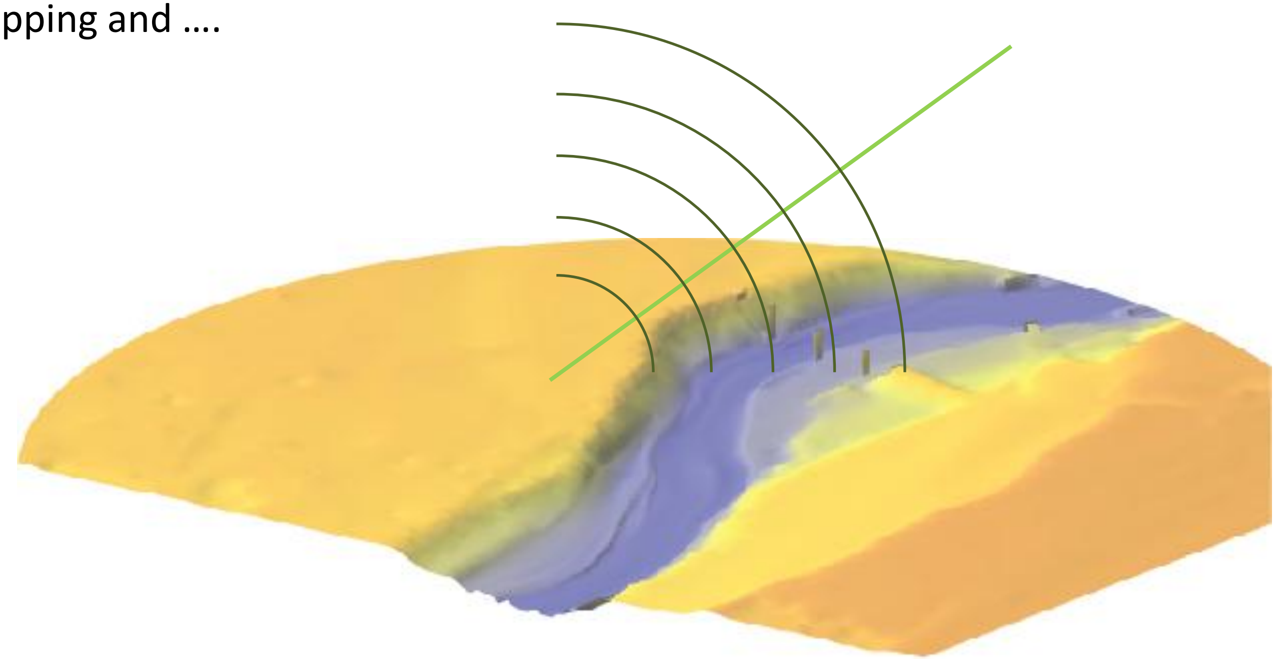
Modelling a Mountain Stream by Topo-Bathymetric LiDAR Data

Contents:

Motivation:

Received Echo Signal

Green Laser is capable of
land mapping and ….



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

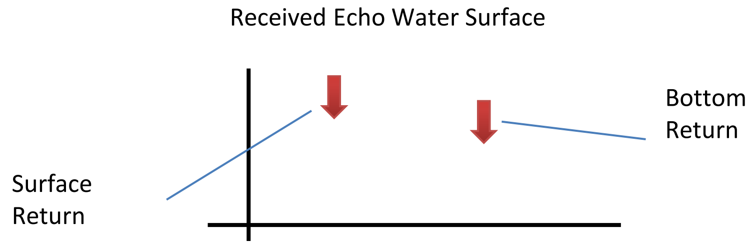
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

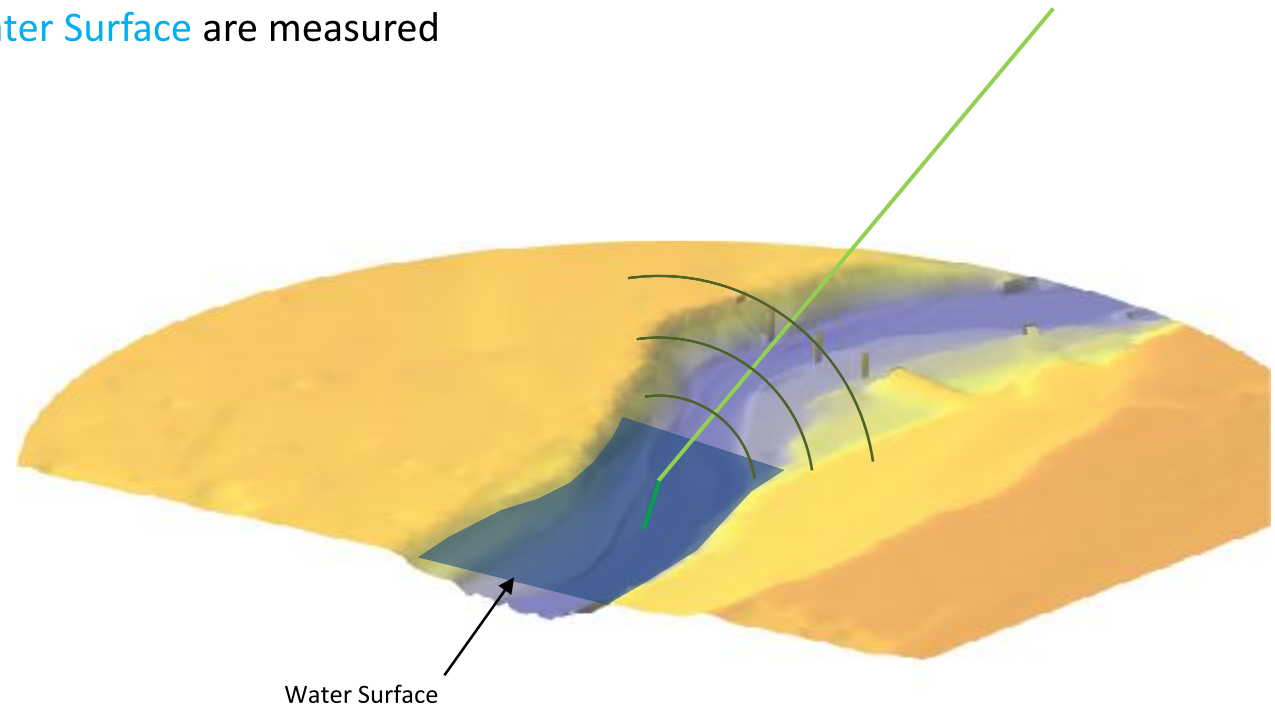
AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Motivation:



…. of bathymetry. River Bed
and Water Surface are measured



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

AHM AIRBORNE LAND MAPPING

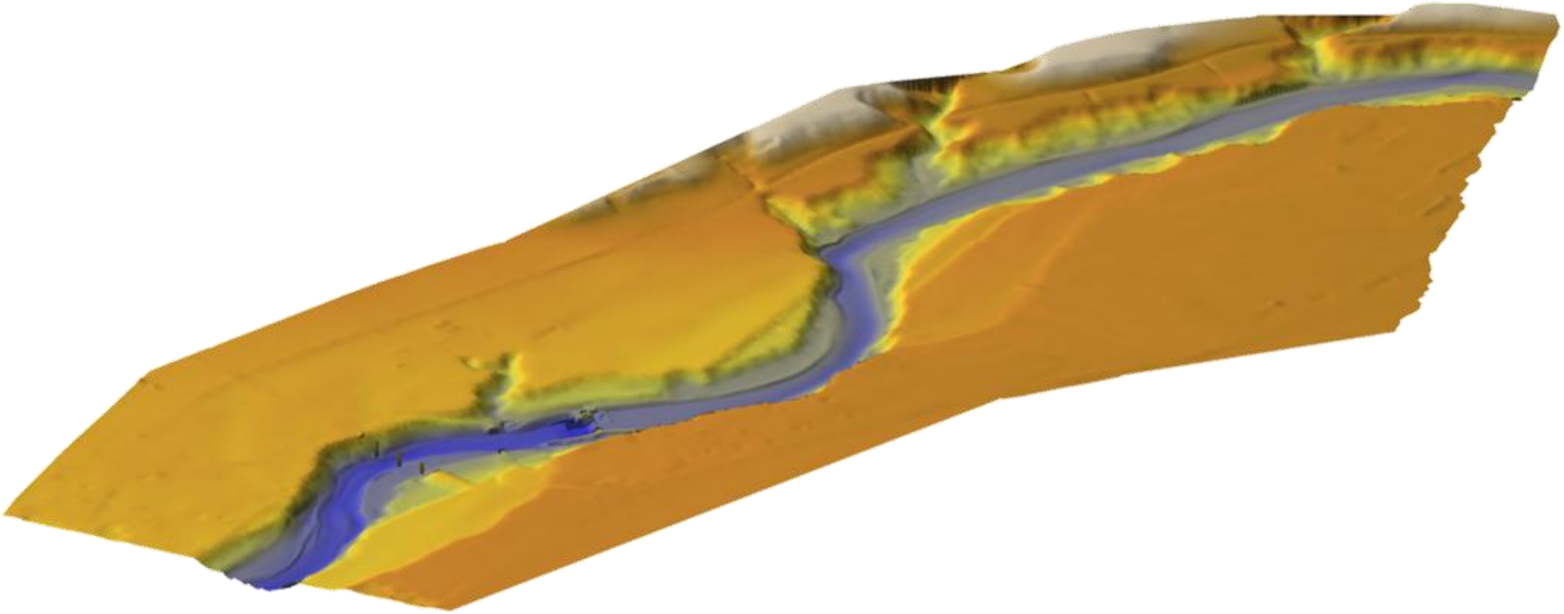
AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Motivation:

The topobathymetric LiDAR dataset enables the first time an entire and areal calibration of a numerical model with Water Surface, River Bed and Foreland as well as discharge (gauge stations).



GREENSURVEY

AIRBORNE HYDRO MAPPING

AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Project Area:

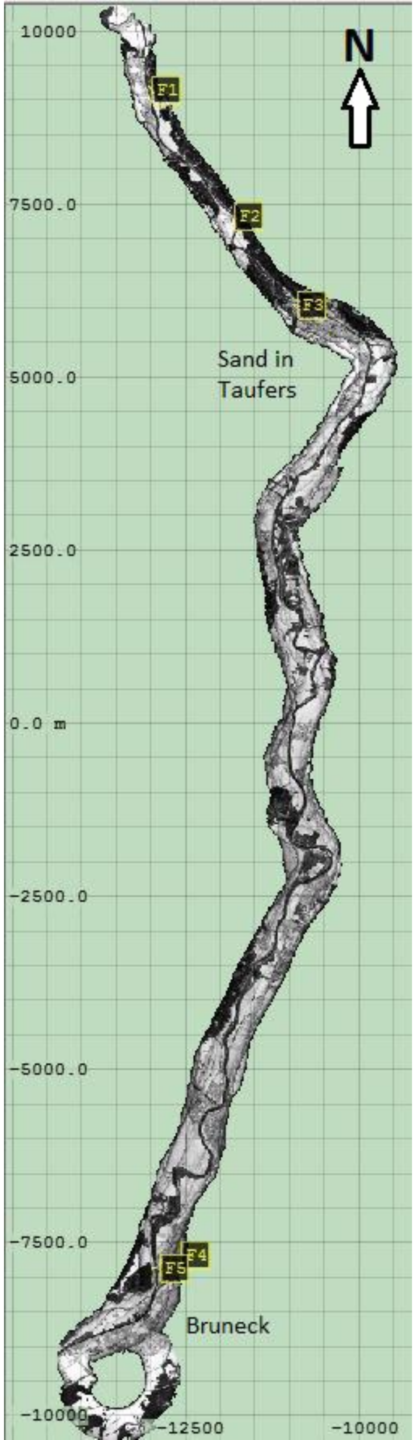
Location:
Italy, South Tirol, Between Sand in Taufers and Bruneck

Length: ca. 15 km

Point Density: 25 – 40 pts/m^2

Strip adjustment: 6 cm

Georeferencing:
3 cm (5 Reference planes along the river)



GREENSURVEY

AIRBORNE HYDRO MAPPING

AIRBORNE LAND MAPPING

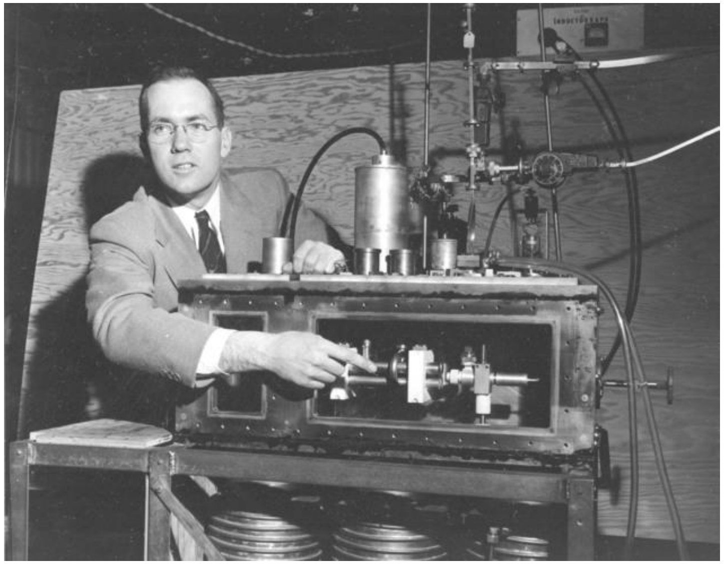
AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Convert data from laser to F5 (HDF5)

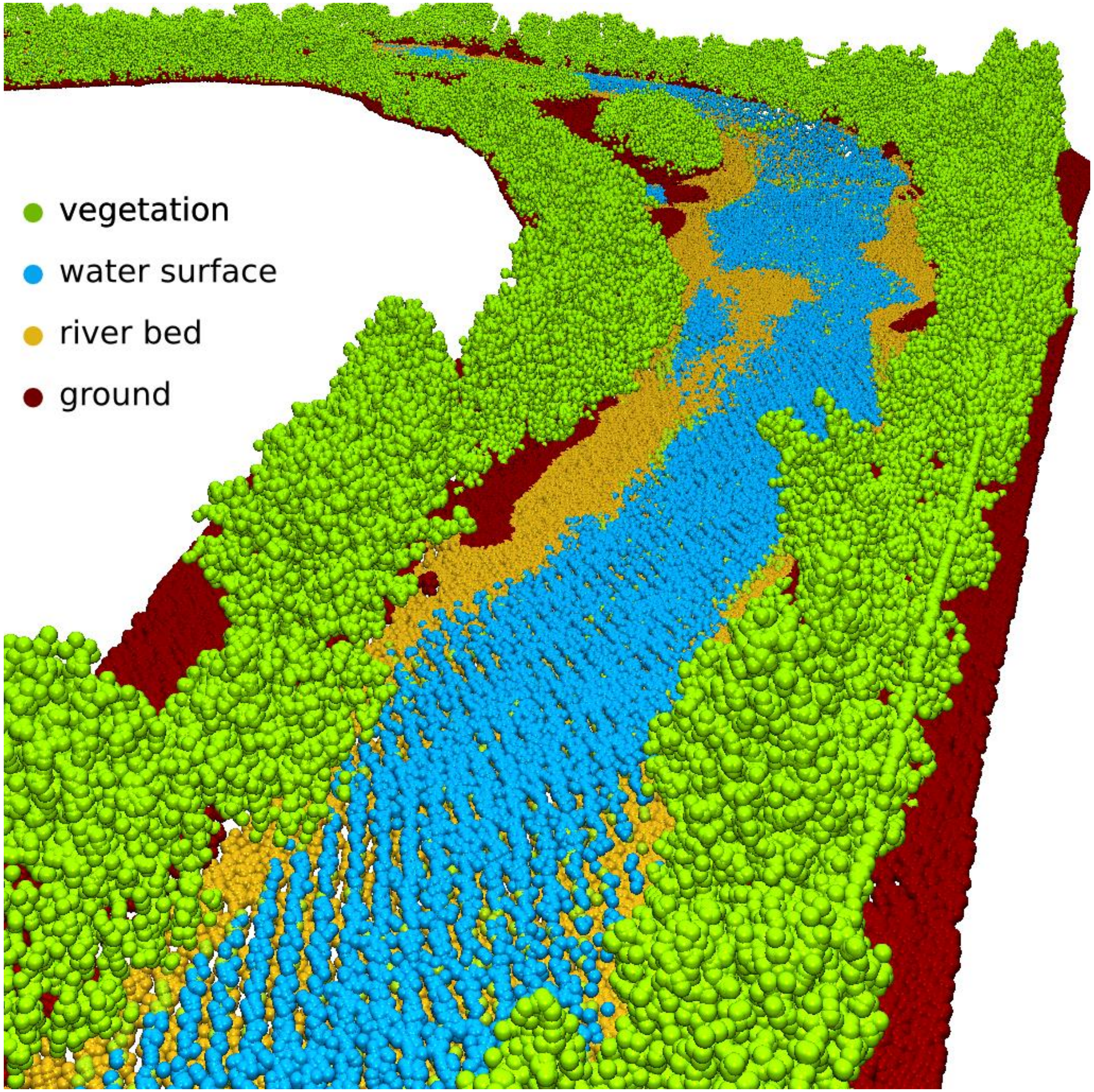
Charles Hard Townes, 1955



RDB (Riegl-Database) to F5 – Transformation to local coordinate system e.g ETRS/UTM

raw data: 10 GB -> 12 min -> 6 GB as f5

Classification and refraction of the Point Cloud:



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

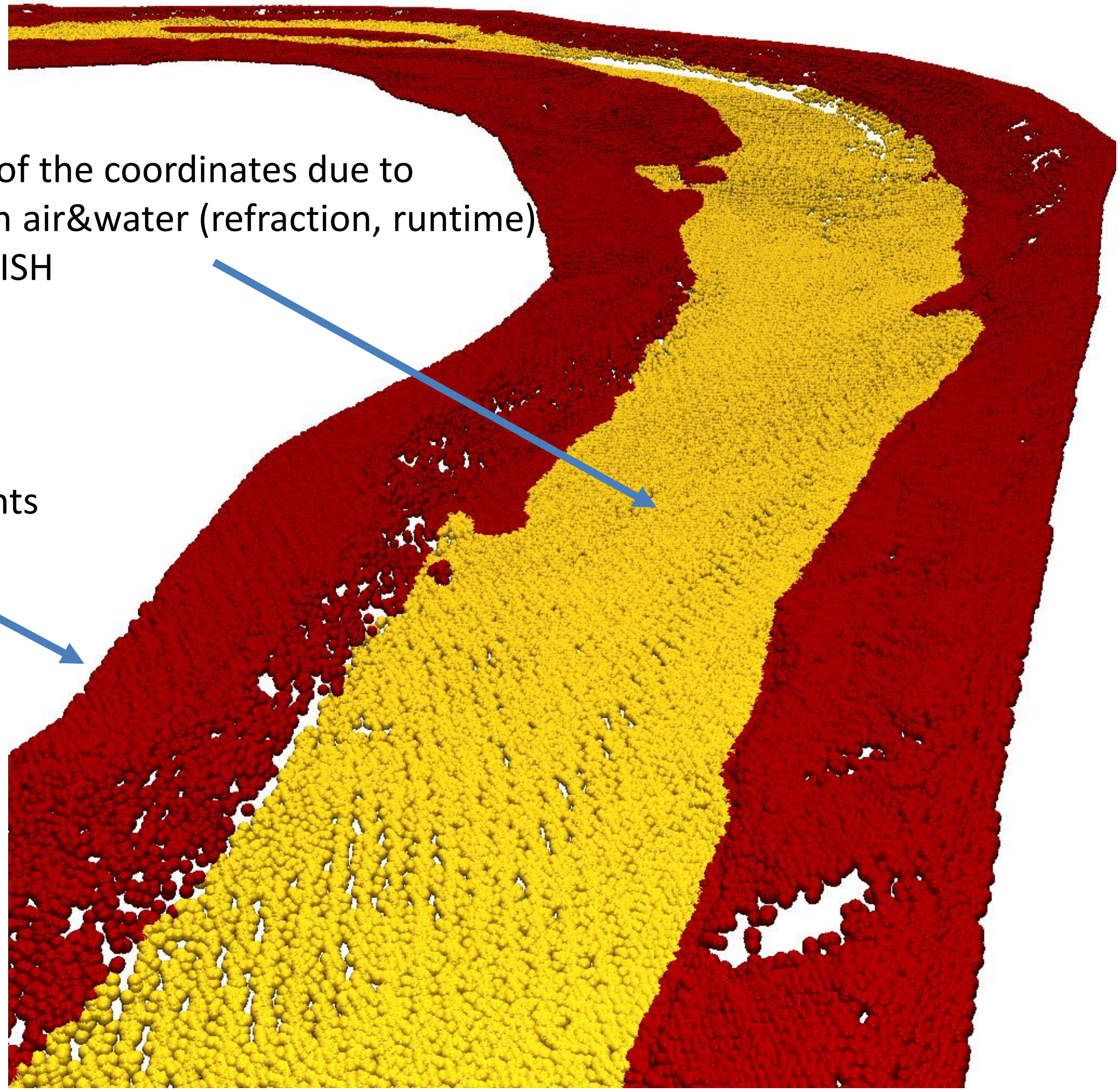
AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

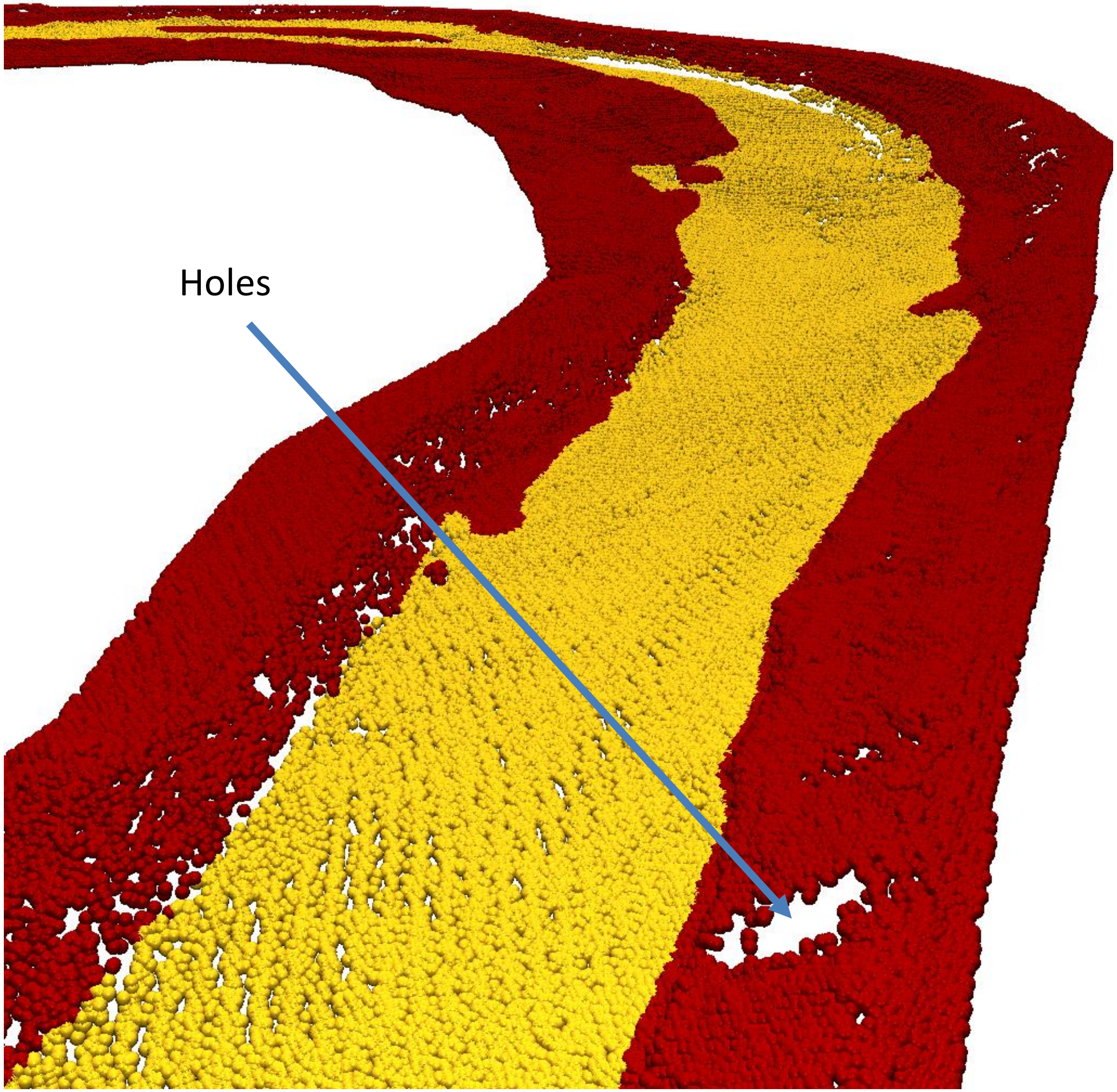
Mesh -> Only ground- and river bed points are needed:

River Bed: Correction of the coordinates due to the transition between air&water (refraction, runtime) are applied by HydroVISH

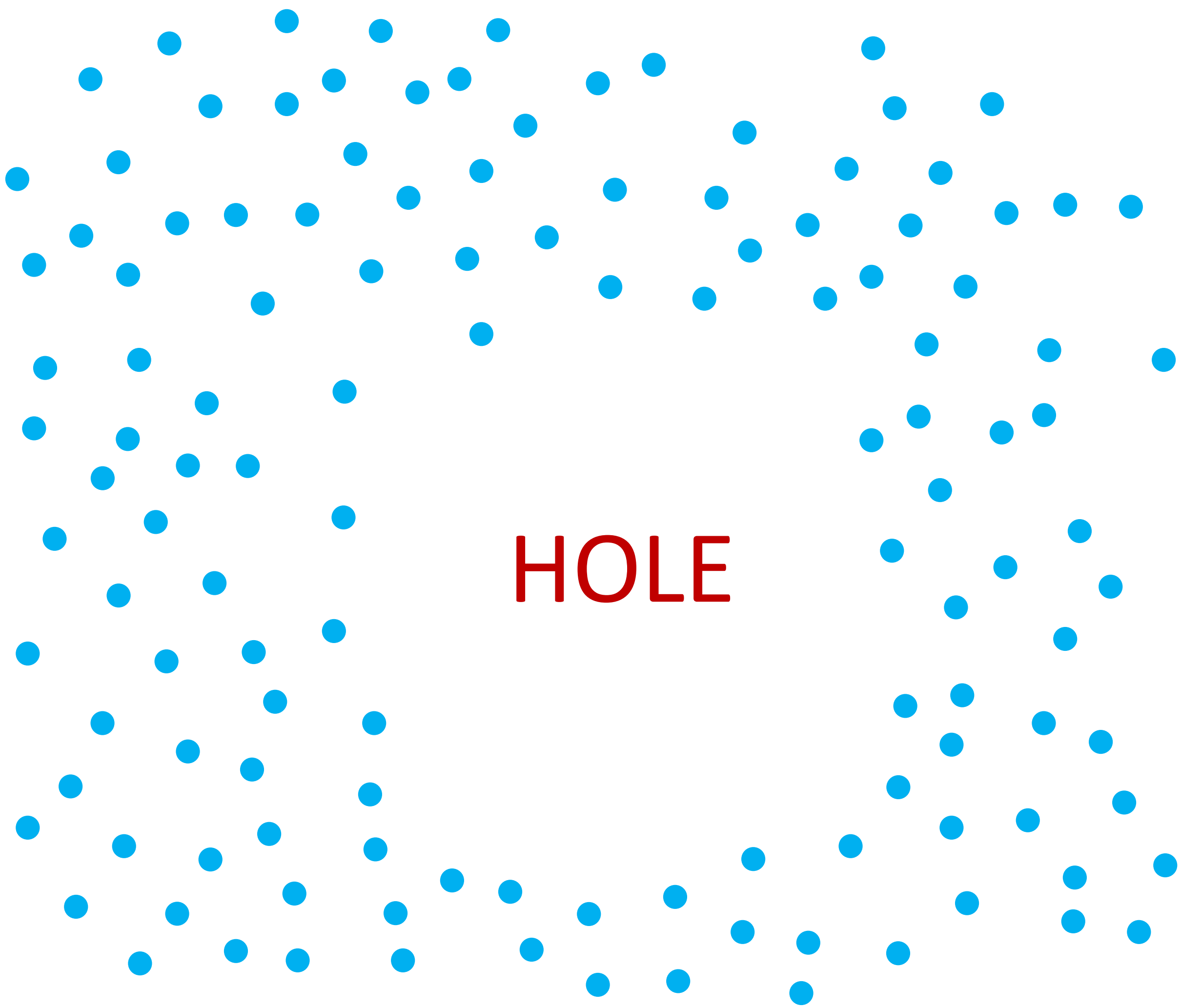
Foreland: Ground Points



Mesh -> Missing data by shadowing effects are filled up with a region growing algorithm:



Fill holes in point cloud:



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

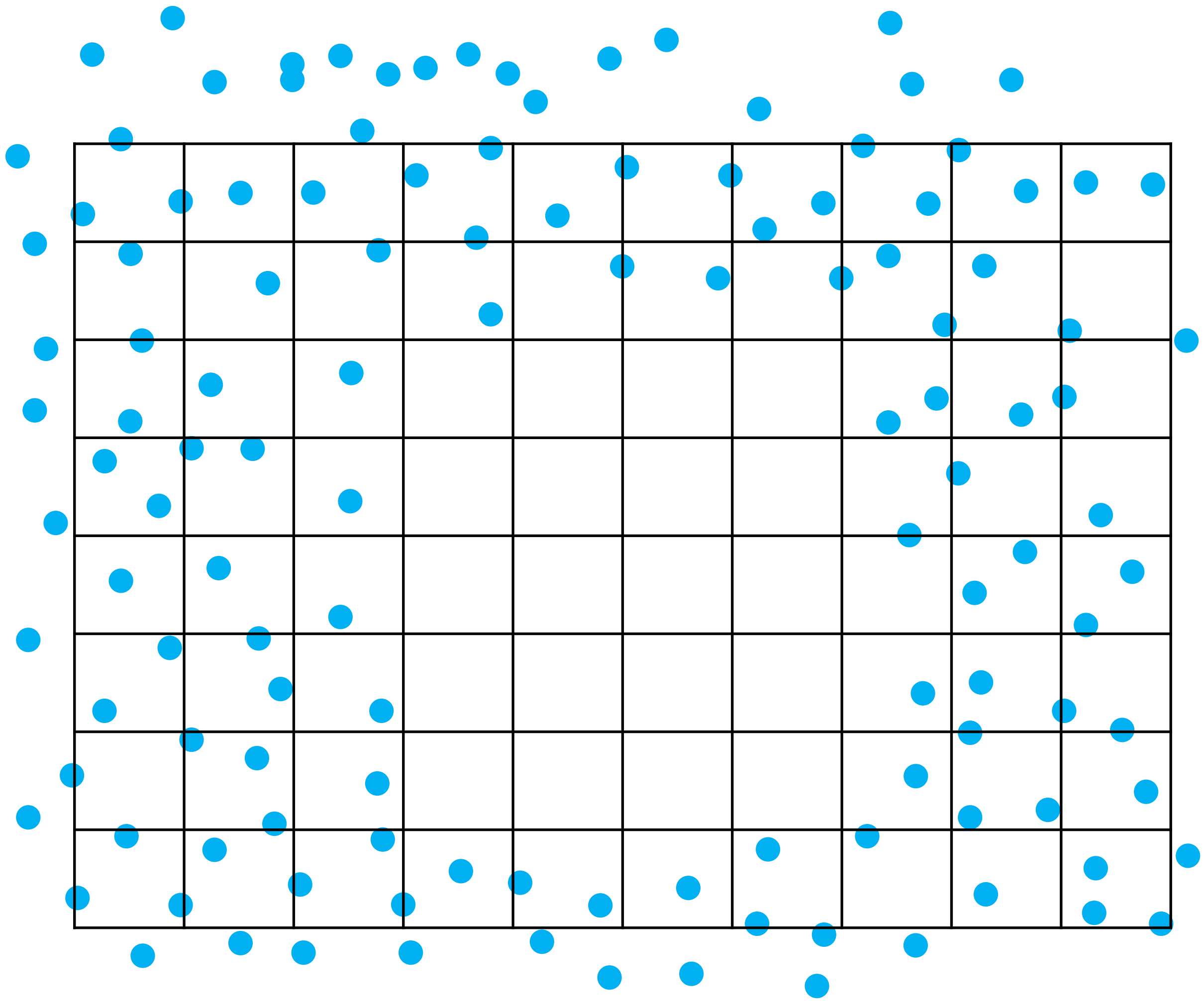
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Fill holes in point cloud: Map points on a raster



GREENSURVEY

AIRBORNE HYDRO MAPPING

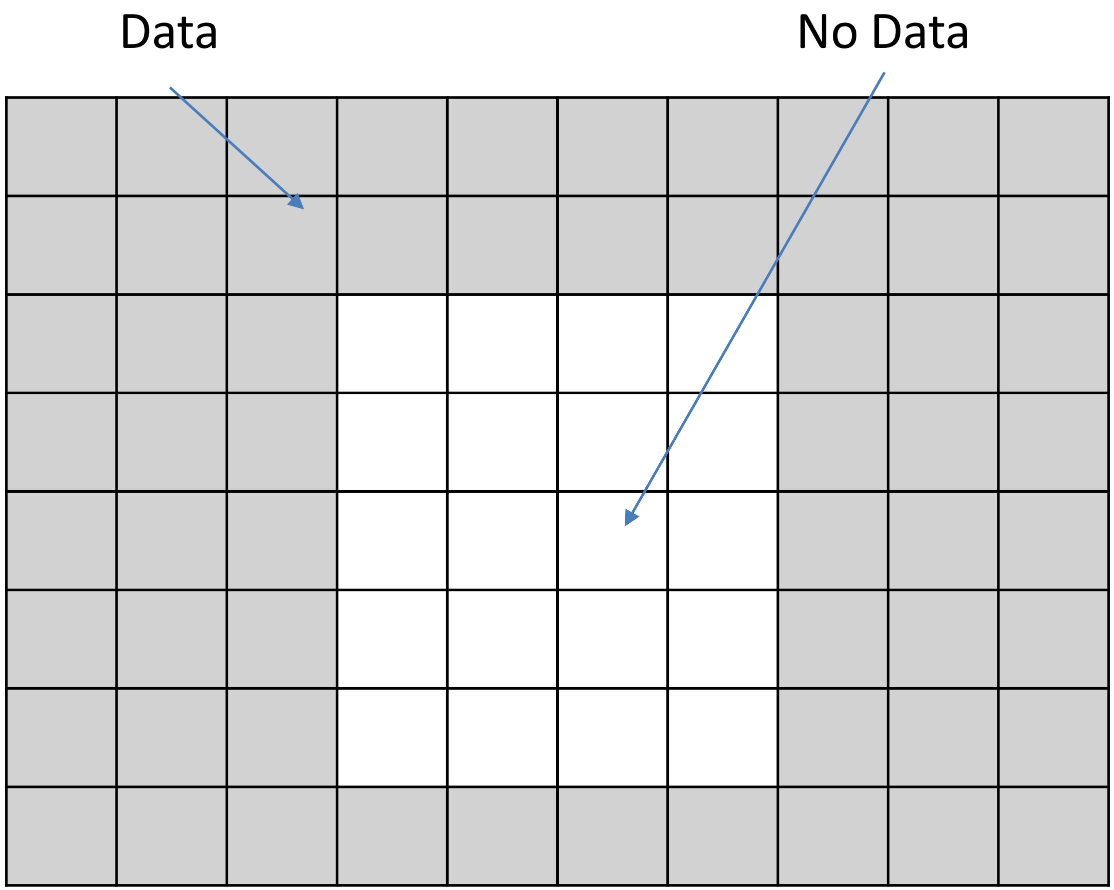
AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

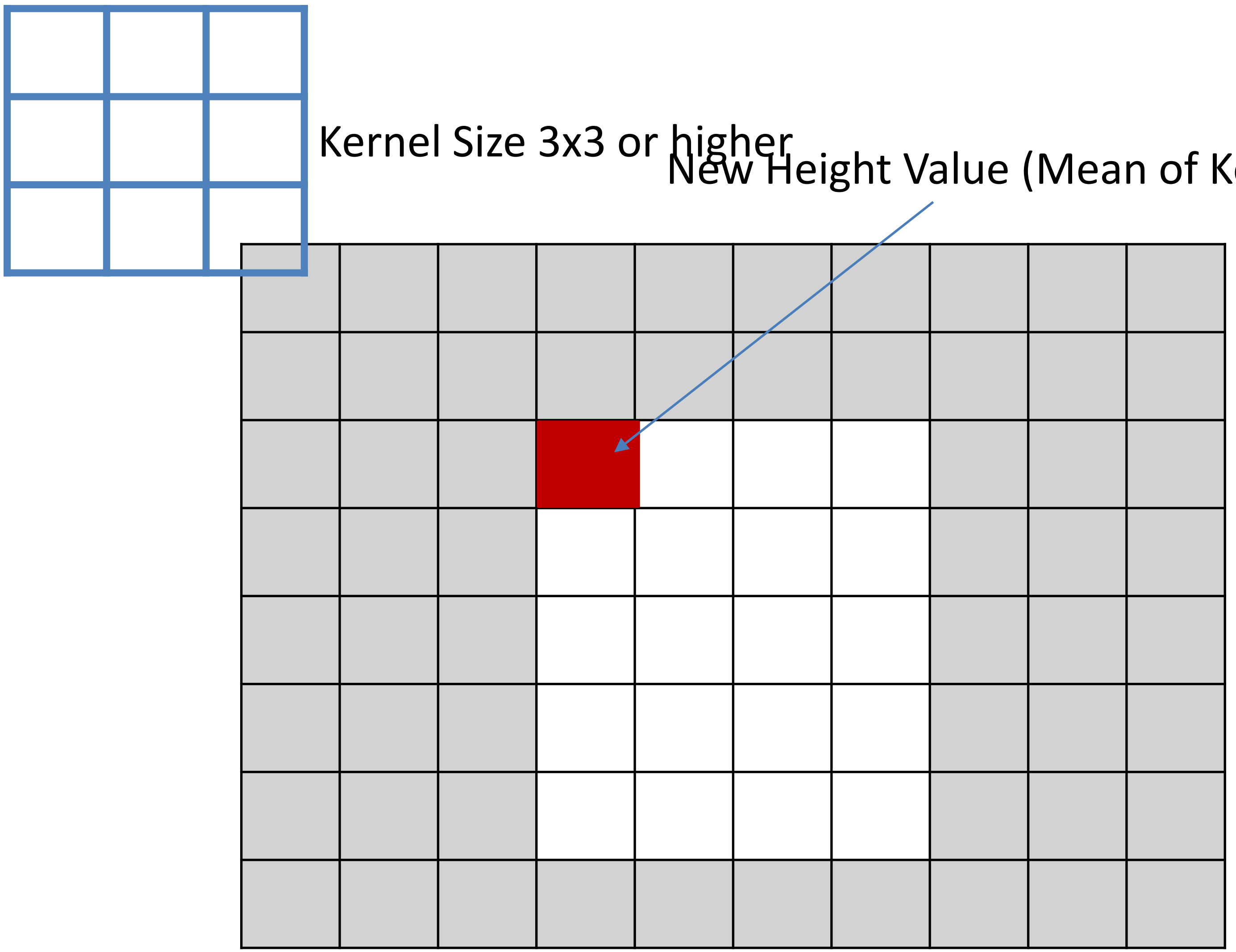
AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Fill holes in point cloud: Region Growing



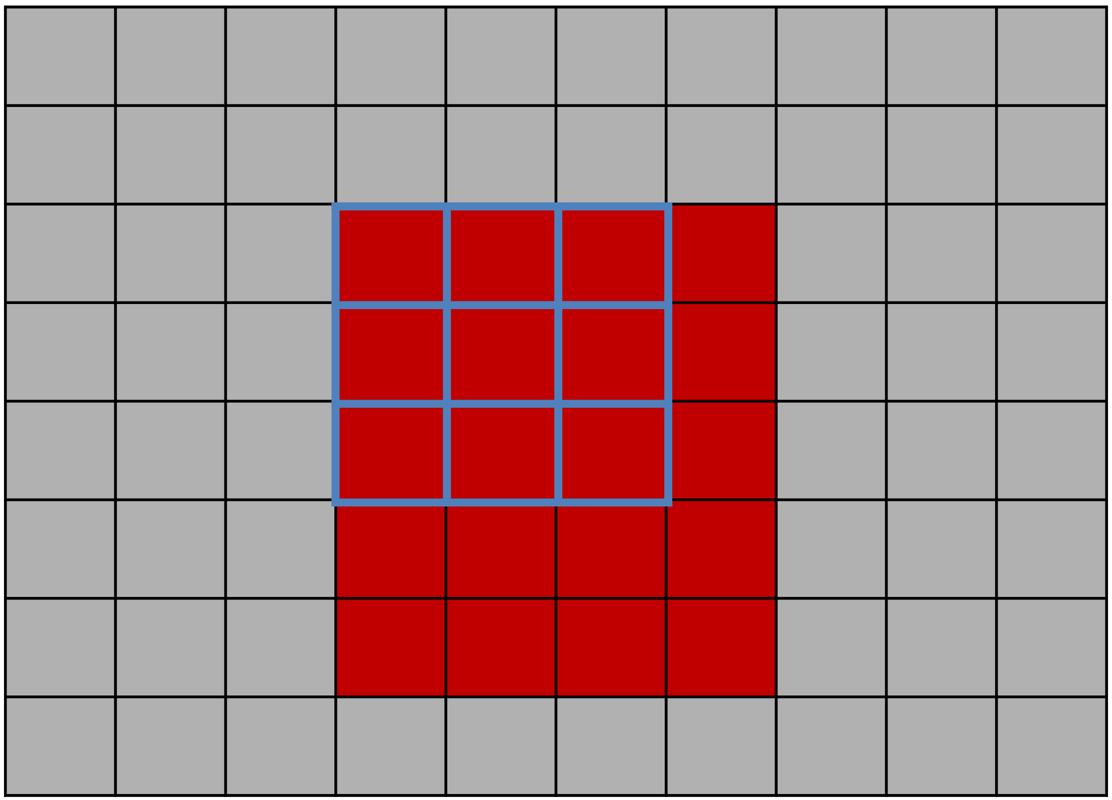
Fill holes in point cloud: Region Growing



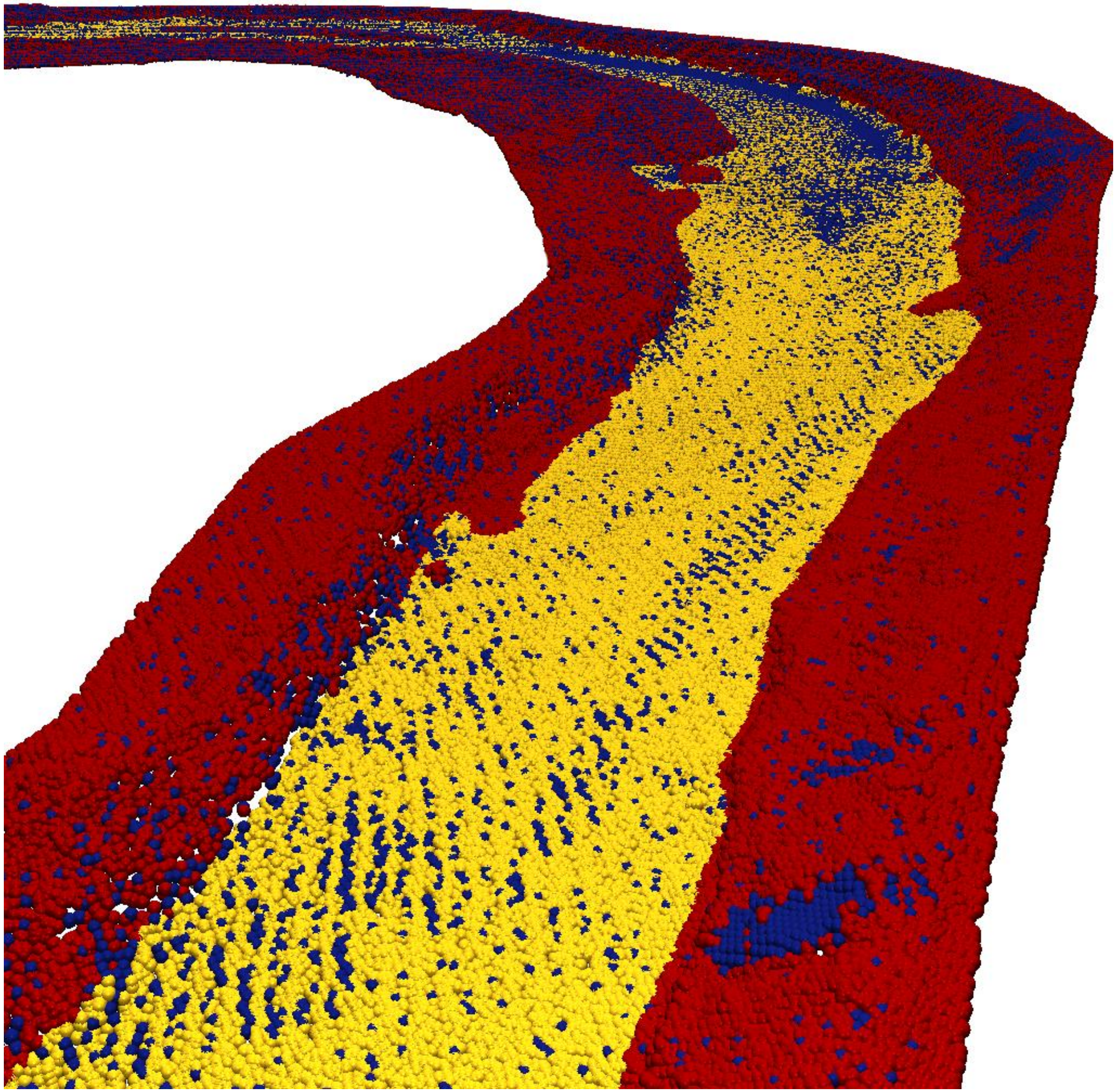
Fill holes in point cloud: Region Growing

First run over the entire raster

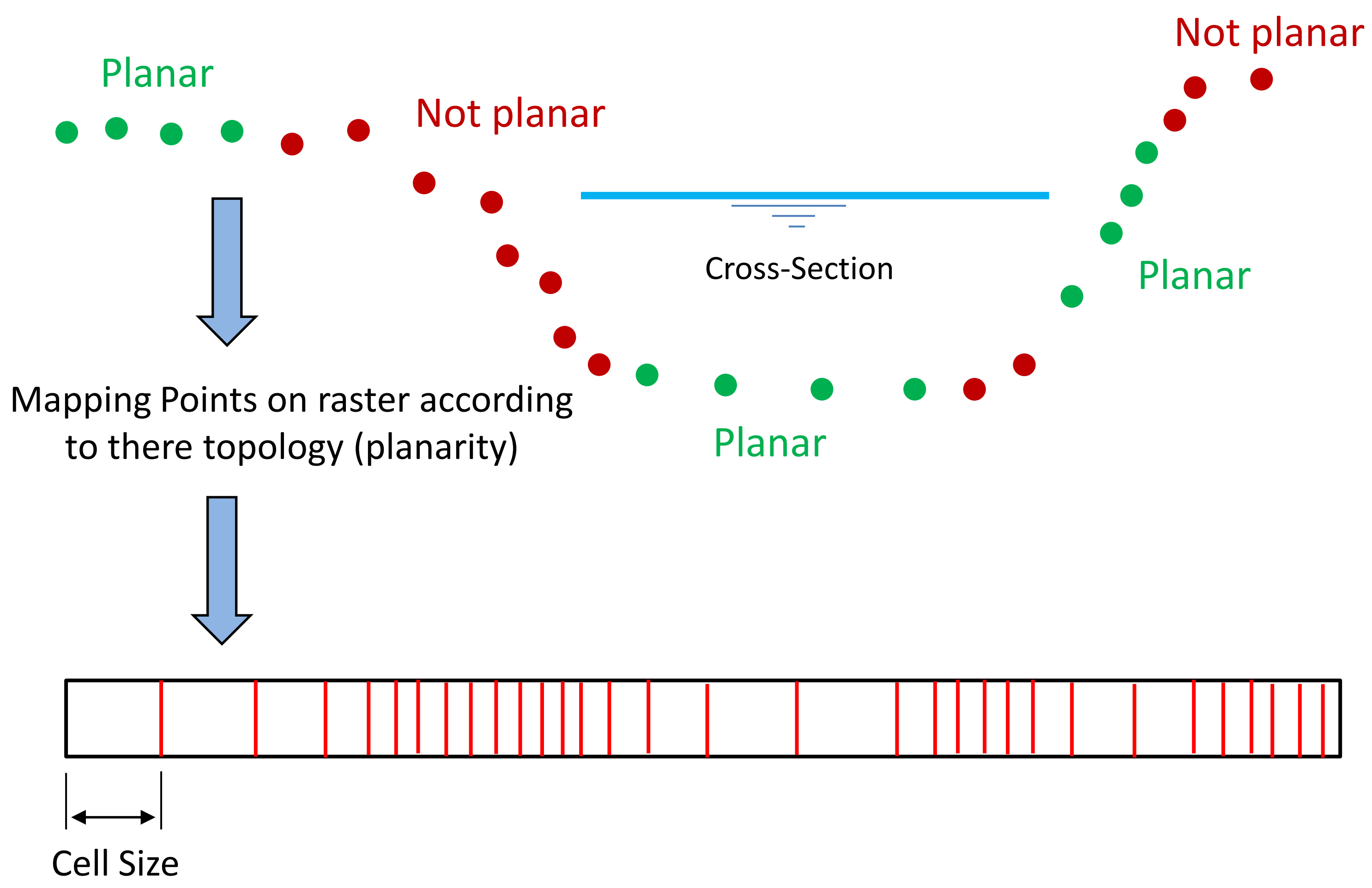
Second run over the entire raster



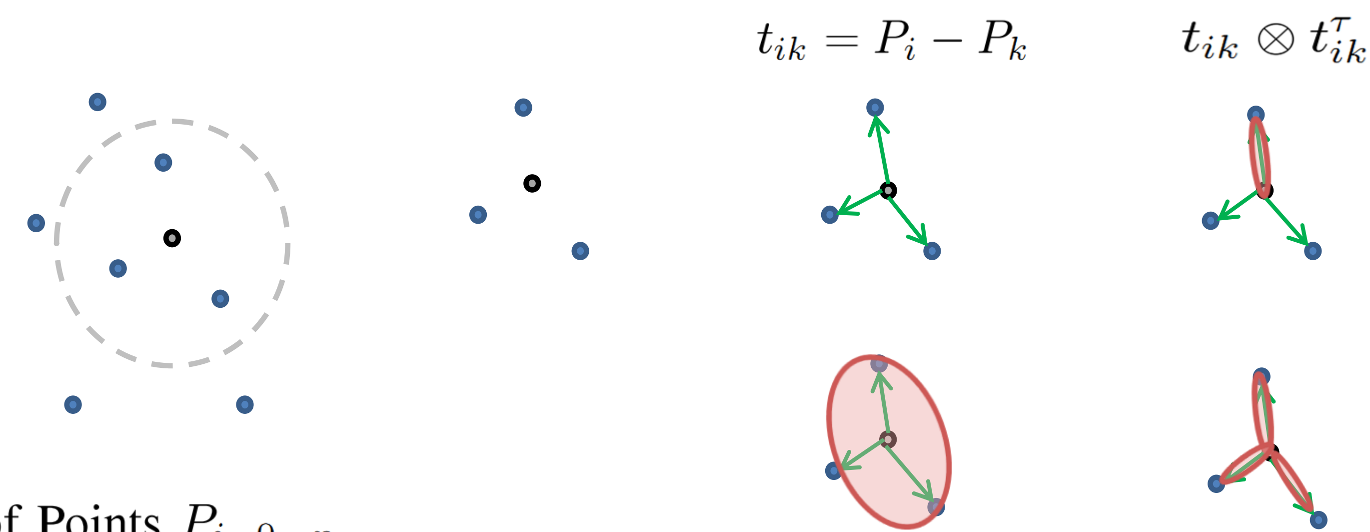
Missing point in the point cloud are filled up



Downsampling: Mapping points on raster with different cell size



Downsampling: Calculating the planarity of points



set of Points $P_{i=0\ldots n}$

$$S(P_i) = \frac{1}{N} \sum_{k=1}^{N} \omega_n(|t_{ik}, r|)(t_{ik} \otimes t_{ik}^{\tau})$$

$\omega_n(|t_{ik}|, r)$ weighting function

Ritter & Benger 2012

Downsampling: Eigen-Values of the point distribution tensor

- Shape factors by [Westin97]
- $S(P_i)$ is a 3x3 symmetric tensor and positive definite

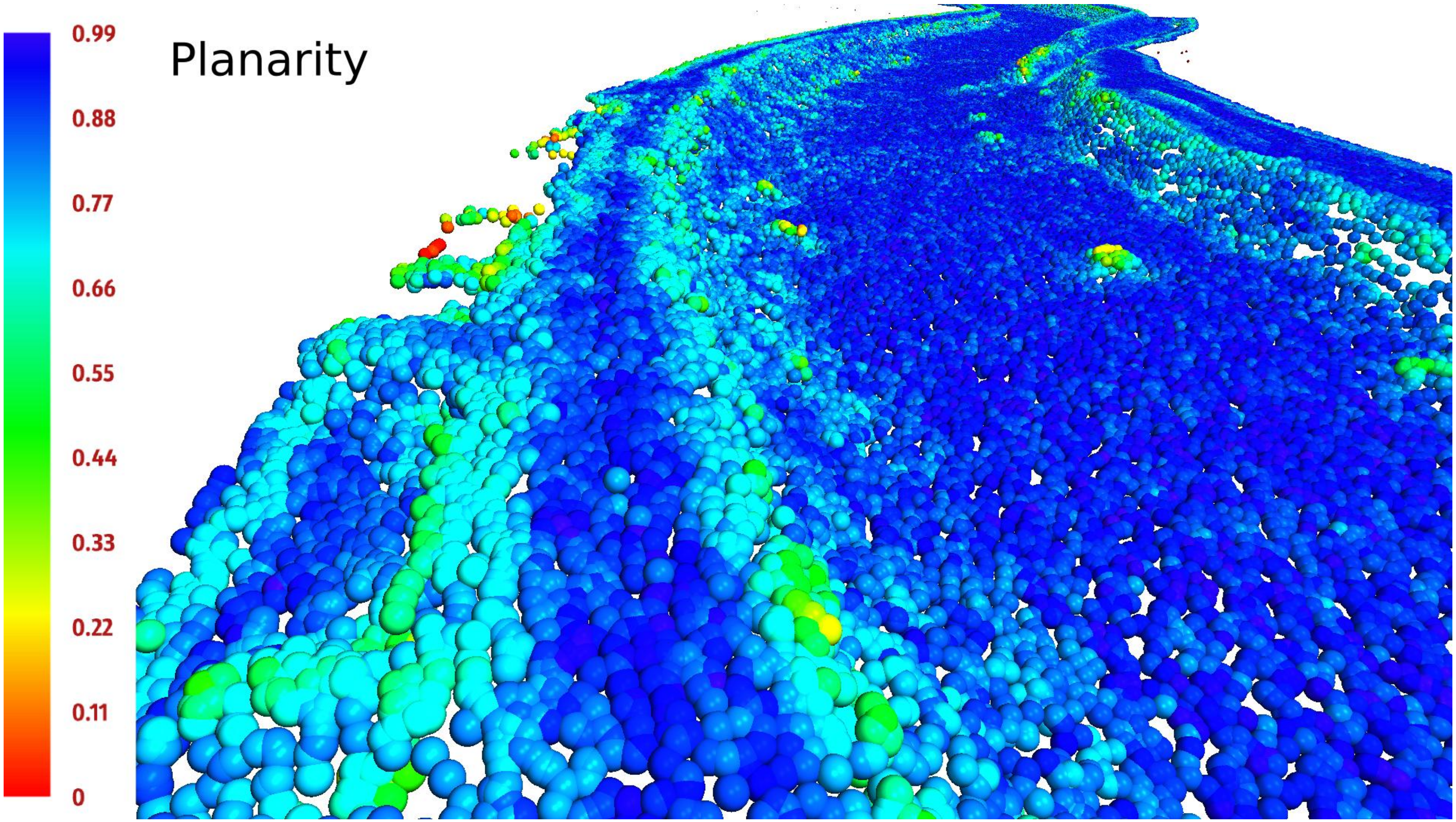
- 3 Eigen-Values: $\lambda_3 \geq \lambda_2 \geq \lambda_1$

- Shape factors:

$$\begin{aligned} c_{linear} &= (\lambda_3 - \lambda_2) \quad /(\lambda_1 + \lambda_2 + \lambda_3) \\ c_{planar} &= 2(\lambda_2 - \lambda_1) \quad /(\lambda_1 + \lambda_2 + \lambda_3) \\ c_{spherical} &= 3\lambda_1 \quad /(\lambda_1 + \lambda_2 + \lambda_3) \end{aligned}$$

[Ritter]

Downsampling: Planarity of the Point cloud



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

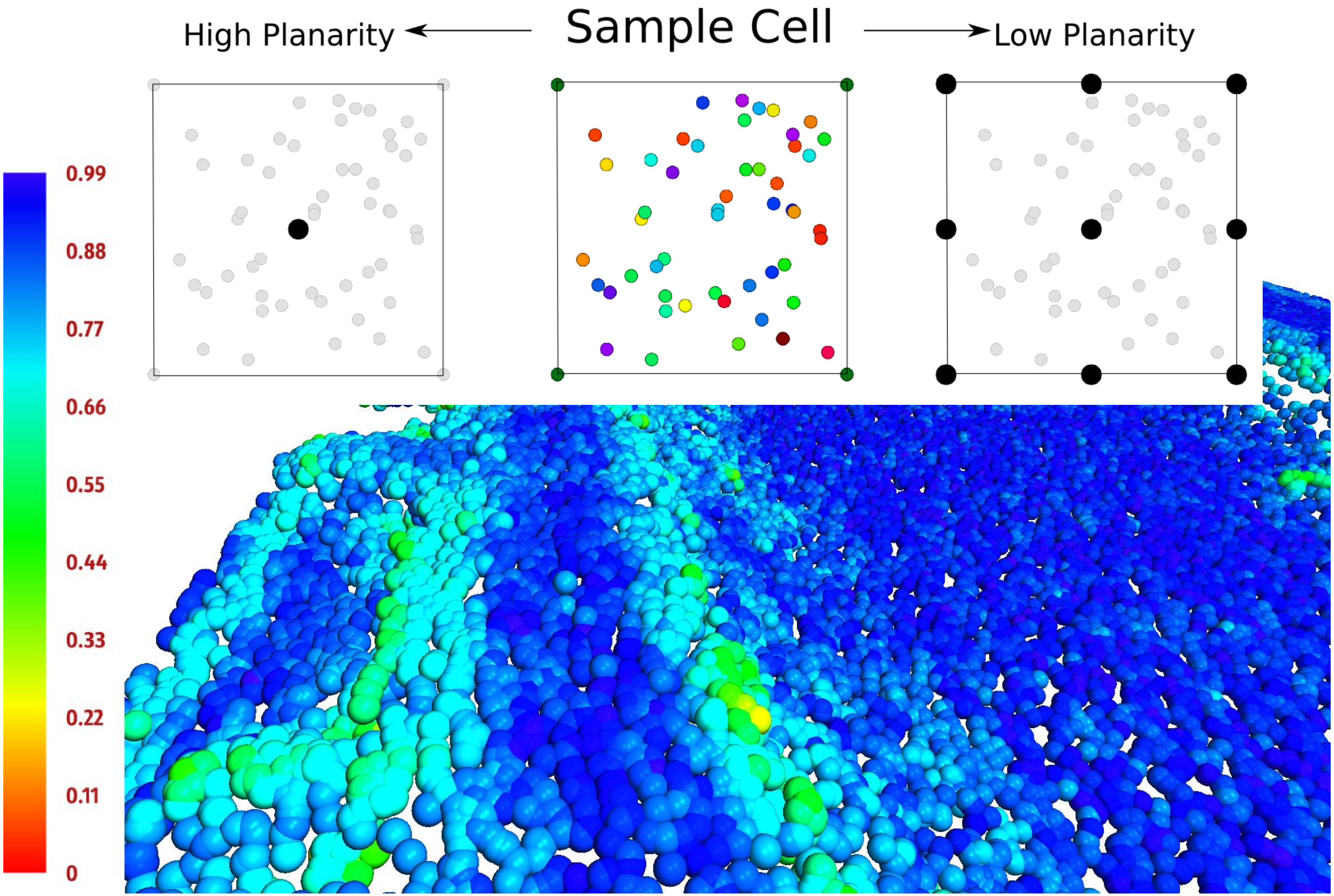
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Down sampling: Switching between grids



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

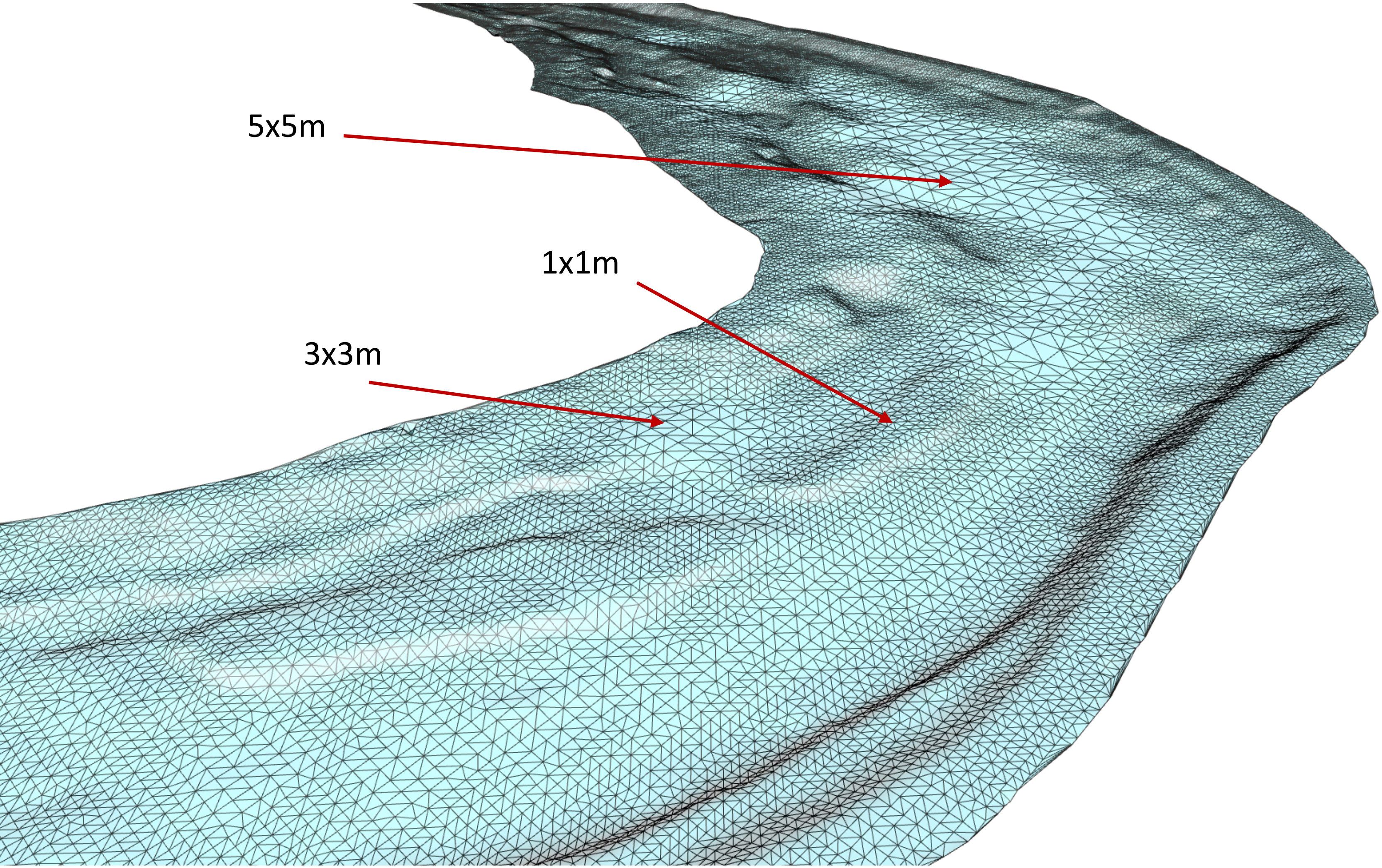
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Downsampling: Resulting points on a uniform grid with different cell size-> Qhull triangulation:



Merging Shape Lines of Buildings with Mesh

GREENSURVEY

AIRBORNE HYDRO MAPPING

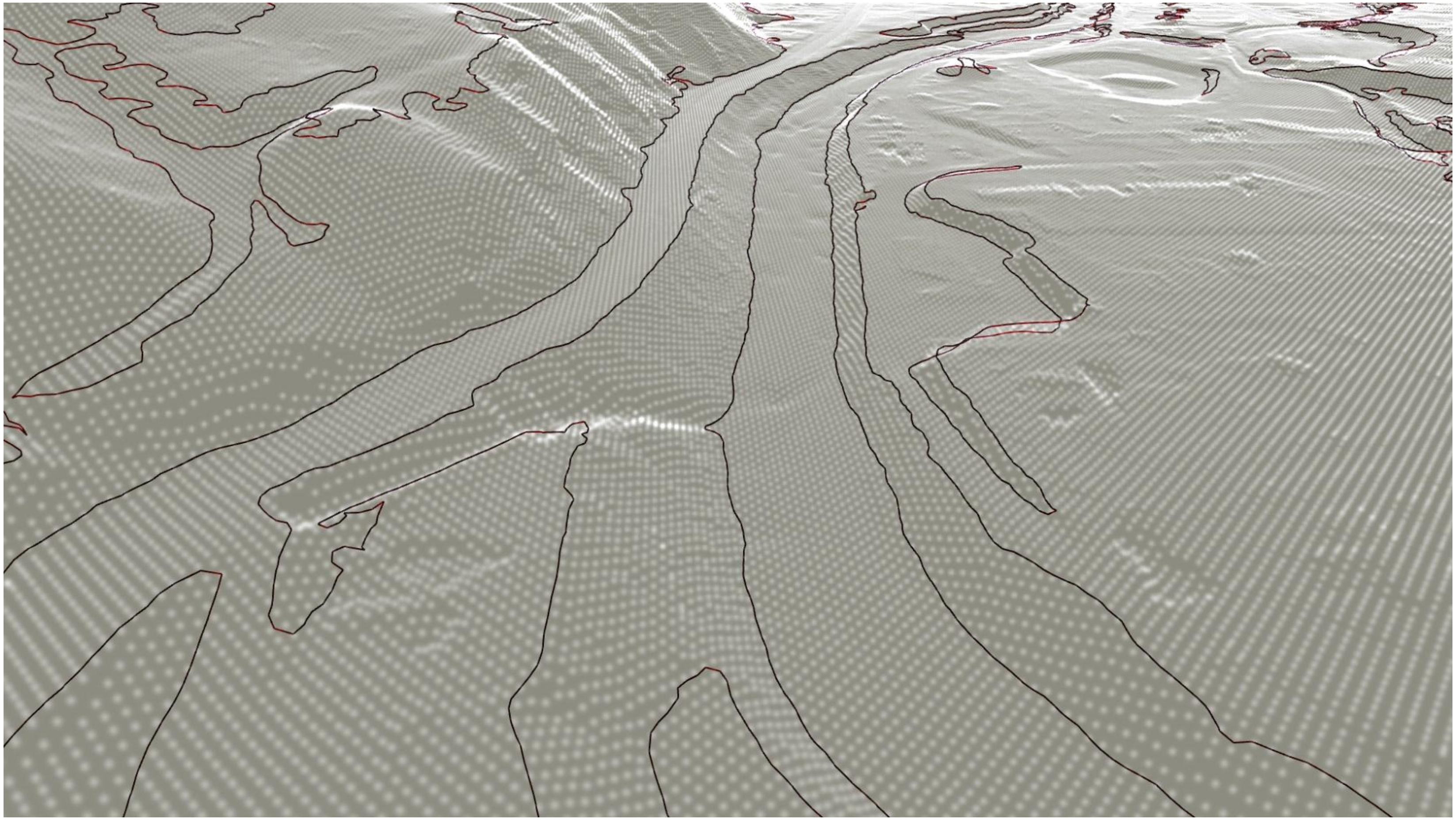
AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

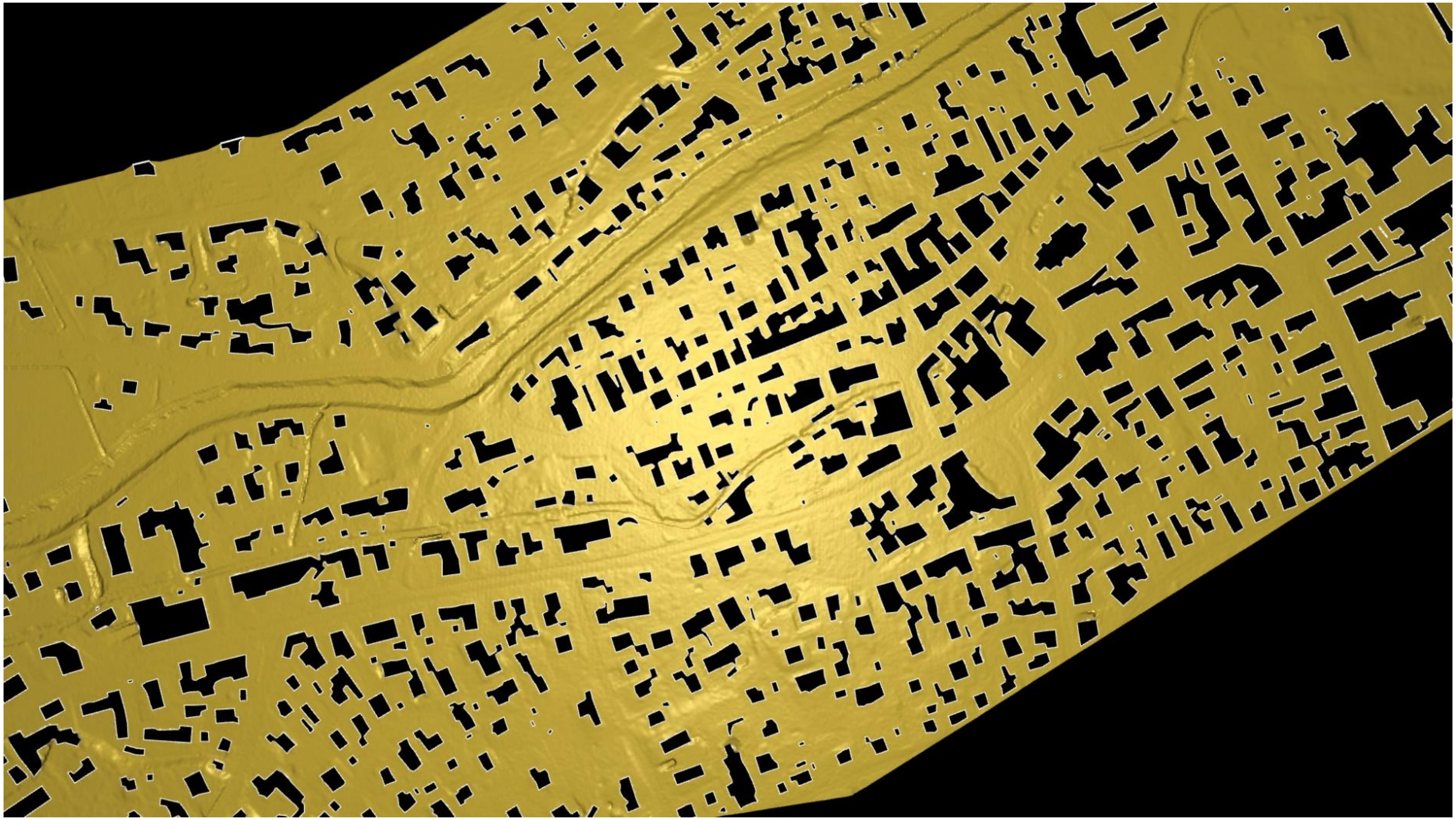
AIRBORNE ICE&SNOW MAPPING

universität innsbruck

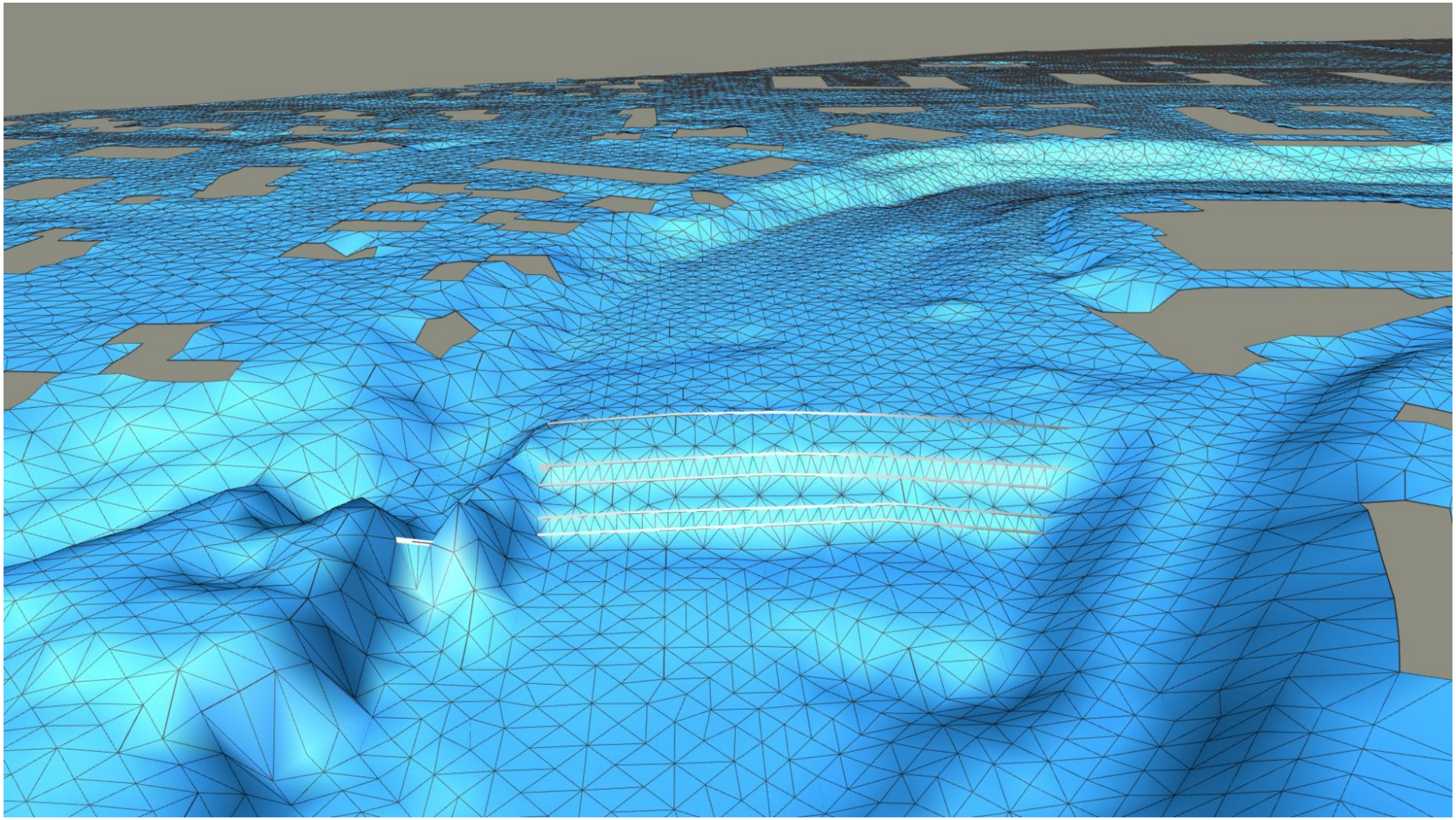
Merging Breaking Edges with Mesh



Merging Shape Lines of Buildings with mesh



Merging Shape Lines of Buildings with mesh



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

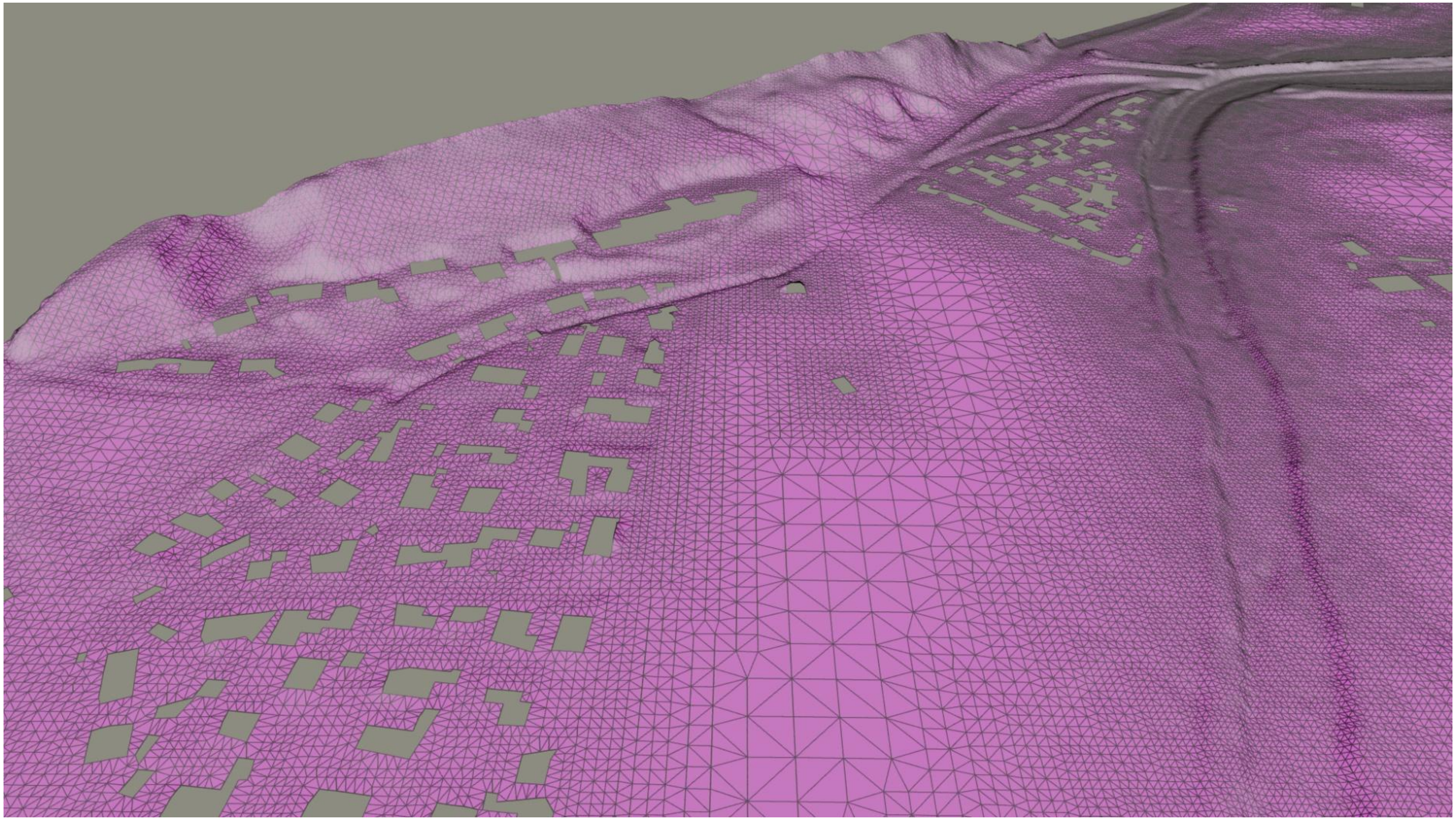
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Merging Shape Lines of Buildings with mesh



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

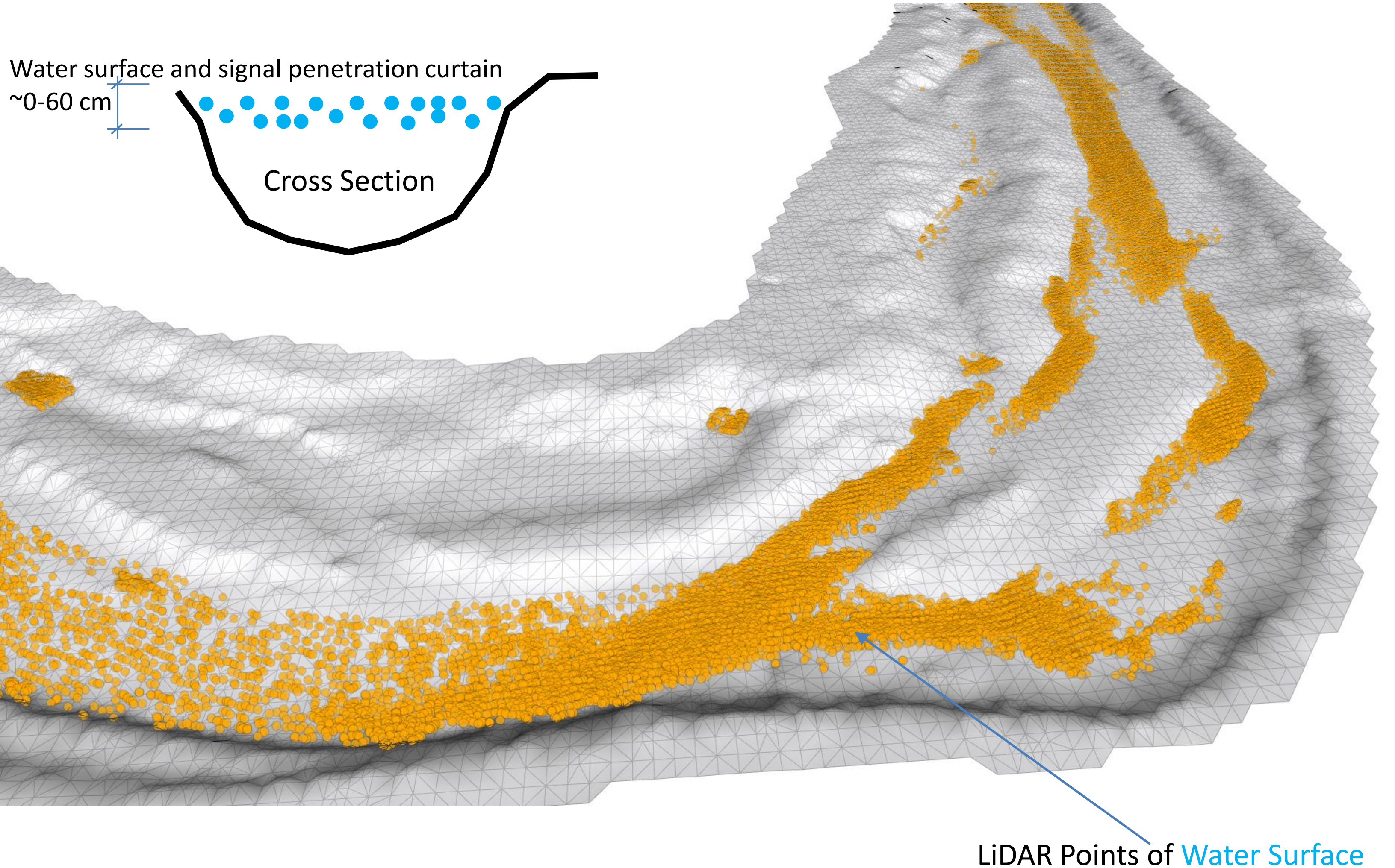
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

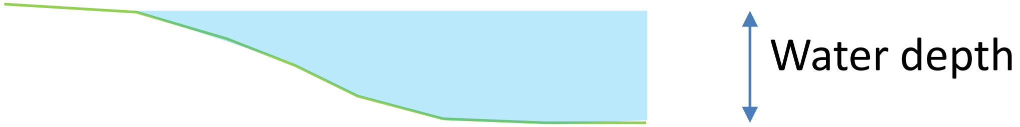
universität innsbruck

Preparing the LiDAR Water Surface modelling: extraction of 1.1 mio points out of the signal penetration curtain within a 30 cm layer:

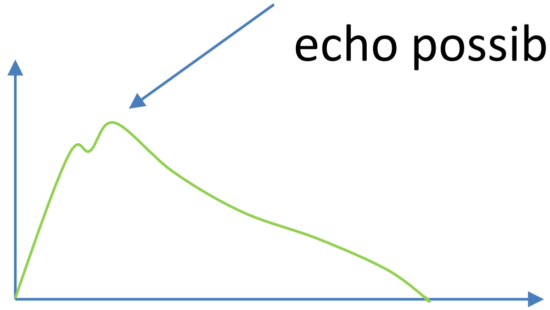


Not every laser shot delivers a water surface signal:

1. Too low water depth
2. Smooth water surface
3. Low turbidity

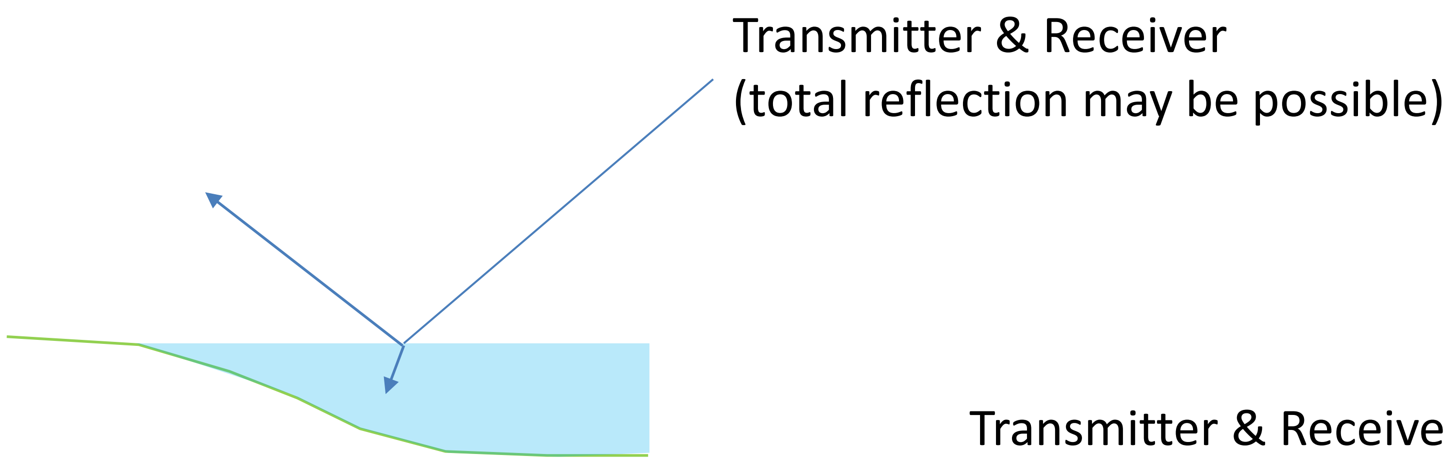


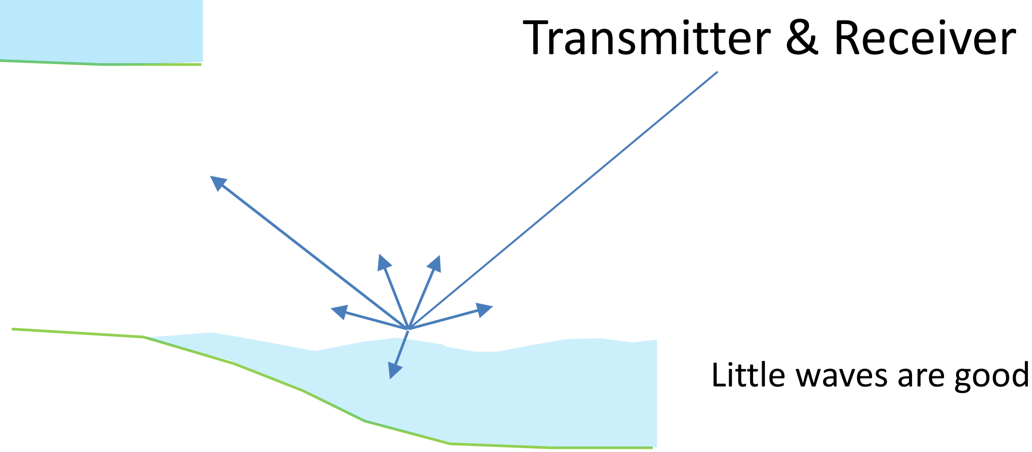
Time difference too small. No discretion of water surface echo and ground echo possible (~15cm)



Not every laser shot delivers a water surface signal:

1. Too low water depth
2. Smooth water surface
3. Low turbidity





Little waves are good!

GREENSURVEY

AIRBORNE HYDRO MAPPING

AIRBORNE LAND MAPPING

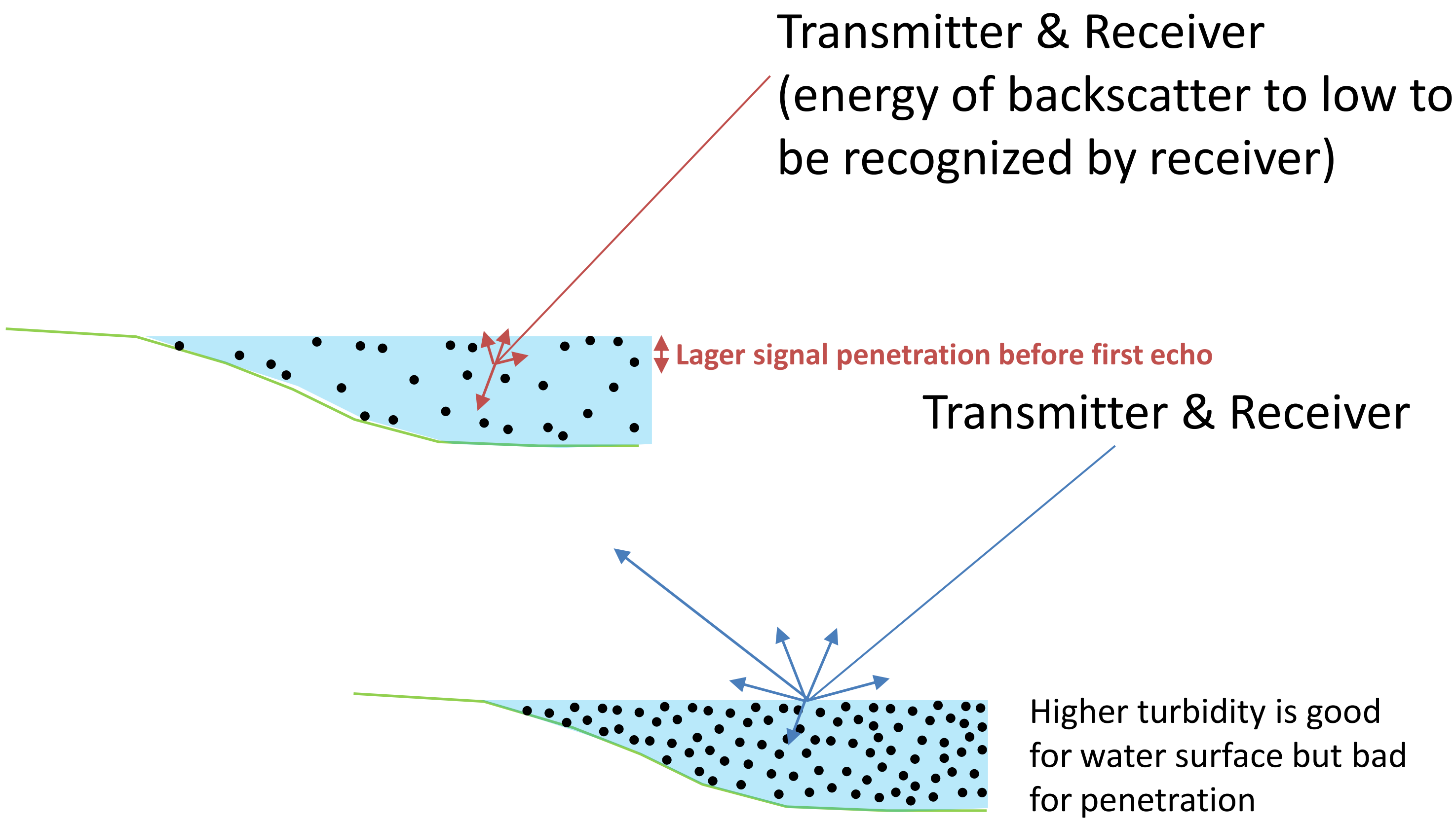
AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

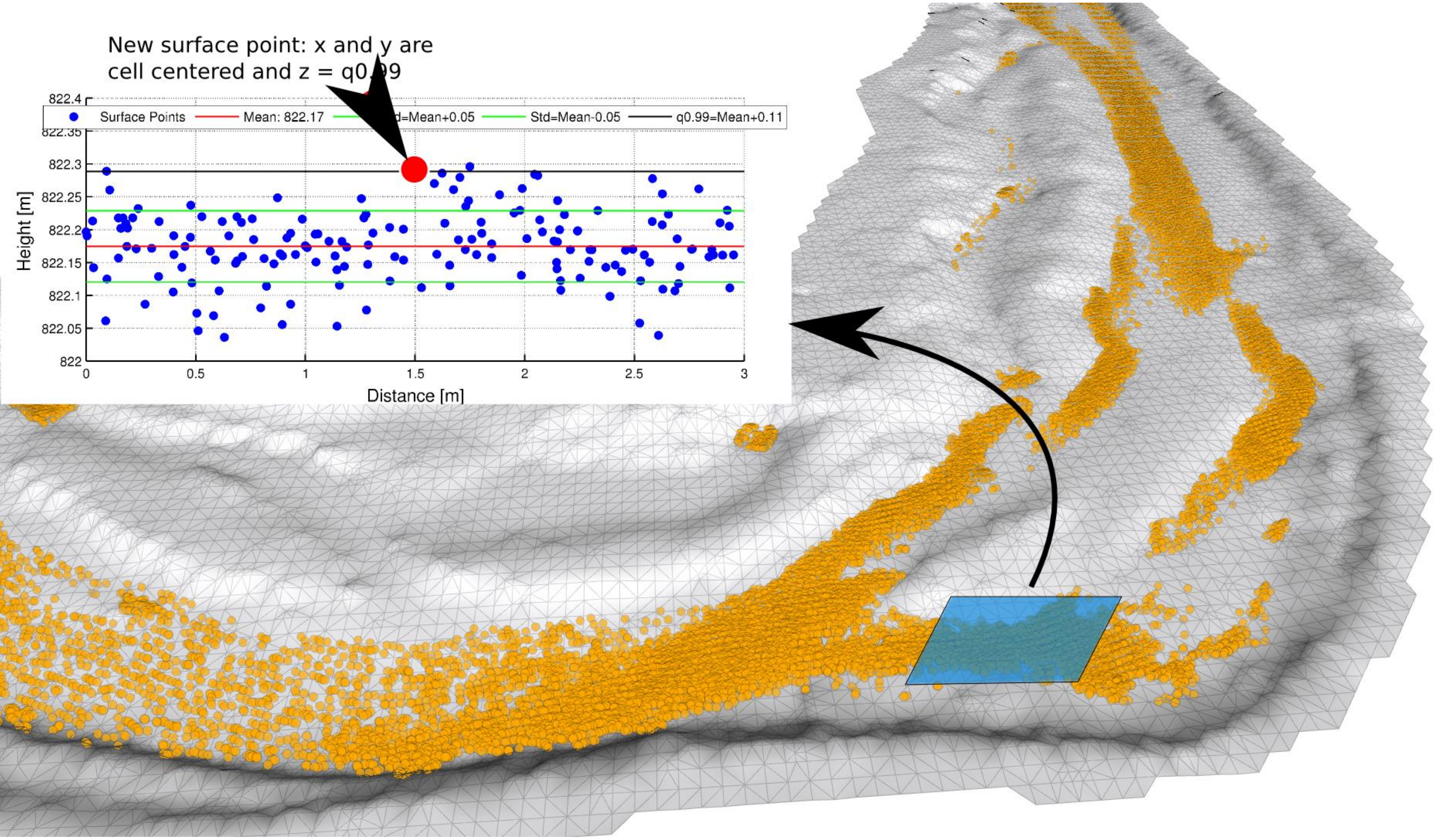
universität innsbruck

Low turbidity may deliver first echo underneath actual water surface:

1. Too low water depth
2. Smooth water surface
3. Low turbidity

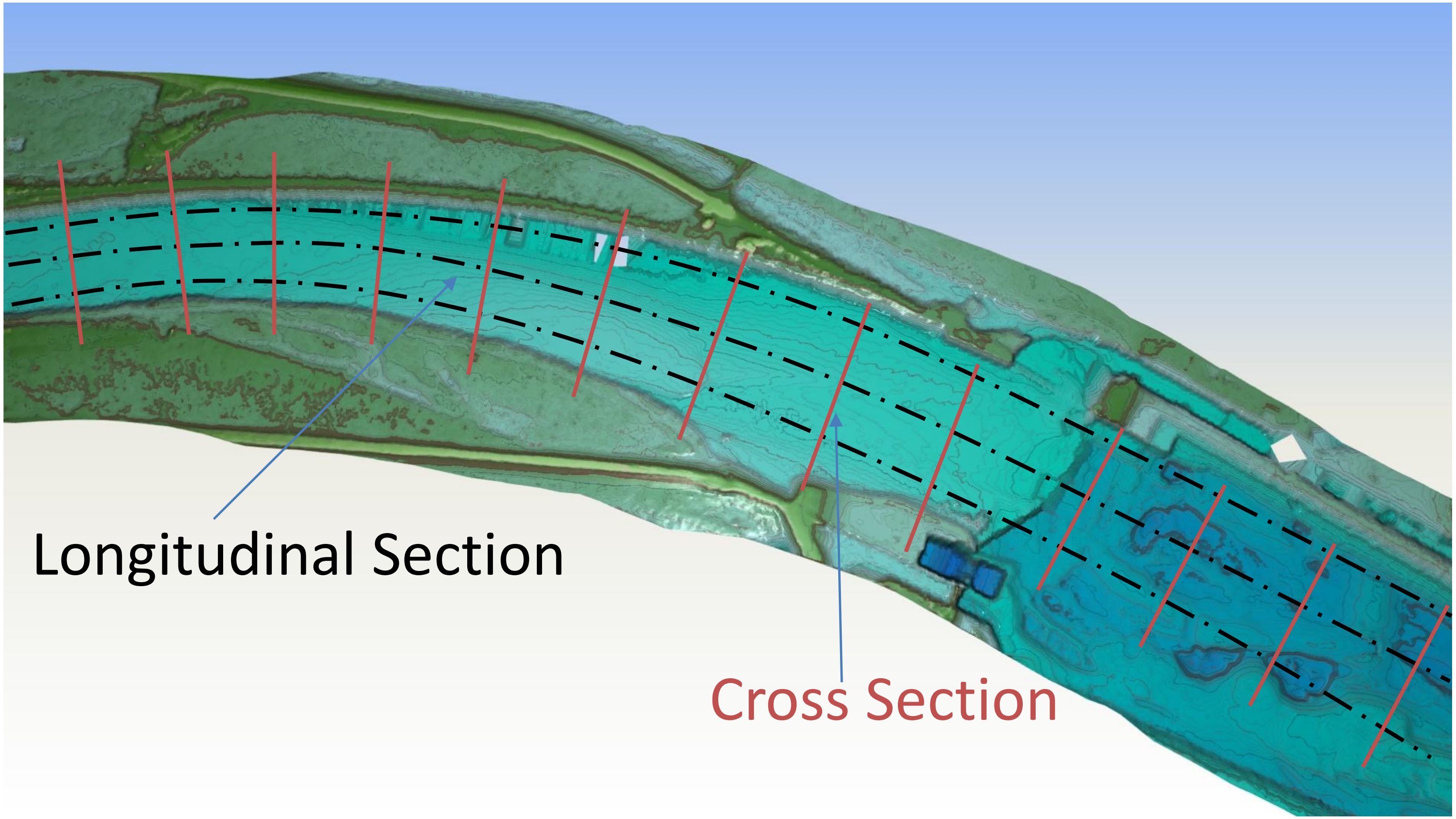


LiDAR Water Surface: reconstruct water surface based on 1x1 m cell. 99% Quantile is used



Mandlburger, G., Pfennigbauer, M. & Pfeifer, N., 2013

Reconstruct Water Surface based on a Curvilinear Grid (Transient interpolation)



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

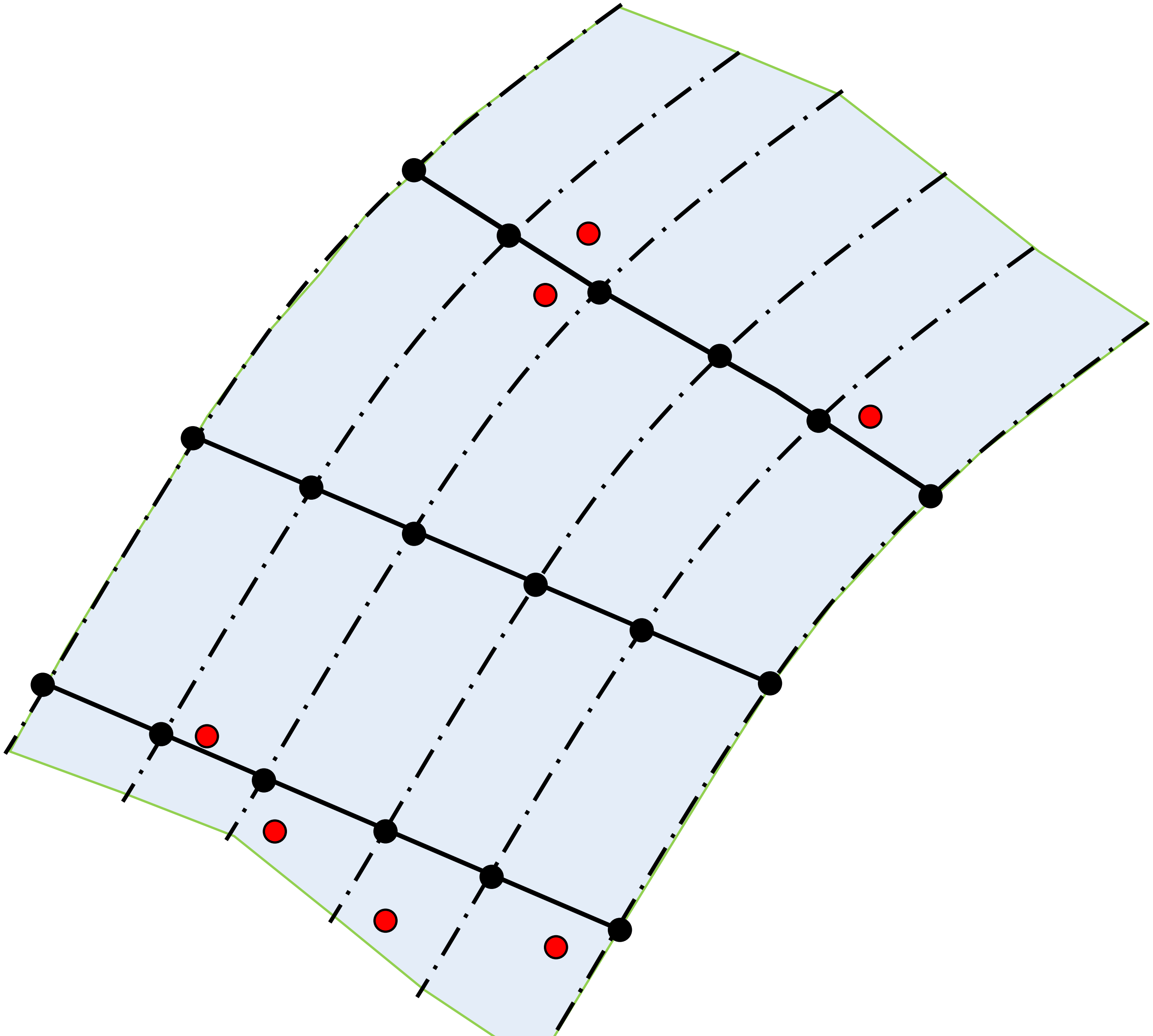
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

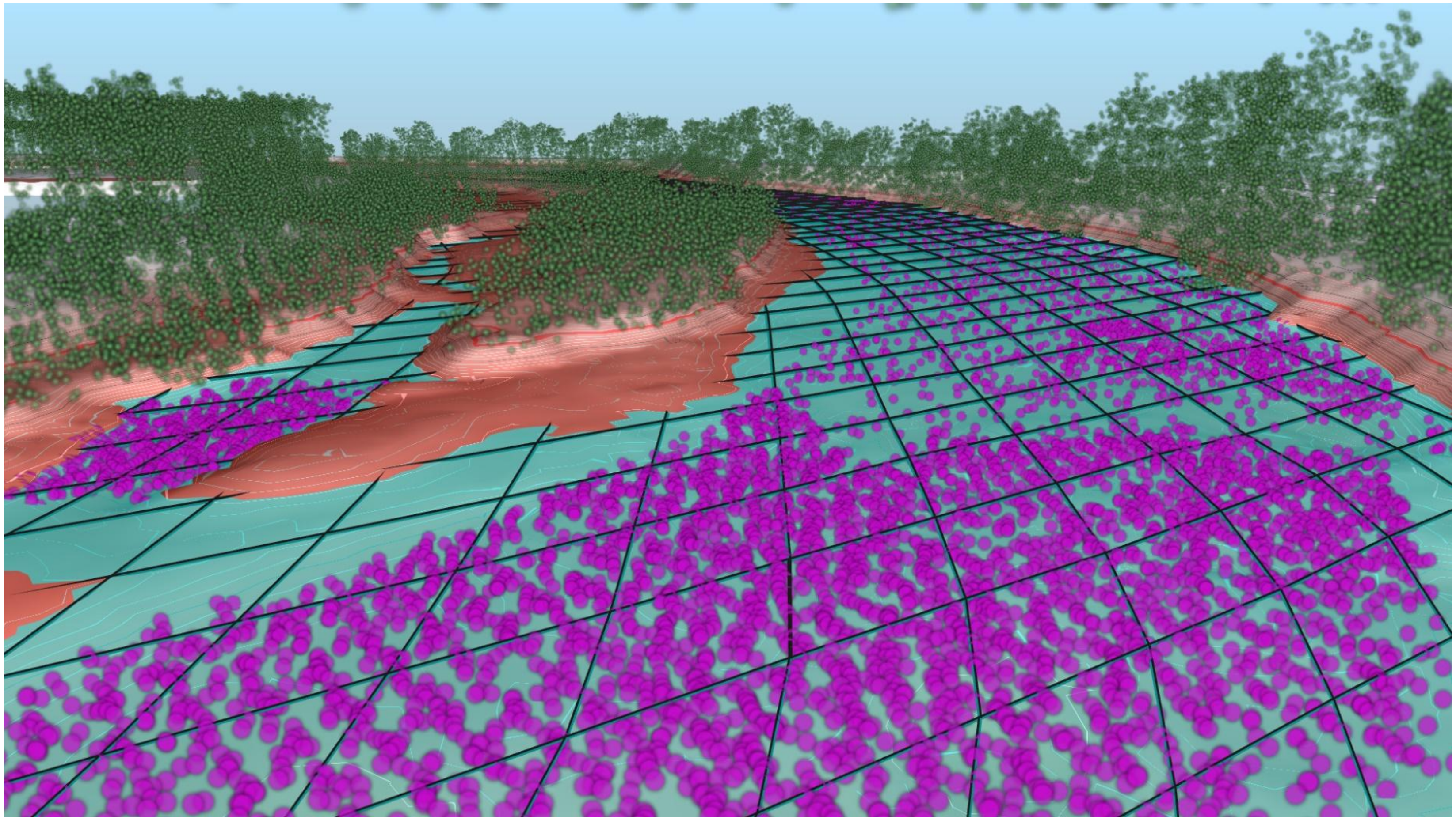
AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Reconstruct Water Surface based on a Curvilinear Grid (1m x 1m)



Reconstruct Water Surface based on a Curvilinear Grid



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

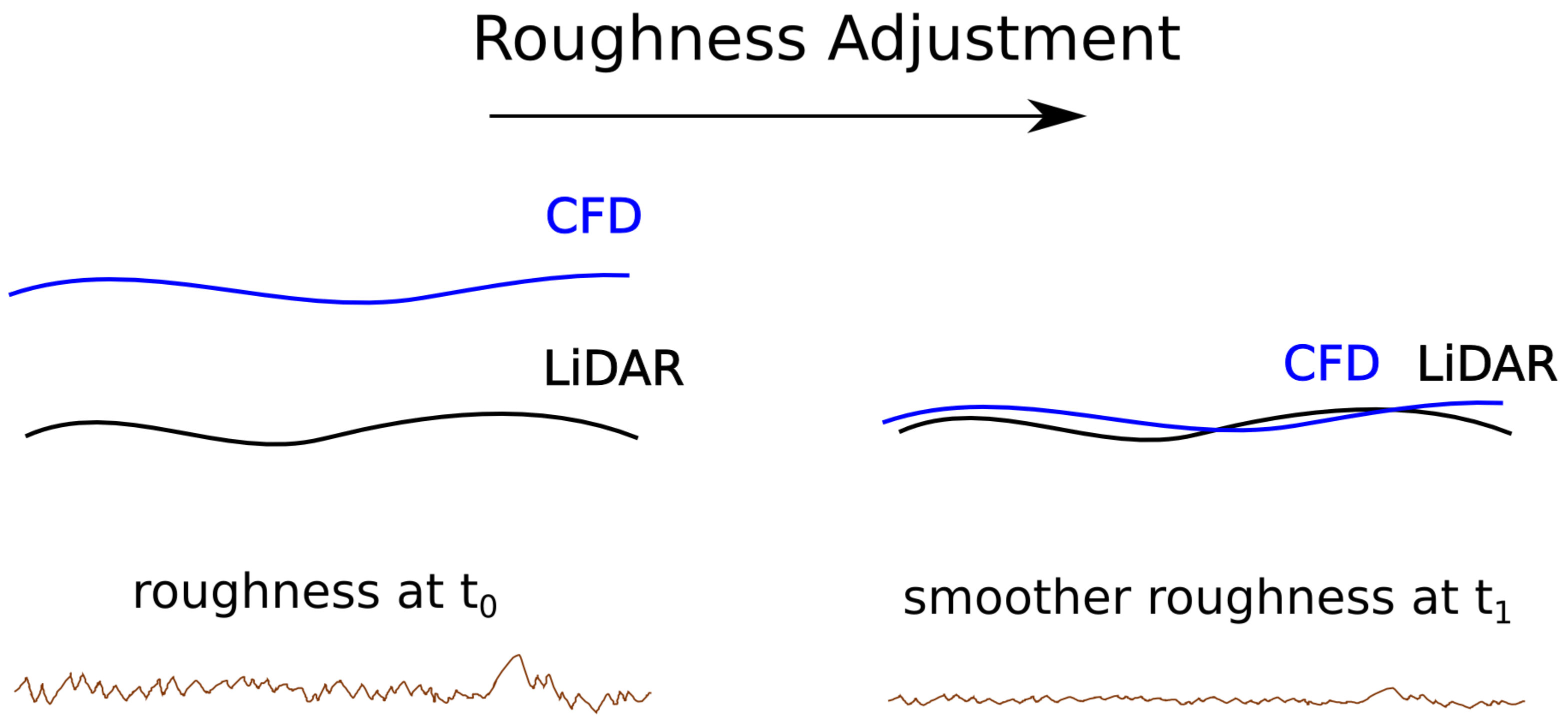
AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Calibration of the Telemac2d-Simulation:

- Discharge q=13.00 m^3/s
- Inlet: prescribed q
- Outlet: prescribed height
- Turb. model: constant eddy viscosity (0.1 m^2/s)
- Roughness: automatically calculated based on LiDAR Water Surface Model

Roughness height based on LiDAR



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

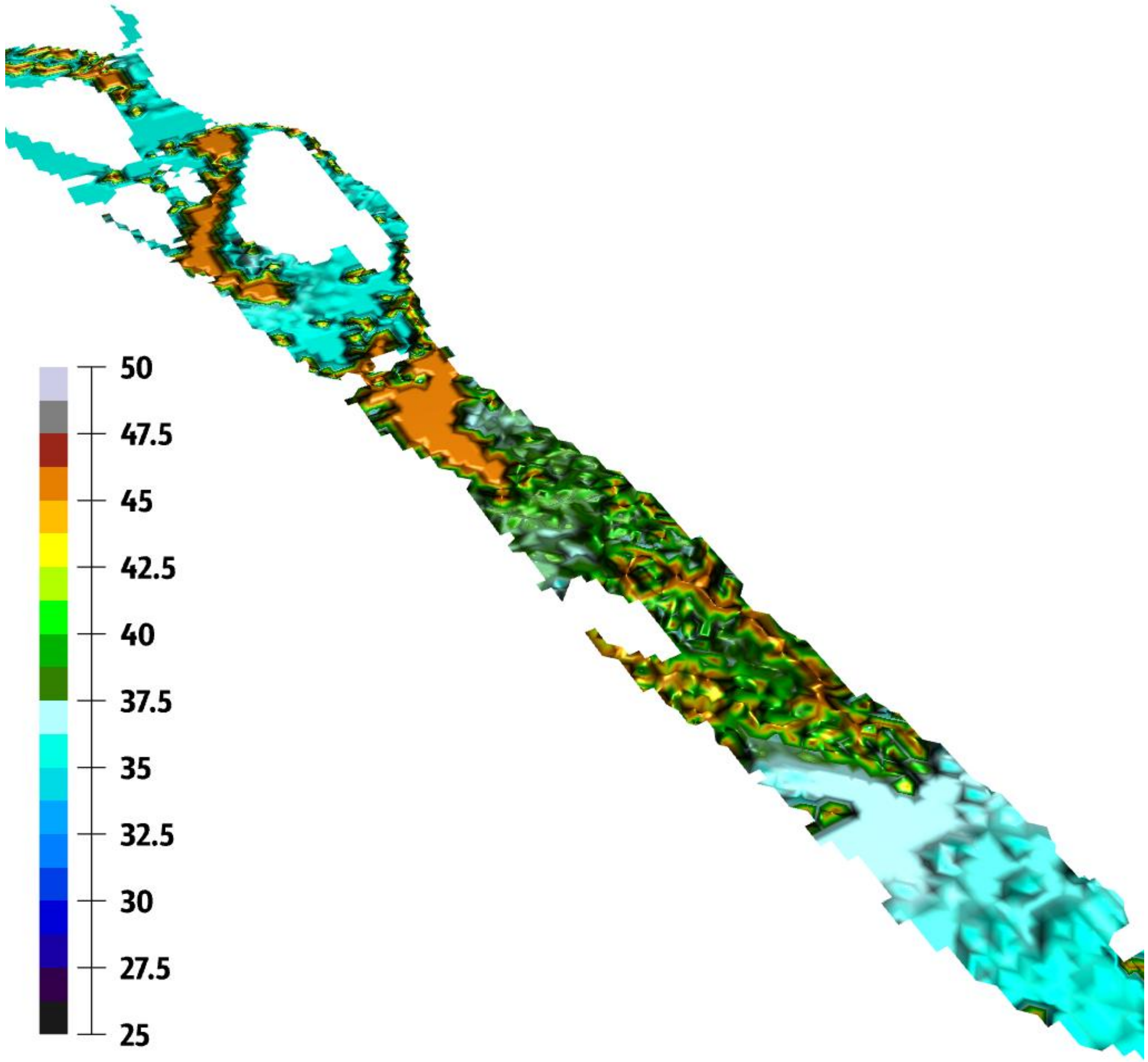
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

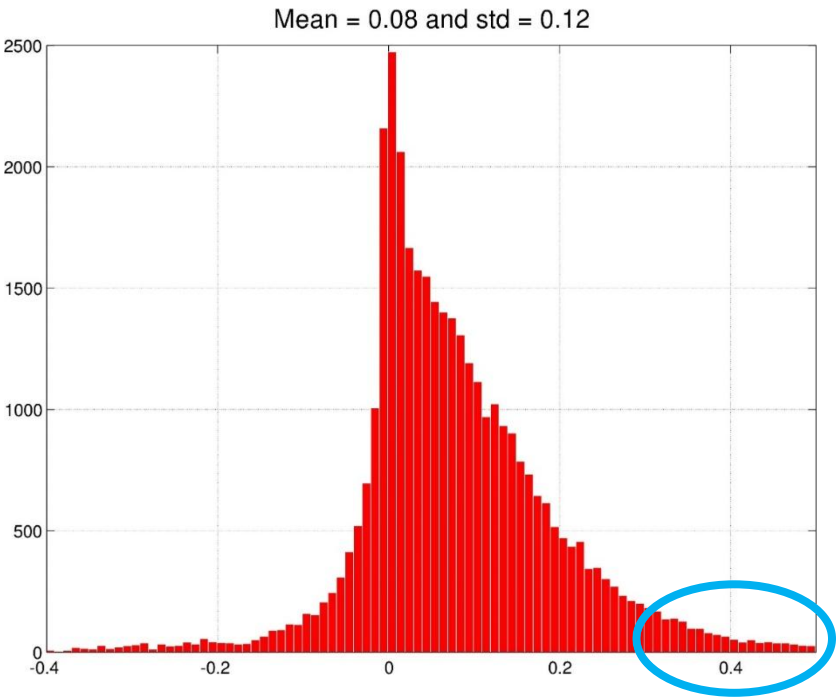
AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Based on LiDAR Water Surface intermediate Strickler values [$m^{1/3}/s$] are calculated



Difference of the water surface between CFD and LiDAR: 8 cm

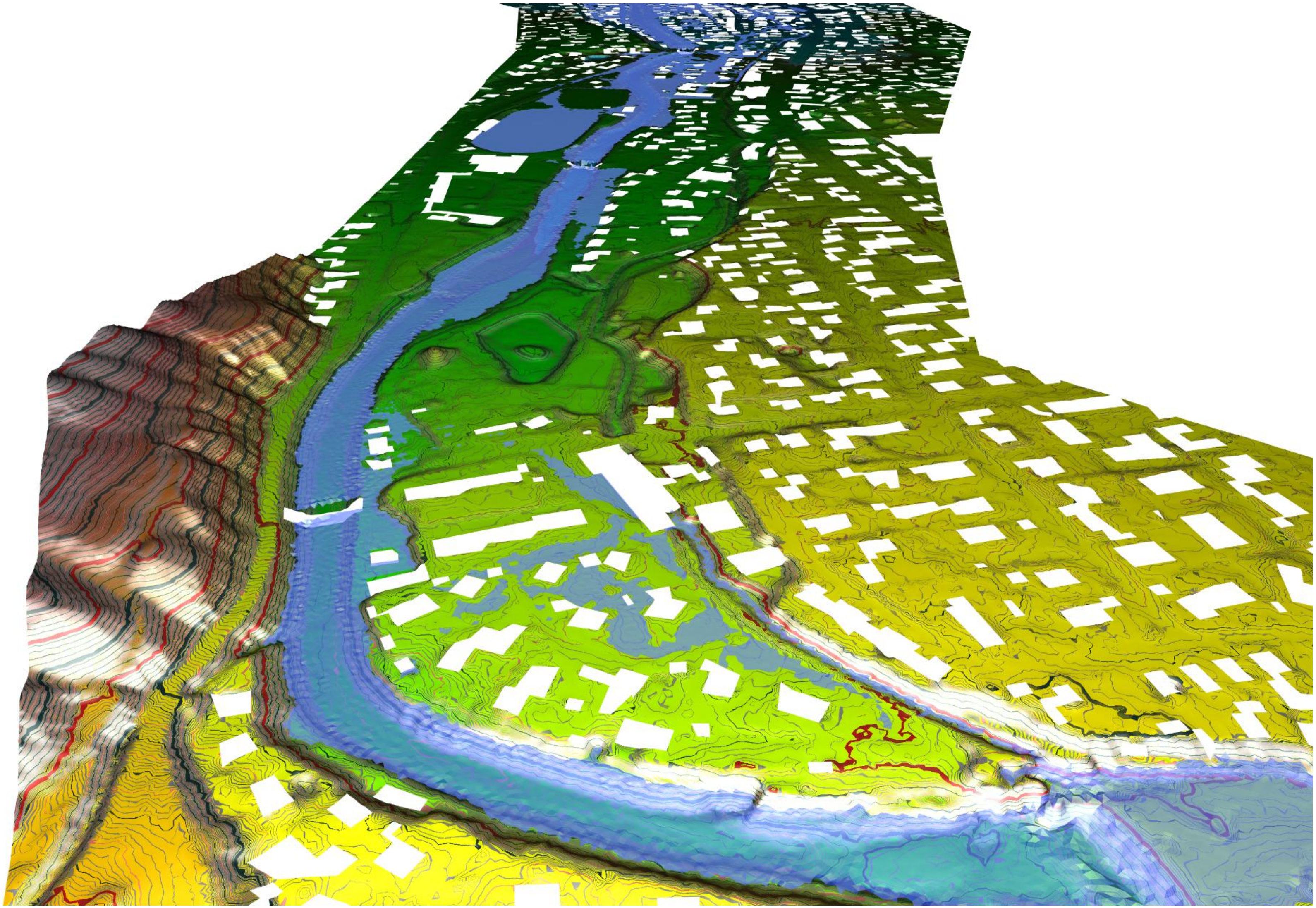


CFD Water surface in the domain is slightly higher than LiDAR (not including ~5cm signal penetration before first lidar echo)

-> different intensities of signal penetration (middle of river/bank area due to turbidity change in river sections)

-> adjustment of water table may be necessary – tendency of deeper signal penetration (for first echo) is an indicator for low turbidity.

Result of flood wave



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

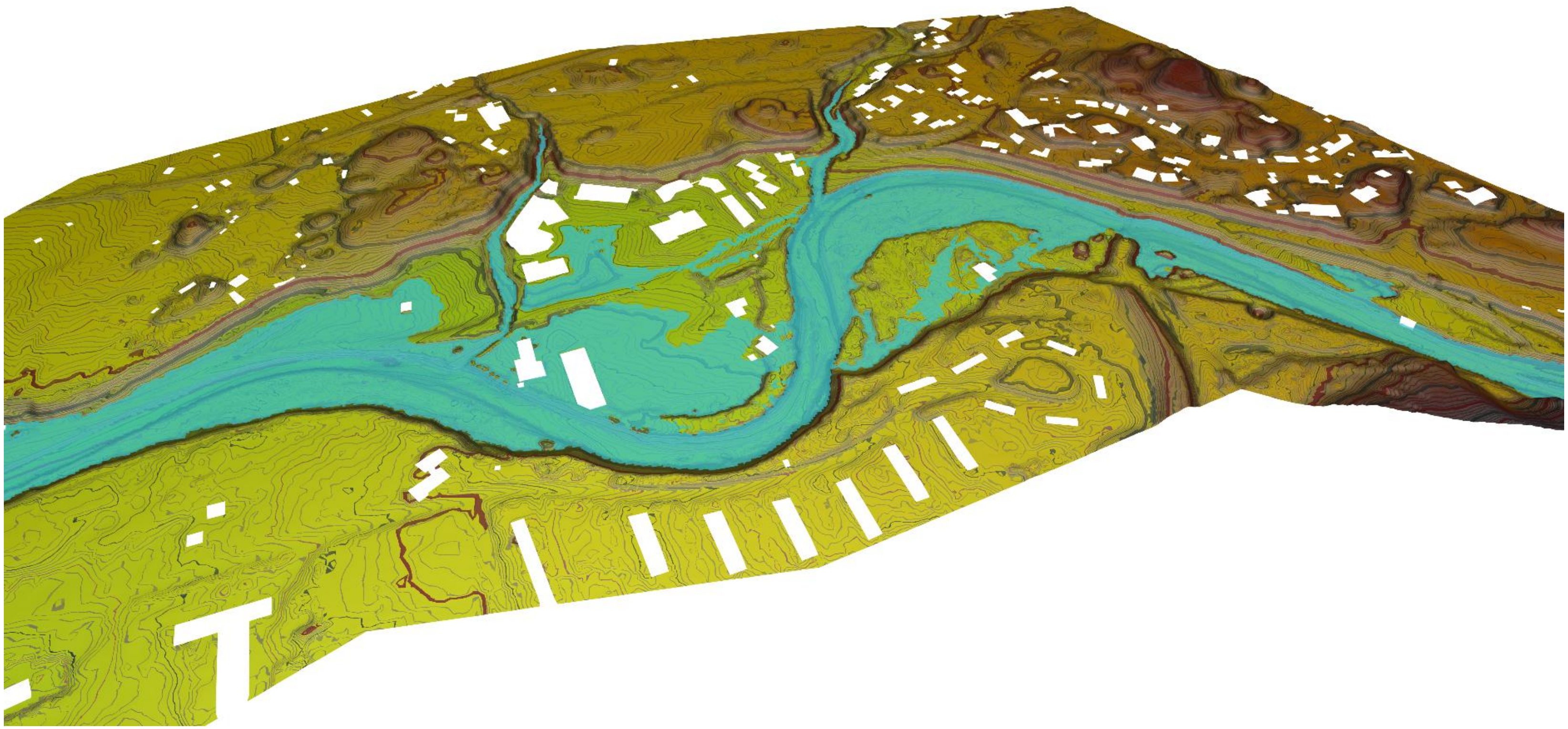
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Result of flood wave



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

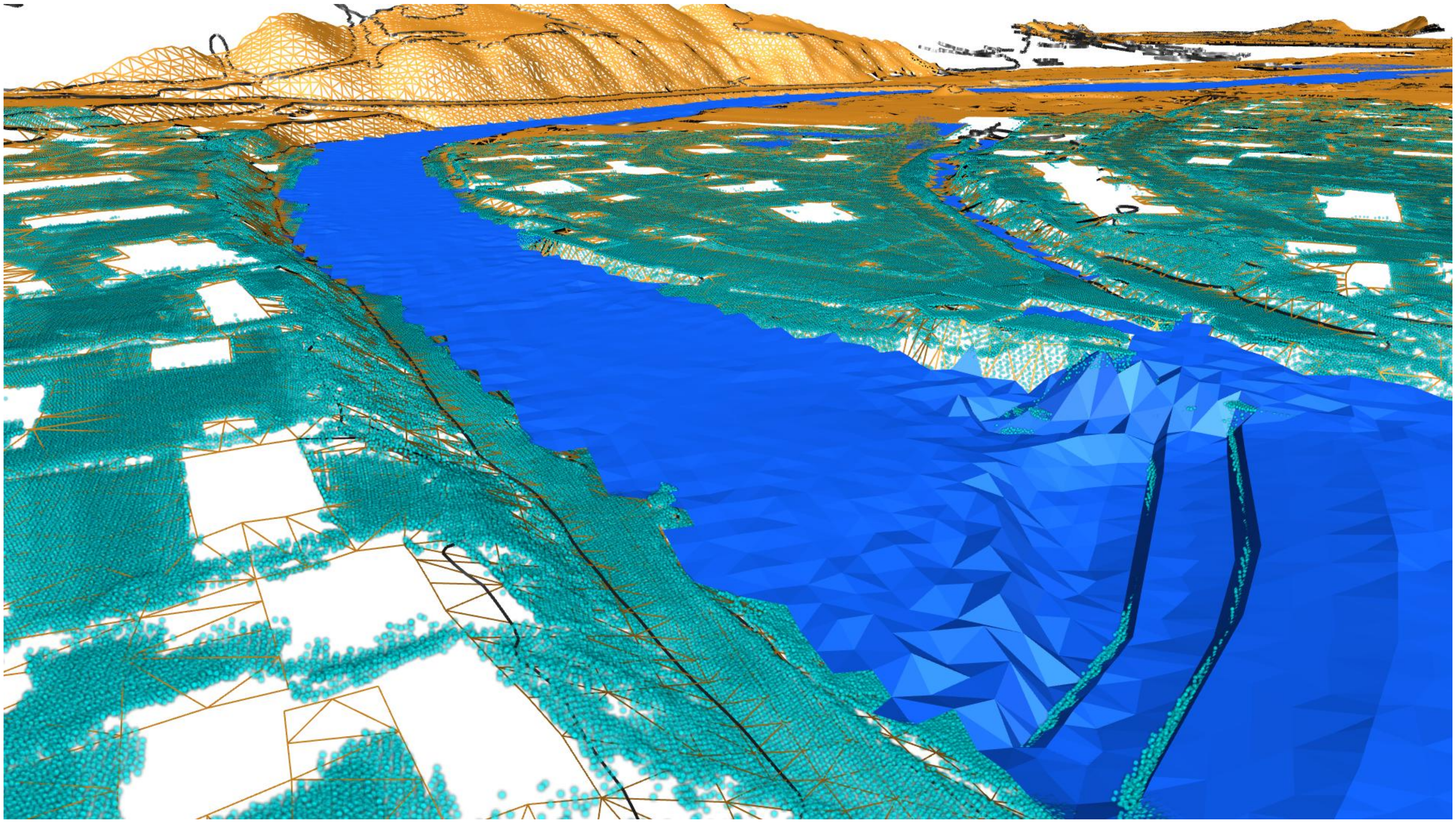
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

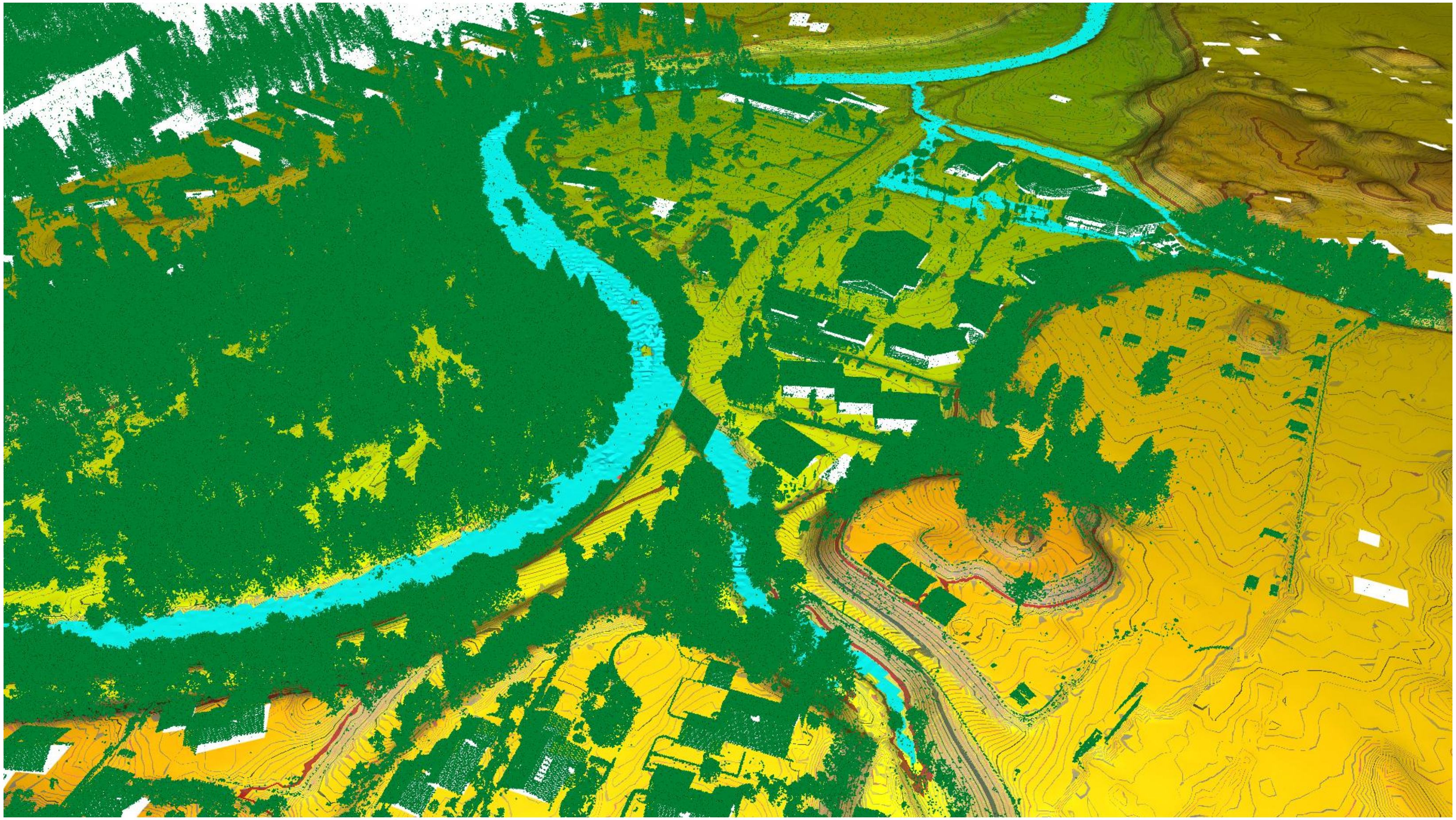
AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Result of flood wave



Result of flood wave



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

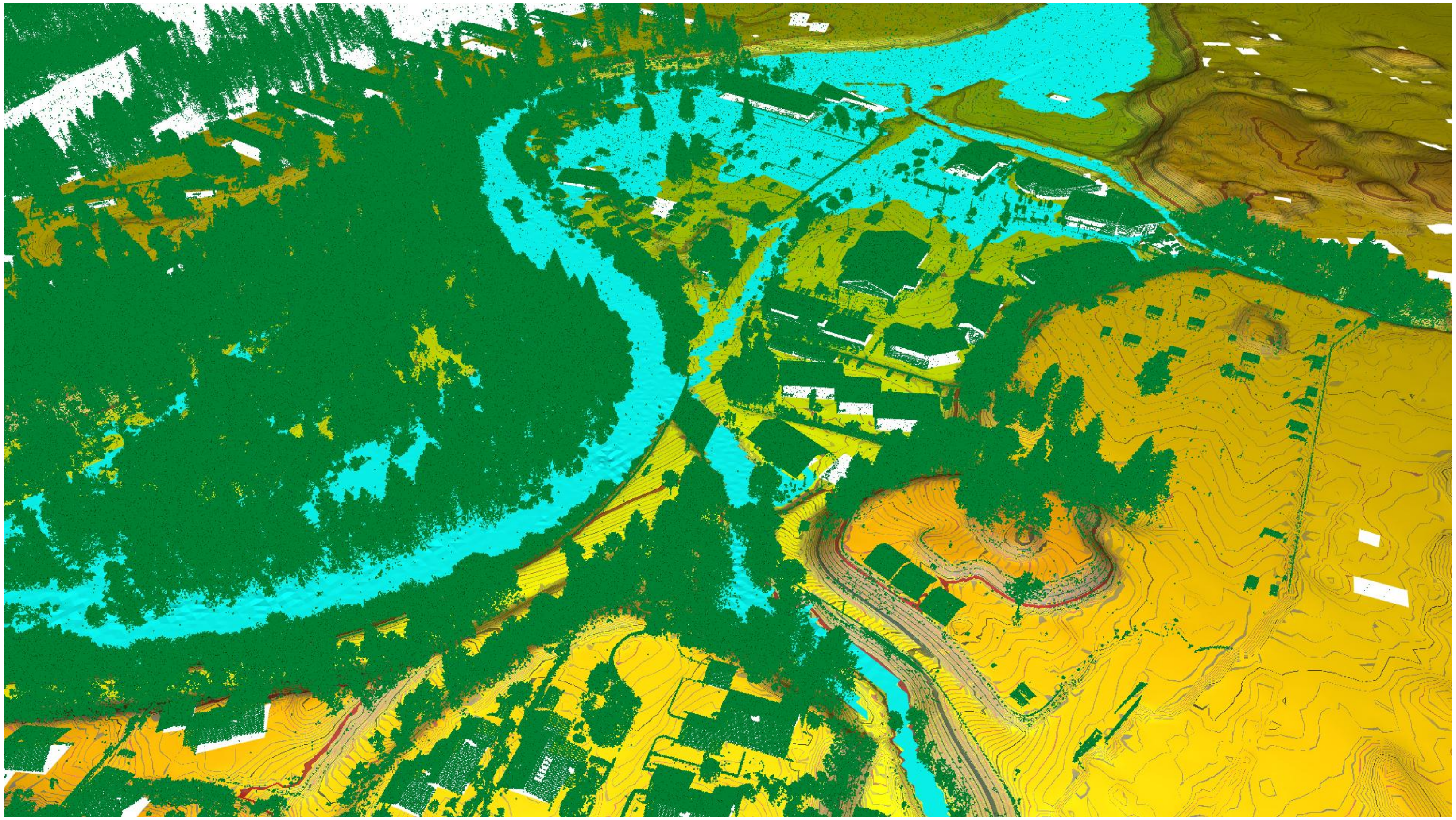
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Result of flood wave



GREENSURVEY

AIRBORNE HYDRO MAPPING

AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Conclusion:

1. Topo-Bathymetry (25 – 40 pts/m^2) provides better data for hydraulic modelling and calibration due to spatial, dense geometrical information of water surface, foreland and river bed compared to classical approaches.
2. High point density needed to guarantee a high quality water surface model for refraction and run-time correction.
3. First echo penetration depends on water depth, water surface conditions and turbidity.
4. Reconstruction of Water surface model based on survey points (99% quantile) and a curvilinear grid
5. Time for hydraulic modelling improved due to reduced work load on mesh generation

GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

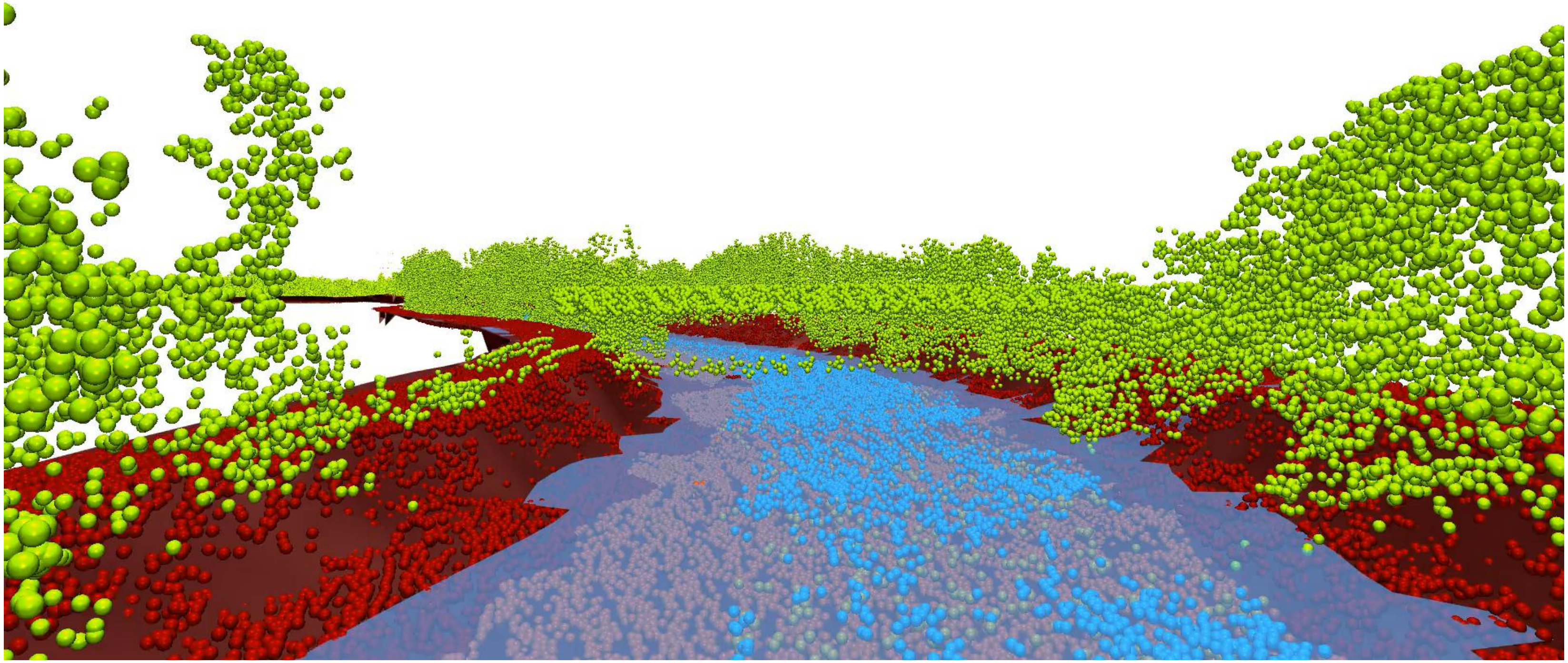
AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Thank you!



GREENSURVEY

AIRBORNE HYDRO MAPPING

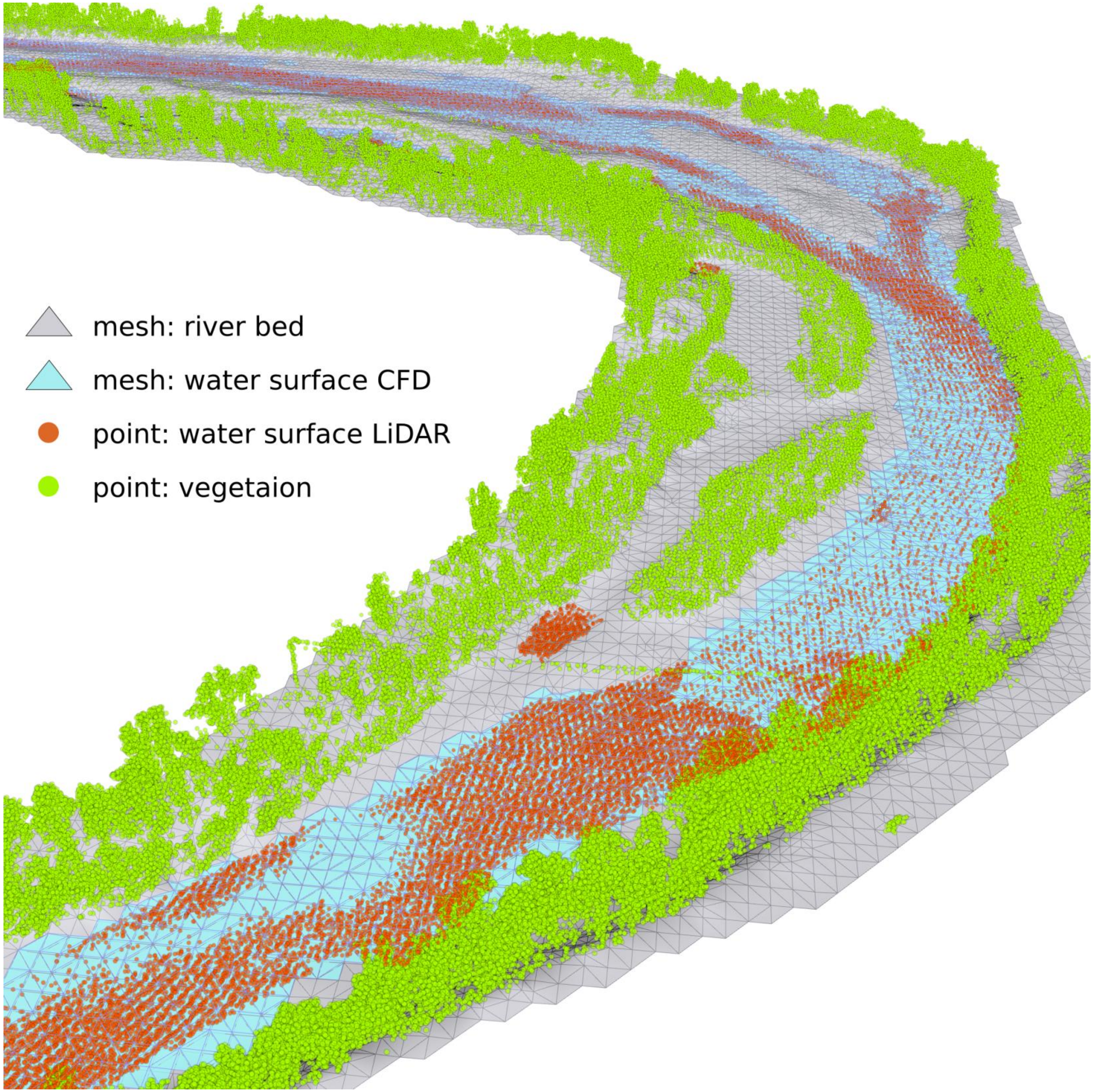
AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

universität innsbruck

Thank you!



GREENSURVEY

AIRBORNE HYDRO MAPPING

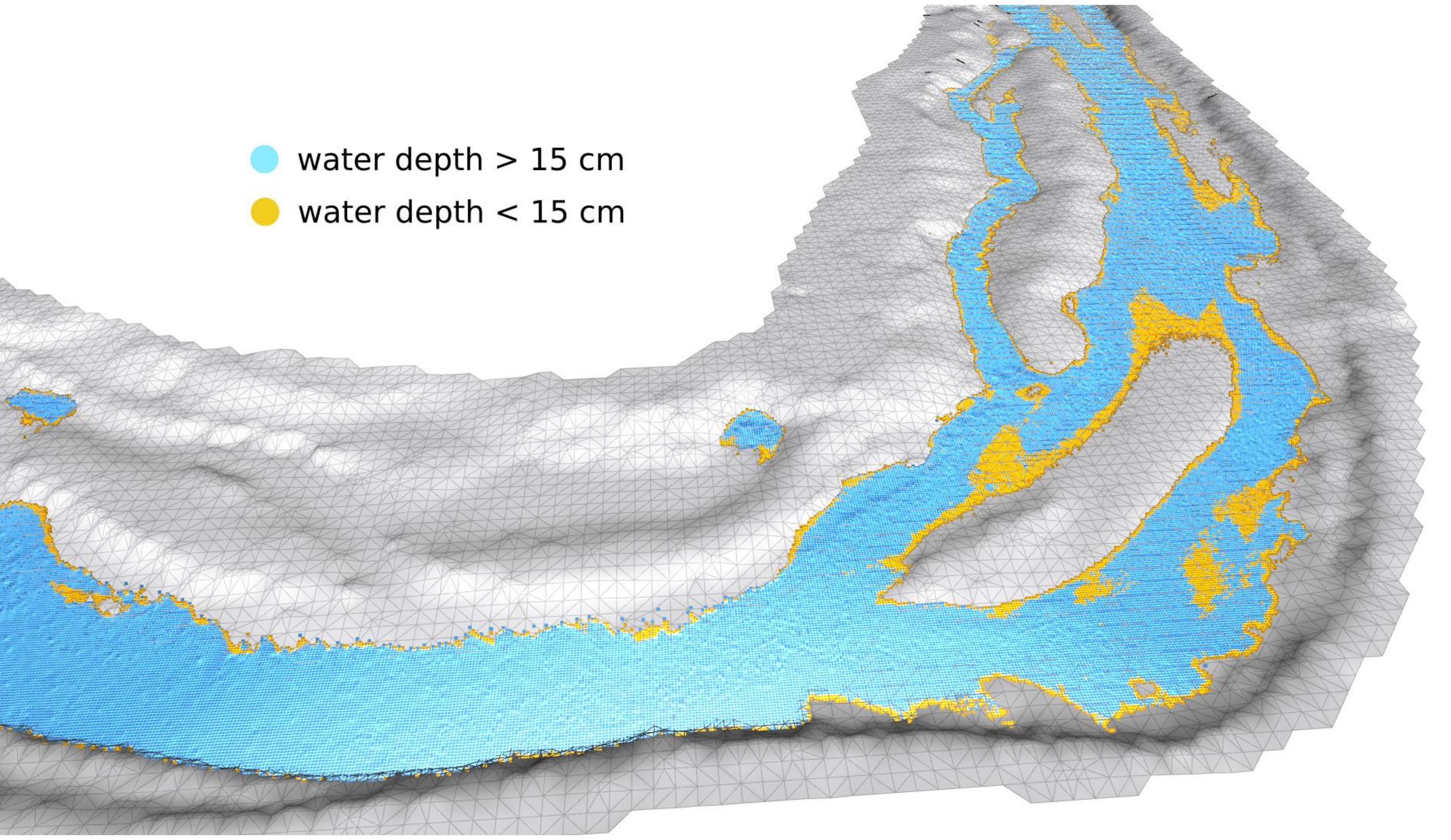
AIRBORNE LAND MAPPING

AIRBORNE NATURE MAPPING

AIRBORNE ICE&SNOW MAPPING

universität innsbruck

LiDAR Water Surface: For very shallow waters (< 15cm) no water surface points are measured



GREENSURVEY

AHM AIRBORNE HYDRO MAPPING

AHM AIRBORNE LAND MAPPING

AHM AIRBORNE NATURE MAPPING

AHM AIRBORNE ICE&SNOW MAPPING

universität innsbruck