3D Vegetation Mapping and Classification using Full-Waveform Laser Scanning
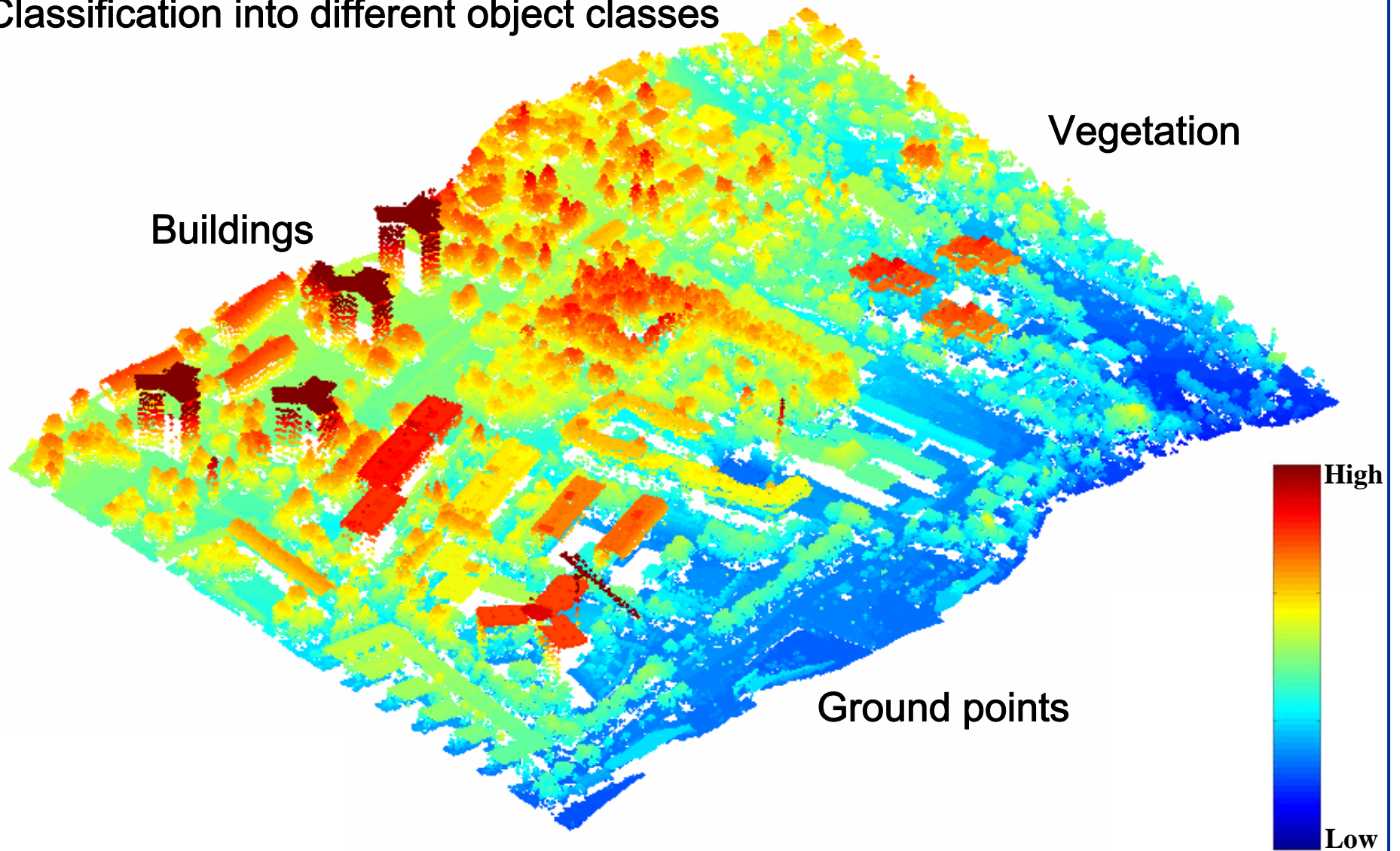
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and Thomas Melzer[1]

1 Christian Doppler Laboratory for Spatial Data from Laser Scanning and Remote Sensing, Vienna University of Technology, Vienna, Austria
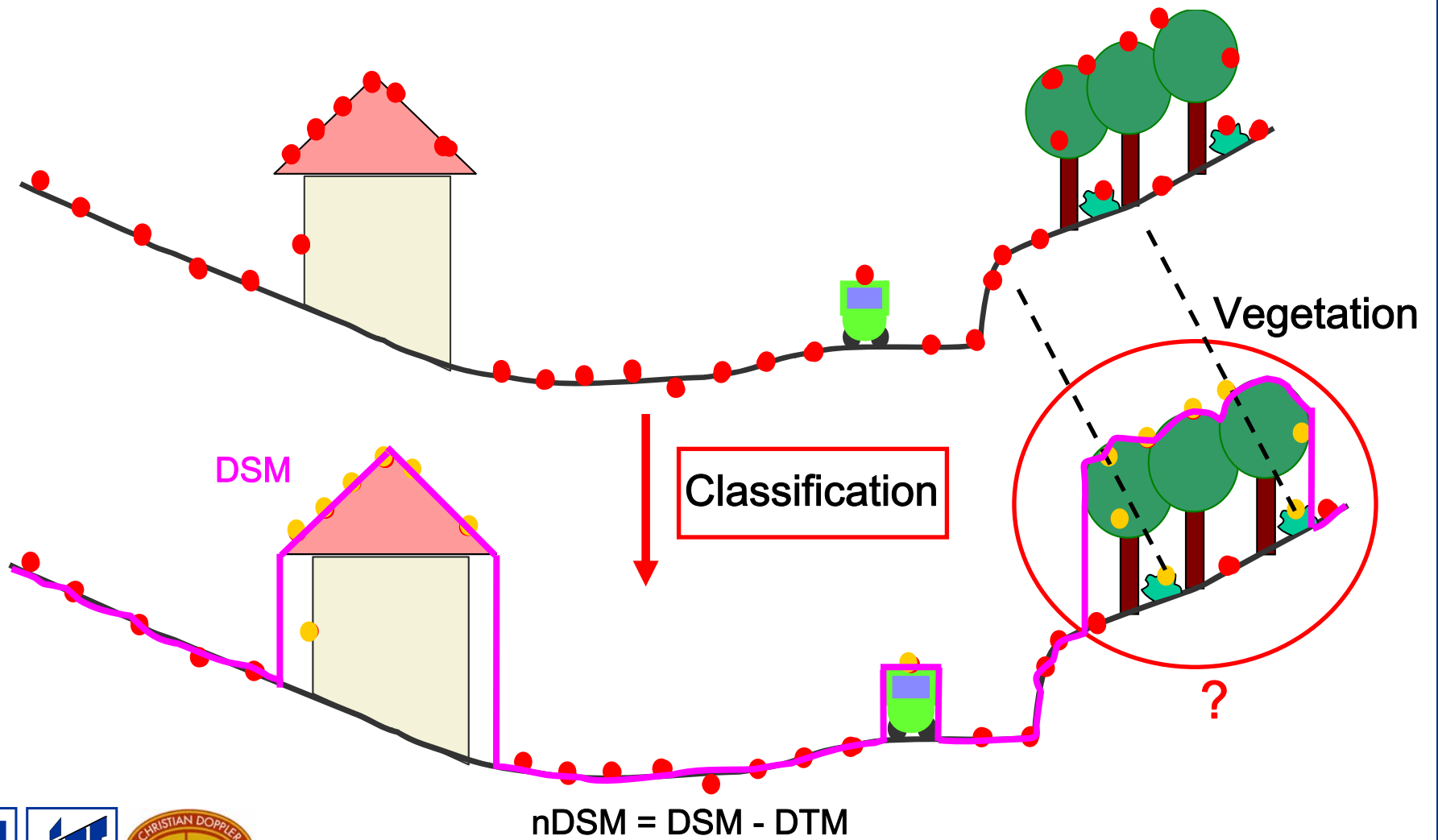2 Riegl Research GmbH, Horn, Austria

3D data cloud

Classification into different object classes

Vegetation

Buildings

Ground points

High

Low

Vegetation analysis


DSM

Classification

Vegetation

?

nDSM = DSM - DTM

Basic problem in laser data processing

- Classifying vegetation points from ALS data may be problematic (in particular low vegetation)
  - ◆ Correct identification of ground hits below canopy is challenging

- Current classification approaches rely on geometric information only (conventional ALS systems provide only the 3D coordinates of scattering objects)

- Need further physical observables

Full-waveform laser scanner system

Full-waveform digitising laser scanners

- **Digitally sample and store the entire waveform**

- **Off-line analysis of the digitized waveforms**
  - Detailed analysis of complex waveforms (forest and vegetation areas, …)

  - Maximum number of registered returns not limited by manufacturer

  - Additional physical and quality parameters can be derived (amplitude, pulse width, …)
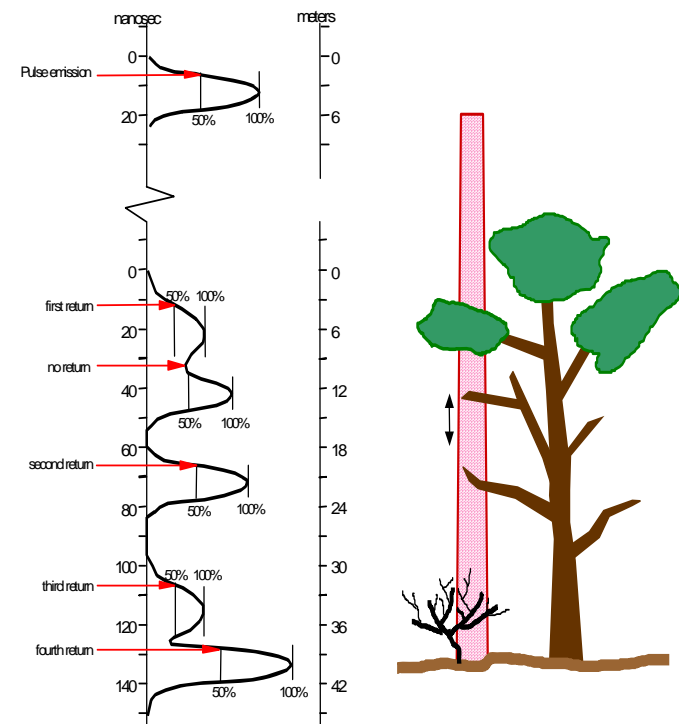
Courtesy: Spencer Gross

Riegl full-waveform LMS-Q560

- Full-waveform digitising
- Waveform sampling interval
  - 1 ns
- Laser Pulse Repetition Rate
  - up to 100 000 Hz
- Frequency
  - Near-infrared
- Laser Beam Divergence
  - 0.5 mrad
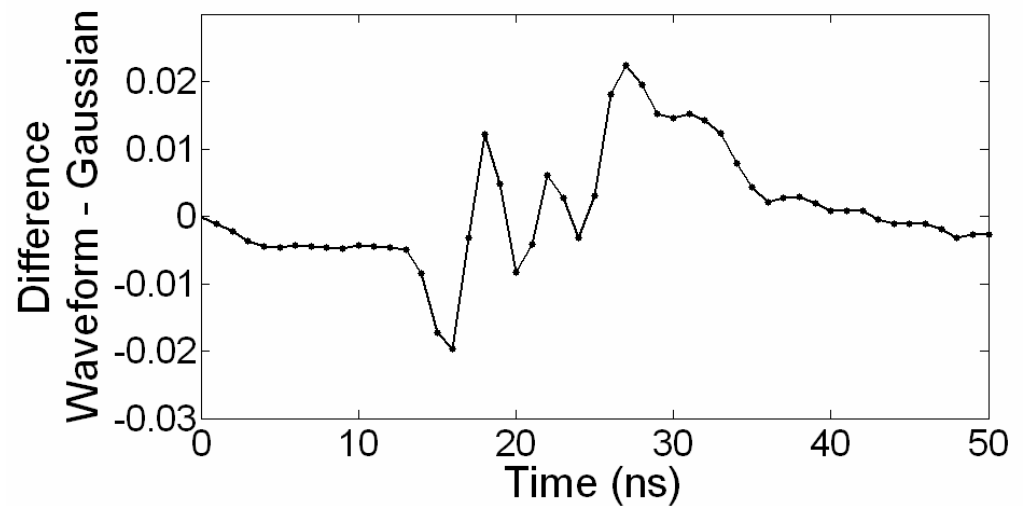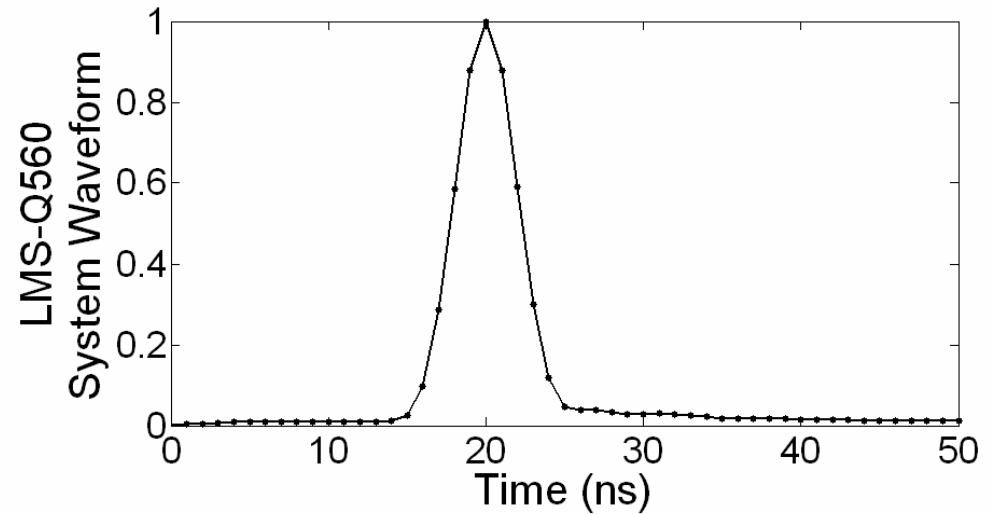- Scan Angle
  - $\pm$ 22.5 deg
- Range
  - 800 – 1500 m

LMS-Q560 System Waveform

Wagner et al., 2006

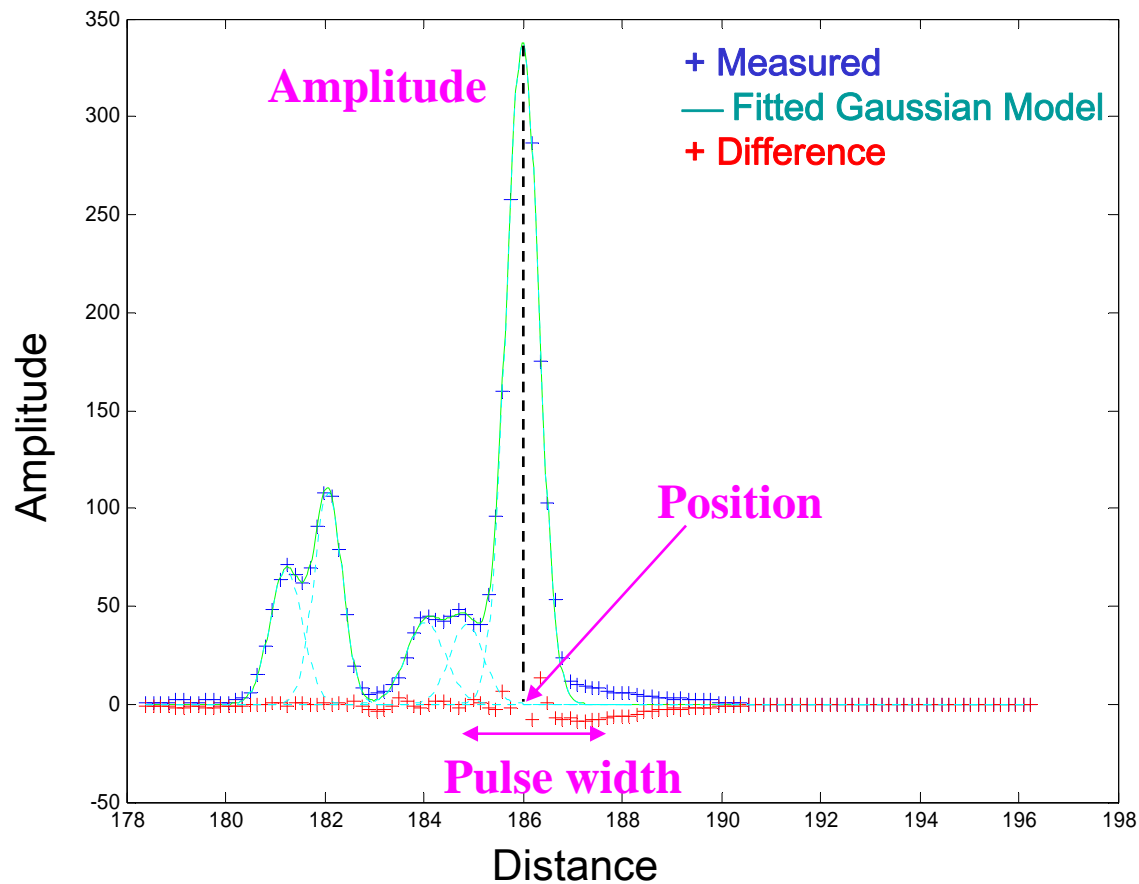- Well described by a **Gaussian distribution function**

$$S(t) = \hat{S}e^{-\frac{t^2}{2s_s}}$$

- Relative deviation < 2 %

Waveform Decomposition

- Fitting of Gaussian pulses

Complex targets

How to classify vegetation points without using the geometry information?

- Amplitude
- Pulse width
- Number of returns

Valuable source of information for classification purposes

- Classification algorithm based on a decision tree technique

- Distinction between vegetation (trees + bushes) and non-vegetation points

Schönbrunn flight campaign

- 30 August 2004
  LMS-Q560 (RIEGL waveform digitising ALS system)

- by Milan-Flug

- 11 stripes

- Study area
  ~ 2 km^2

- Large variety of land
  cover types
- Buildings
- Residential areas
- Allotment gardens
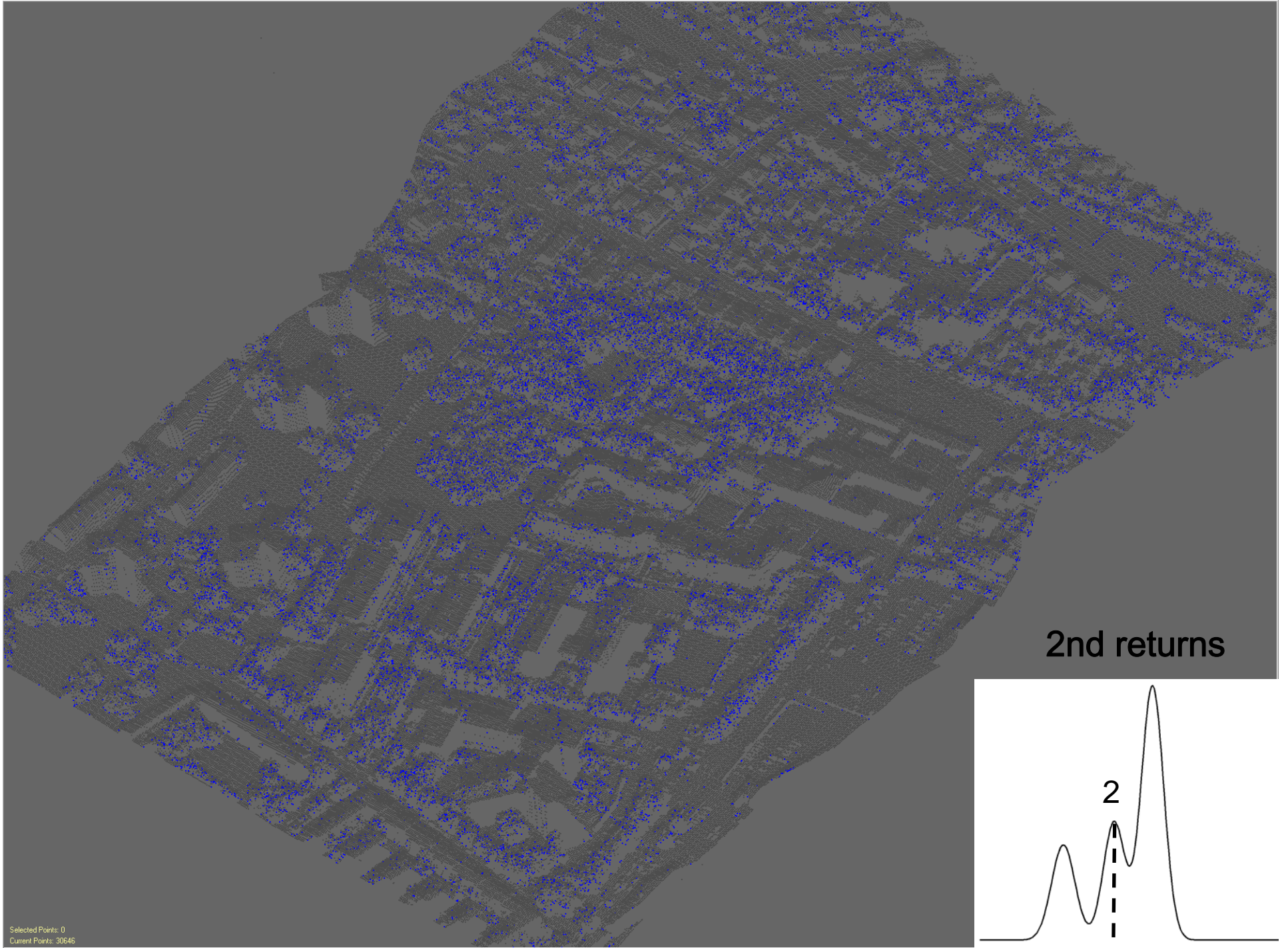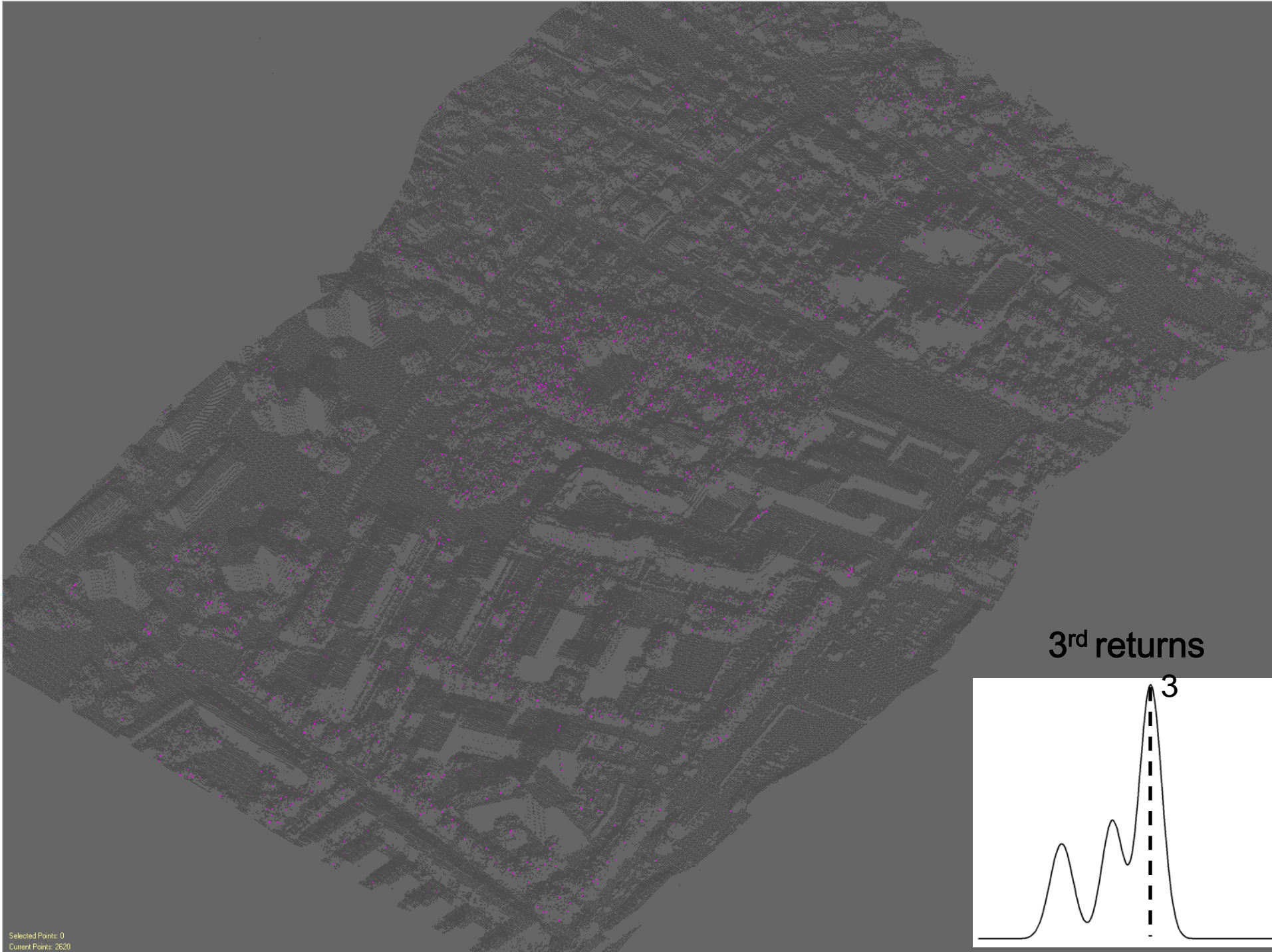- Natural forest

Flight tracks

Google-Earth image

Schönbrunn flight campaign

- Small-footprint full-waveform ALS system

- 3 million laser pulses / each track

- Scan rate = 66 kHz
  - ⇒ 4 measurements / m²

LMS-Q560

~ 500 m

Footprint size ~ 25 cm

Laser Beam Divergence ⇒ 0.5 mrad
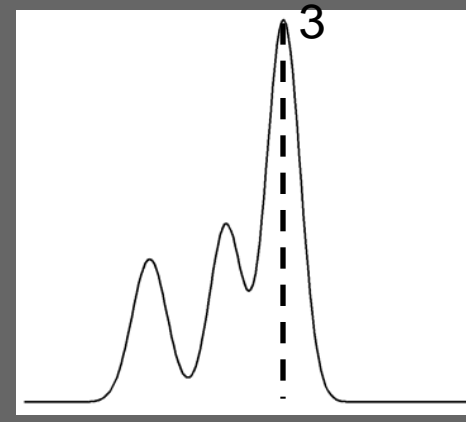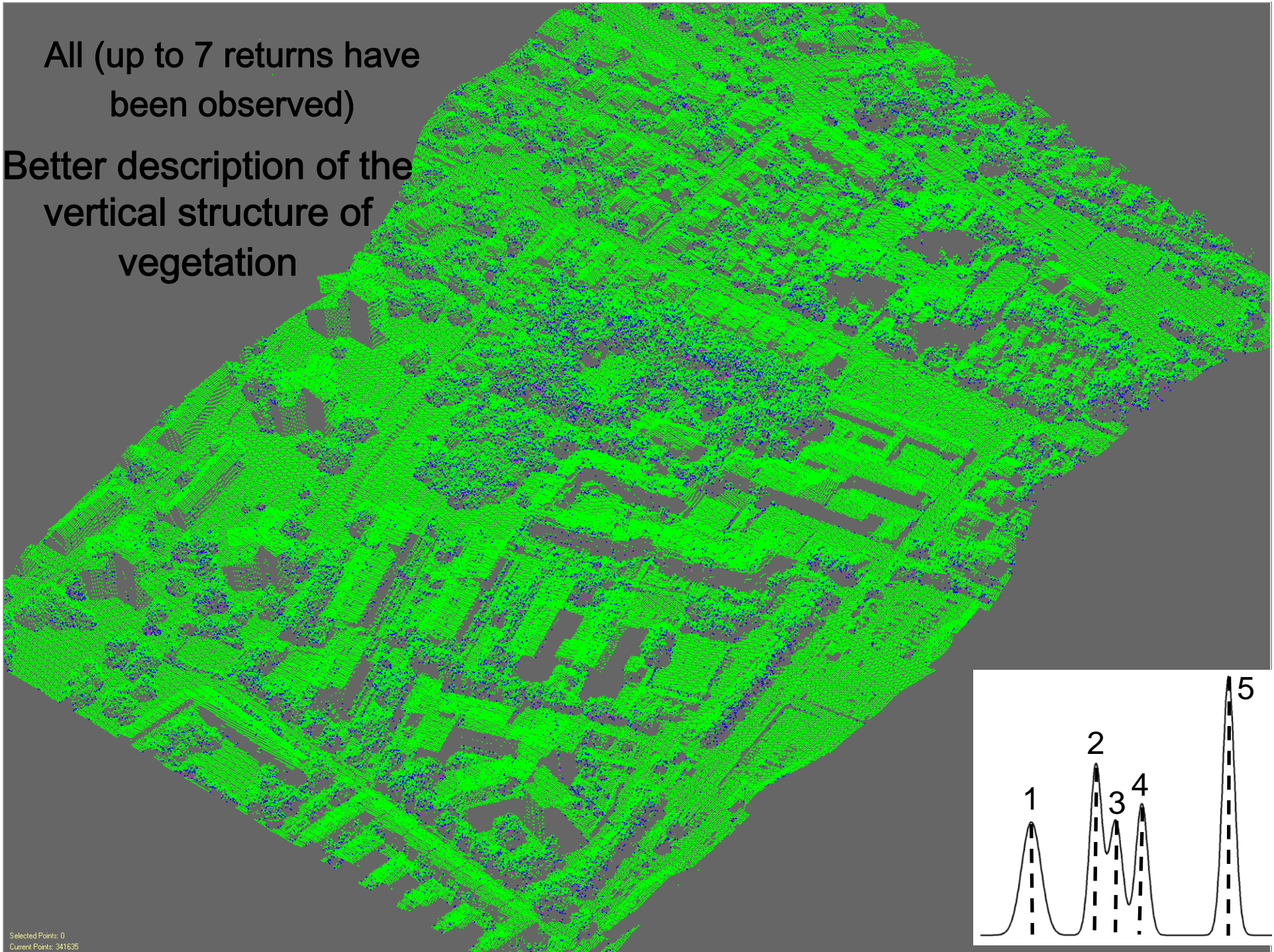
1st returns

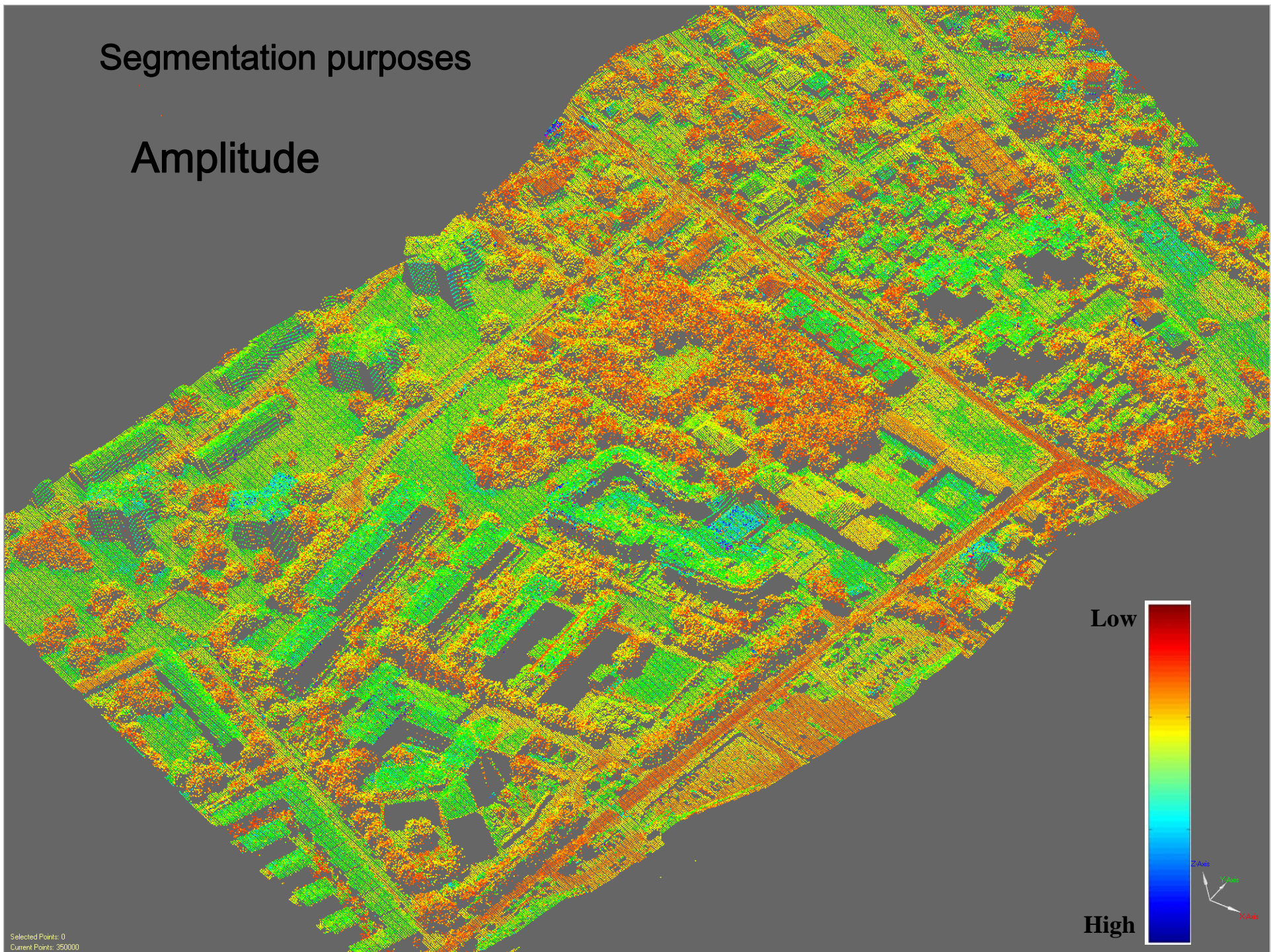and

1

2nd returns

2
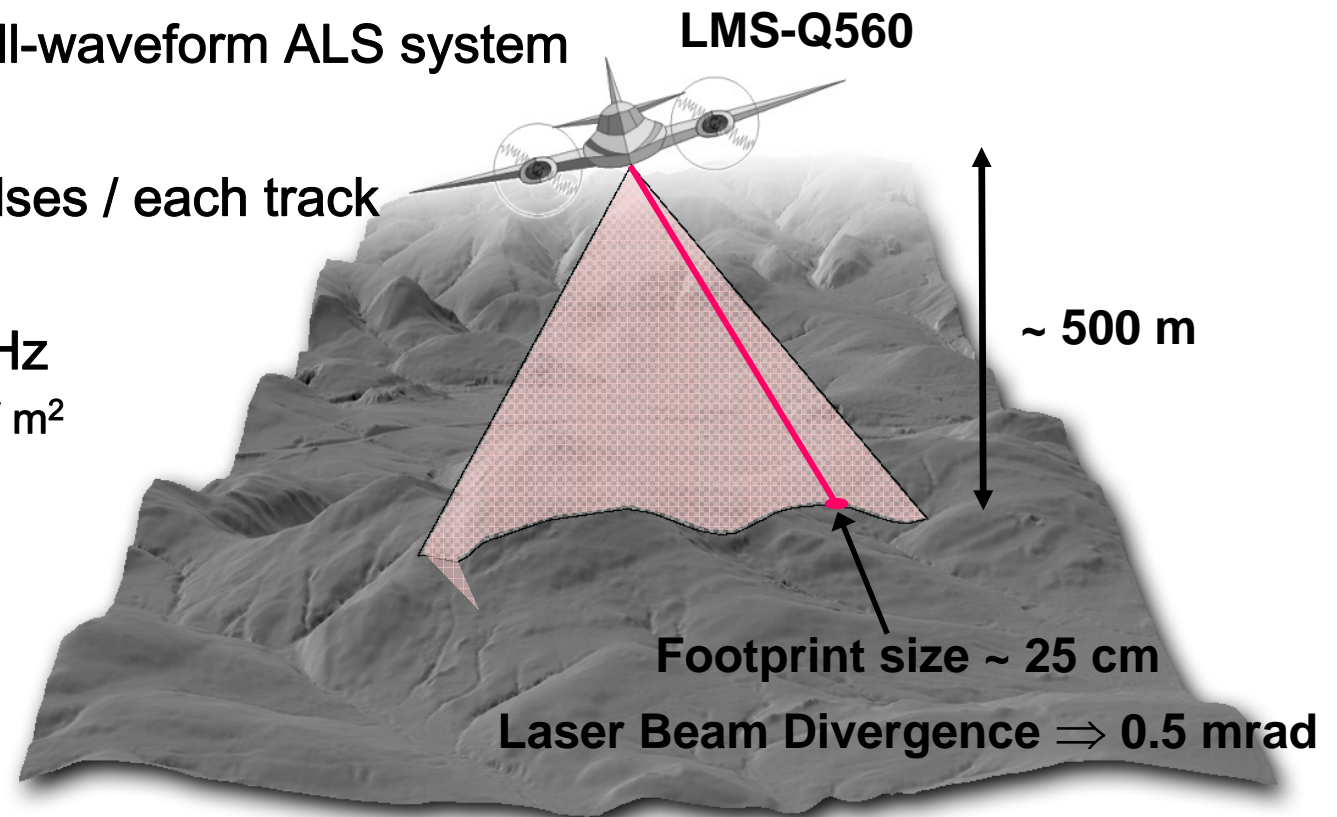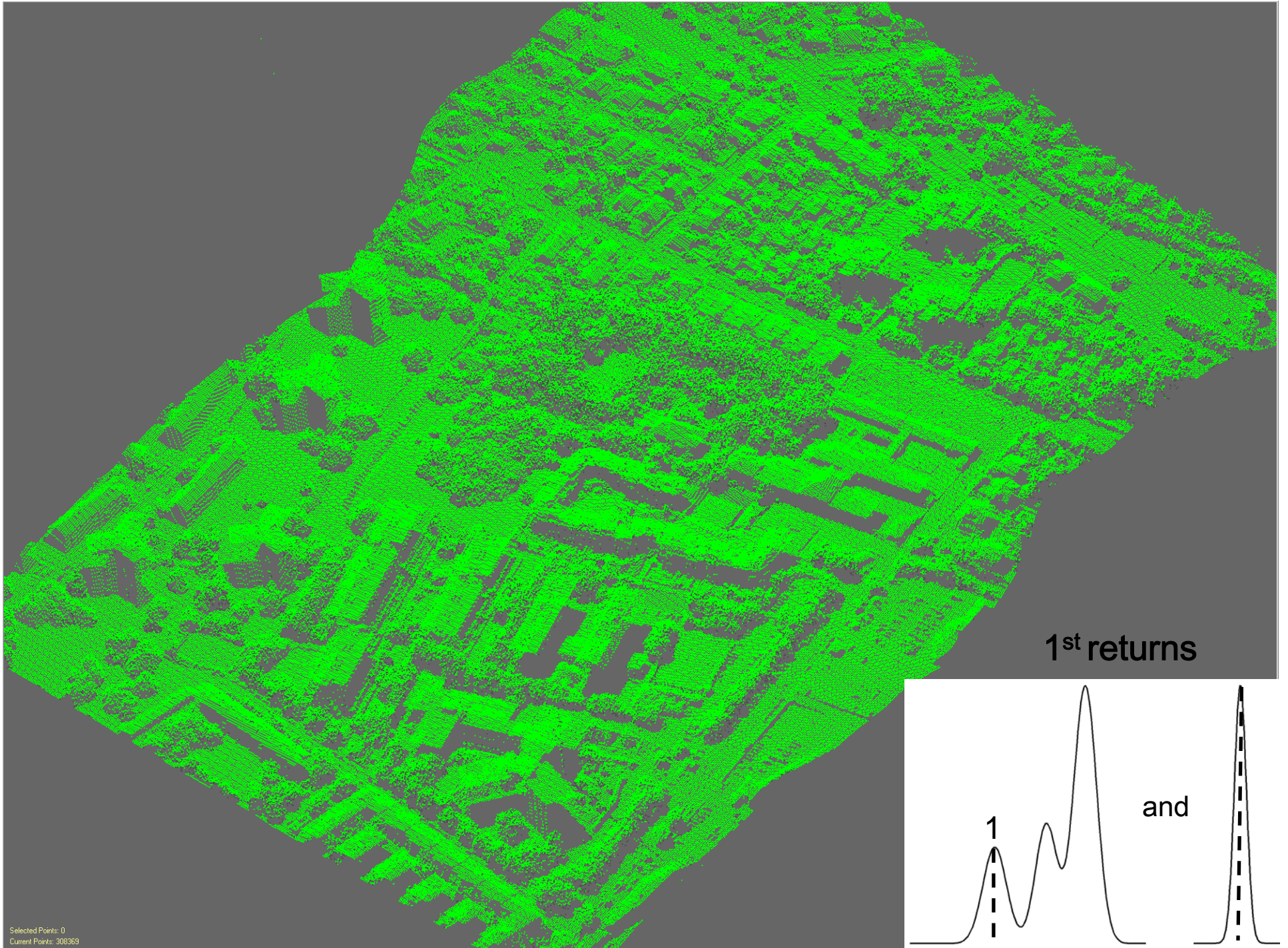
3rd returns

Selected Points: 0
Current Points: 2620

All (up to 7 returns have been observed)

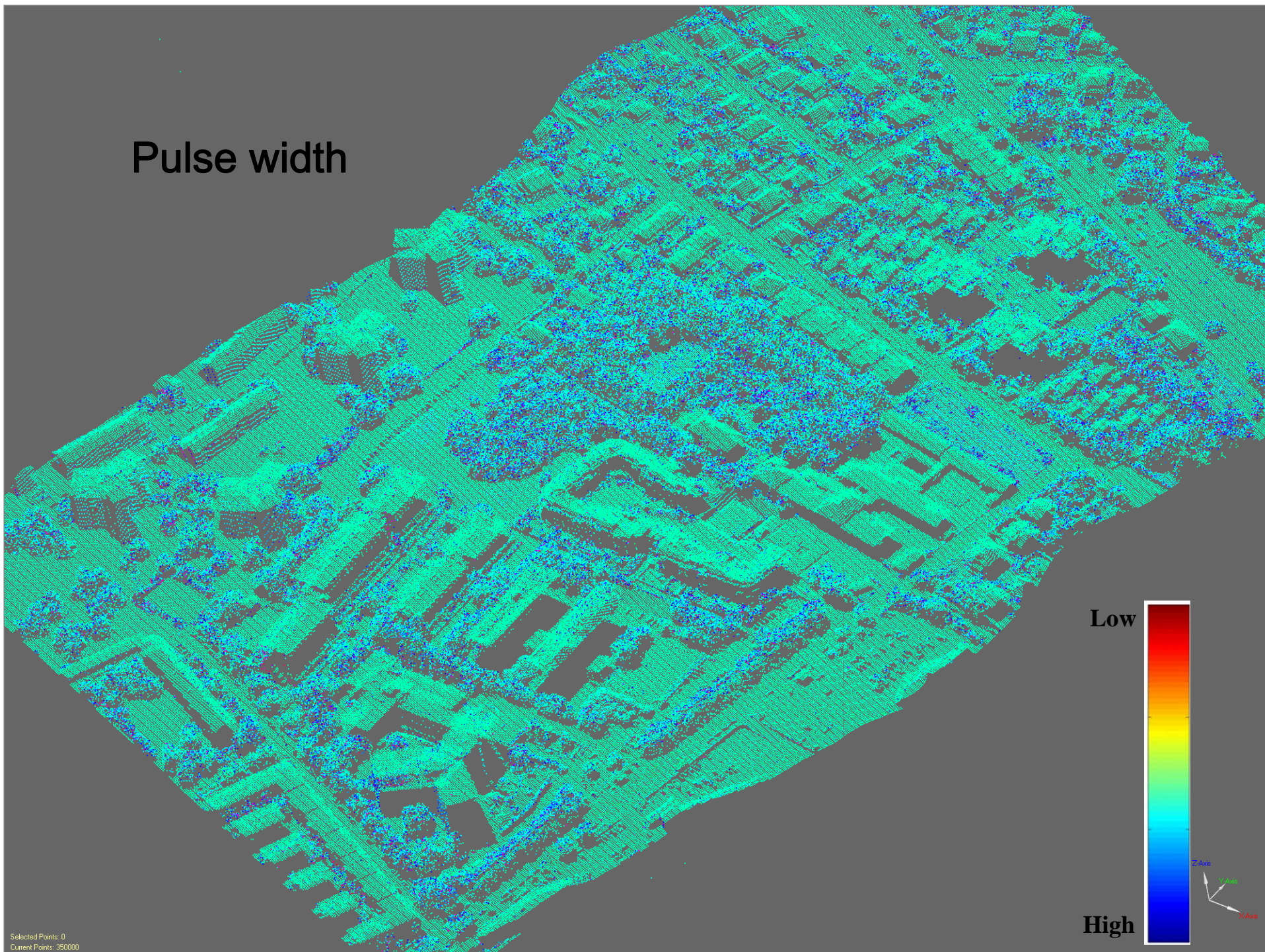Better description of the vertical structure of vegetation
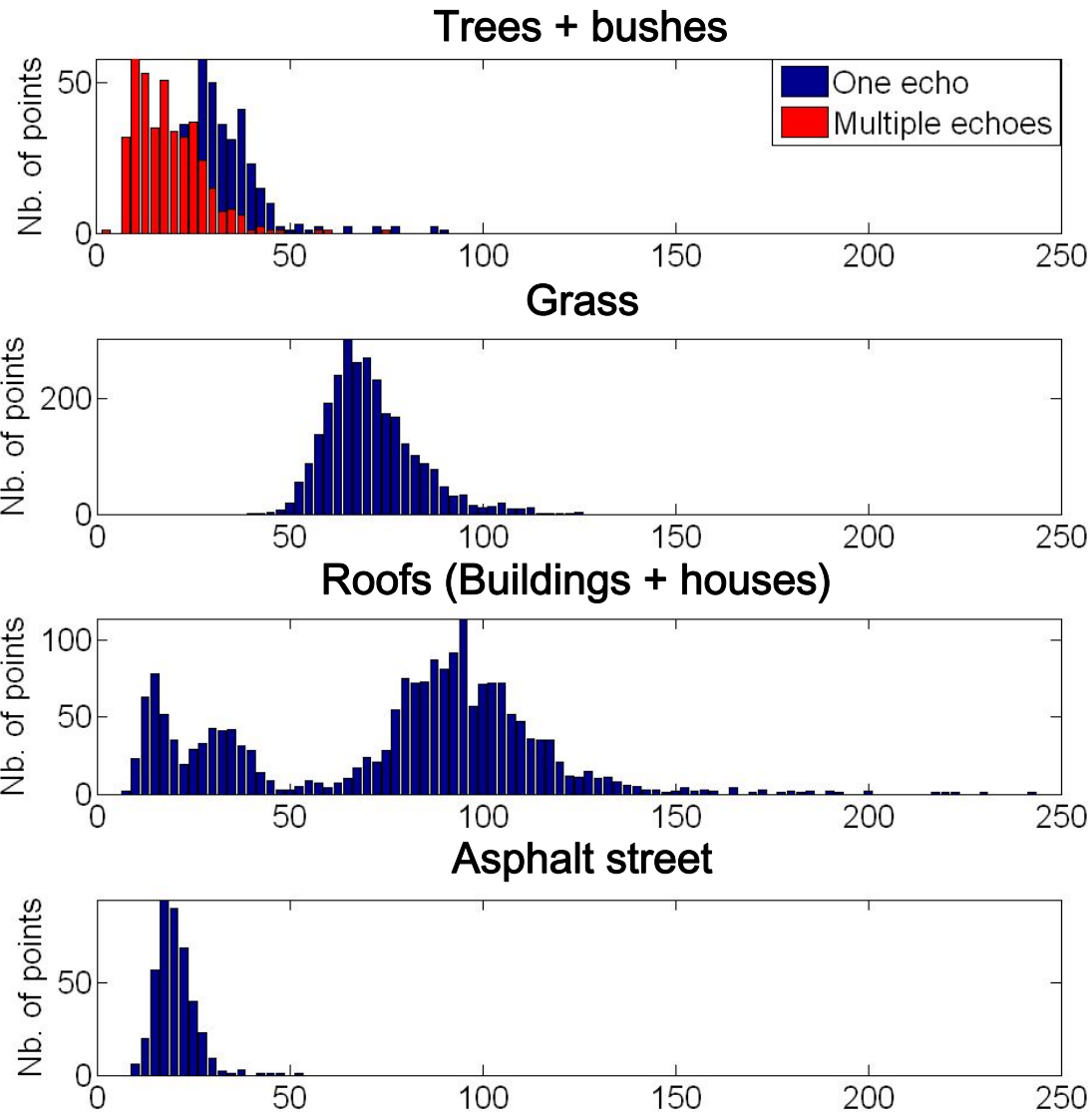
Segmentation purposes

Amplitude

Low

High

Pulse width

Low

High

Amplitude
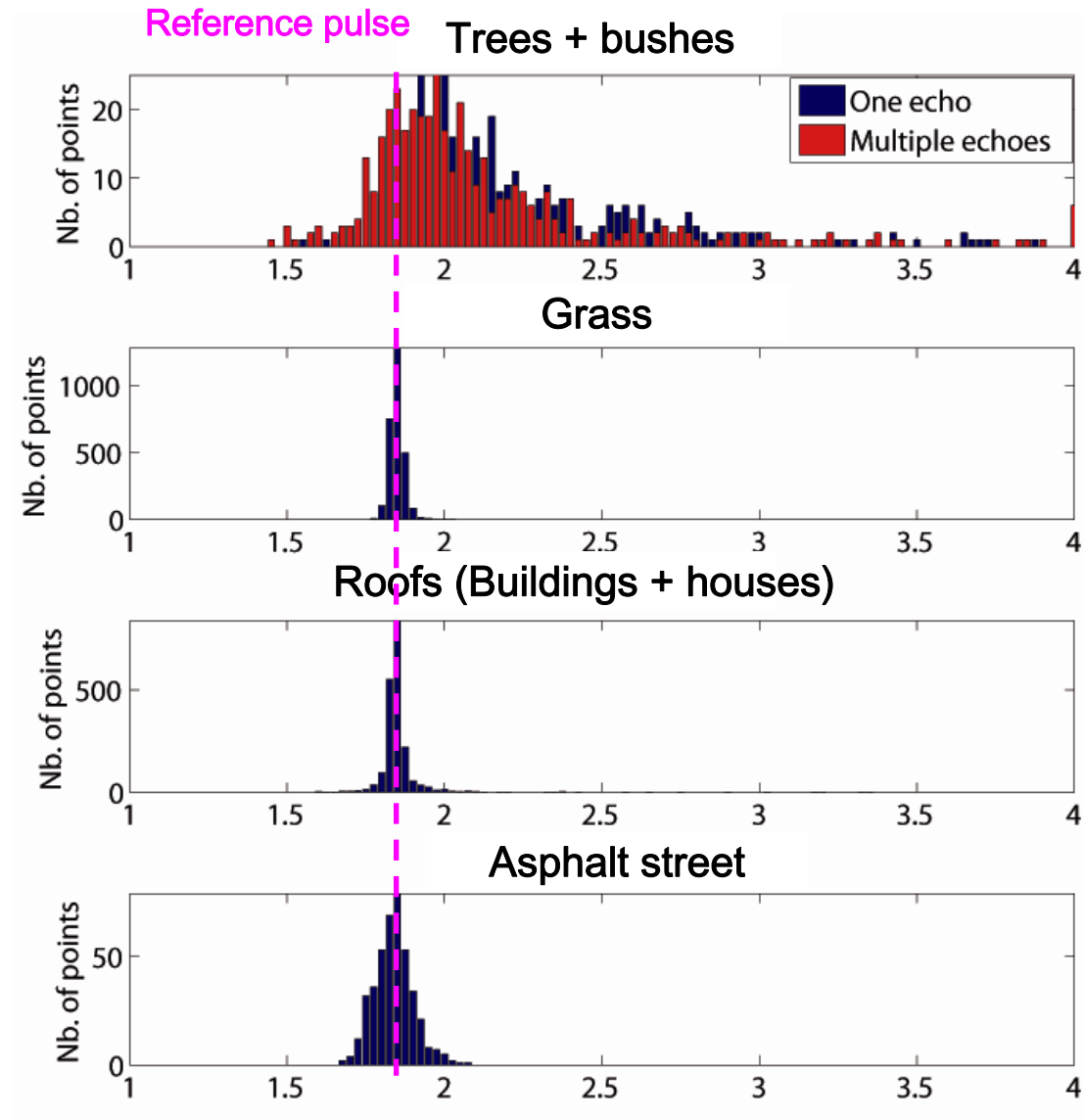

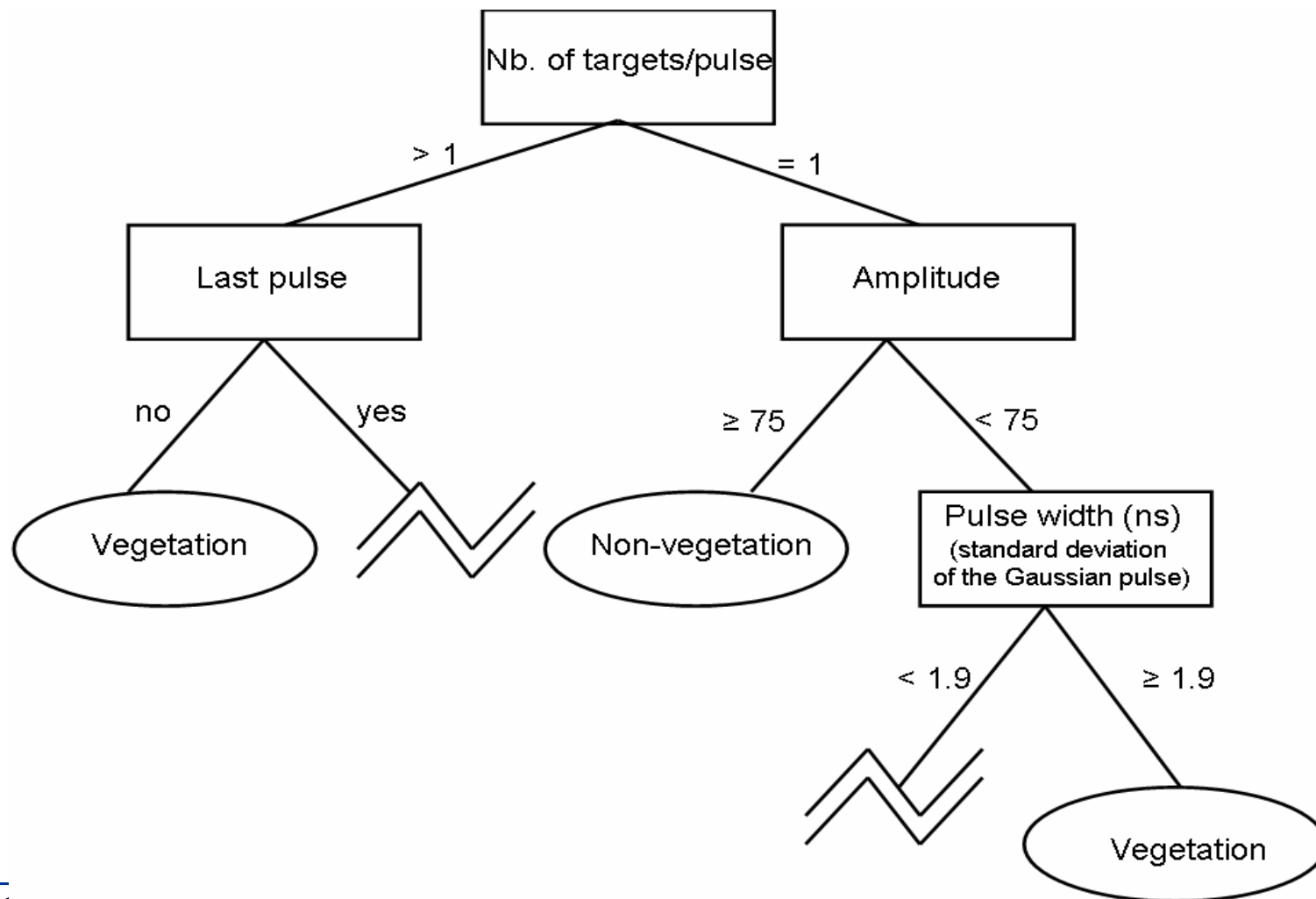Trees + bushes

Grass

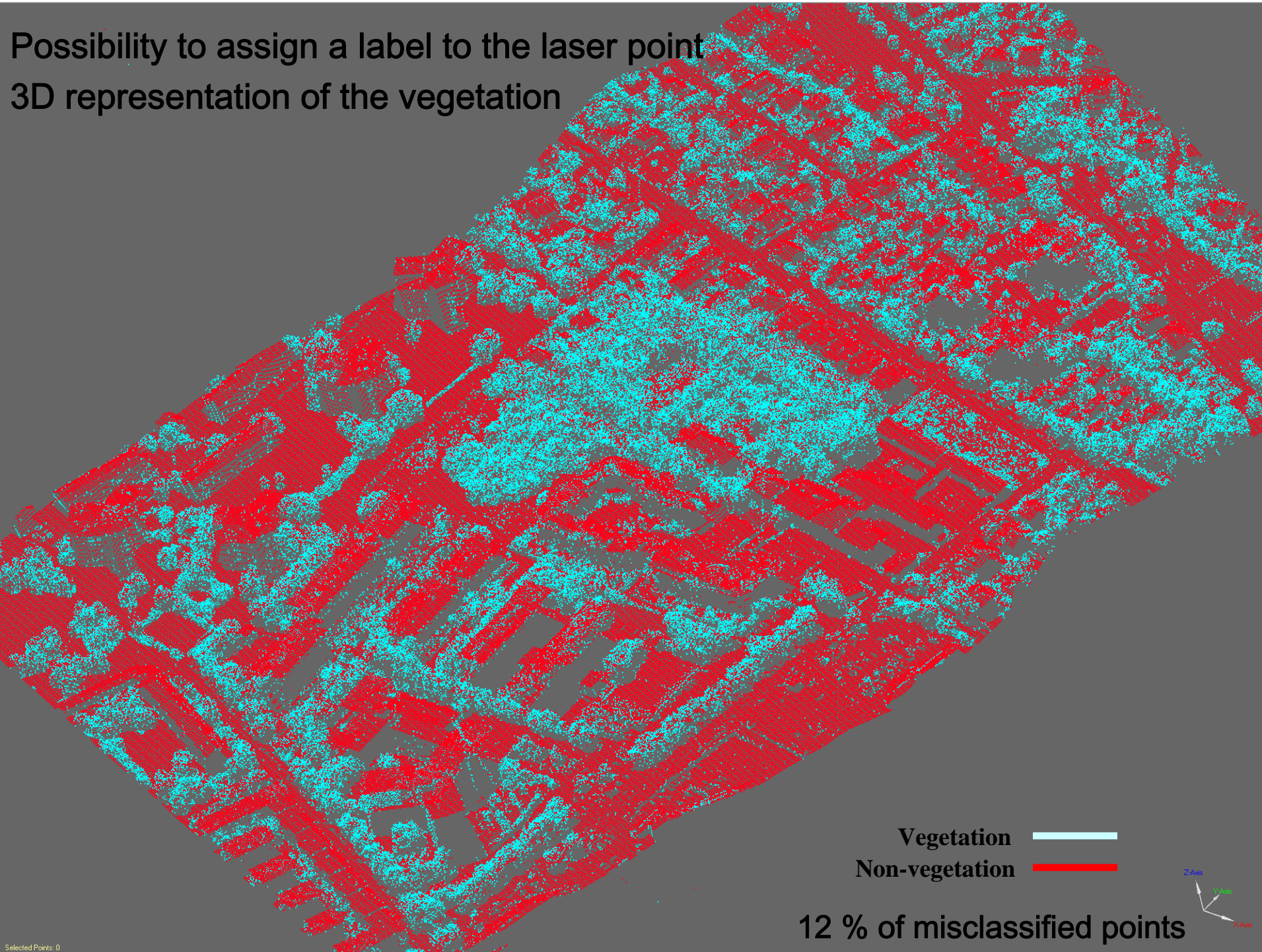Roofs (Buildings + houses)

Asphalt street

Pulse width

Decision tree for vegetation classification

Possibility to assign a label to the laser point

3D representation of the vegetation
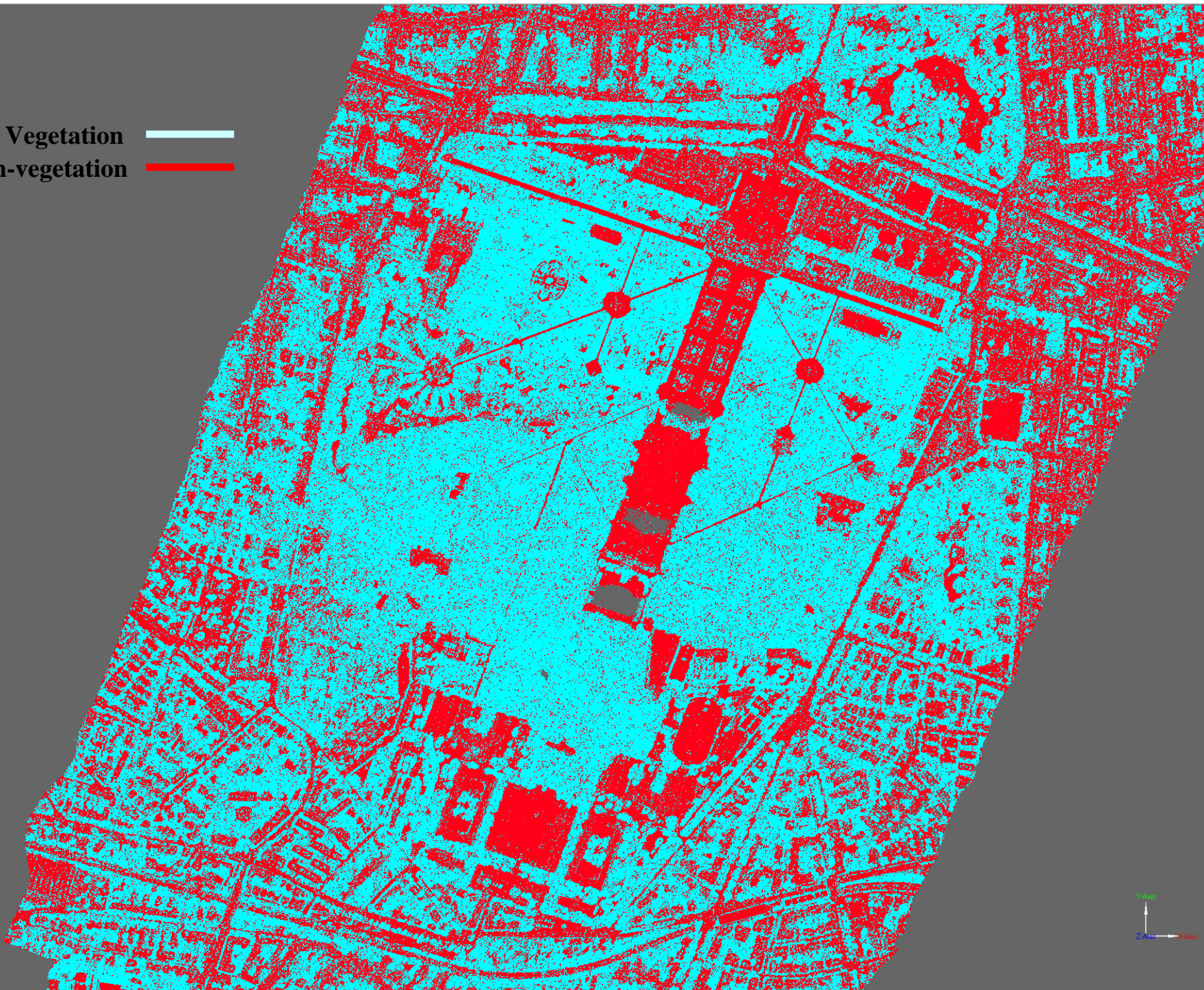
Vegetation

Non-vegetation

12 % of misclassified points

Selected Points: 0

Conclusions

- Pulse-wise analysis of the backscattered signal allow to derive additional observables

- The additional data, i.e. amplitude, width, is valuable for segmentation and classification purposes
  - Classifying vegetation and non-vegetation points
  - Classifying terrain and non-terrain points for DTM filtering

- 3D forest representation
  - Extraction of forest parameters
  - Tree species classification

Vegetation

Non-vegetation