BORKY

Tree heights estimation from photogrammetric and laser data

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The aim

- Tree height evaluation based on aerial images and accurate DTM data
- Evaluation of the suitability of winter aerial images for DTM creation over forested areas

Metodological approach

Data inputs

Data processing

Tree height extraction

Metodological approach

Data inputs

DTM from Czech Cadastral service CUZK

Laser scanning data

Aerial images

Ground true reference data

Metodological approach

Data processing

Laser data	Point cloud classification Extraction of terrain points DTM interpolation
Aerial images	Images preprocessing Creation of DTM Creation of DSM

DTM: Photogrammetric method

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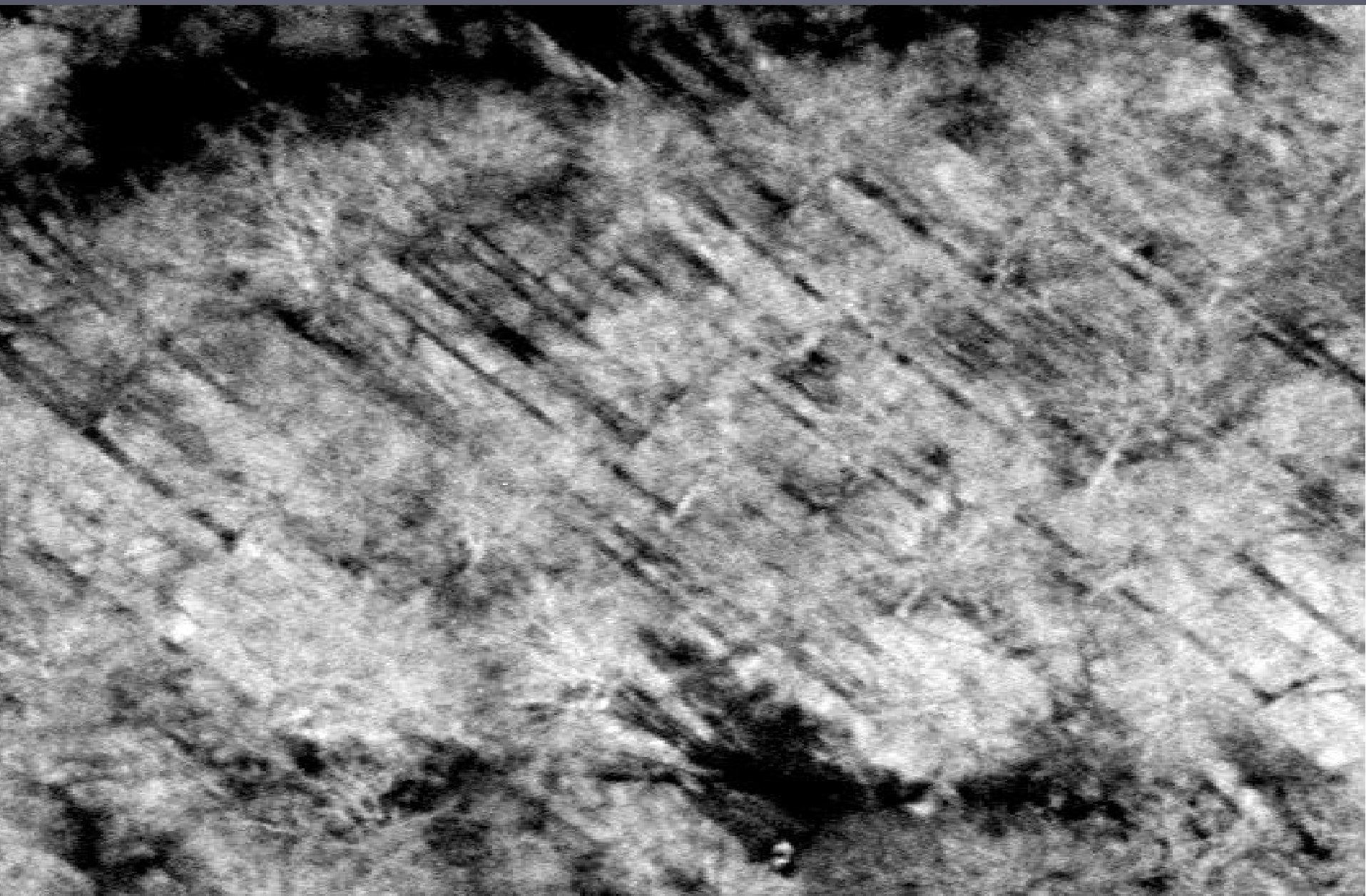
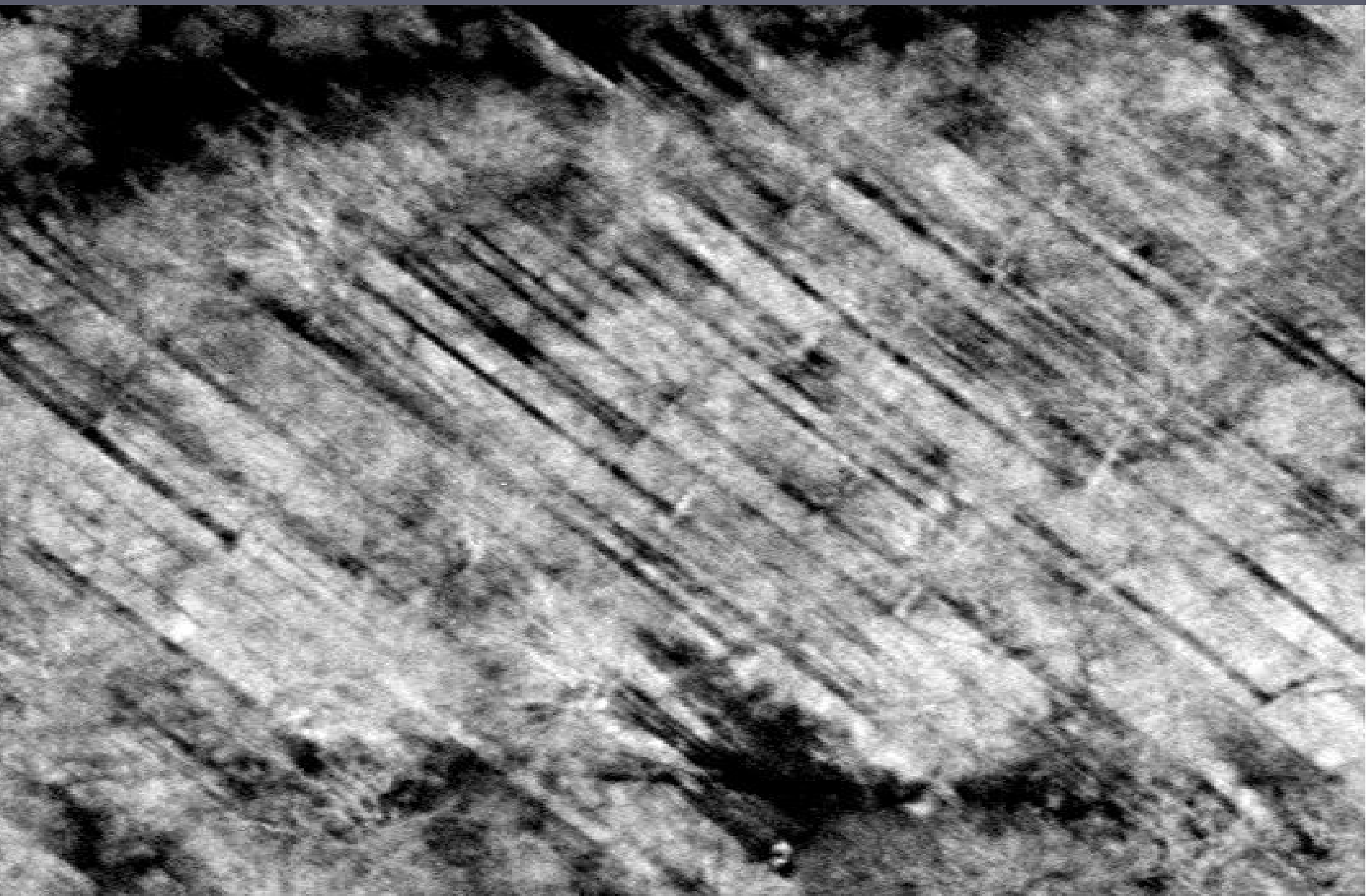
- DTM creation using image matching techiques
- DTM creation from manually measured points

DTM: Photogrammetric method



DTM: Photogrammetric method



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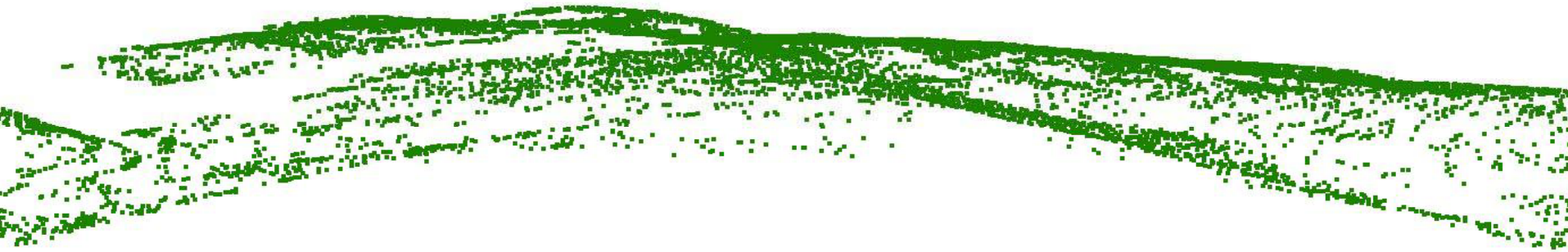
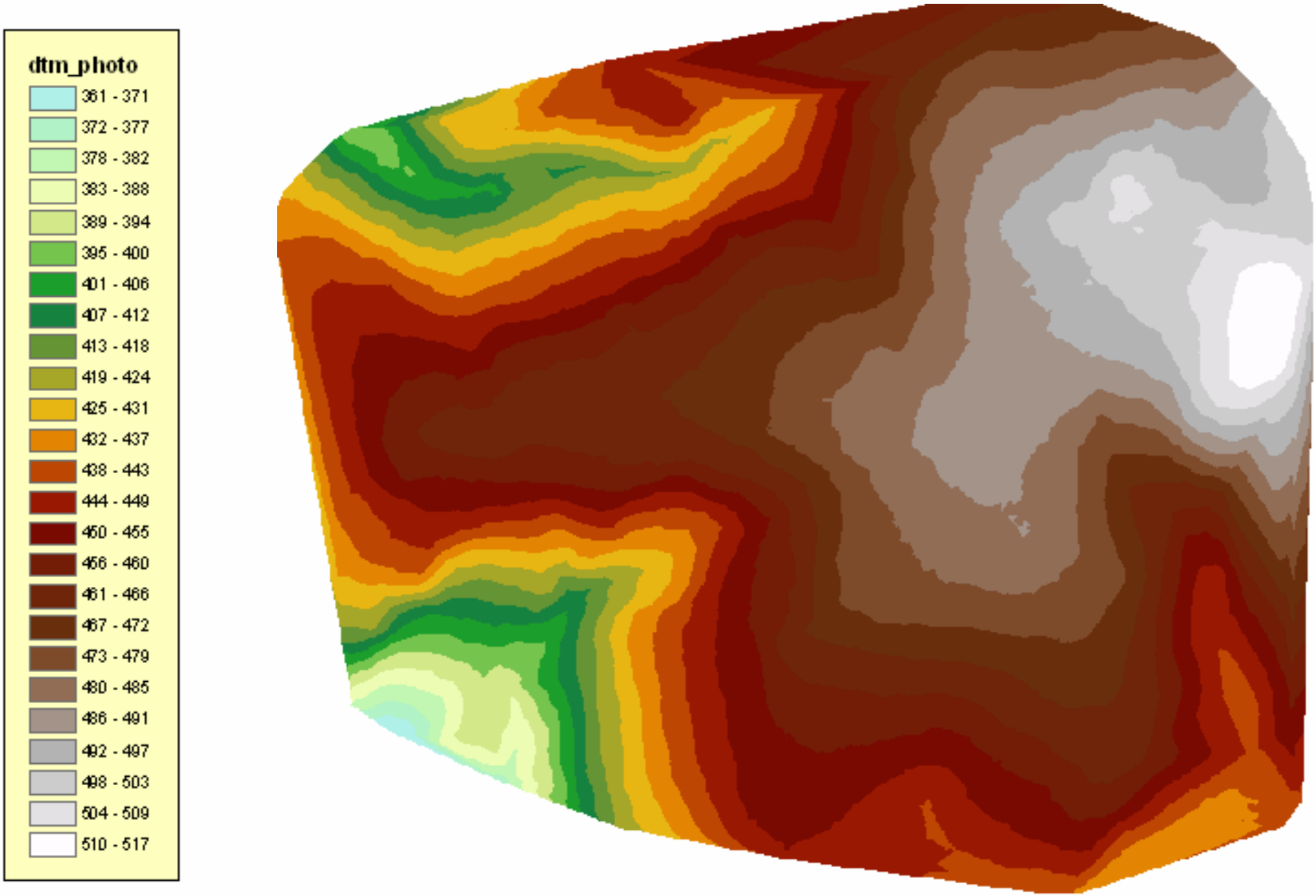


DTM: Photogrammetric method



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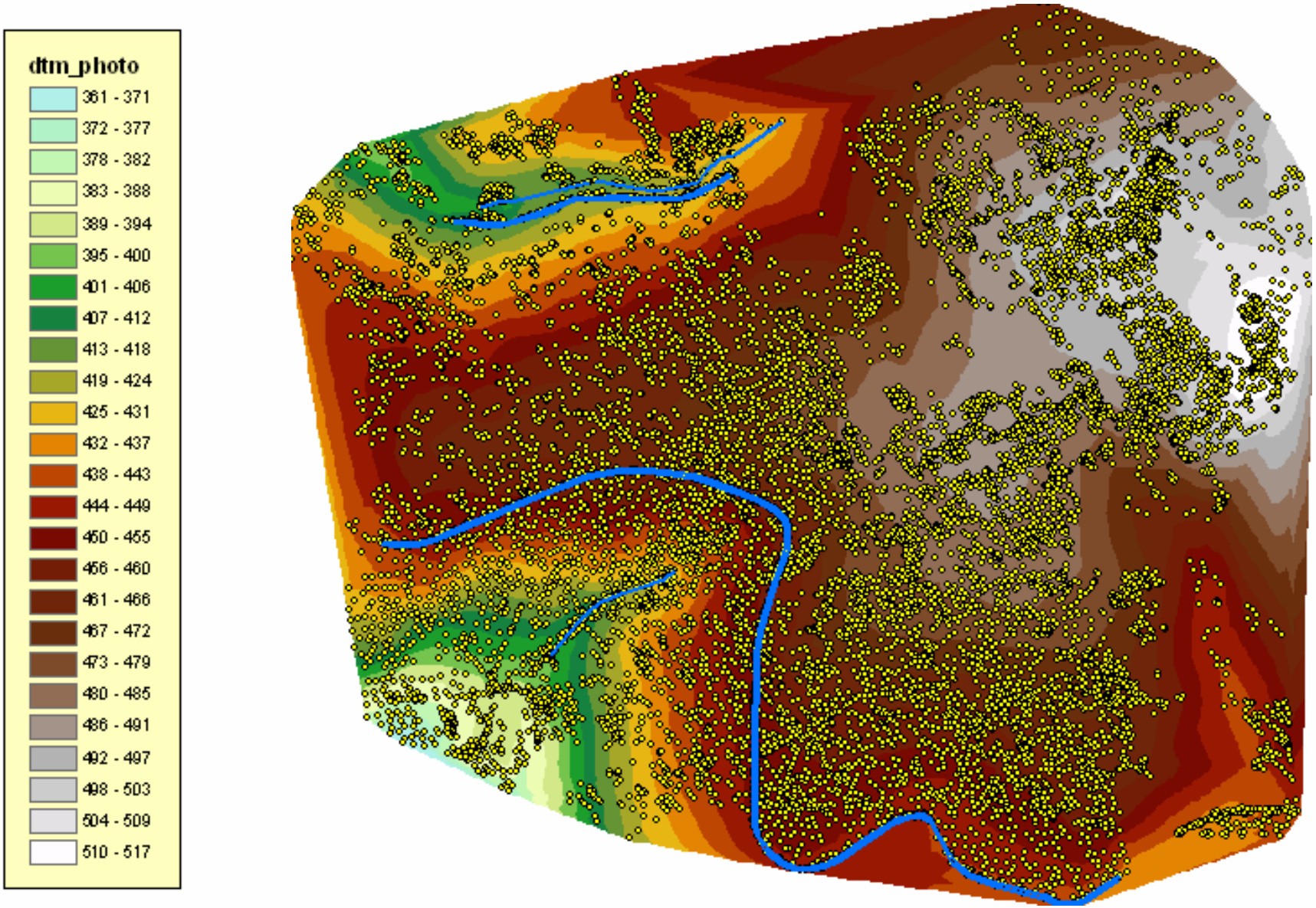
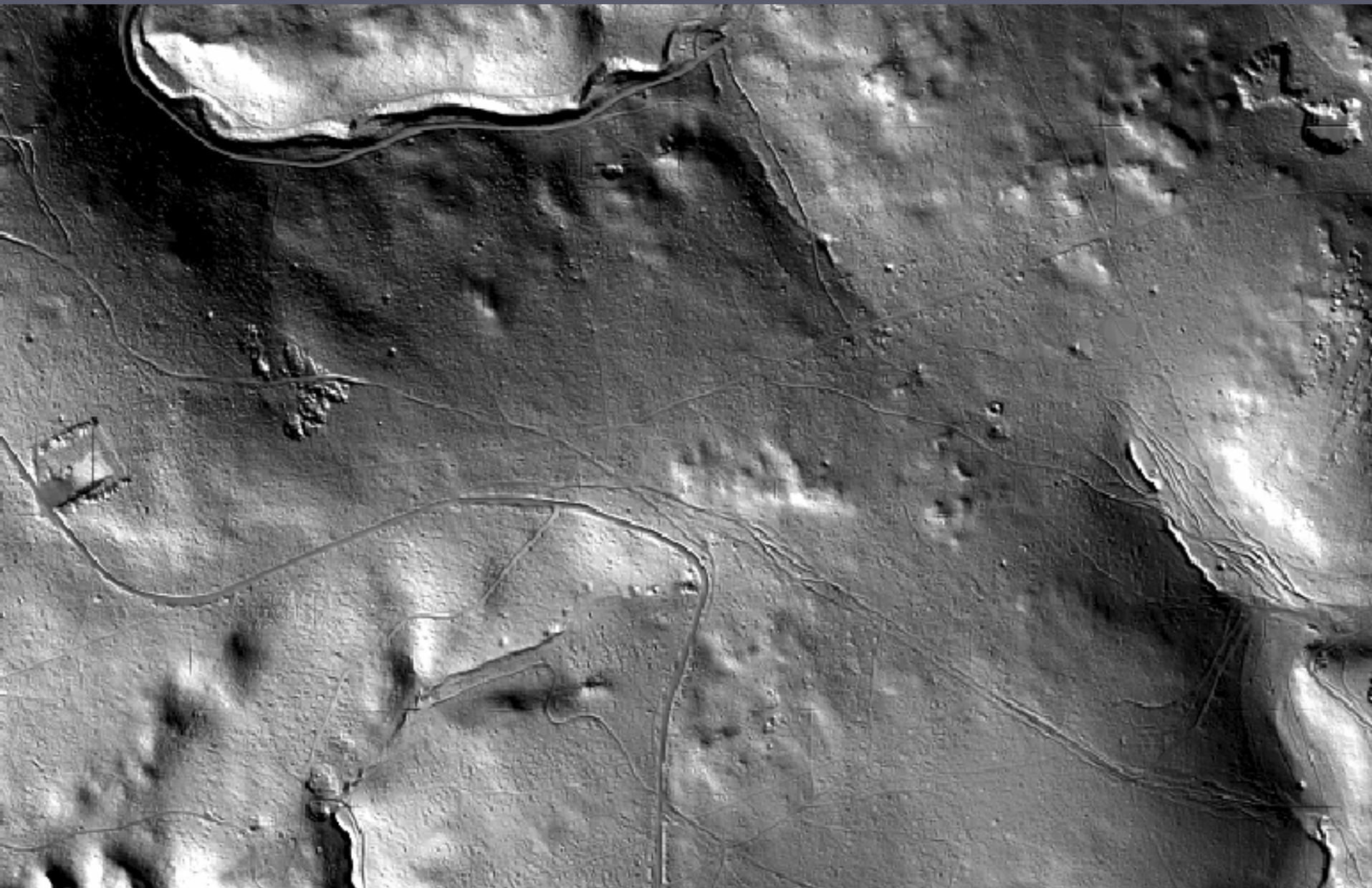


Laser DTM

- High accuracy
- Fast creation of DTM
- No special photogrammetric software needed
- Higher costs
- Missing spectral information

- **The best DTM results**

DTM: Laser

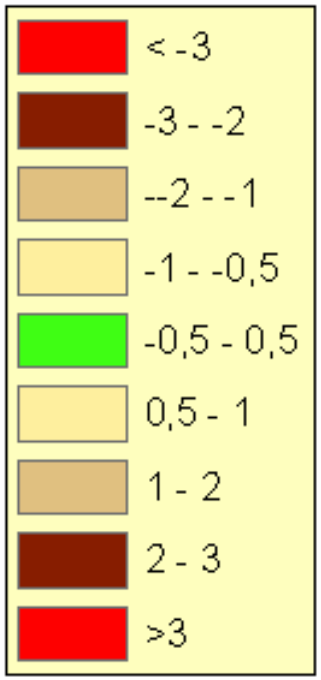


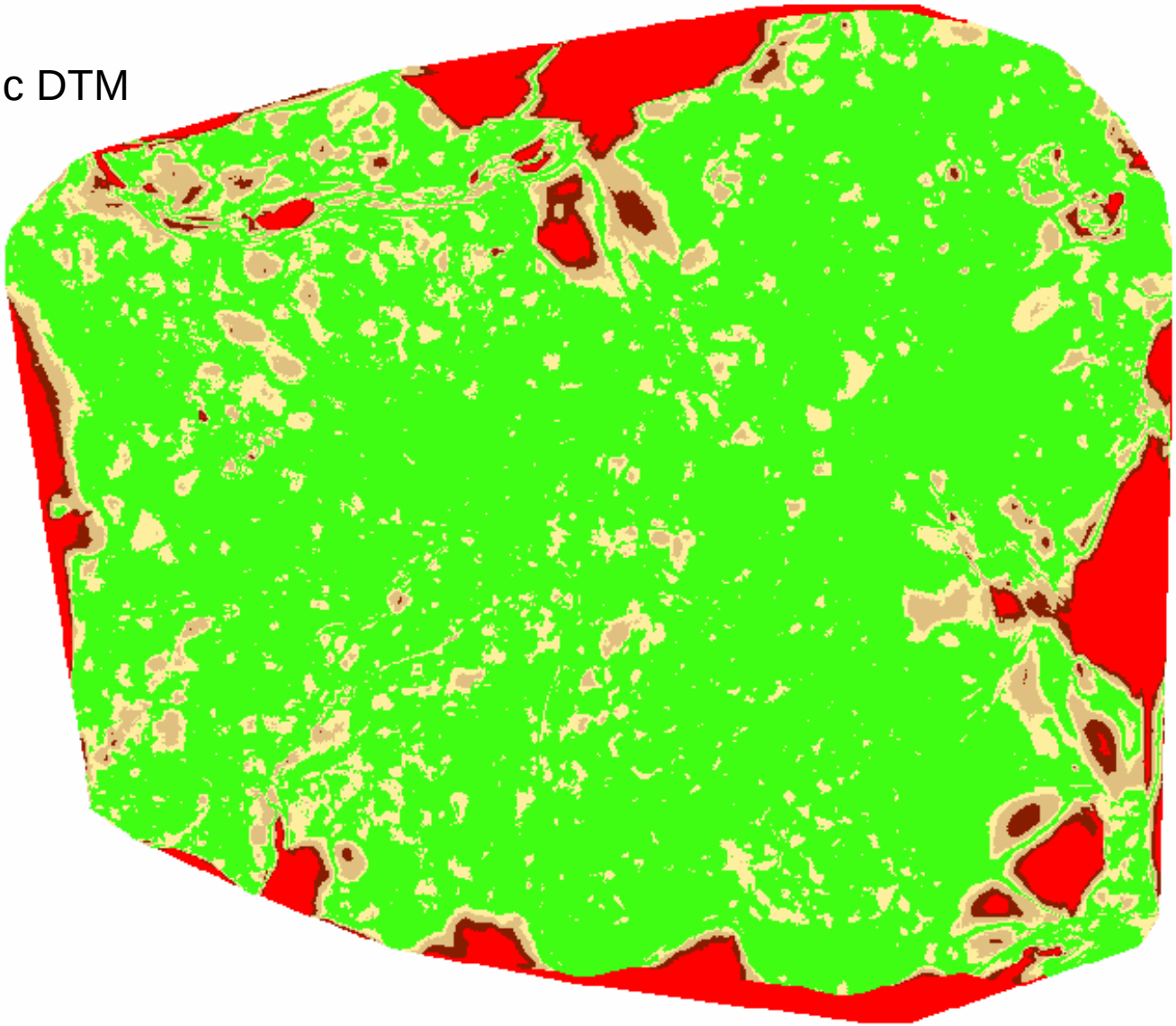
DTM: Laser

DTM: Quality assesment

Laser-Photogrammetric DTM

Difference [m]

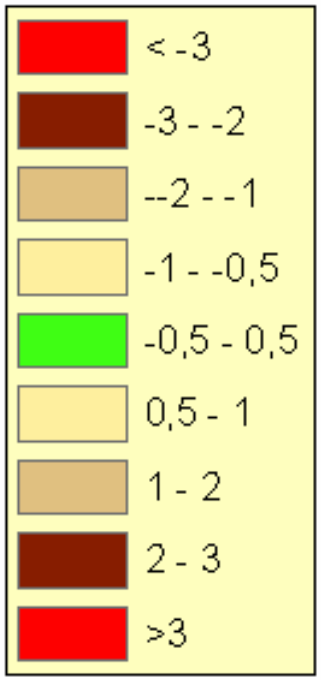


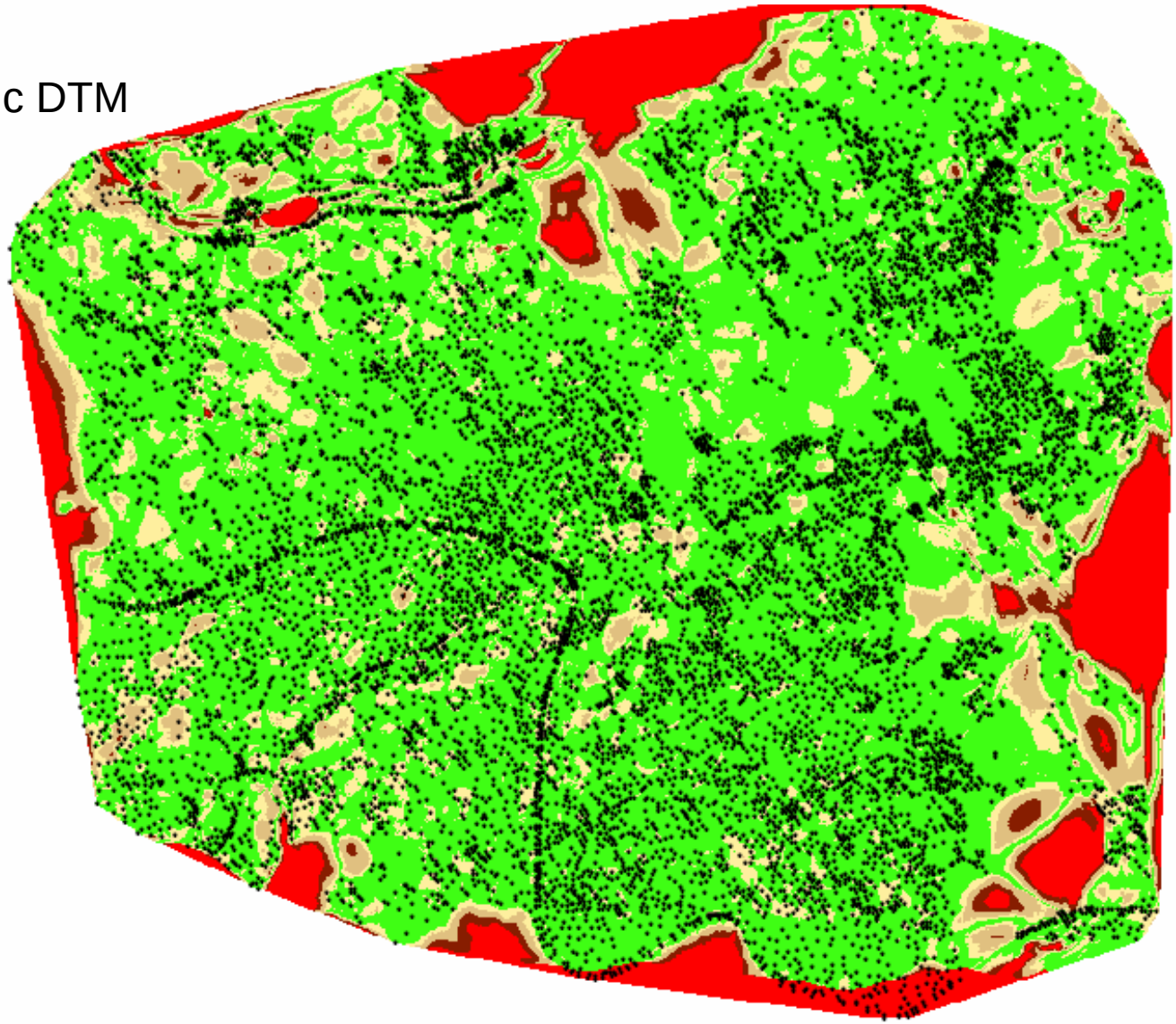


DTM: Quality assesment

Laser-Photogrammetric DTM

Difference [m]





DSM creation

- **Sommer images**
- Nominal scale 1:10 000
- Scanned to 15 microns
- Radiometric resolution 8bits per band
- First principal component used
- Extraction of DSM points

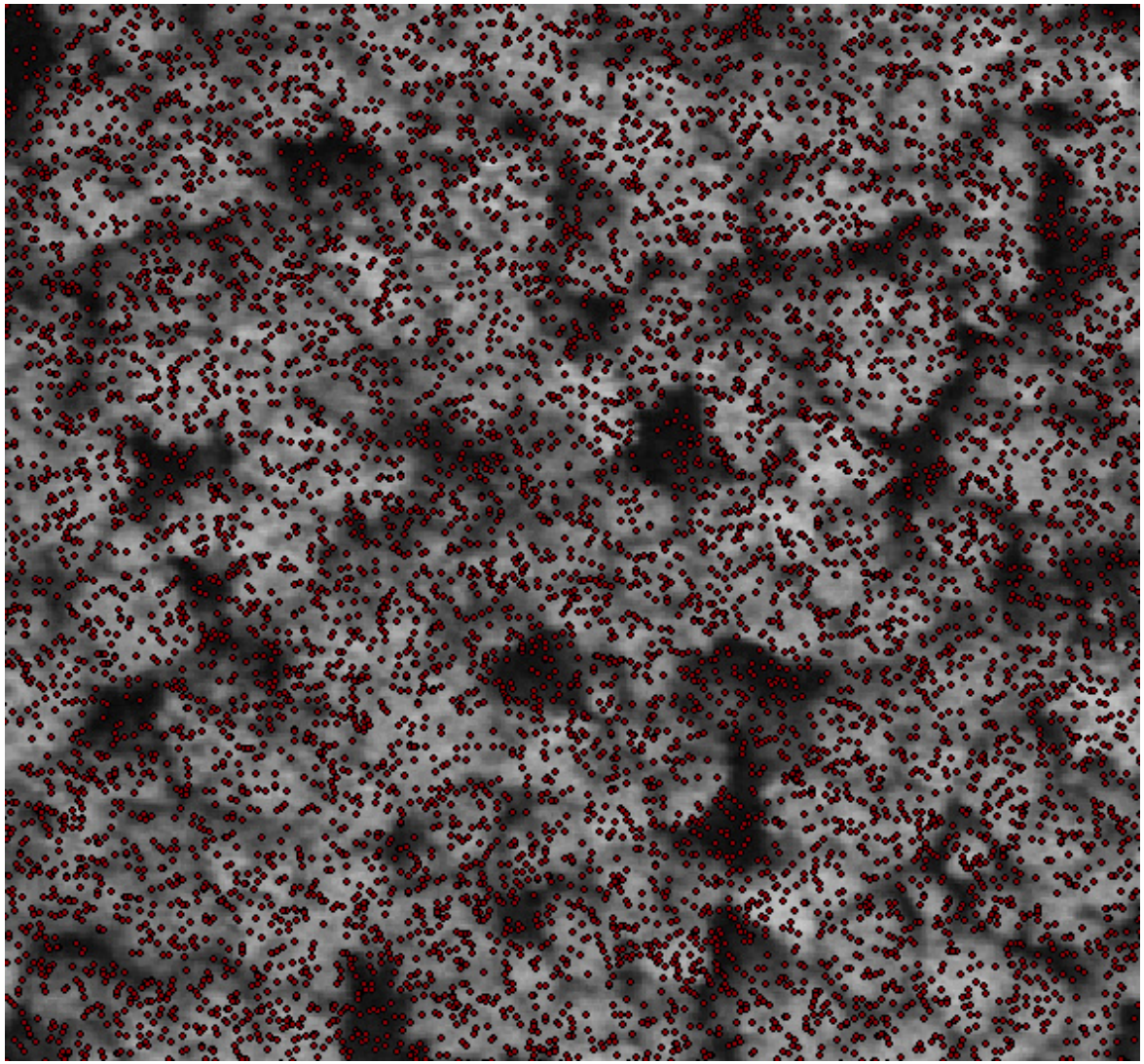
nDSM filtering

- Leave one out cross validation - ordinary kriging approach (nDSM value is predicted on each point, using surrounding points, based on the difference between true and predicted nDSM value and the variance of prediction, probability of each point is evaluated, low probability points are filtered out)
- Local histogram filtering (cutoff treshold 2.5 % on both sides)

Size of crowns

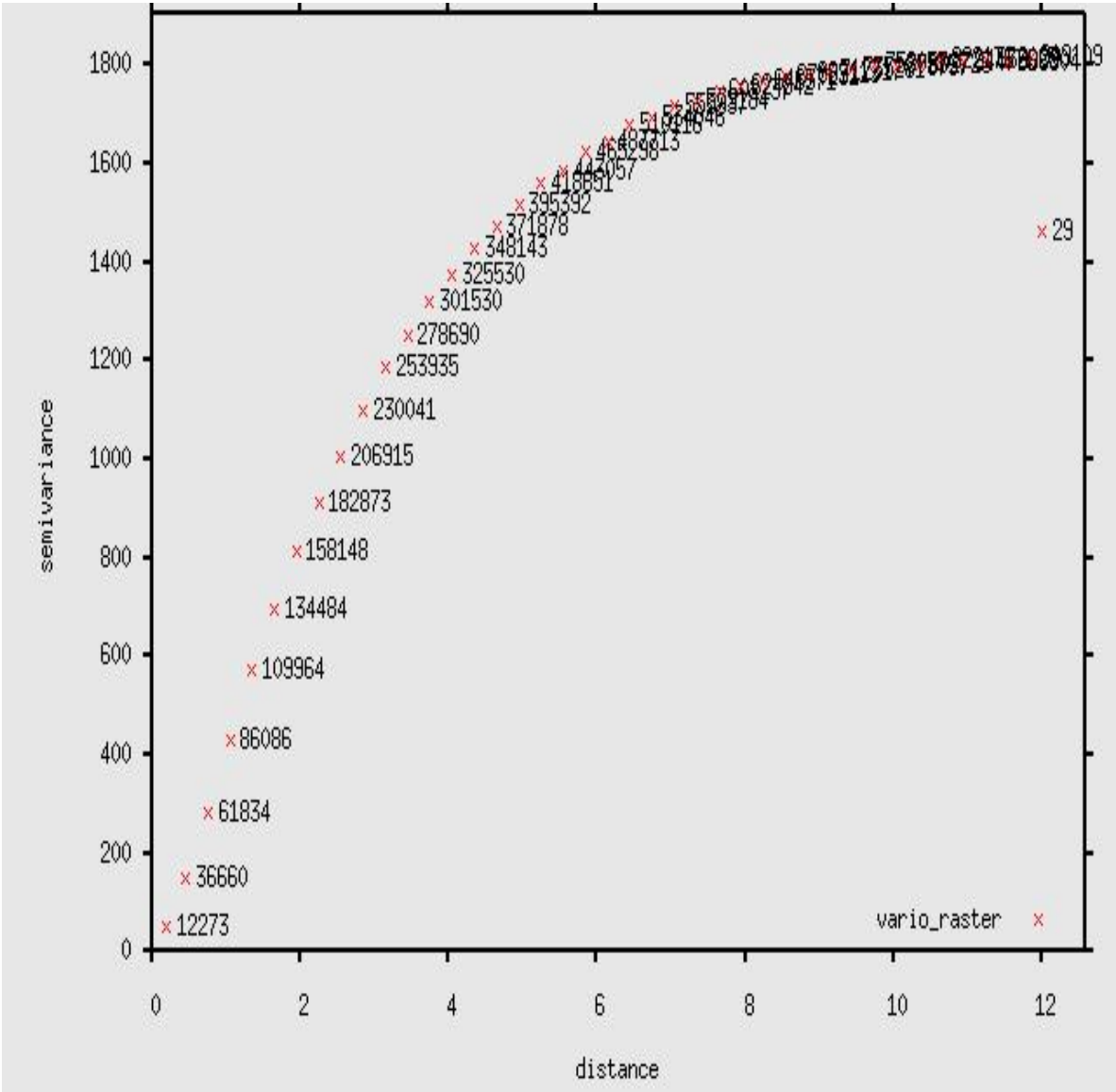
- Needed to assure size of neighbourhood of tree tops, when selecting relevant nDSM points
- The semivariogram modelling technique has been used, input data were DN from red band of the spectrozonal image

SAMPLING of red band digital values



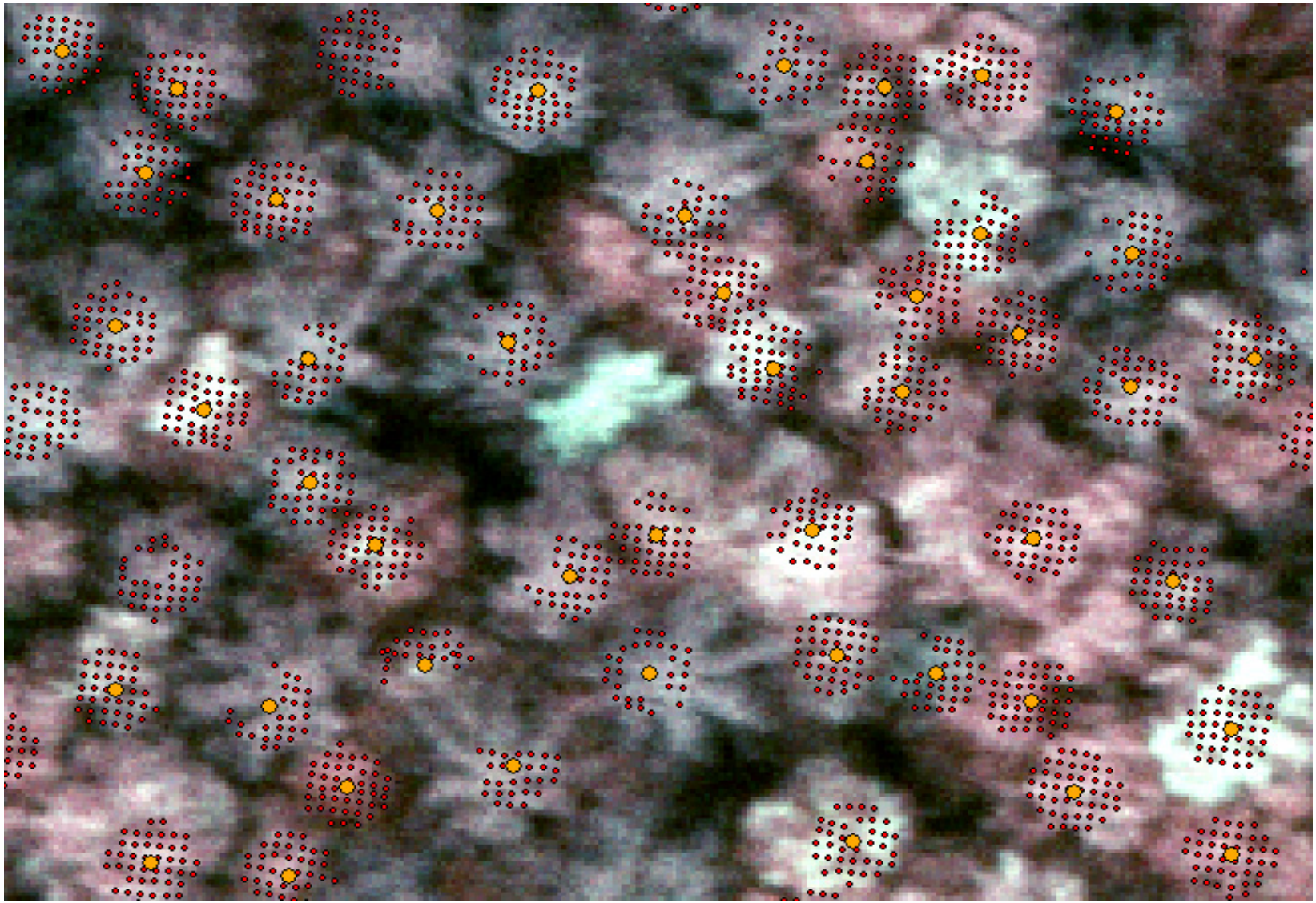
To estimate the semivariogram range,
red band of spectrozonal image was sampled (mean density of 5 pts. per sq.m)

SEMIVARIOGRAM - red band digital values



The semivariogram range is strongly related to mean crown size

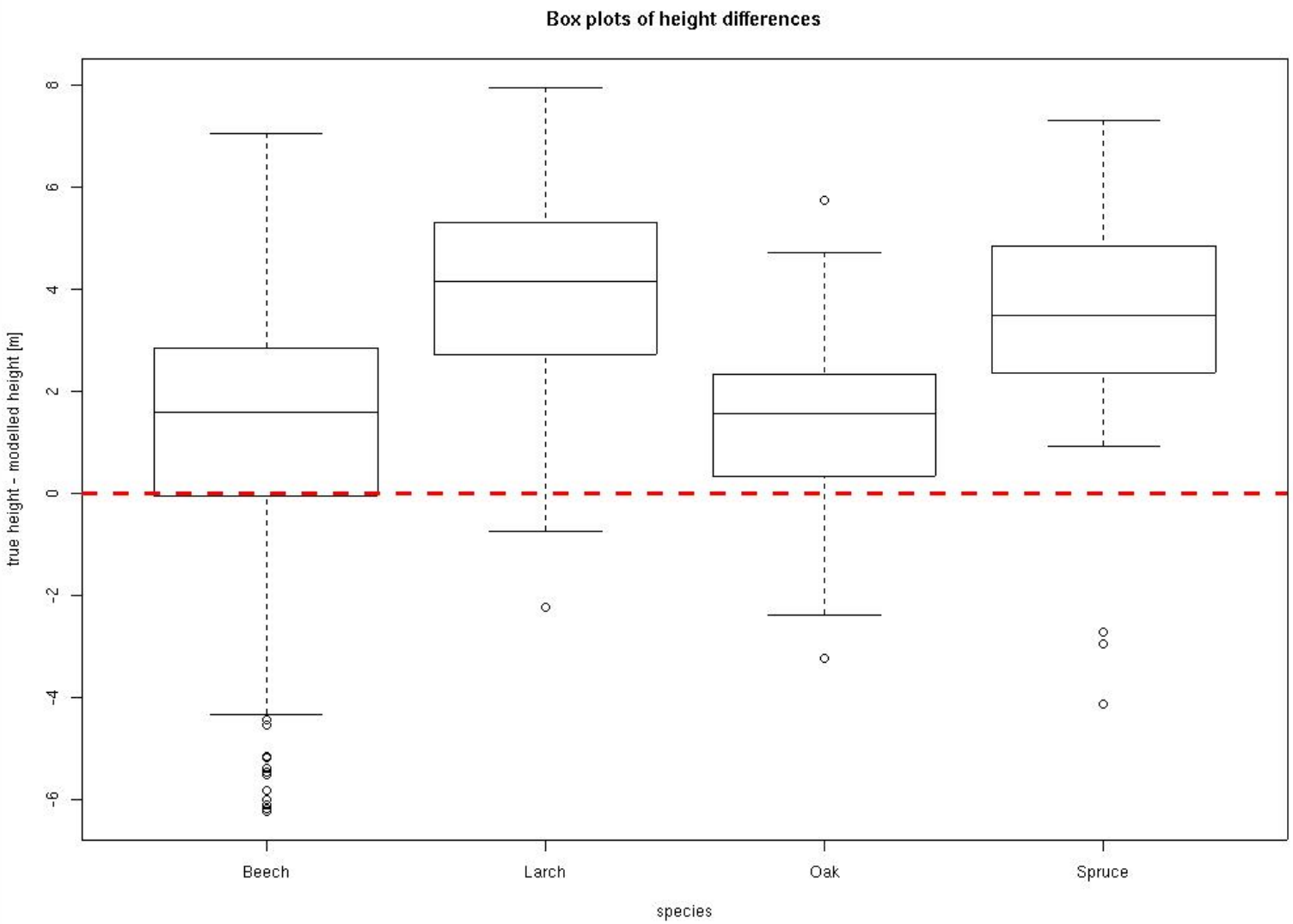
nDSM sets centered at tree locations



nDSM sets parameter estimation and selection

- median (best parameter, fairly low variance of estimation and robustness)
- 75% percentile (higher variance of the estimation)
- 90% percentile (very high variance)
- arithmetic mean (after cutting off 0.25% from both sides of histogram, outliers sensitivity)

DIFFERENCES of true and estimated tree heights



OVERVIEW of achieved accuracy by species

Characteristic/species	Beech	Oak	Spruce	Larch
Mean value of differences between mesured and moddeled tree height (bias)	1.3	1.43	3.8	4.08
Standard error of differences	2.52	1.77	1.6	1.84
Minimium number of analyzed trees to comply with 1m mean height accuracy	60	42	30	45
Linear model DBH~difference	Significant	Not significant	Significant	Significant

Minimum number of measured trees has been calculated using variance of tree heights in the stand (evaluated for our sample area) and variance of measurement errors (according Lindeberg-Lévy's theorem).Statistical uncertainty amounts to 0.05.

Challenges for future work

- The use of digital camera data with higher overlaps
- A method to filter spatially clustered outliers
- An automatic identification of tree tops, tree species classification
- Implementation of methods into a software tool