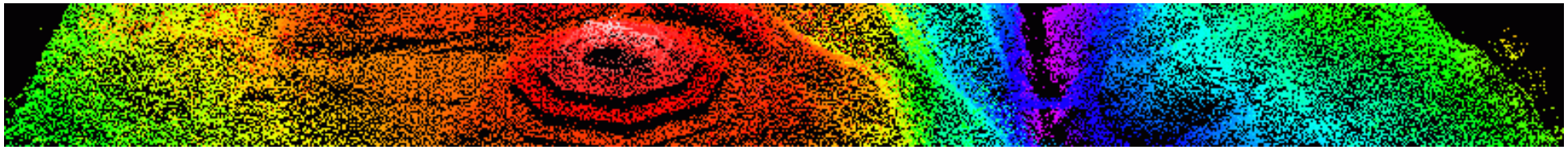
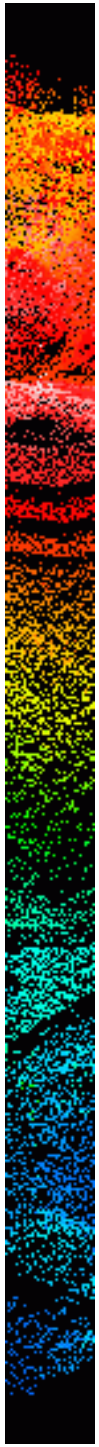


Application of laser scanning (lidar) data for land cover classification

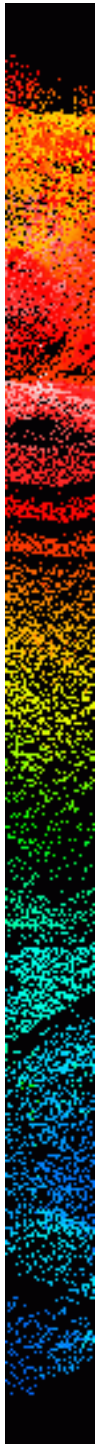
Scientific Research Centre of the
Slovenian Academy of Sciences and Arts

"Always start your presentation with a joke, but be careful not to offend anyone! Don't mention religion, politics, race, age, money, technology, men, women, children, plants, animals, food...."



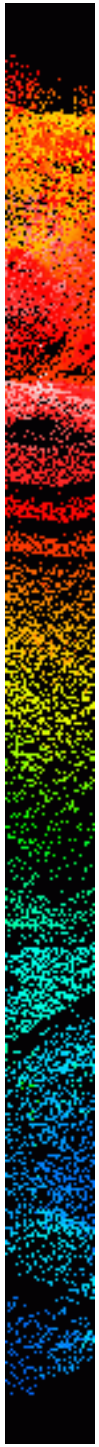
Introduction

- What is lidar and how does it work
- What information does it provide
- How to process lidar data
- Land cover classification from lidar and opt data
- Step by step procedure
- Advantages and limitations



What is lidar

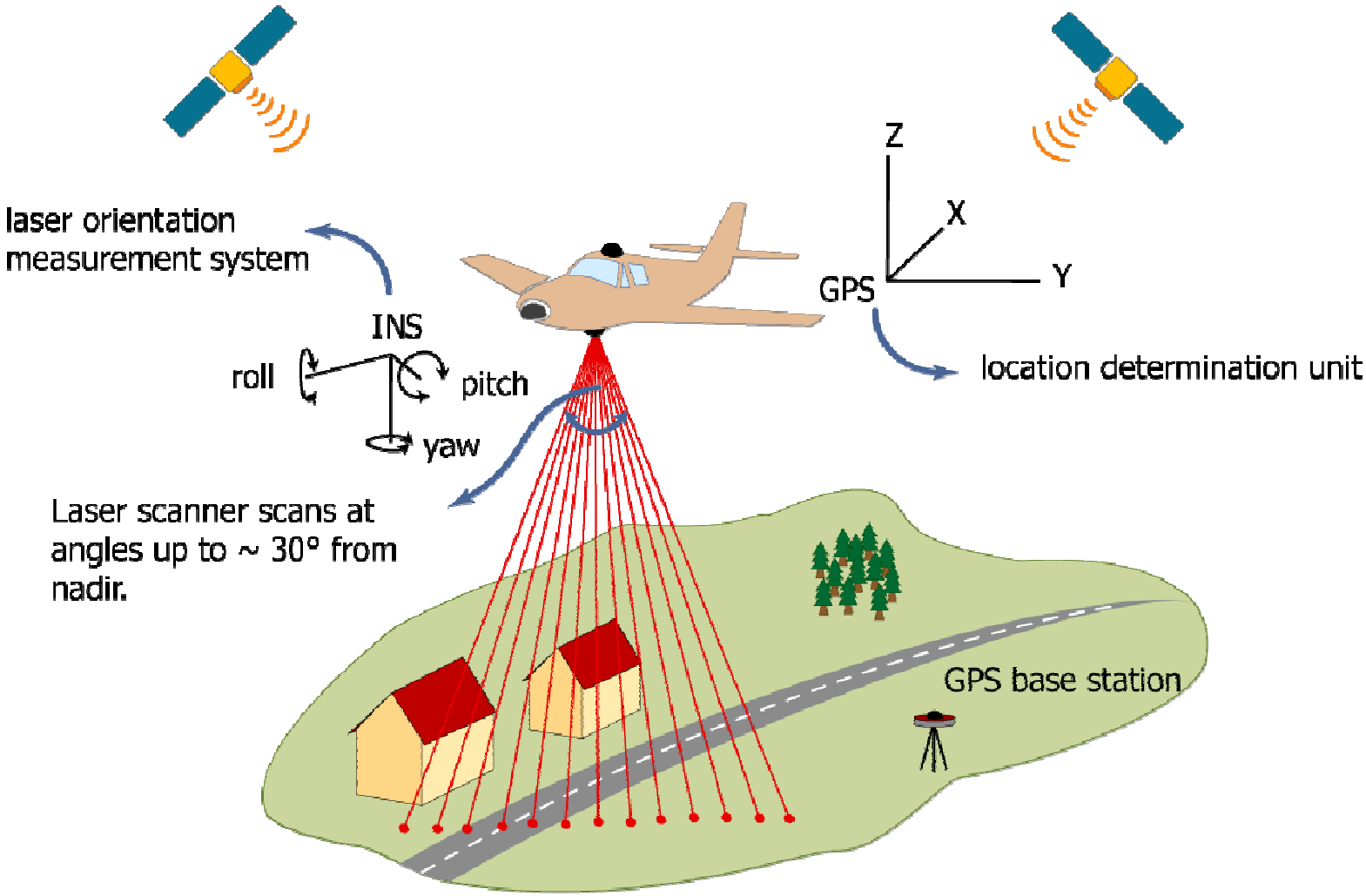
- Lidar is an active instrument, that emits sh laser pulses and observes their return – measures the distance and reflection intens
- LIght Detection And Ranging or Laser Imagi Detection And Ranging
- 30 year old technology that became cost effective recently
- Currently the most accurate method of 3D data acquisition



Laser scanning applications

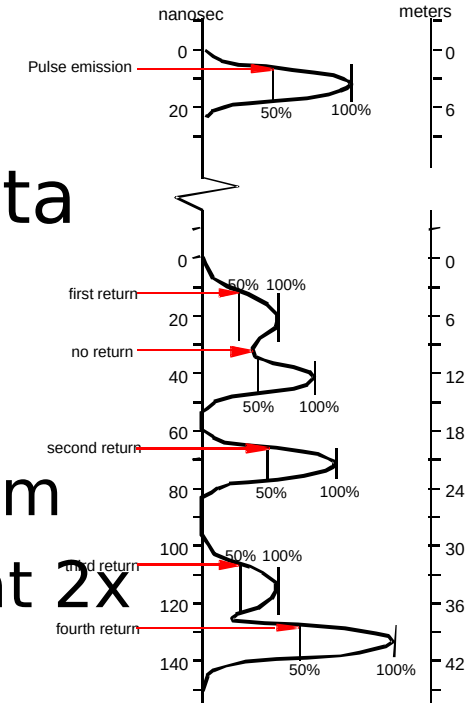
- 3D visualisation
- archaeology
- architecture and facade measuring
- archiving: historical, legal
- as-build surveying
- atmospheric / aerosols research
- (3D) city modelling
- digital factory
- forest management
- forensics
- geomorphology, hydrology, glaciology
- infrastructure and communications
- interface checking
- medical imaging / medical applications
- military
- mining / open pit modelling
- movie industry
- monitoring and civil engineering
- power line + poles measurement
- preservation
- process automation and robotics
- profiles, volumes, area calculation
- quality control / quality assurance
- rapid prototyping
- reverse engineering
- rock face analysis
- topography
- tunnel surveying
- urban planning
- virtual reality and simulations

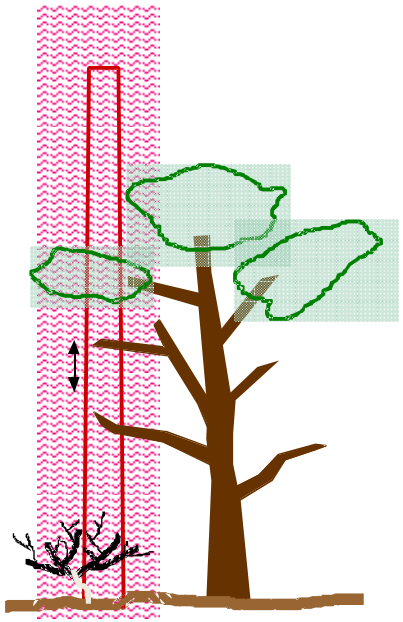
How does it work

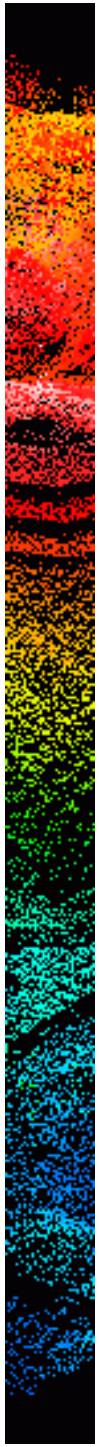


Lidar measurements

- Multiple return values
- Positional data and intensity data
- Remarkably large data files (huge!)
- Accuracy
  - Vertical RMSE at 10 cm
  - Horizontal accuracy at 2x the footprint size
- Lidar can see through (beside) vegetation

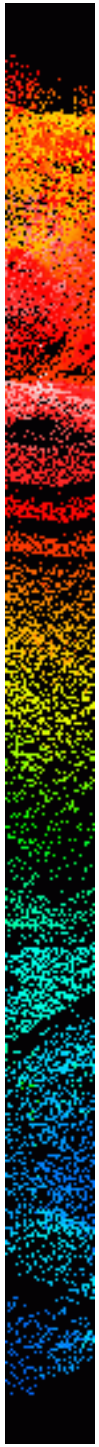




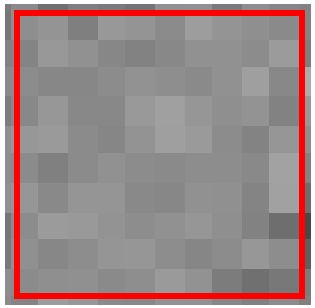


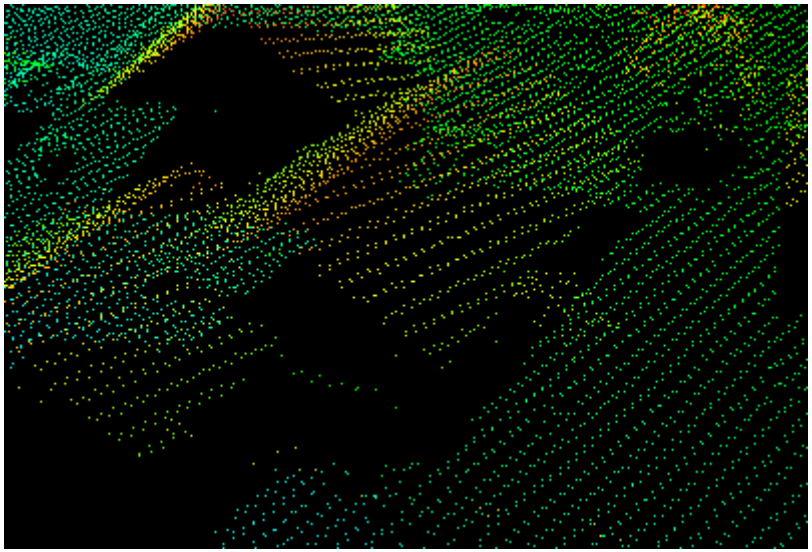
What results does it produce

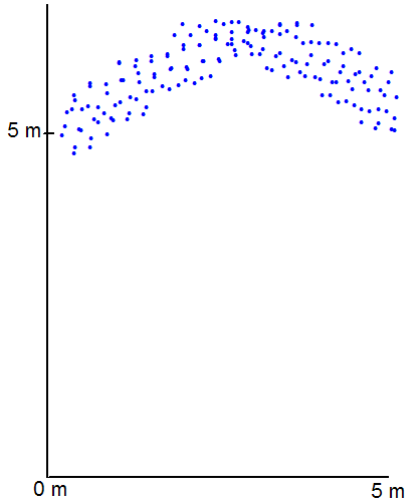
X	Y	Z	intensity	echo no.
389838,44	126050,22	476,88	11	1
389838,45	126049,95	452,19	17	2
389838,49	126051,21	452,15	18	3
389838,32	126054,99	468,47	10	1
389838,31	126055,10	469,56	14	1
389838,34	126055,85	469,25	19	1
389838,44	126050,13	452,22	13	3
389838,48	126051,39	452,18	40	3
389838,30	126055,27	469,62	11	1
389838,35	126056,63	469,34	14	1
389837,72	126049,74	452,45	55	3
389837,74	126050,35	452,47	22	2
389837,77	126051,04	452,30	27	2
389837,79	126051,65	452,33	28	2
389837,81	126052,32	452,22	52	3
389837,84	126052,98	452,14	26	3
389837,86	126053,62	452,09	41	2
389837,88	126054,24	452,10	45	2
389837,91	126054,90	452,03	26	3
389837,93	126055,54	452,00	25	3
389837,96	126056,22	451,88	23	3
389837,98	126056,85	451,86	24	3
389838,04	126058,63	452,05	18	3
389838,06	126059,22	452,14	31	2
...	...	...	...	...



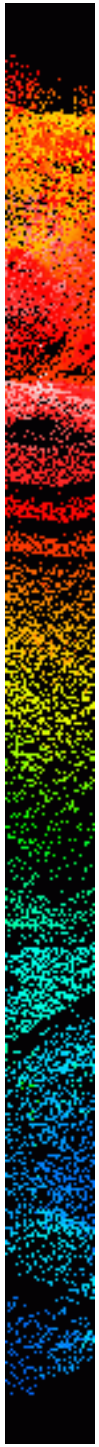
Buildings



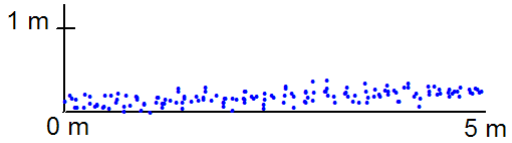


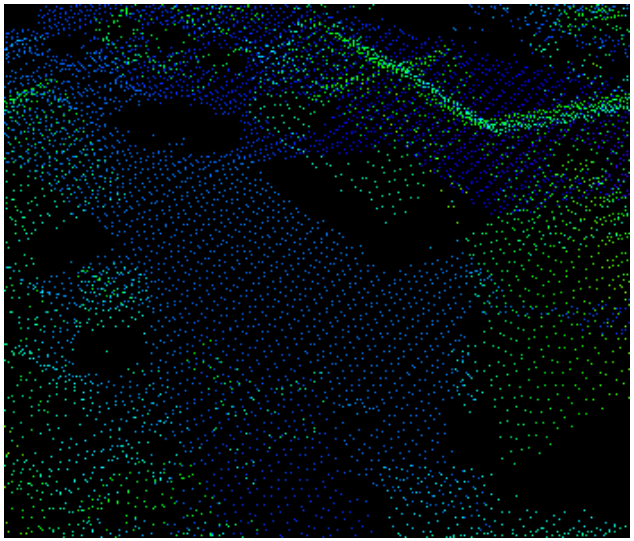


Minimum:	612.14
Maximum:	614.09
Range:	1.95
Sum:	100,583.43
Mean:	613.314
Variance:	0.229595
Standard Deviation:	0.479161



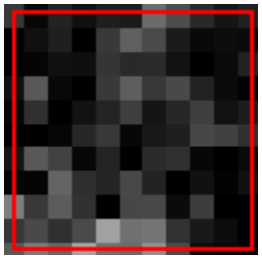
Roads

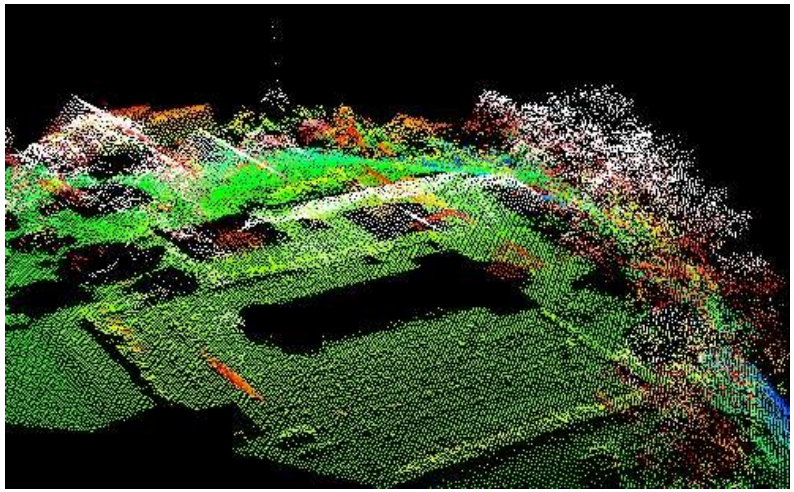


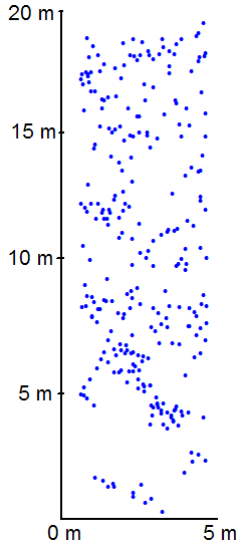


Minimum:	602.91
Maximum:	603.29
Range:	0.38
Sum:	90,463.36
Mean:	603.089
Variance:	0.0061338
Standard Deviation:	0.0783186

High vegetation

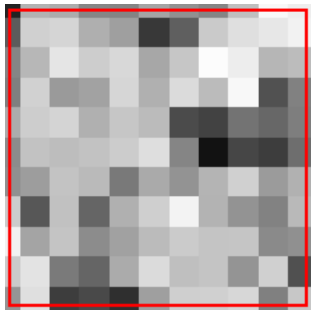


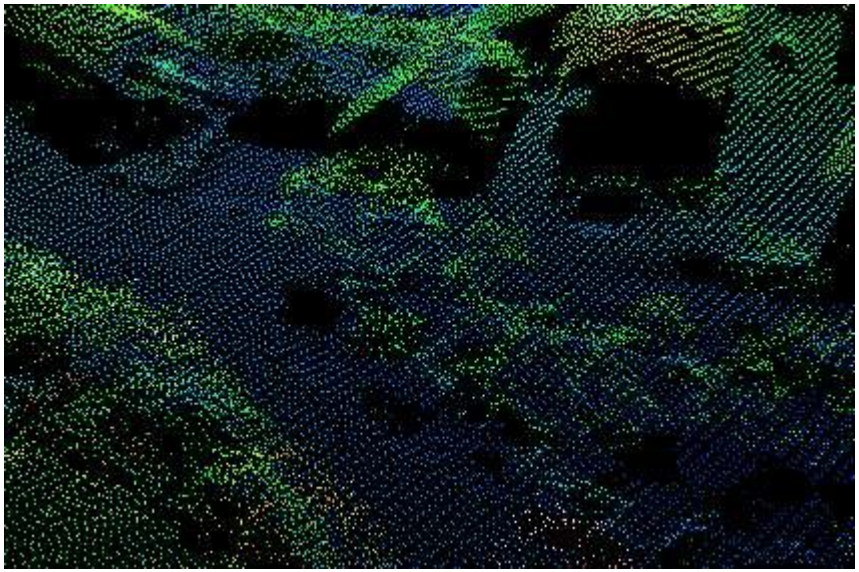


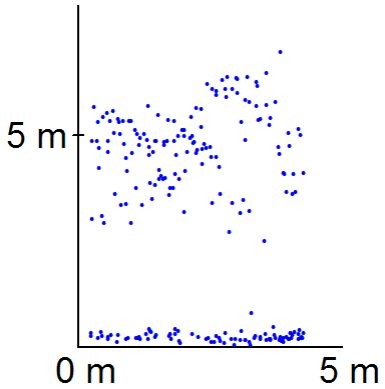


Minimum:	609.03
Maximum:	628.31
Range:	19.28
Sum:	175,262.44
Mean:	619.302
Variance:	26.8657
Standard Deviation:	5.18321

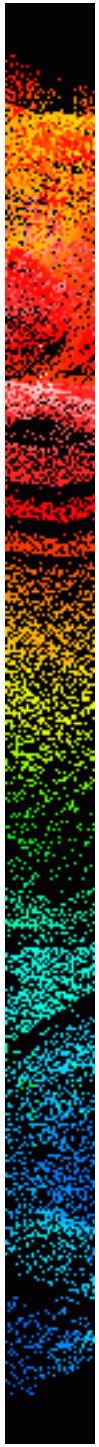
Low vegetation



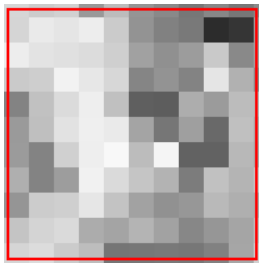


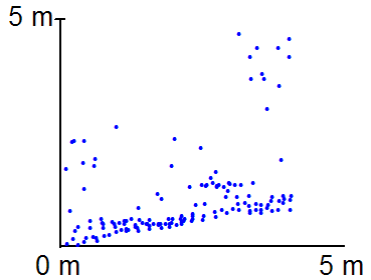


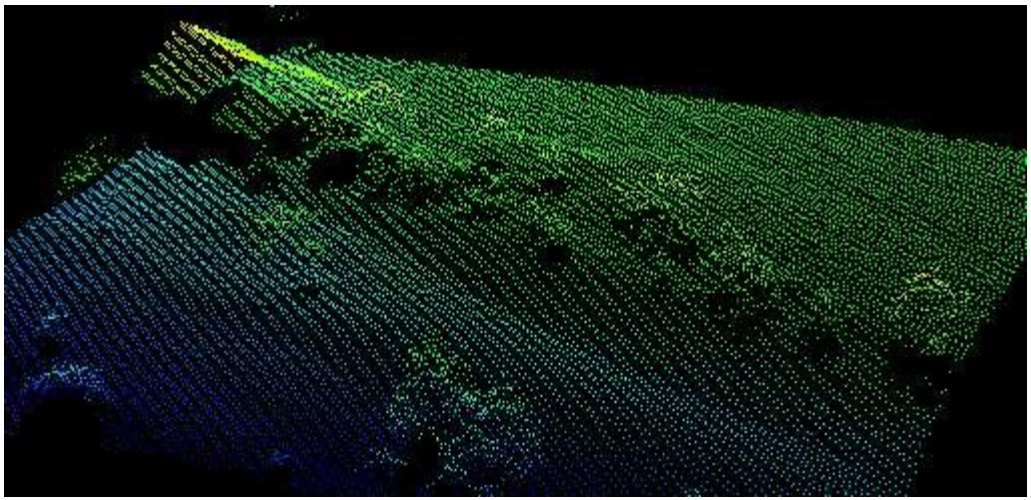
Minimum:	602.59
Maximum:	609.46
Range:	6.87
Sum:	132,613.72
Mean:	605.542
Variance:	5.28777
Standard Deviation:	2.29951



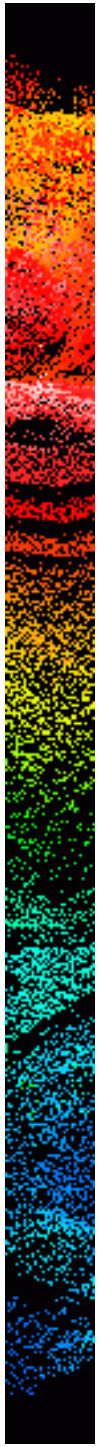
Bushes



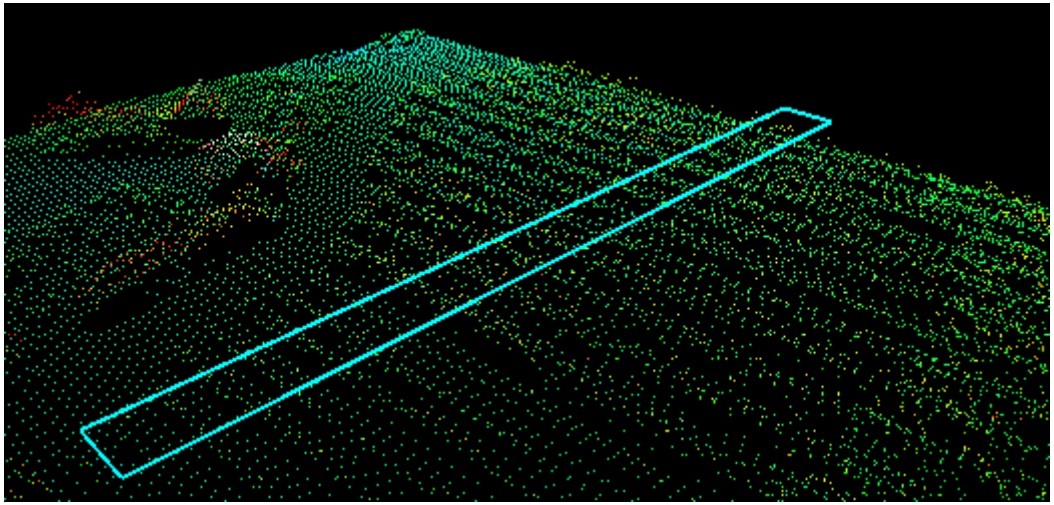


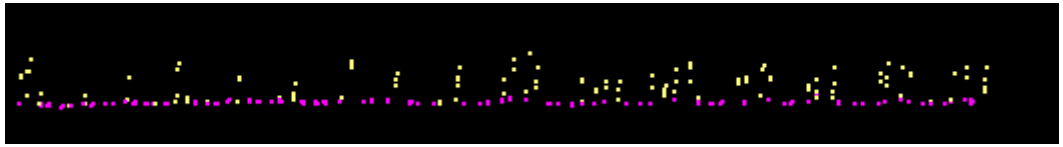


Minimum:	607.92
Maximum:	612.51
Range:	4.59
Sum:	88,299.15
Mean:	608.96
Variance:	0.956474
Standard Deviation:	0.977995

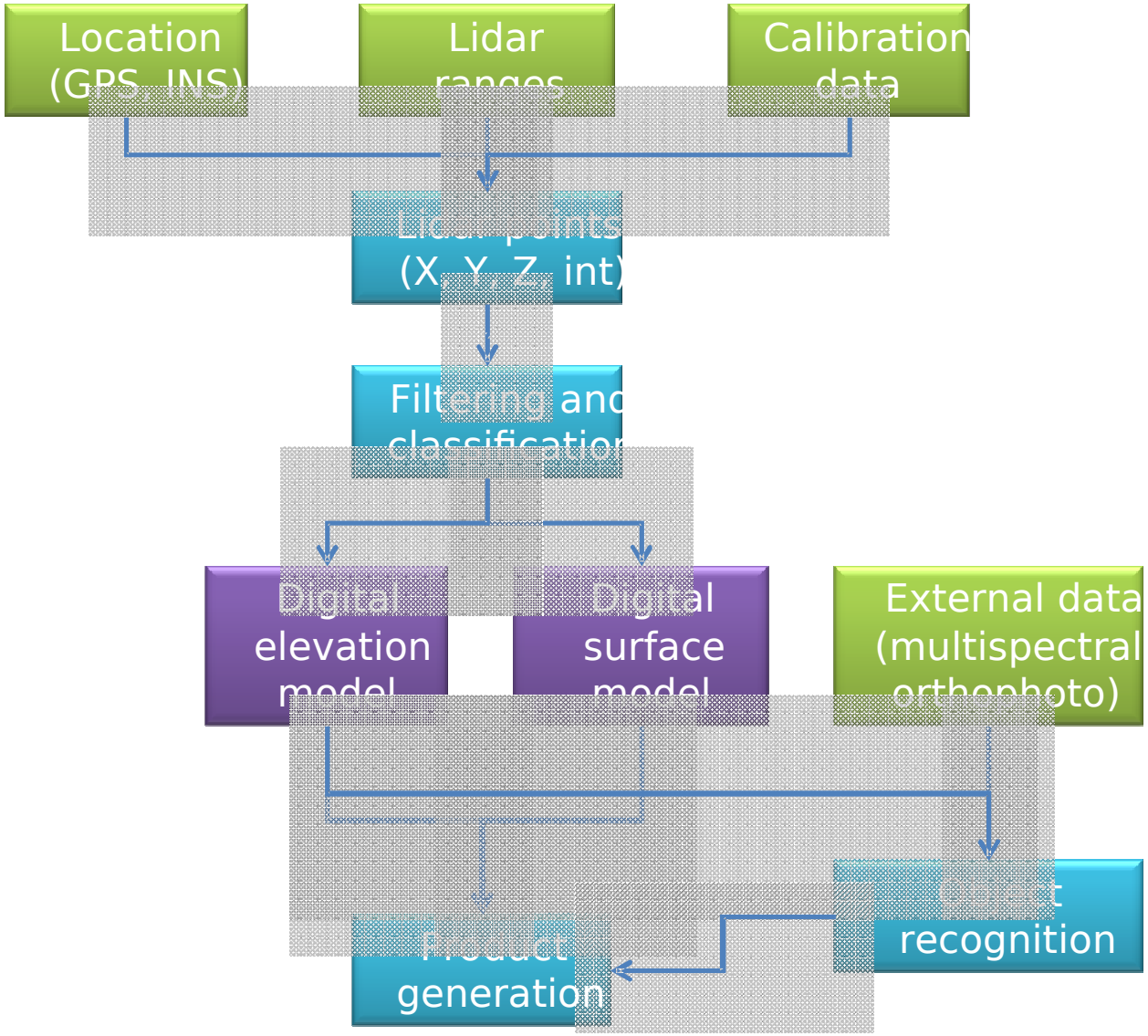


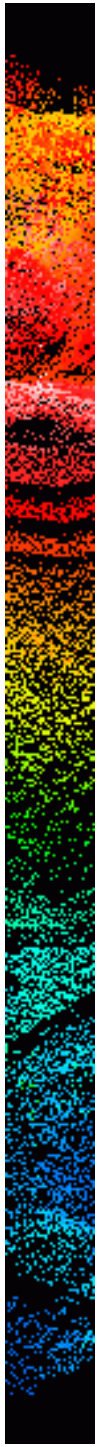
Hops





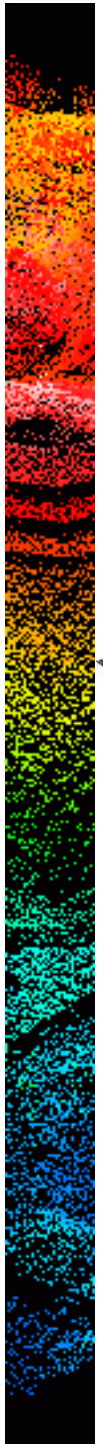
Data processing



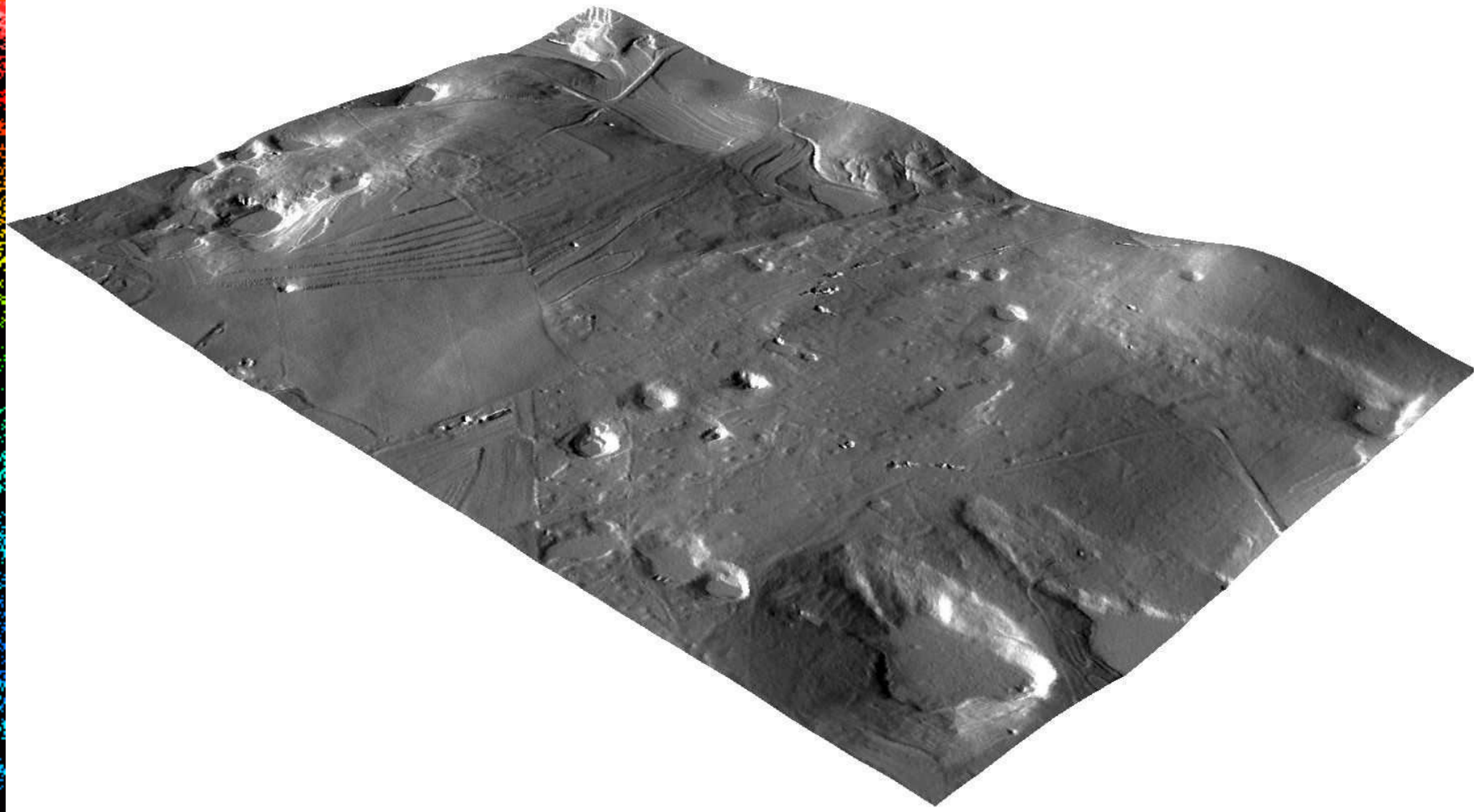


DEM and DSM production

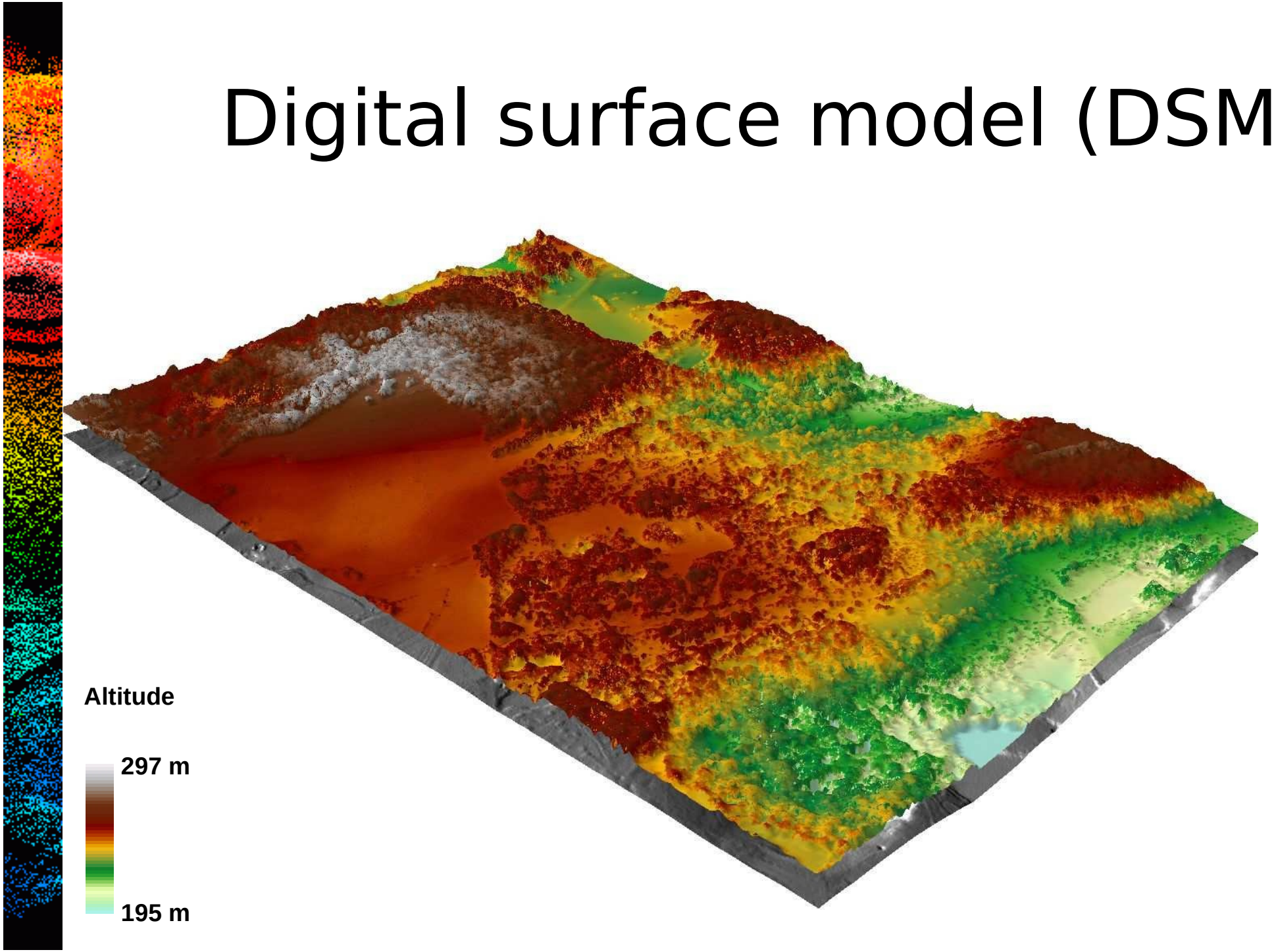
- Digital elevation model and digital surface models are the most important products derived with laser scanning
- From 3D data it is not easy to classify point into ground, top and in-between
- Filtering: classification of points into terrain and off-terrain



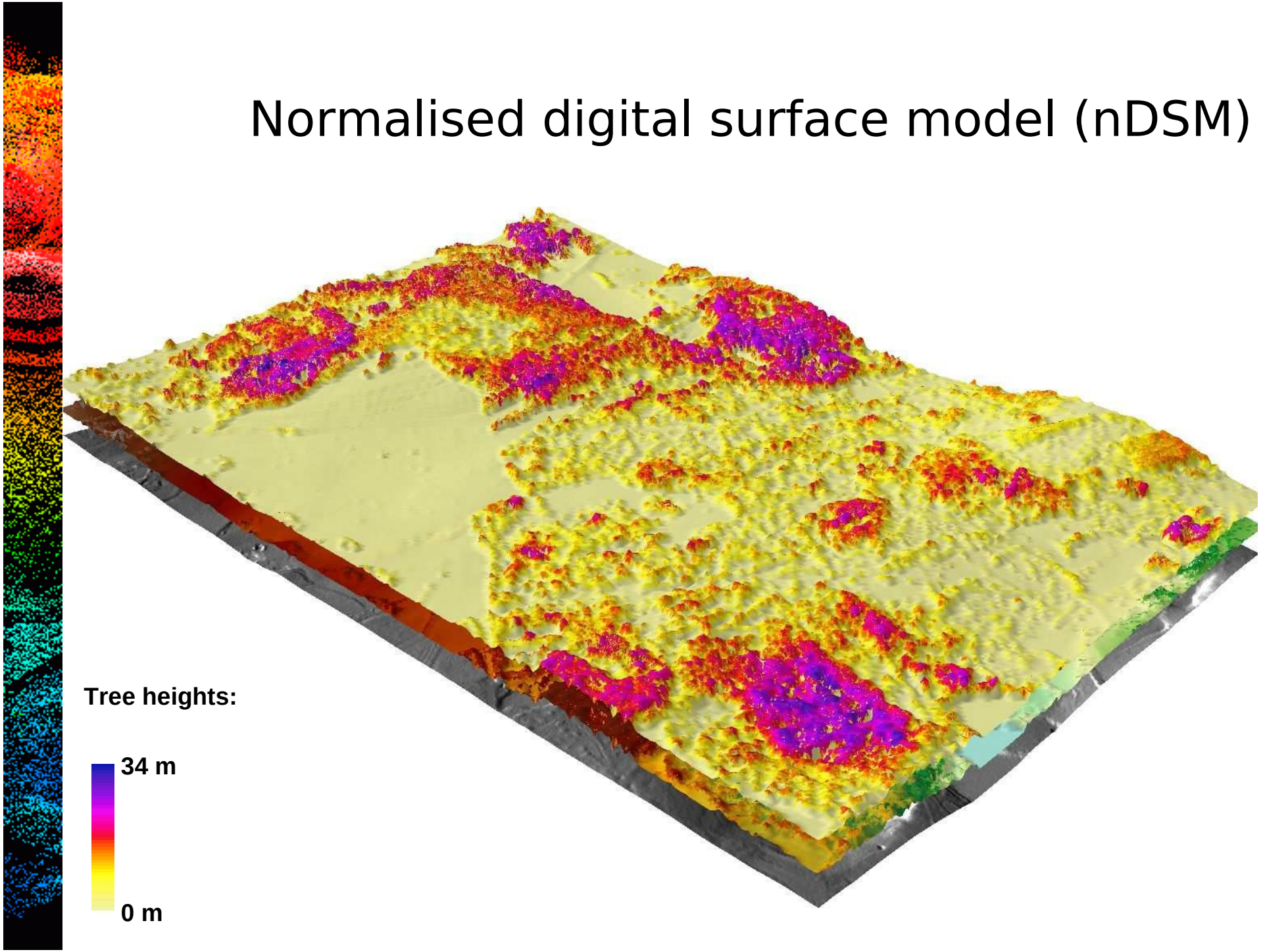
Digital elevation model (DEM)

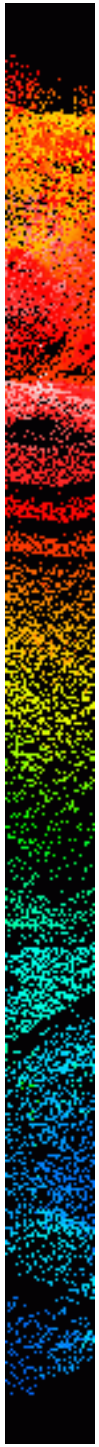


Digital surface model (DSM)



Normalised digital surface model (nDSM)

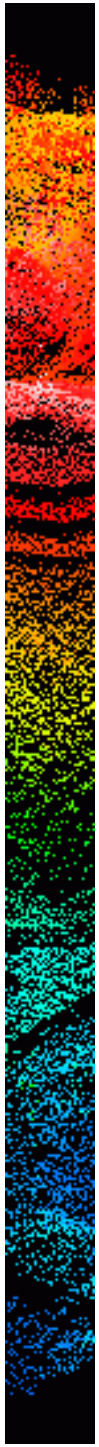




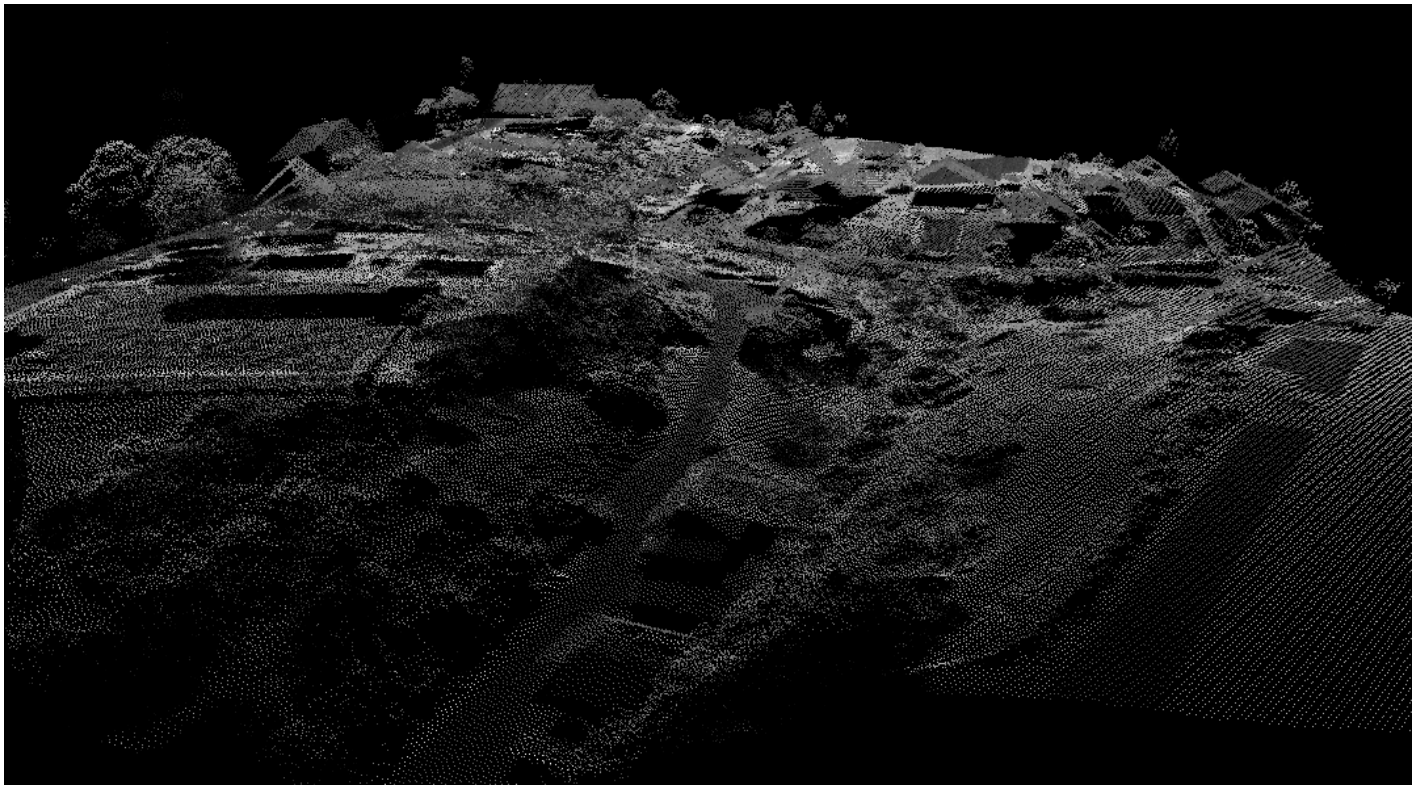
Land use classification

- Only basic land cover classes were analyse
  - buildings
  - trees
  - roads
  - grass
  - fields
- Lidar data with attributes (intensity, return number) and aerial orthophoto

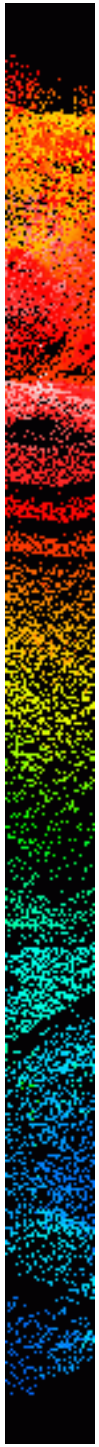
Aerial photography (BDOF)



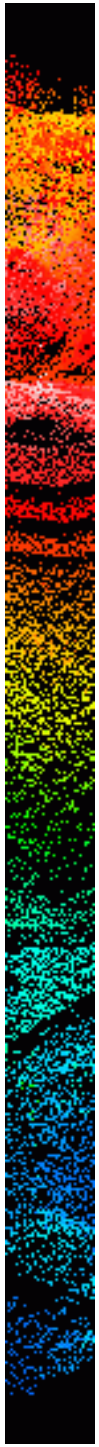
Lidar intensity



$$I = \frac{energy\ of\ received\ light}{energy\ of\ transmitted\ light}$$



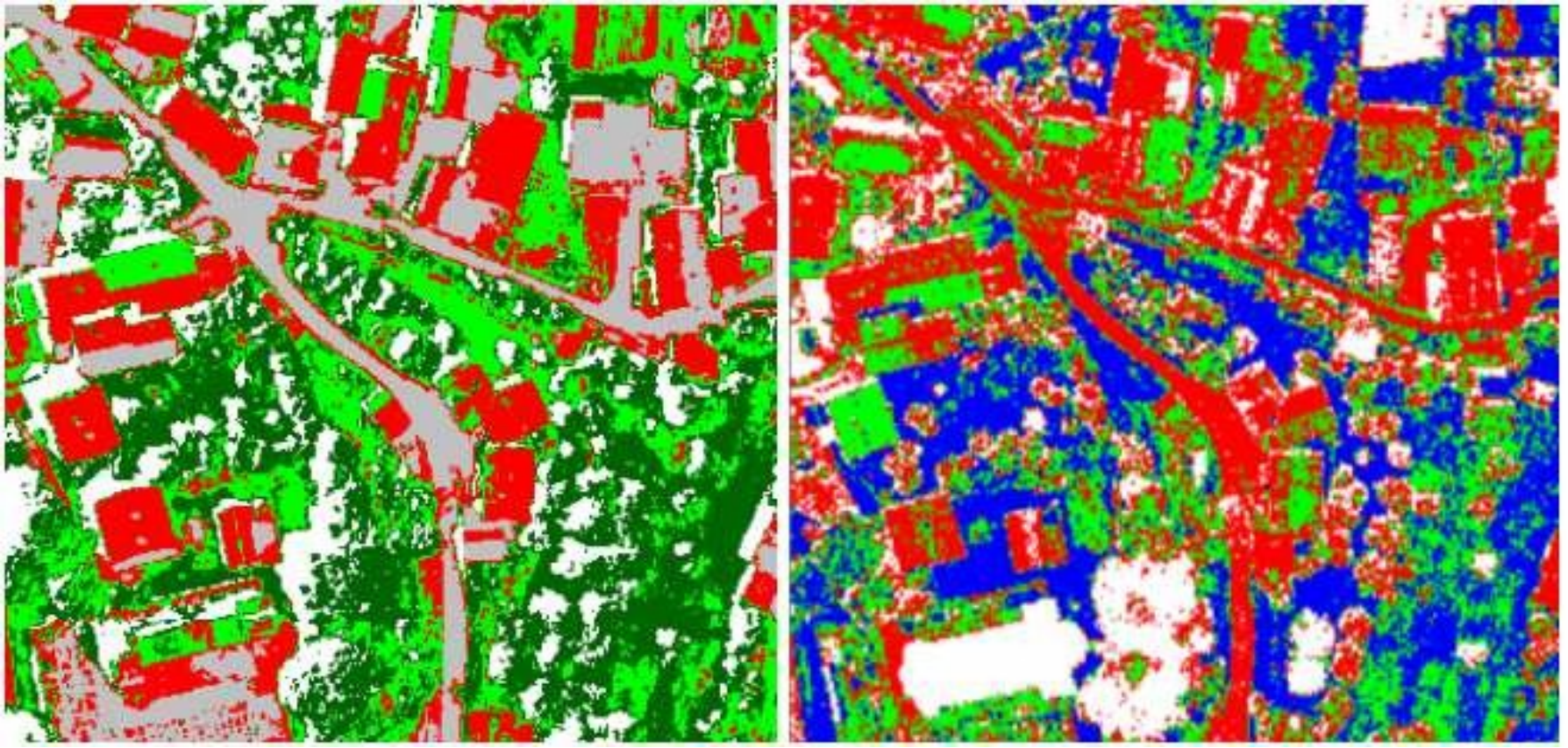
Intensity image



Classification procedure

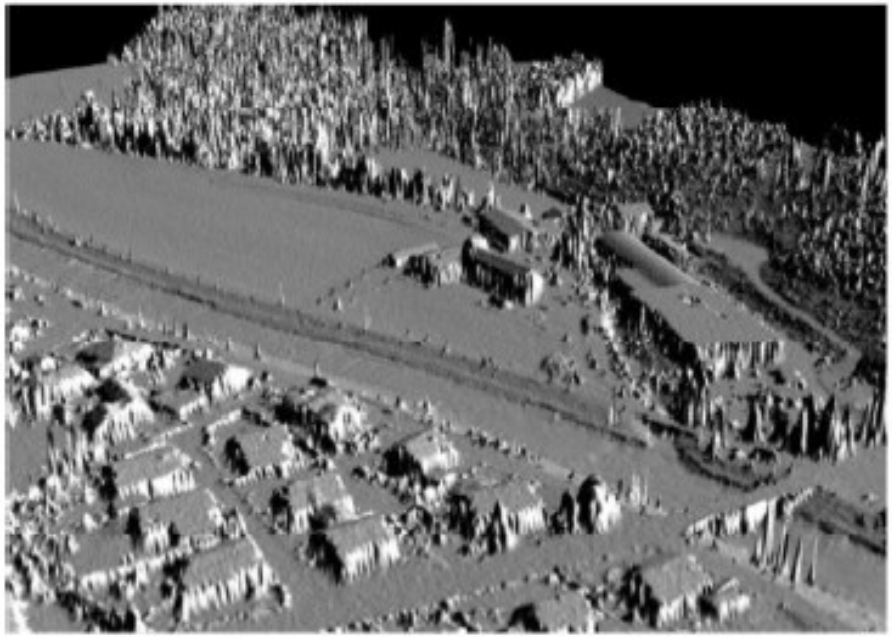
- Classification of intensity and / or colour ae photography (BDOF)
- Use of height levels
- Use of standard deviation
- Classification post-processing and quality control

Initial classification with laser scanning data

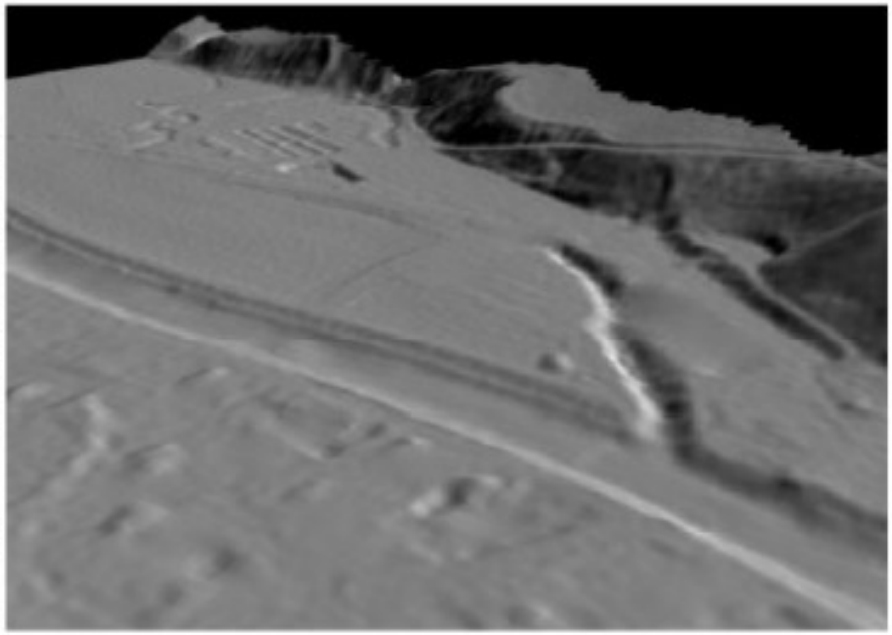


Classification of BDOF (left) and classification of intensity image (right).

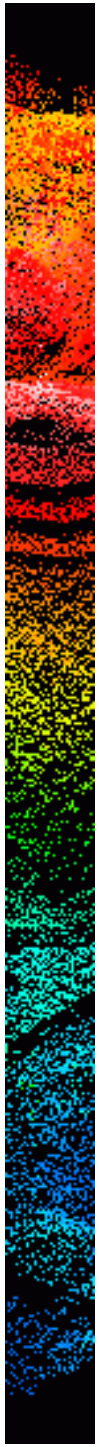
Use of height levels



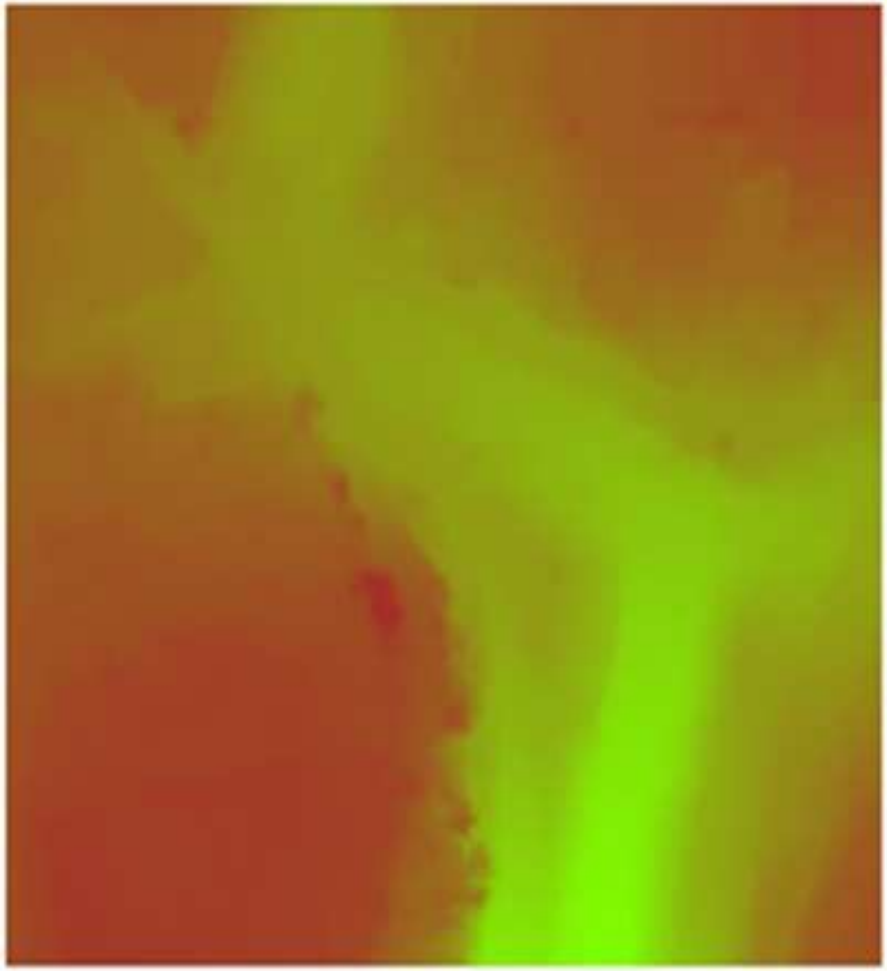
digital surface model (DSM)



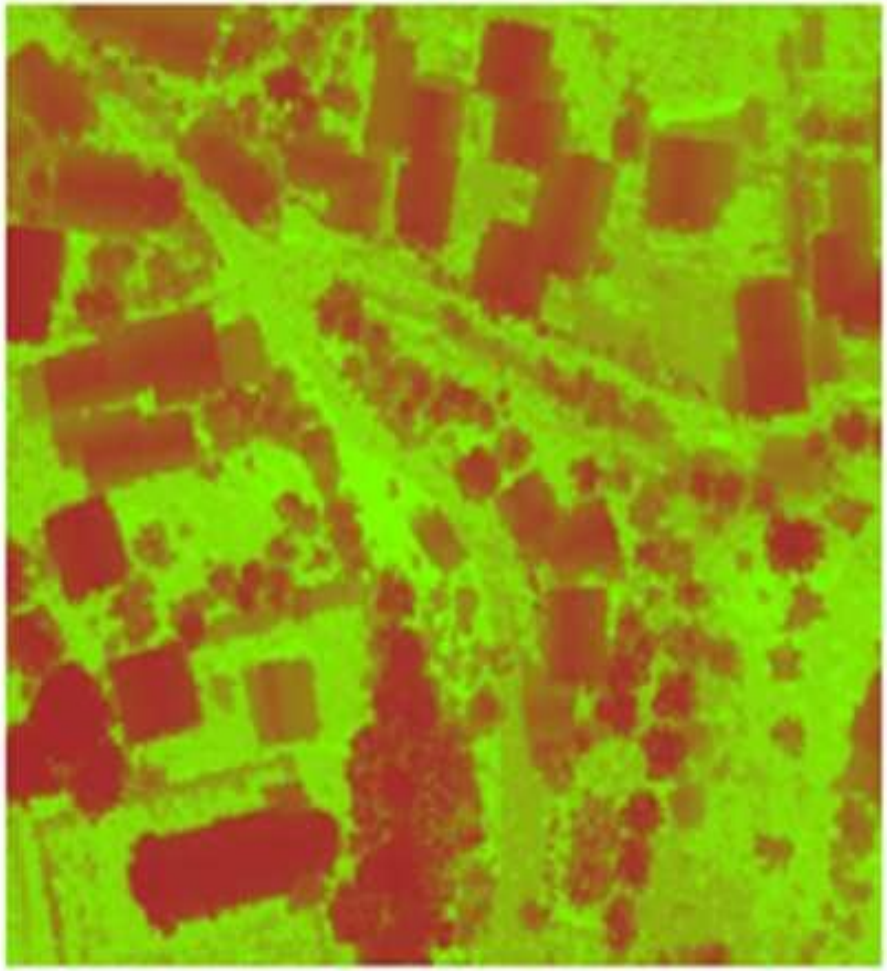
digital elevation model (DEM)



Use of height levels

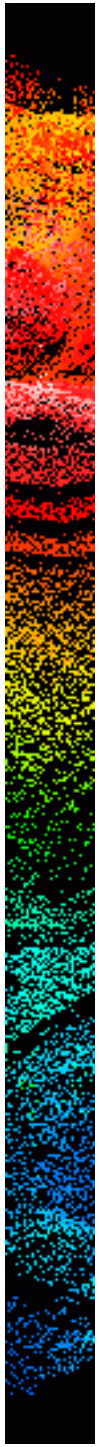


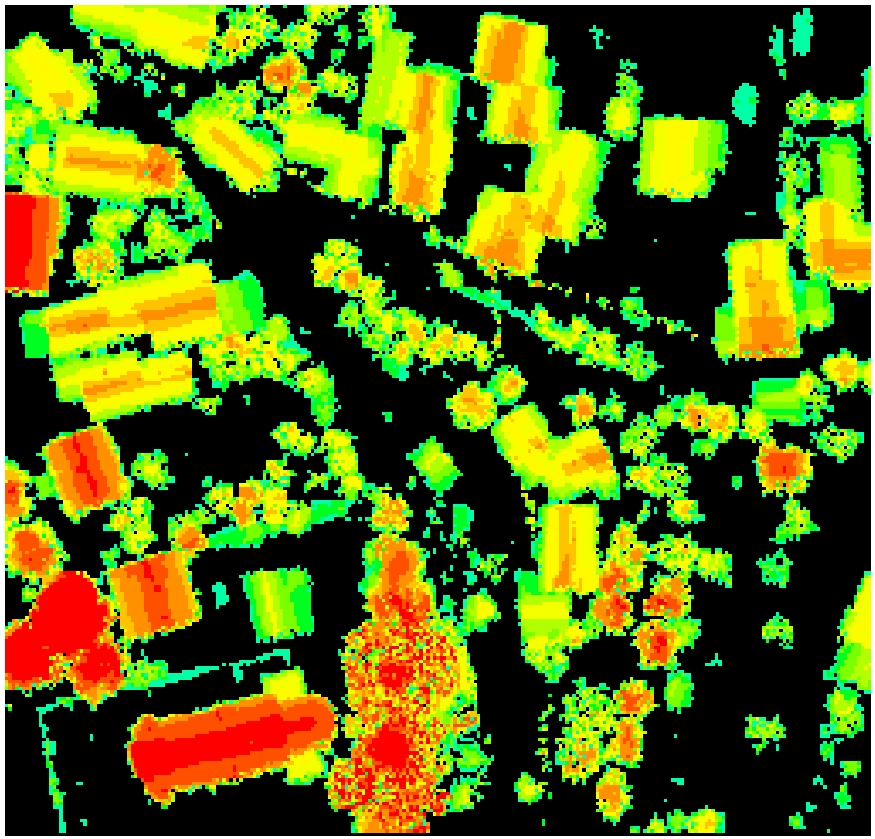
DEM

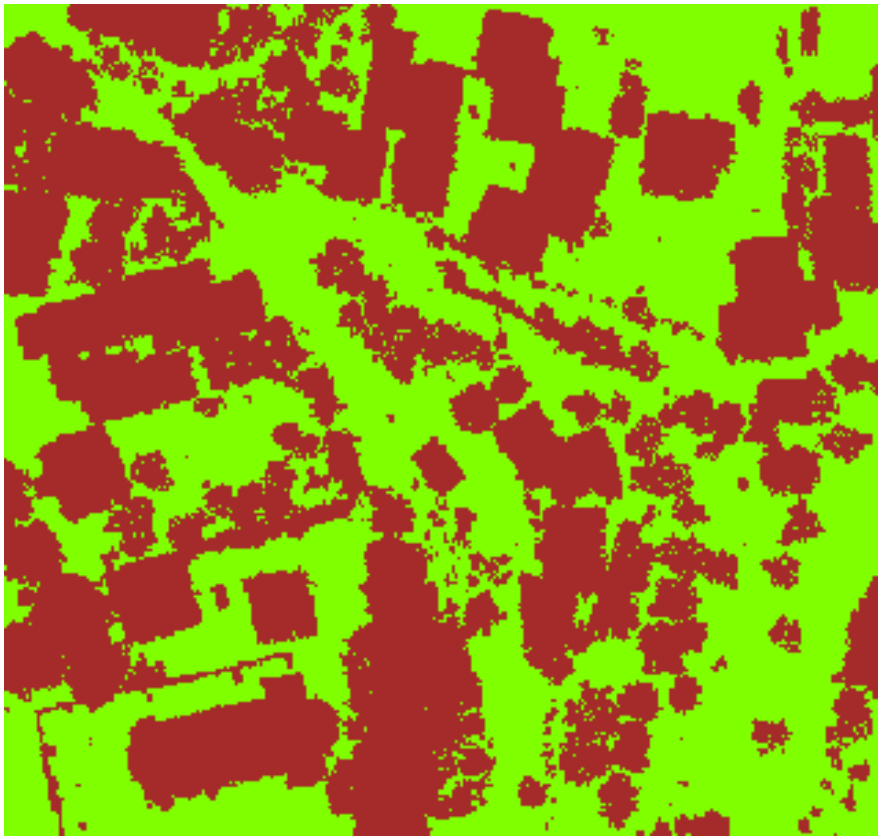


nDSM

Use of height levels







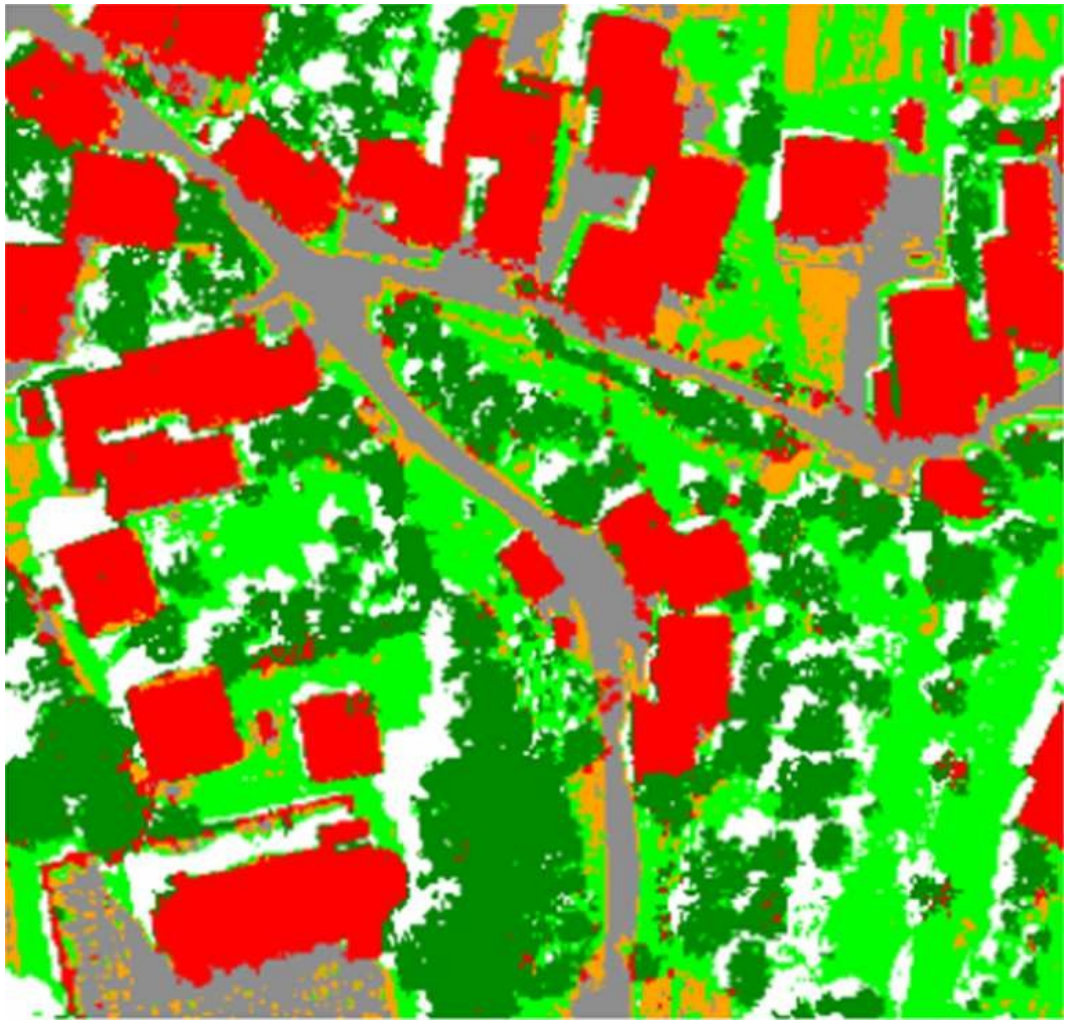
0 m

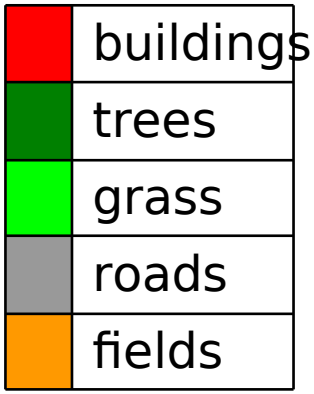
20 m

h < 1 m

h ≥ 1 m

Use of height level BDOF



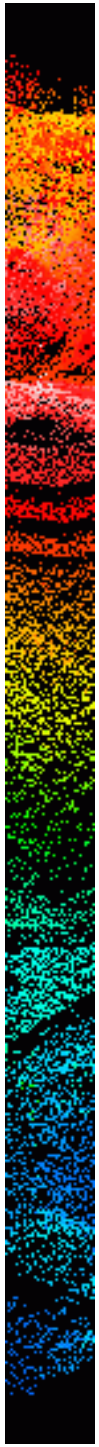


almost correct separation

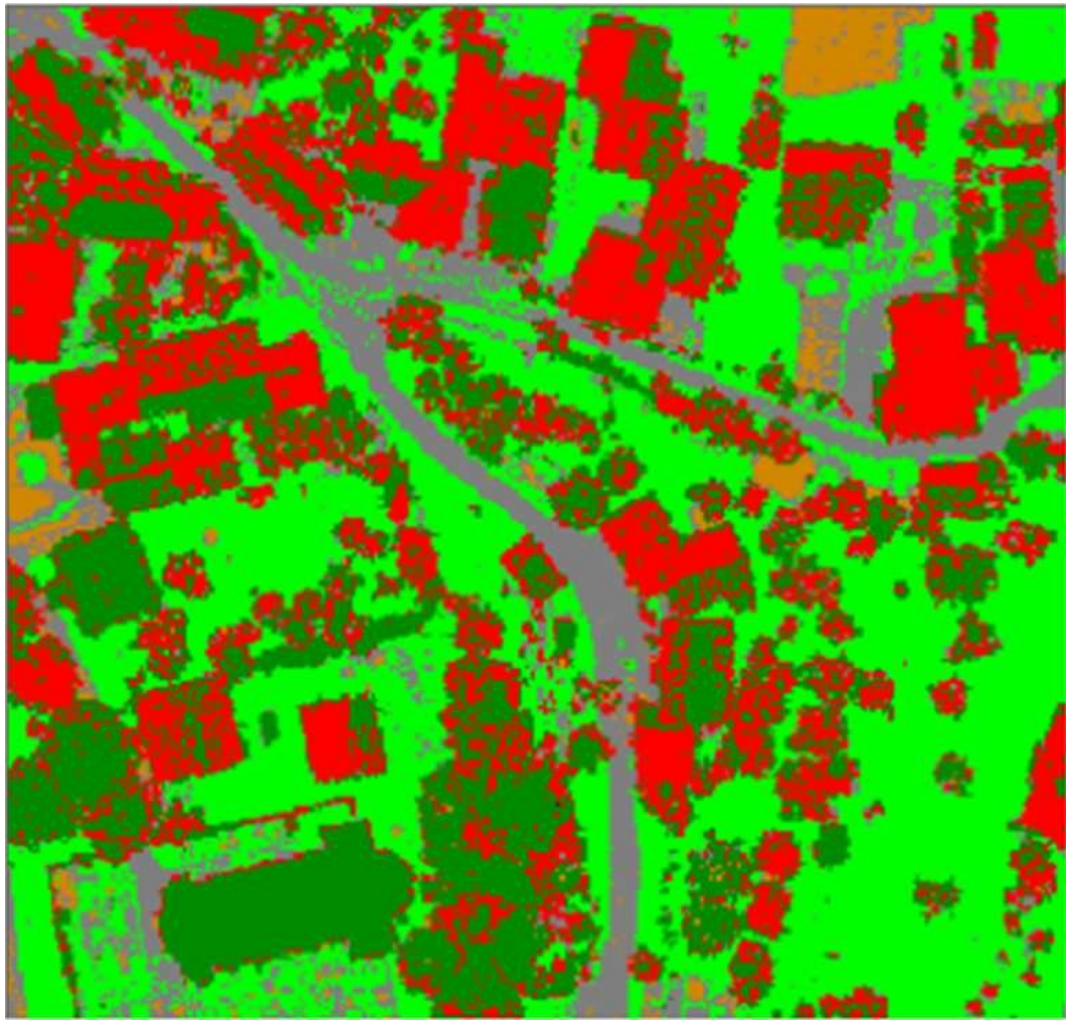
shadows

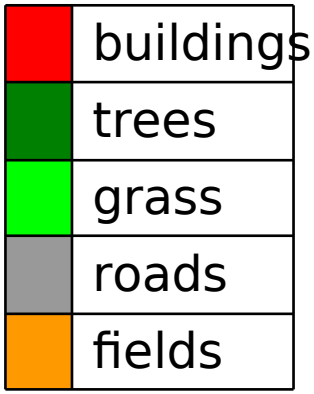
noise

Classification of BDOF after heights separation.



Use of height levels – intensity image





better classification

very good separation of asphalt and grass

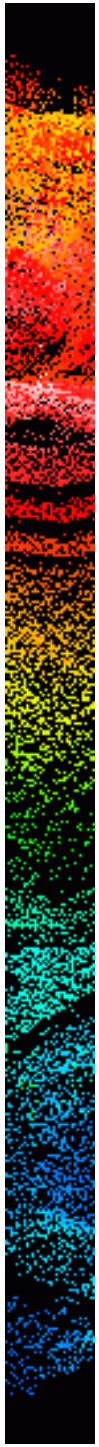
good separation of fields

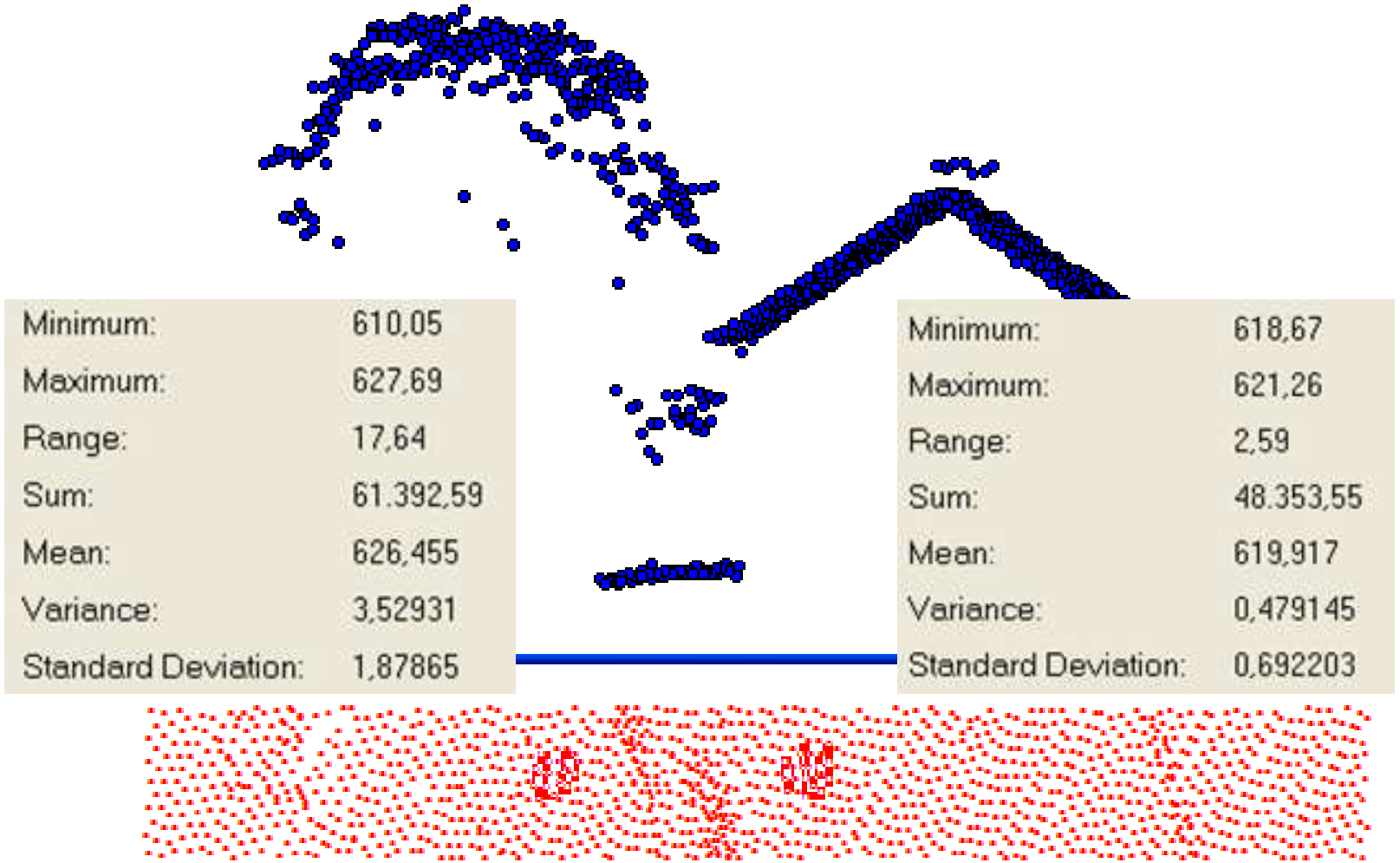
impossible separation of asphalt and trampled grass

impossible separation of trees and buildings

Classification of intensity image after heights separation.

Use of standard deviation



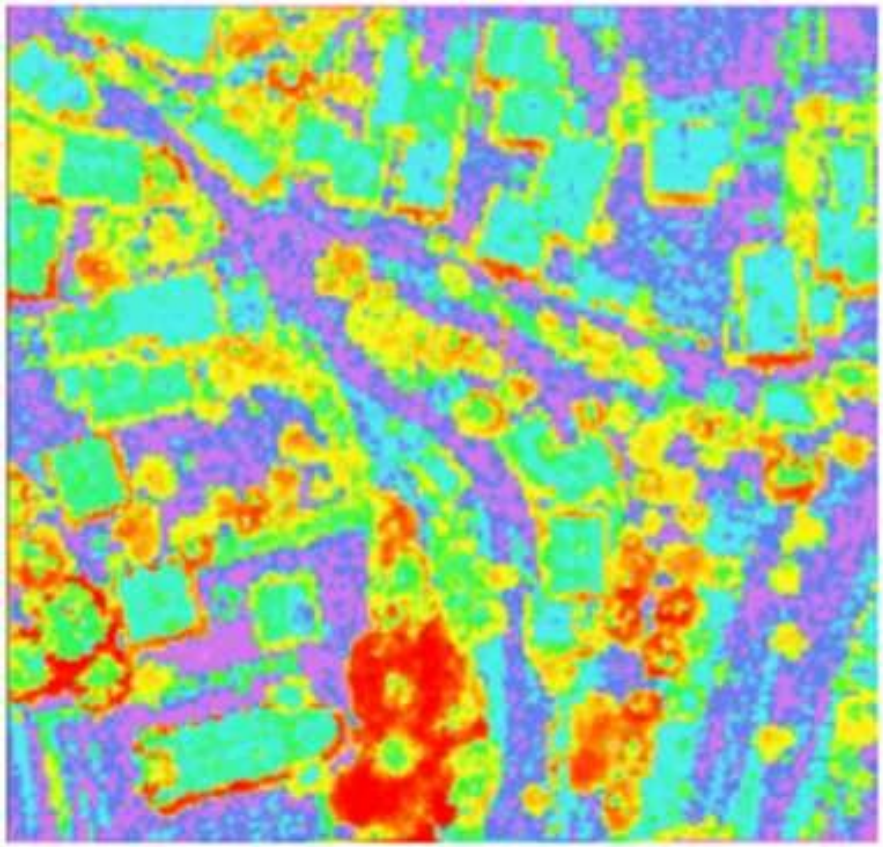


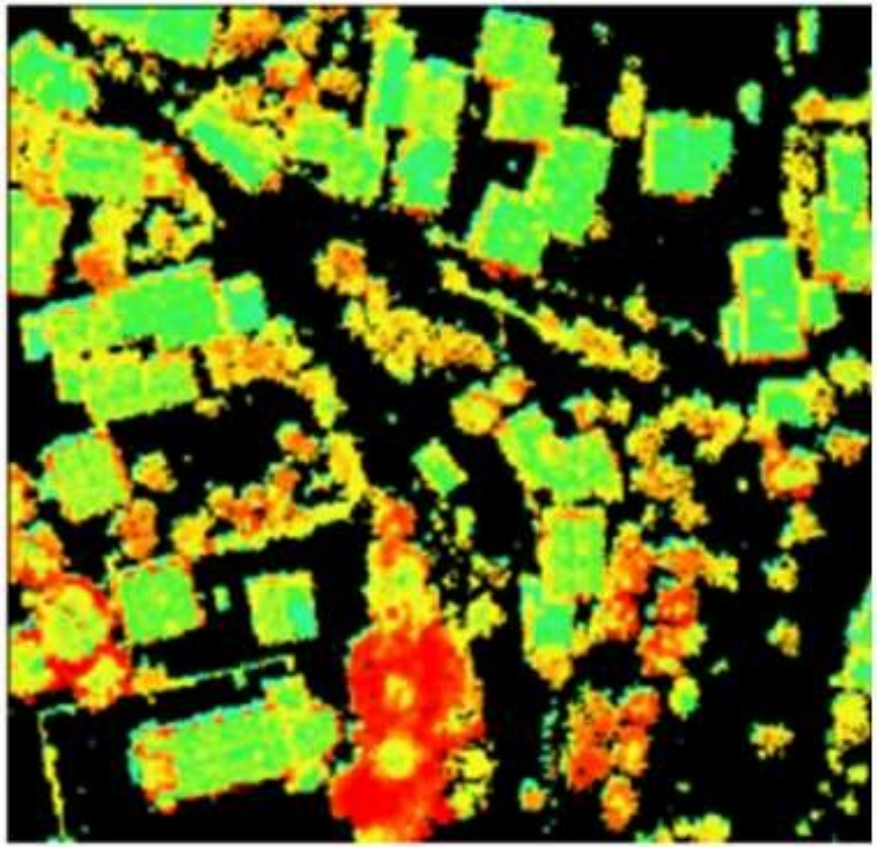
Minimum:	610,05
Maximum:	627,69
Range:	17,64
Sum:	61.392,59
Mean:	626,455
Variance:	3,52931
Standard Deviation:	1,87865

Minimum:	618,67
Maximum:	621,26
Range:	2,59
Sum:	48.353,55
Mean:	619,917
Variance:	0,479145
Standard Deviation:	0,692203

Statistical data of laser points – tree (left) and roof (right)

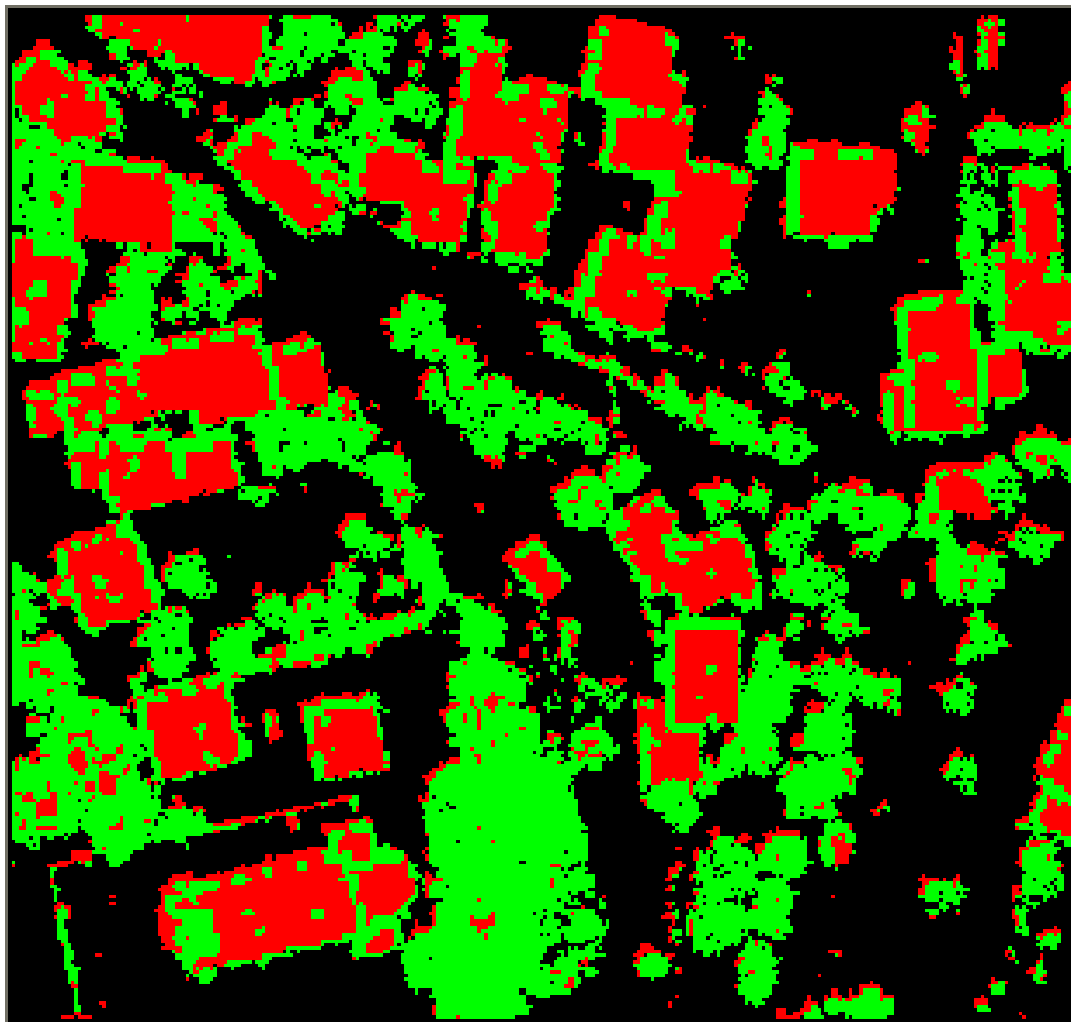
Use of standard deviation





Coloured image of all STD values (left), STD values for objects, higher than 1 m (

Use of standard deviation



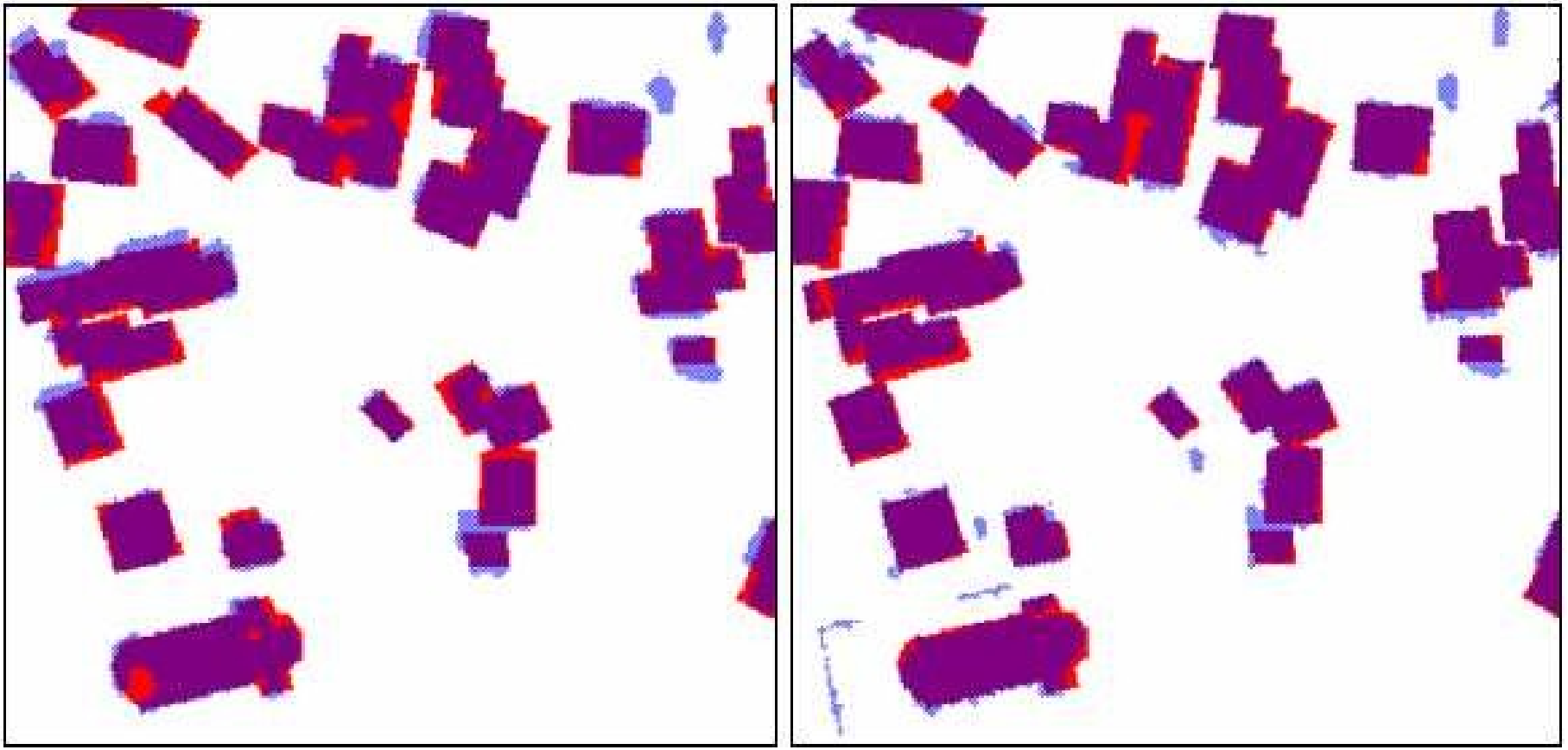
classification much better
almost all buildings correctly separated
irregular building edges
deformed shape of objects
noise

Separation of trees (green) and buildings (red), based on STD values.

Quality of building separation

Manually vectorised buildings in vector (left) and raster (right) form.

Quality of building separation

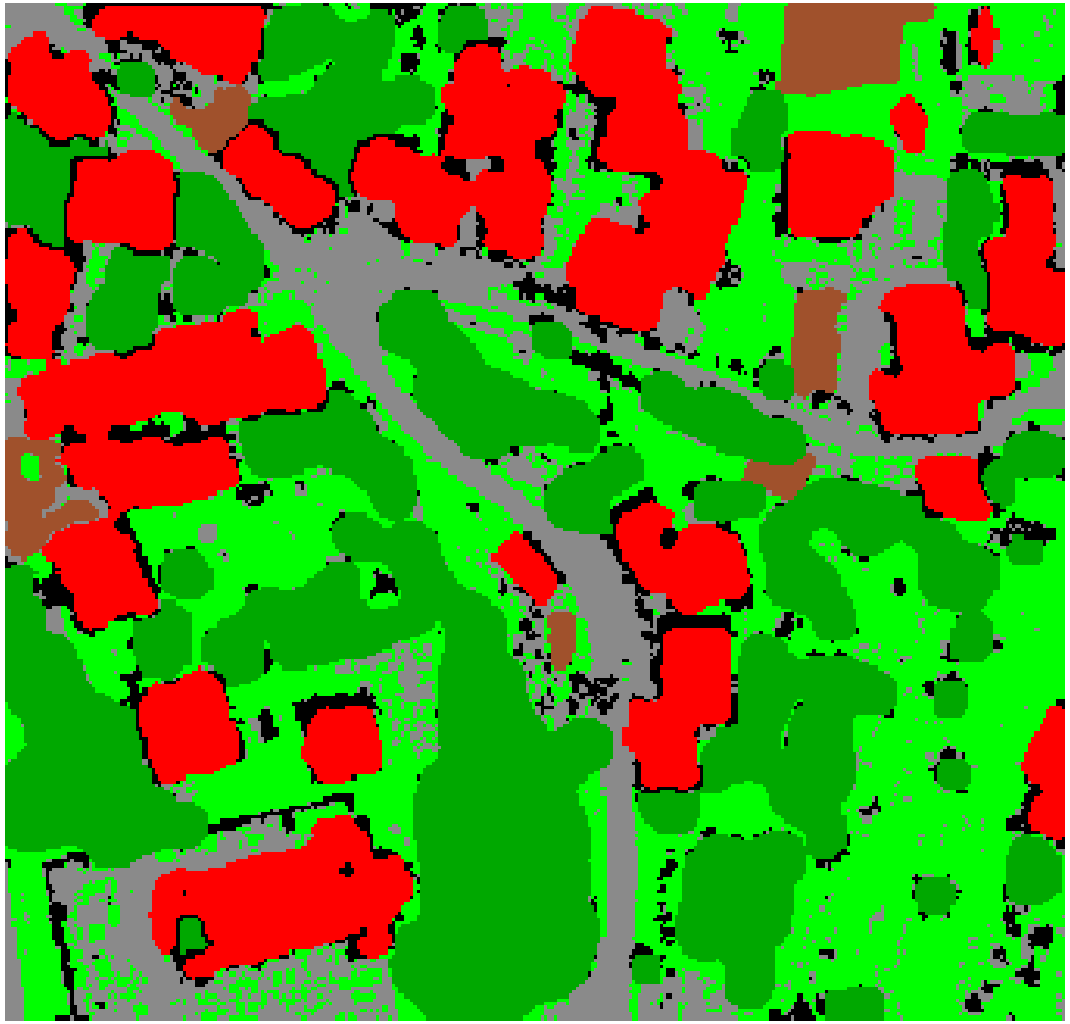


Buildings from lidar data (left) and BDOF (right) compared to manual digitalizati

manually defined buildings
classified buildings

k_{lidar}= 0,94
k_{BDOF}= 0,95

Fusion of classified objects

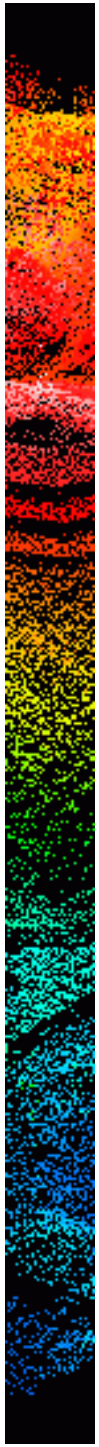


Fusion of trees and buildings with background.

each class is determined separately

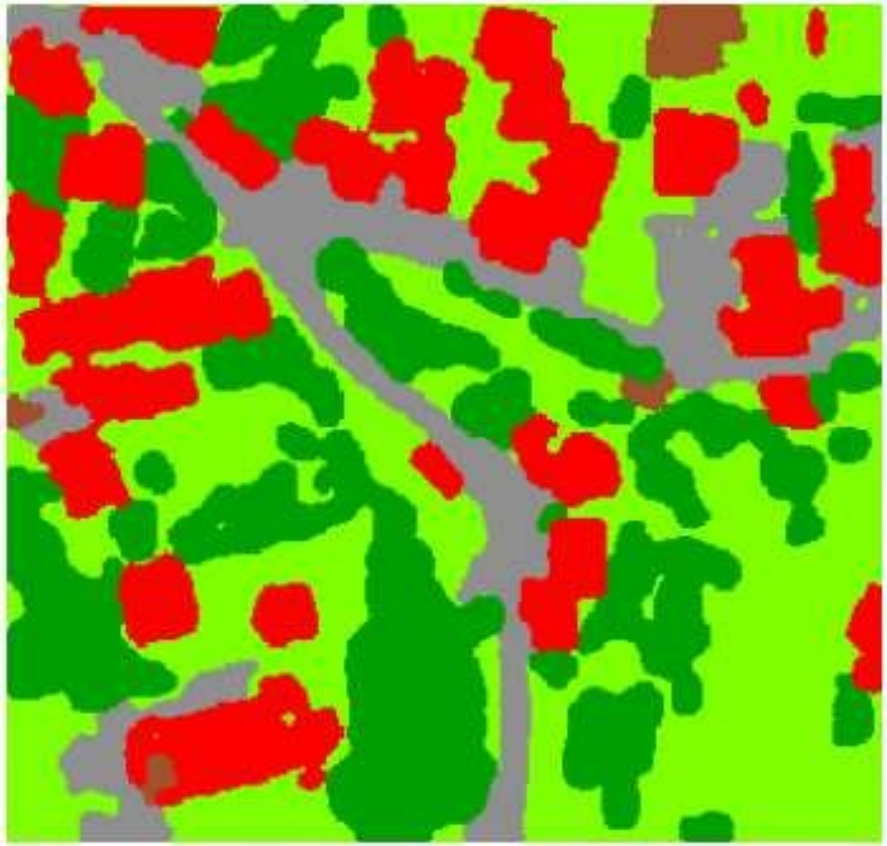
fusion (holes and overcovering)

define order of layers: buildings, trees, fields, roads and grass



Final classification

lidar data



areas well defined

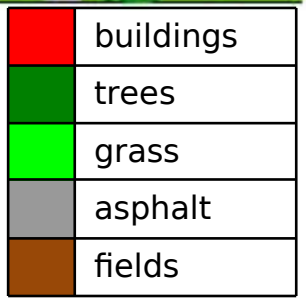
slightly deformed shape of objects

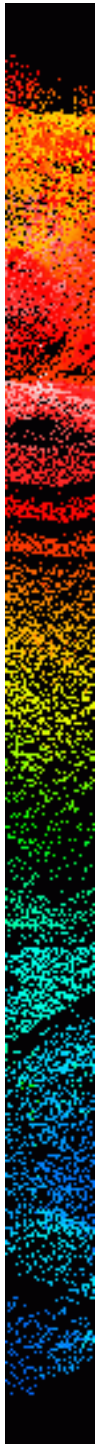
BDOF

good shape of objects

areas well defined

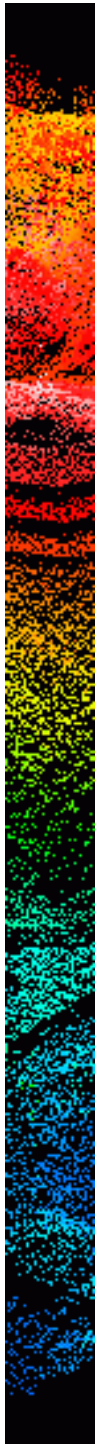
presence of shadows





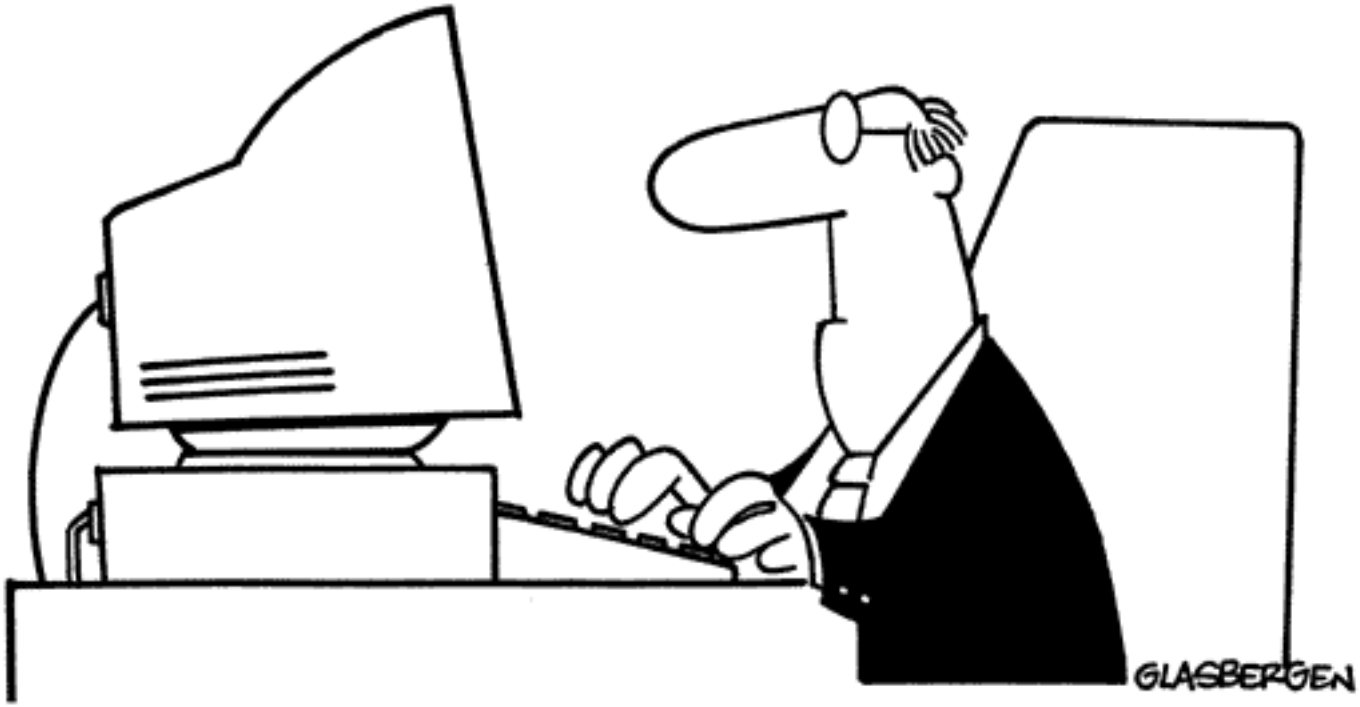
Conclusions

- Land cover map has been produced from li
  data (with attributes) and aerial photograph
- Height information (3D data profile) is
  essential
- Intensity is mostly overlooked – it can
  complement optical data



Conclusions

- Advantages
  - Well defined procedure with high level of automatizatio
  - Useful for local studies
  - Good attribute and positional accuracy
  - No need for orthorectification
  - Prompt and cost-friendly method of layer acquisition
  - Possibility of modification for specific studies
- Disadvantages
  - Useful merely for the study on a local level
  - Huge quantity of point data requires powerful hardware and software technology



"MEMO: It has come to my attention that every time we solve one problem, we create two more. From now on, all problem solving is forbidden."