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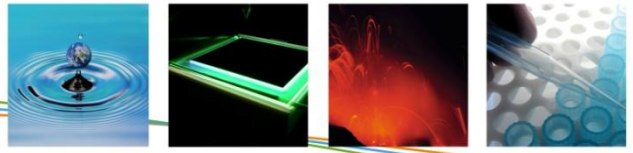

Hyperforest: advanced airborne hyperspectral remote sensing to support forest management

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Luc Bertels (VITO)
Flore Devriendt (University Ghent)
Frieke Van Coillie (University Ghent)
Kris Vandekerckhove (INBO)
F. Morsdorf (RSL)
Renato Cifuentes (University Leuven)
Franz Kai Ronellenfitsch (G. Lippmann Institute)

Objectives

- Hyperspectral data
  - Potential for forestry: tree species mapping
  - Limitations: poor tree delineation, forest structure (tree heights, understorey,…)
- LiDAR data
  - Potential for forestry: tree delineation, forest structure, understorey, stem density
- Combining hyperspectral and LiDAR: data fusion
  - Improved hyperspectral pre-processing using LiDAR data
  - Improved forest parameter retrieval
  - Tree species mapping using combined LiDAR and hyperspectral data (todo)

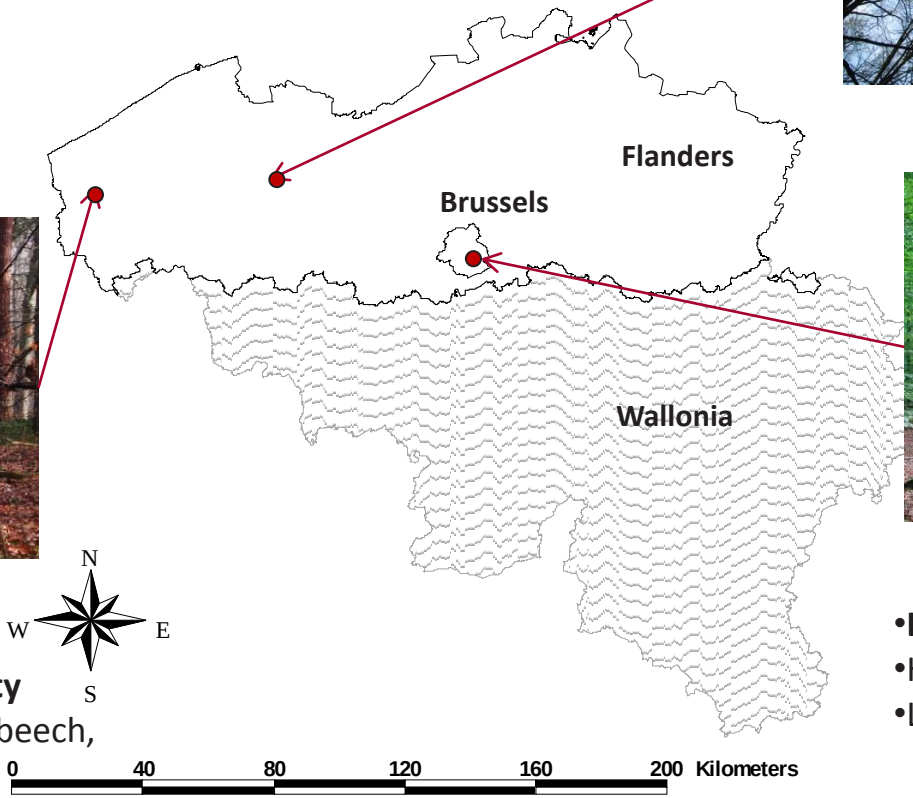
Study area

Aelmoeseneiebos

- **High structural complexity**
- mixed oak, beech, ash and larch stand
- rich understorey

Wijnendalebos

- **Medium structural complexity**
- Mixed oak forest with maple beech, larch, hazel,…



Kersselaerspleyn

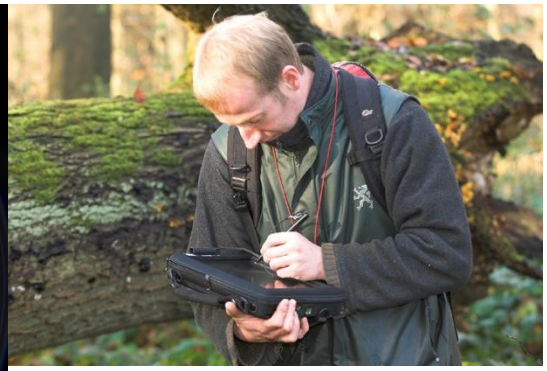
- **Low structural complexity**
- Homogeneous old beech stands
- Limited admixture of oak

Available data

- Field measurements
  - Tree species, heights, stem density,...
- LiDAR
  - Riegl LMS Q560 full waveform
    - Wavelength: 1560 nm
    - point density > 10 points/m^2
- Hyperspectral data

Sensor	Spectral resolution	Spatial resolution
CASI	96 bands (368-1052 nm)	1 m
AHS	63 bands (452-2552 nm)	5 m
APEX	301 bands (375-2500 nm)	1.5 m

Field measurements



Full dendrometric inventories

- tree position;
- species
- DBH all trees > 5 cm diameter;
- tree heights all trees upper canopy

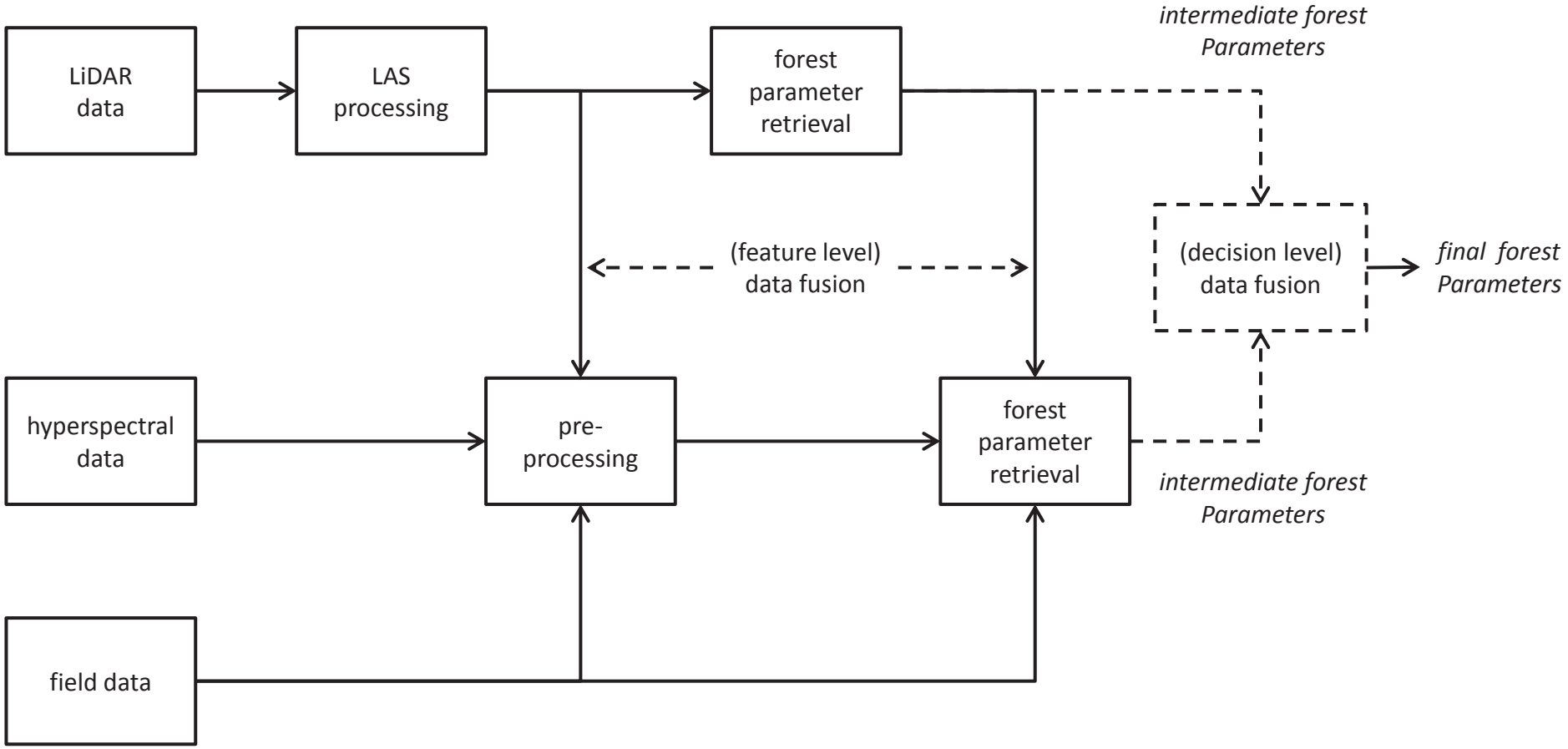
Canopy gaps

- hemispheric photos

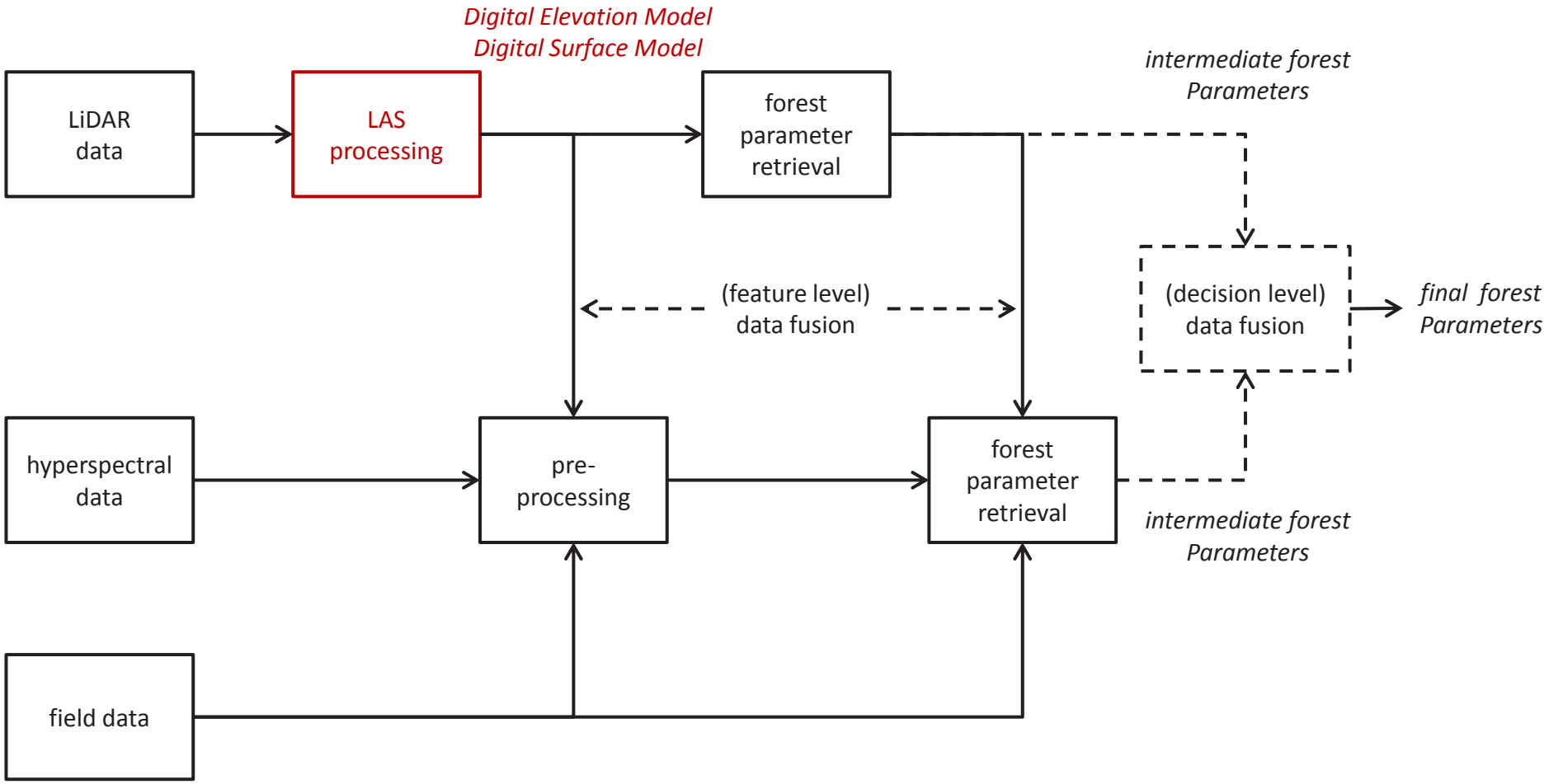
Tree vitality

- On a selection of trees : evaluation of discoloration and leaf loss (international methodology for level I forest vitality evaluation).

Methods



LAS processing

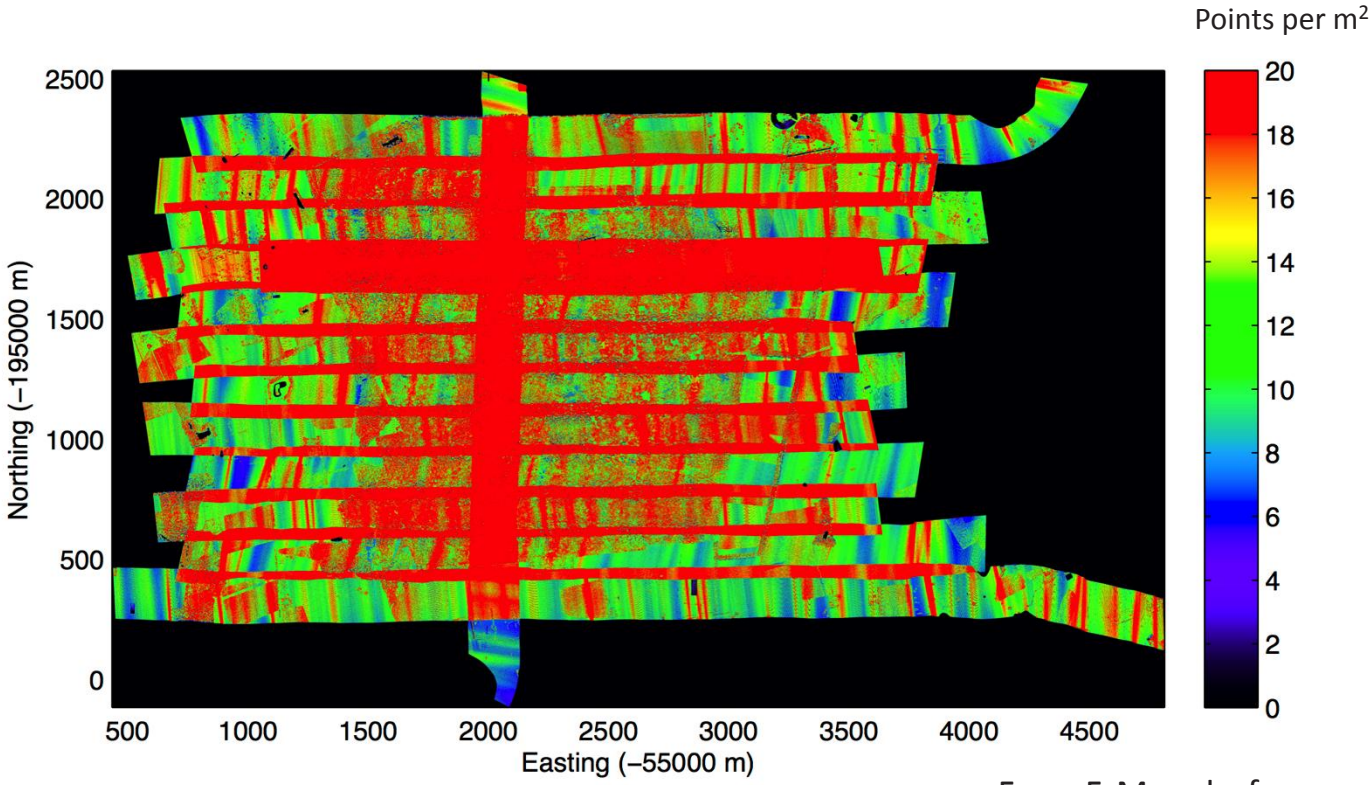


LAS processing

- Producing:
  - Digital elevation model
    - according to Zhang, C. 2003[1]
    - fill holes (weighting proportional to inverse distance)
  - Digital surface model
    - Based on maxima in LAS file
    - Morphological closing filter (3x3)

[1] Zhang, C. (2003). A progressive morphological filter for removing nonground measurements from airborne LiDAR data. IEEE Transactions on Geoscience and Remote Sensing, 41(4), 872-882

Results LAS processing: points per m^2

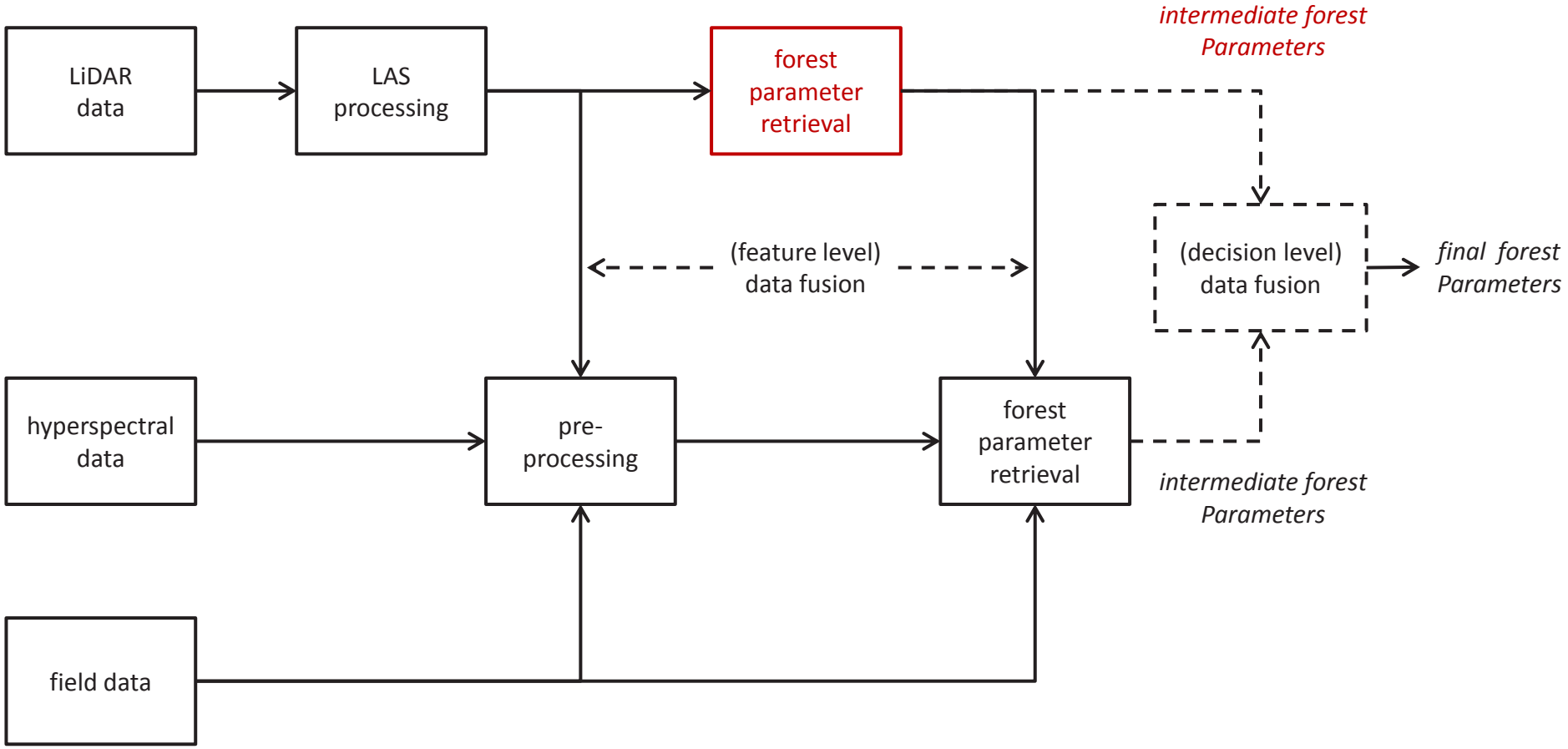


From F. Morsdorf

Results LAS processing: digital terrain model

Results LAS processing: digital surface model

Forest parameter retrieval from LiDAR

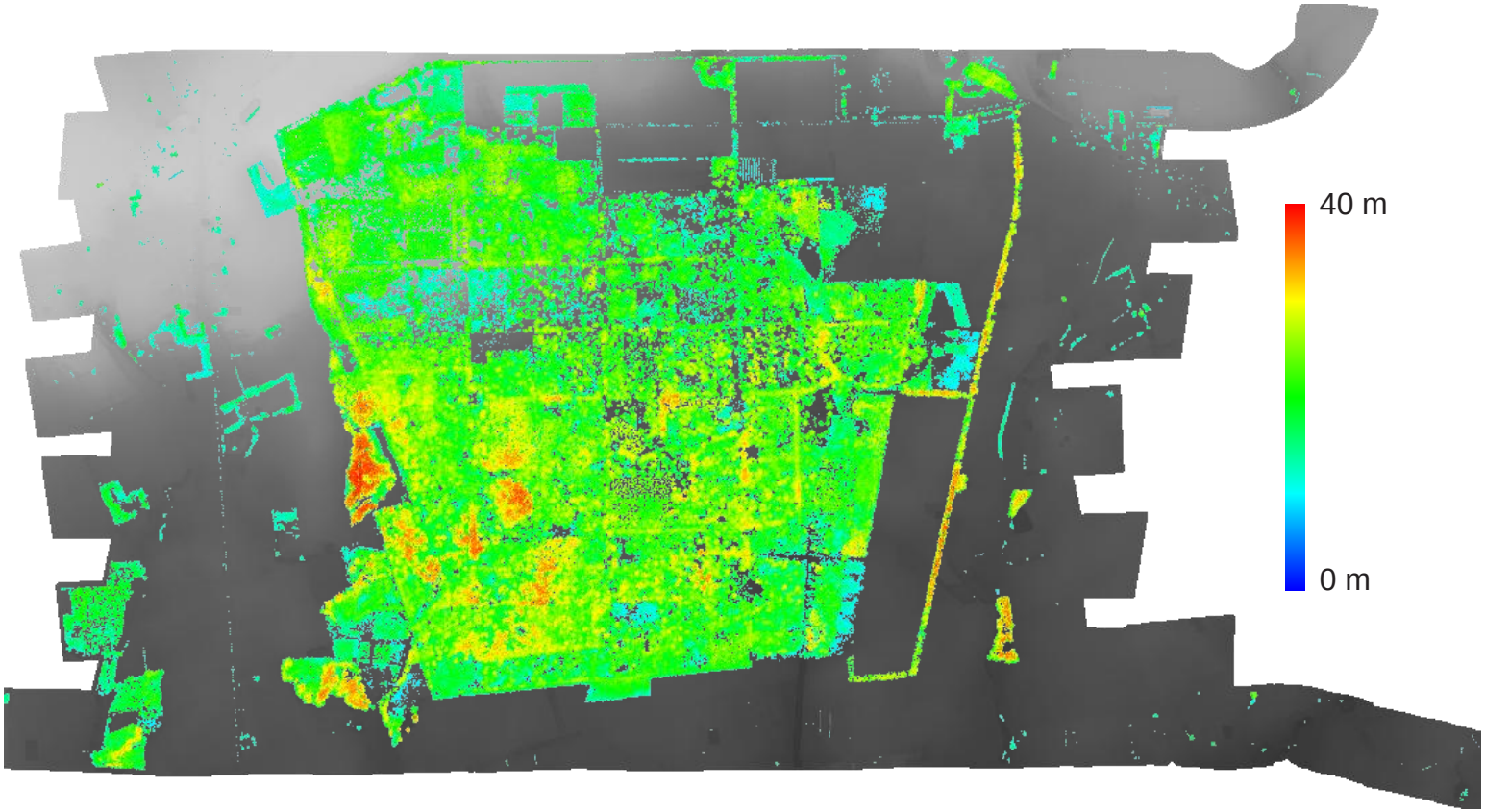


Forest parameter retrieval from LiDAR

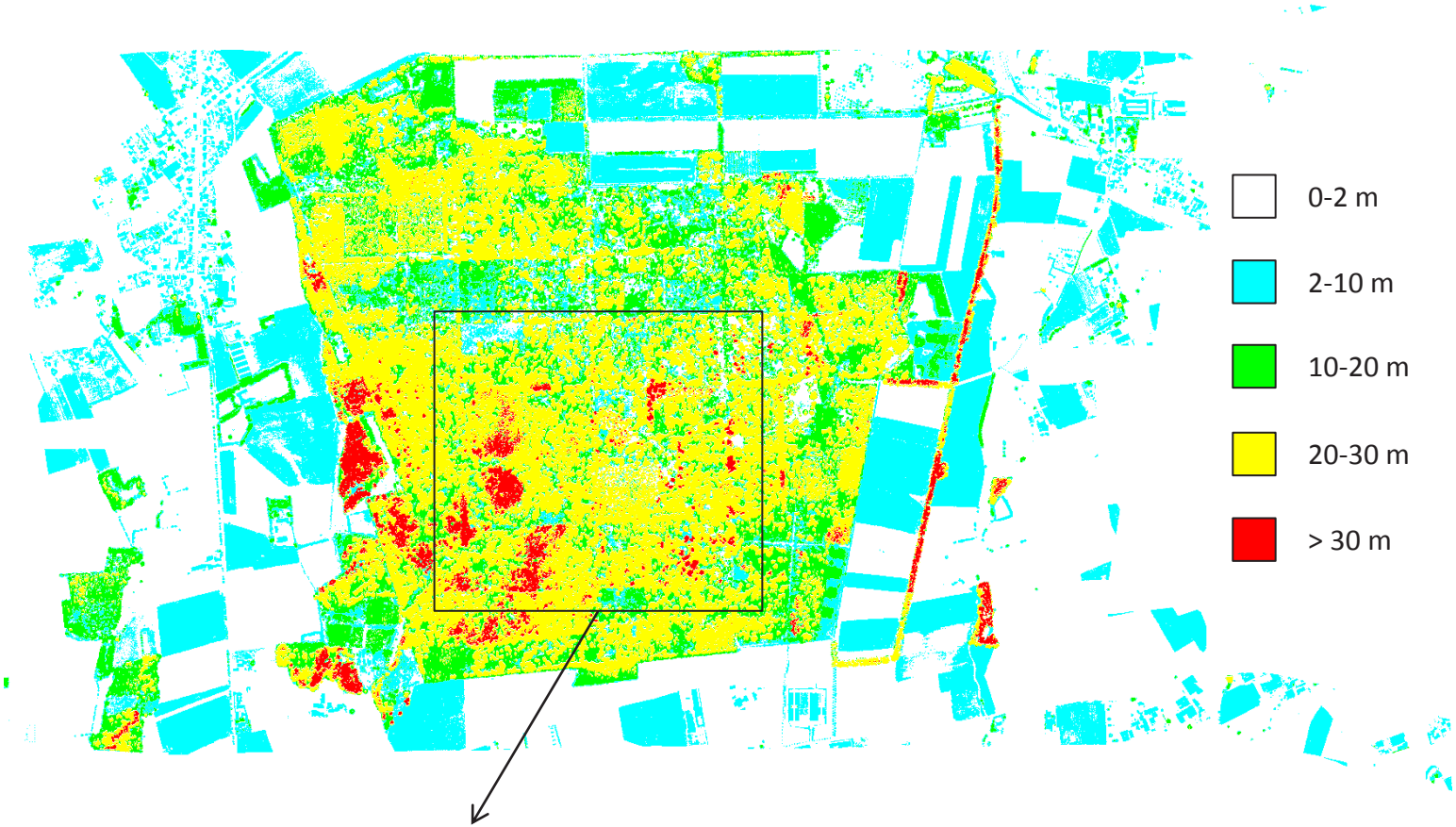
- Vegetation height model
  - Difference(Surface –Elevation)
  - Median filter (3x3)
- Gap fractions at different height levels
- Individual tree heights
- Stand density estimation
  - Directional local filtering[1]

[1]F. M. B. Van Coillie, F.R. Devriendt, L.P. C. Verbeke and R.R. De Wulf, Directional local filtering for stand density estimation in closed forest canopies using VHR optical and LiDAR data, submitted to IEEE Geoscience and Remote Sensing Letters

Results: vegetation height model

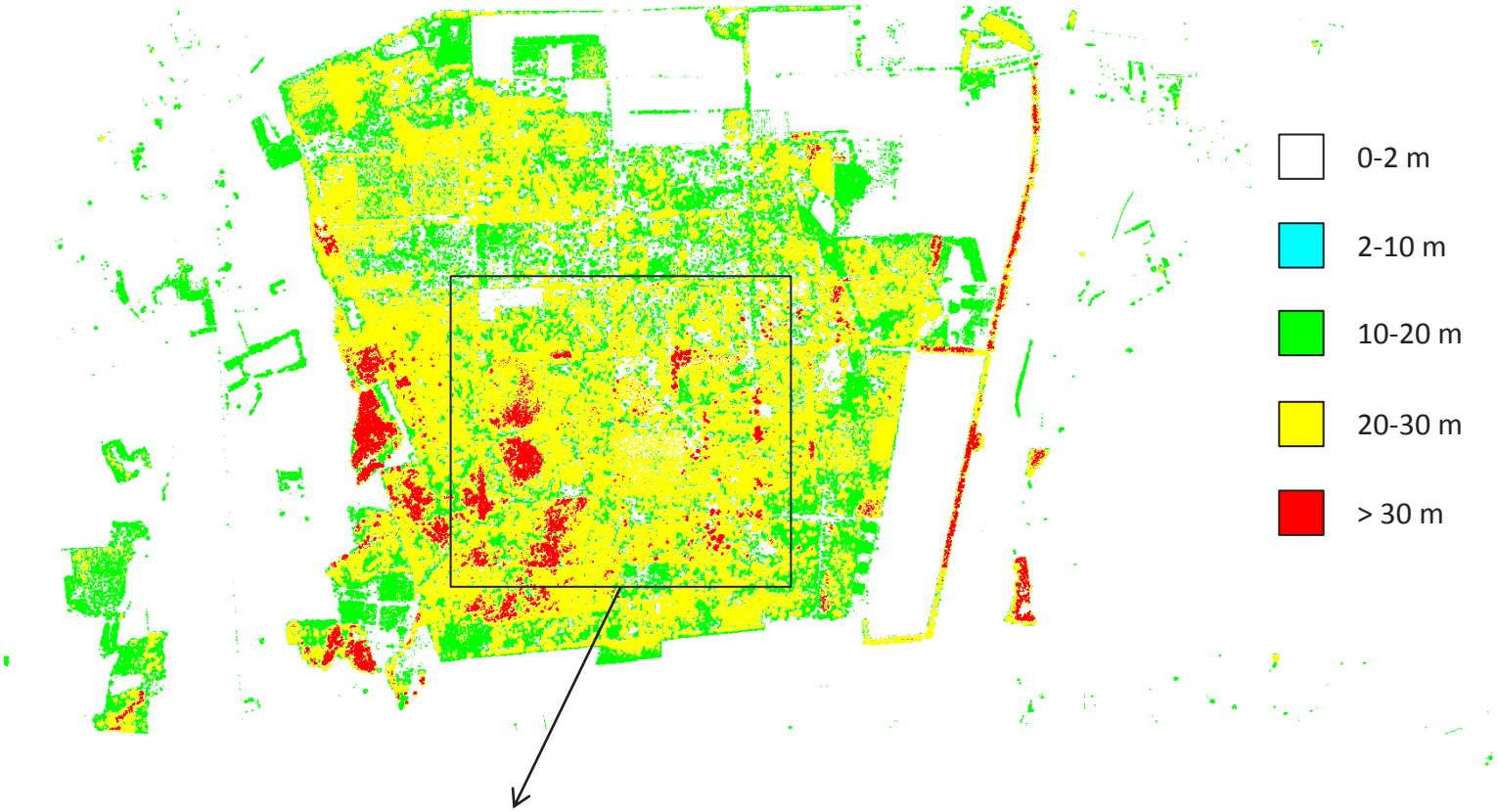


Results: gap fractions



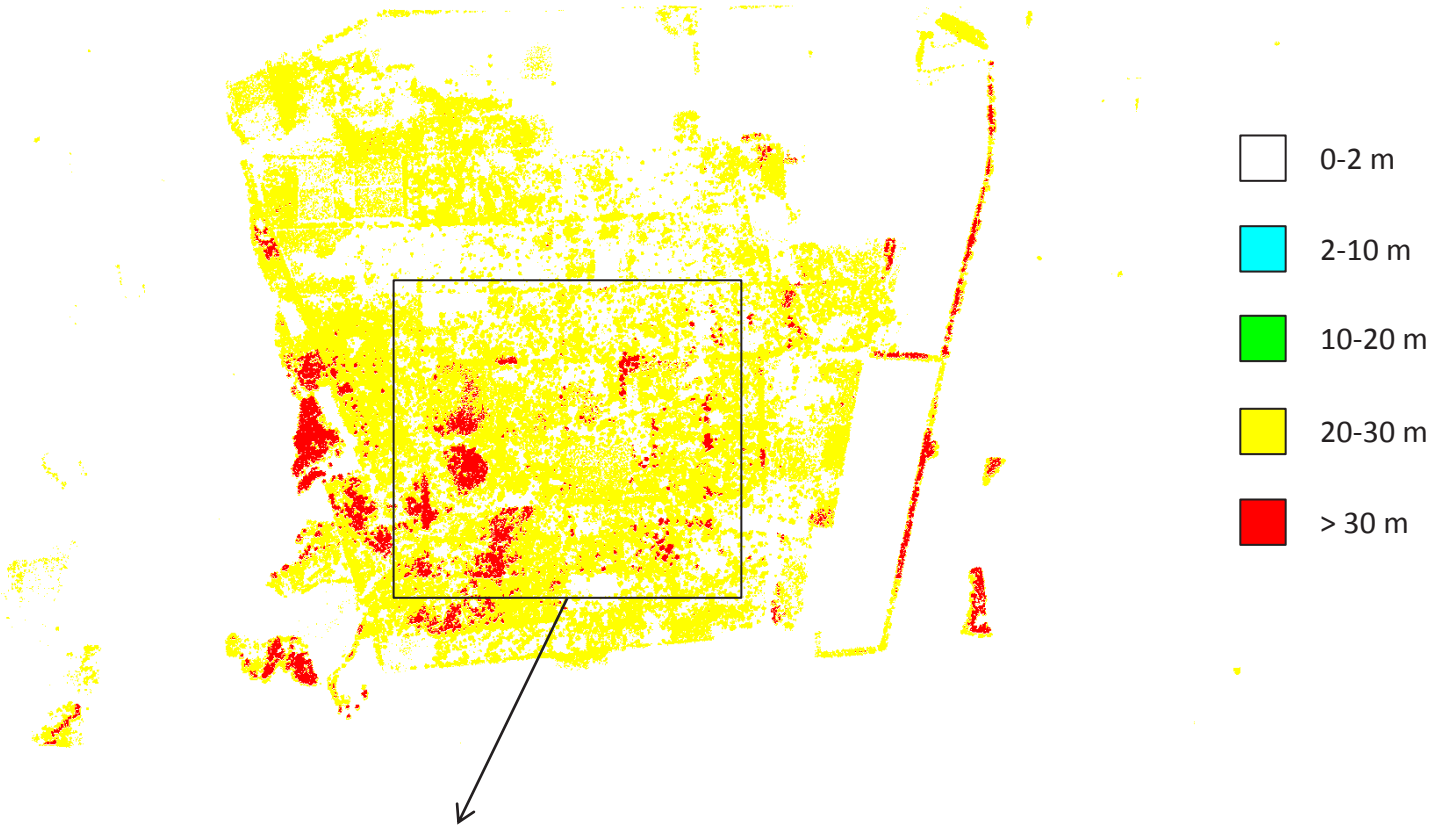
Example: gap fraction at 2 m: 6%

Results: gap fractions



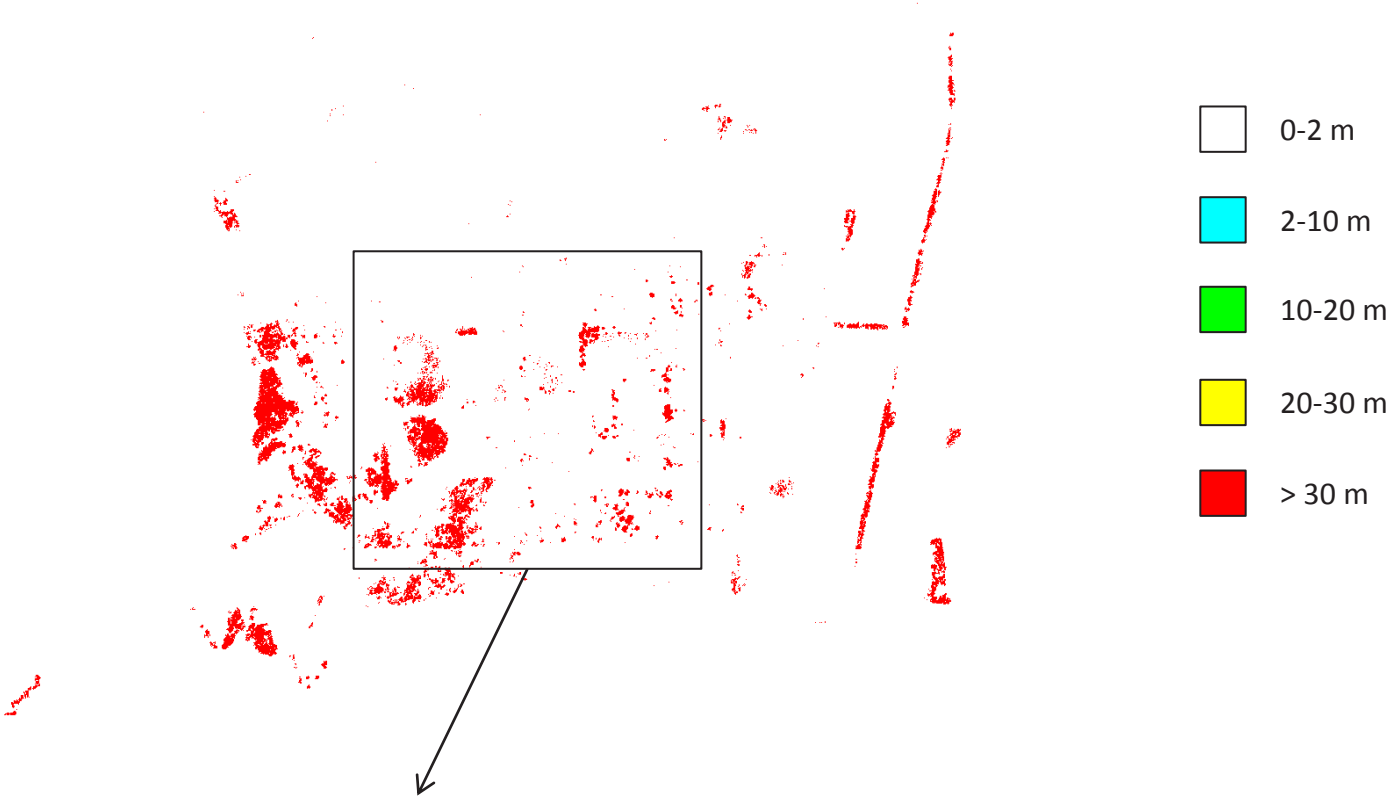
Example: gap fraction at 10 m: 11%

Results: gap fractions



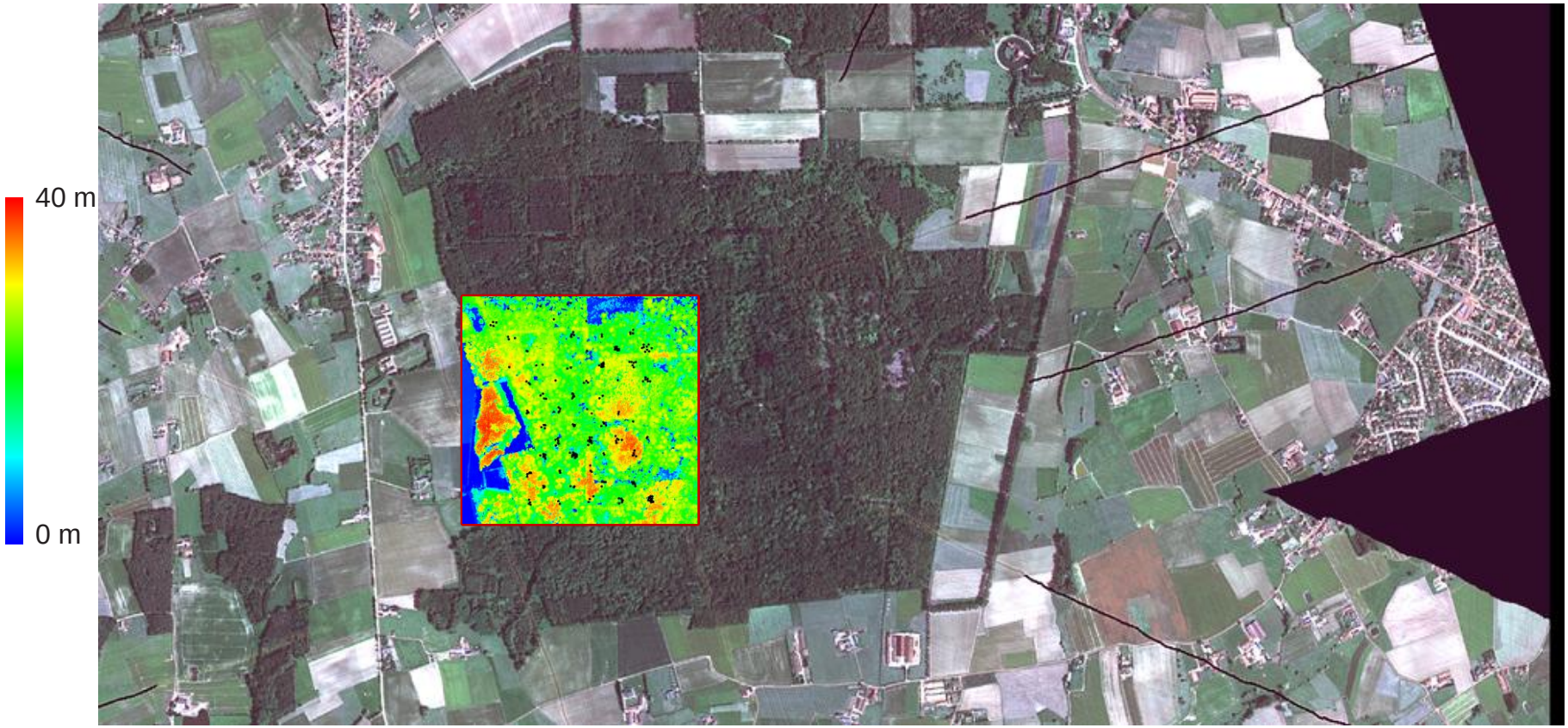
Example: gap fraction at 20 m: 34%

Results: gap fractions



Example: gap fraction at 30 m: 94%

Results: validation of tree heights



Vegetation height model

RGB: True colour APEX image

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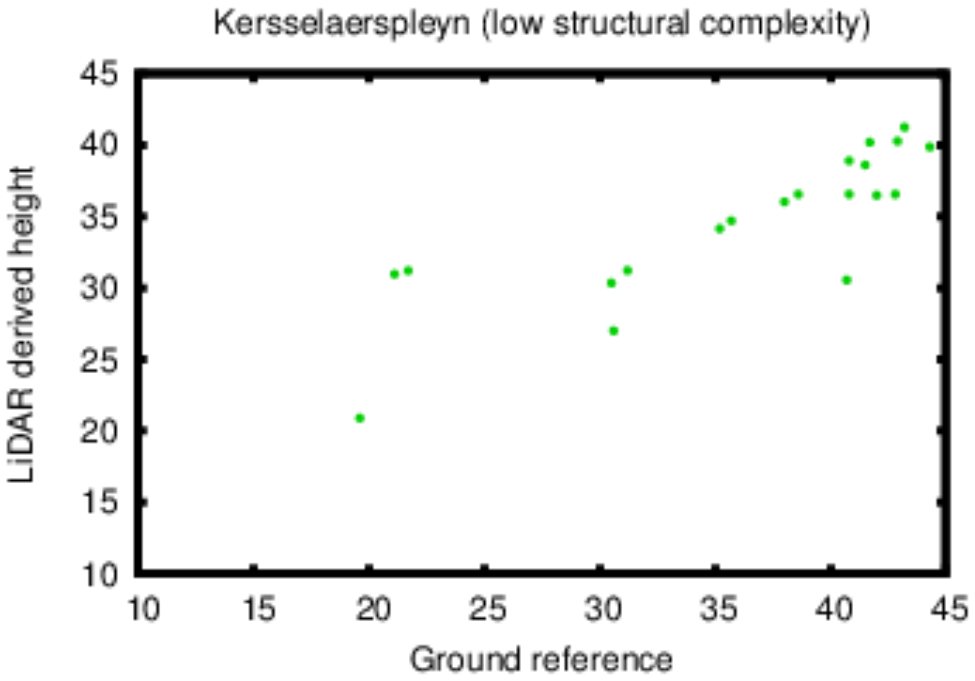
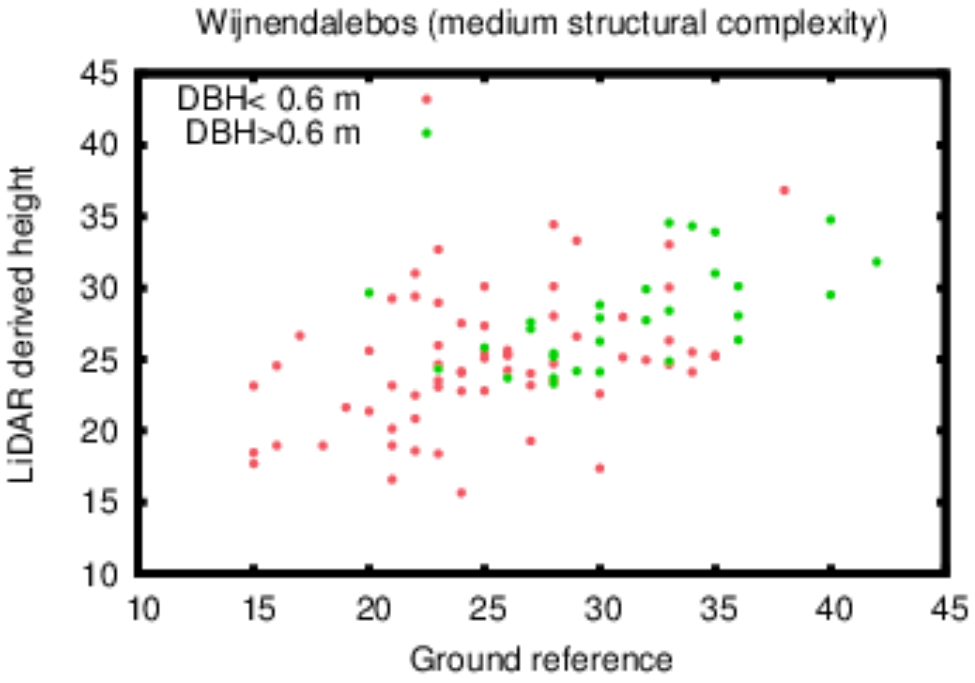
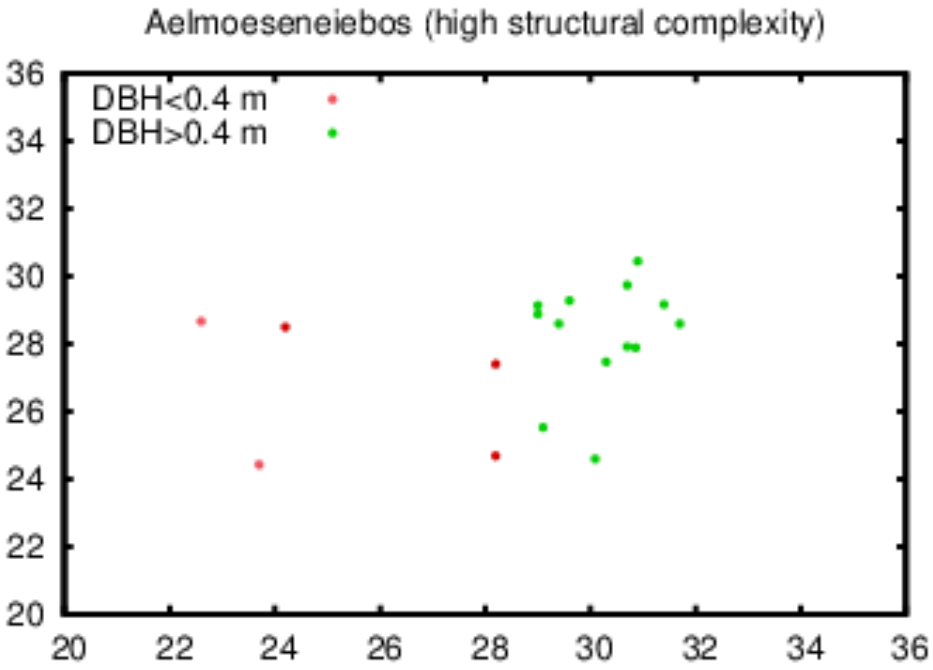
Results: individual tree heights



Results: individual tree heights

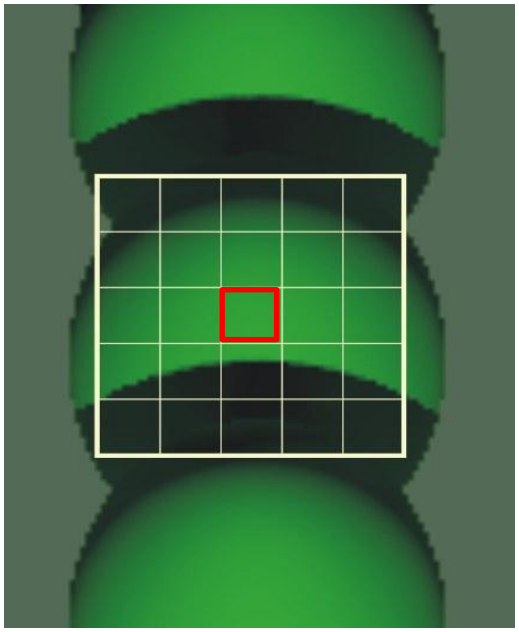


Results: individual tree heights



Results: stand density estimation

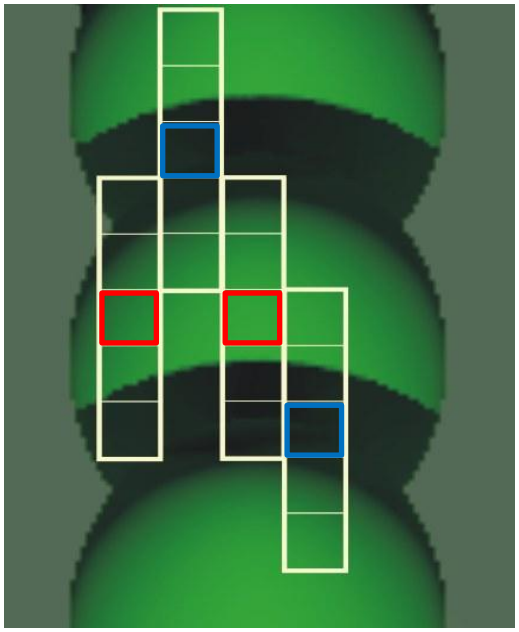
LMF



Local maximum

Local minimum

DLF



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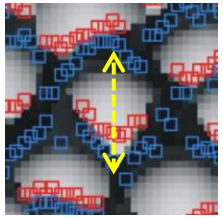
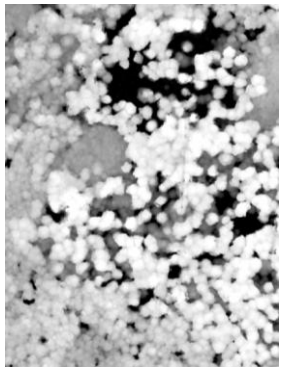
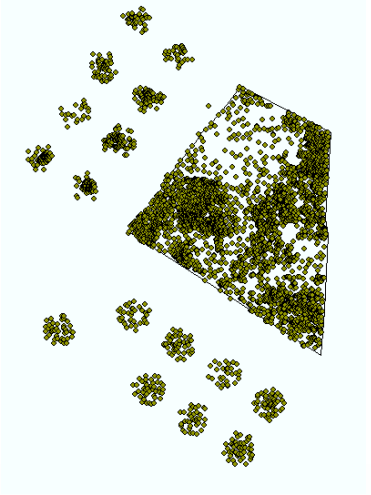
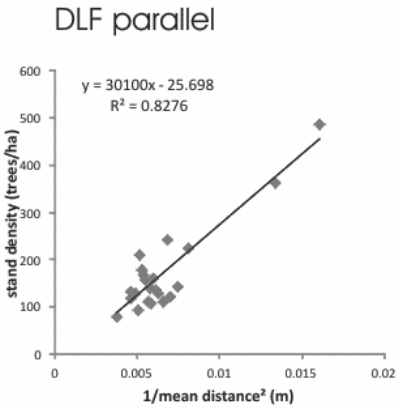
Results: stand density estimation

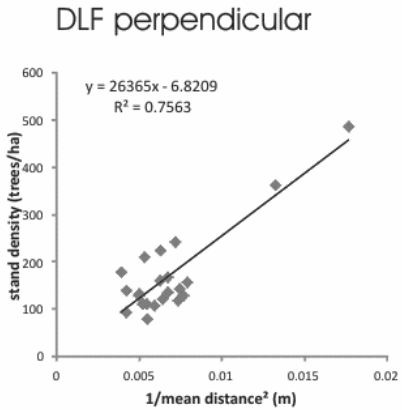


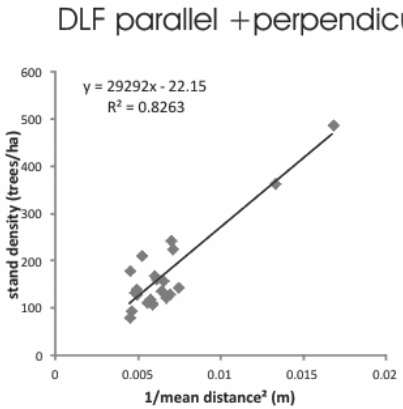
$$\text{stand density} = \alpha * \text{QMD}^{-1.605}$$

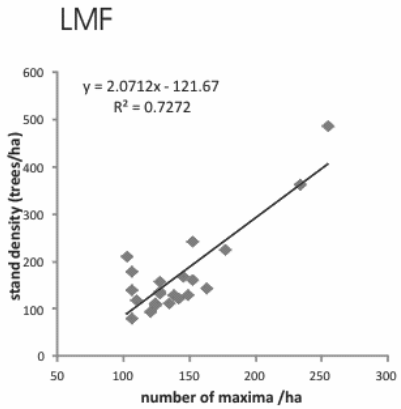












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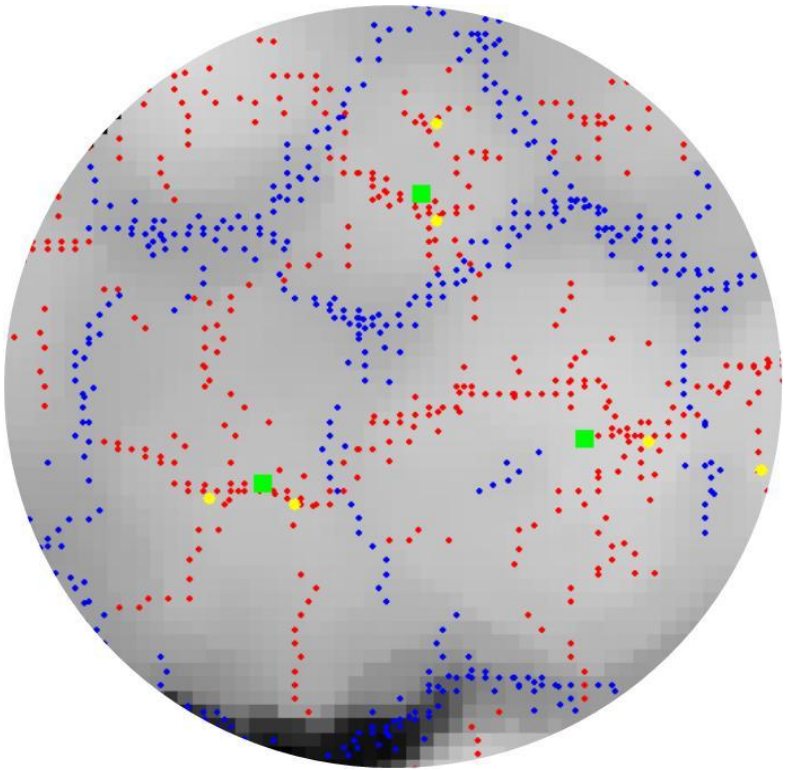
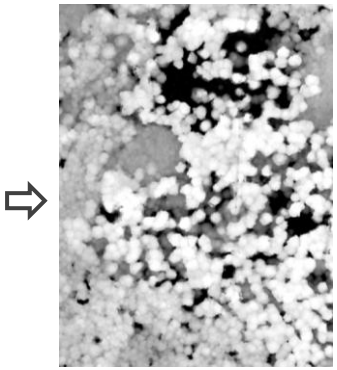
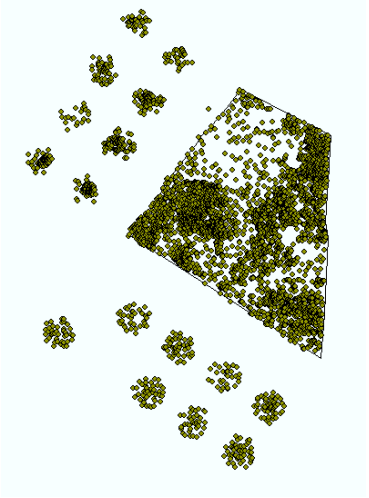
Results: stand density estimation







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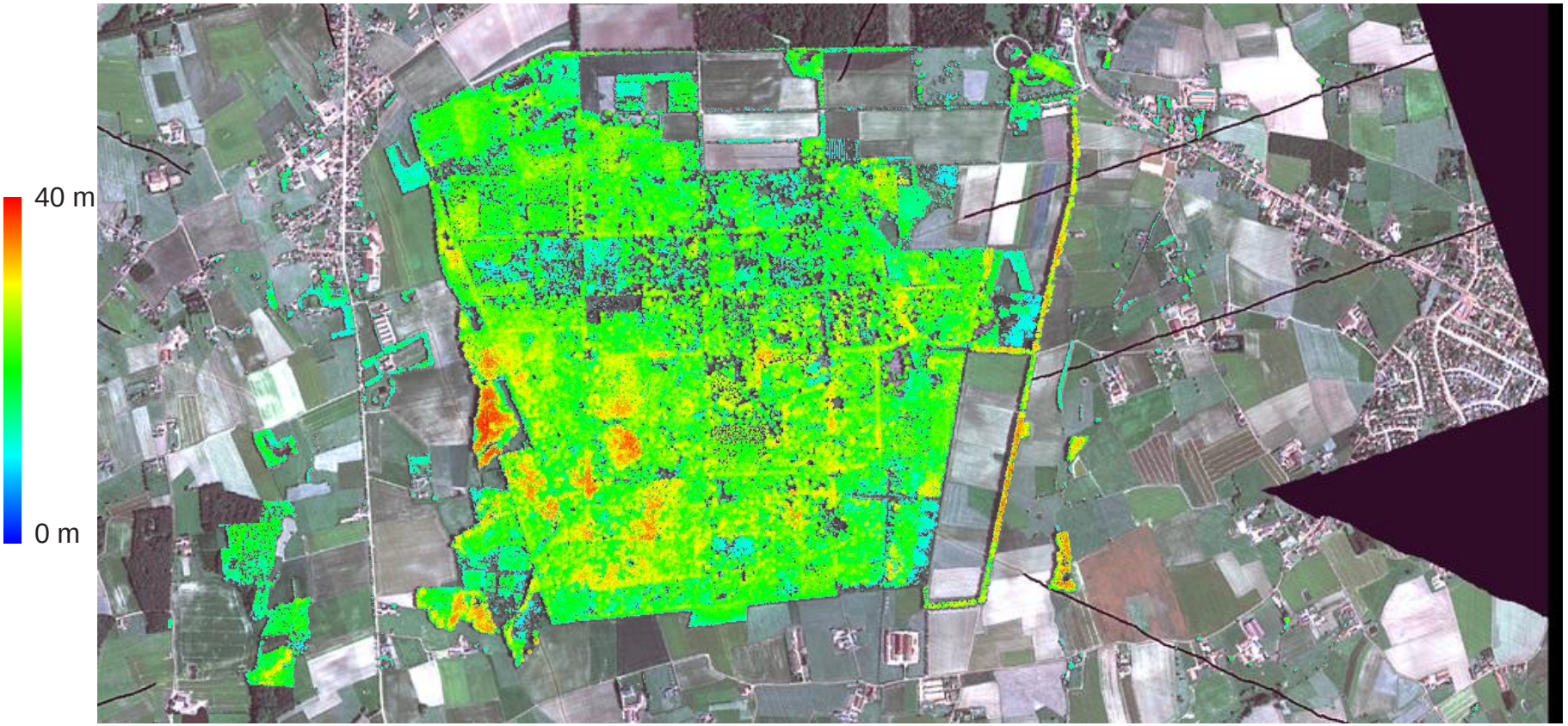
Conclusions

- Preliminary results show potential of data fusion
  - Improved hyperspectral pre-processing using LiDAR data
  - Potential of LiDAR data for forest parameter retrieval
    - Tree heights, stem density
  - Next steps: tree species mapping using combined LiDAR and hyperspectral data



Vegetation height model

RGB: True colour APEX image

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