Derivation of tree height and crown radius based on different airborne remote sensing data

Selina Ganz, Petra Adler

Forest Research Institute Baden-Württemberg, Freiburg, Germany

INTRODUCTION

Advanced remote sensing technologies are capable to detect single tree parameters to assist and improve forest inventories. The aim of this study was to derivate tree height and crown radius from a variety of remote sensing data.

The key contribution was to analyze the impact of point cloud quality and the resolution of Digital Surface Models (DSMs) on calculation accuracy of the aforementioned parameters.

MATERIALS AND METHODS

Study site

- Located in an even aged 50 years old Douglas fir stand in the Black Forest in Baden-Württemberg, Germany

Datasets

- Unmanned Aerial Vehicle (UAV) photogrammetric and Light Detection And Ranging (LiDAR)-based point clouds
- Ultralight aircraft photogrammetric point clouds
- Standard image flight photogrammetric point clouds

Data variation

- Point cloud densities: 4 – 2381 points/m²
- Resolution of DSMs: 10 – 100cm

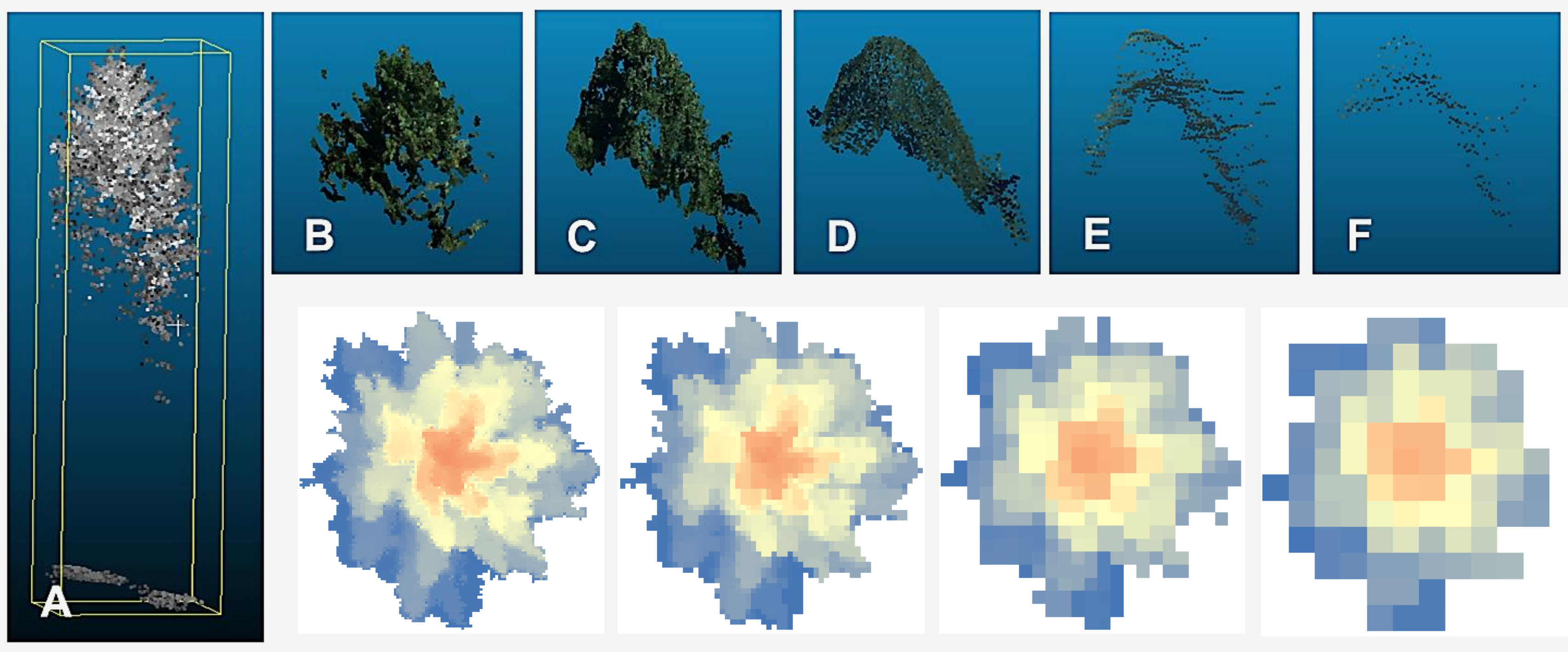

Figure 1: Visualization of point clouds and DSMs of a single crown. A: UAV LiDAR (350 points/m²); B: UAV 1cm (1600 points/m²); C: Gyrocopter 2cm (2381 points/m²); D: Gyrocopter 5cm (300 points/m²); E: Standard 20cm (25 points/m²); F: Standard 50cm (4 points/m²). The indication of size next to the platform represent the Ground Sampling Distance (GSD). DSMs from left to right with 10cm, 20cm, 50cm and 1m resolution. Color scale from blue (low) to yellow and red (high).

Derivation of tree height

- Highest DSM value minus terrain height within a crown boundary

Derivation of crown radius

- Measured average along 8 directions with 45° interval from the location of each tree top
- Fitting a fourth-degree polynomial on each of the resulting height profiles

Figure 2: Characterization of crown radius. Left: In the field. Right: By remote sensing data. The points in the right image represent the height profiles (green = low, red = high) whereas the red line forms the resulting crown boundary.

Reference data

- Collected for crown radius on 34 standing trees and for tree length after felling on 15 lying trees

RESULTS

Tree height

Root-mean-square errors (RMSEs) varied between 0.38m and 1.40m (RMSE%: 1.12% - 4.13%) whereas mean errors (MEs) were between 0.13m and -1.25m (ME%: 0.38% to -3.68%). The best results were achieved with UAV-based LiDAR data. For photogrammetric point clouds, best results were achieved with a high point cloud density, low point cloud filtering and with the usage of ground control points (GCPs).

	Gyrocopter 5cm	Gyrocopter 2cm	UAV 1cm	UAV LiDAR
RMSE	1.40	0.59	1.04	0.38
ME	-1.25	-0.37	-0.98	0.13

Table 1: Best results for tree height for the different datasets. RMSE and ME in meters [m].

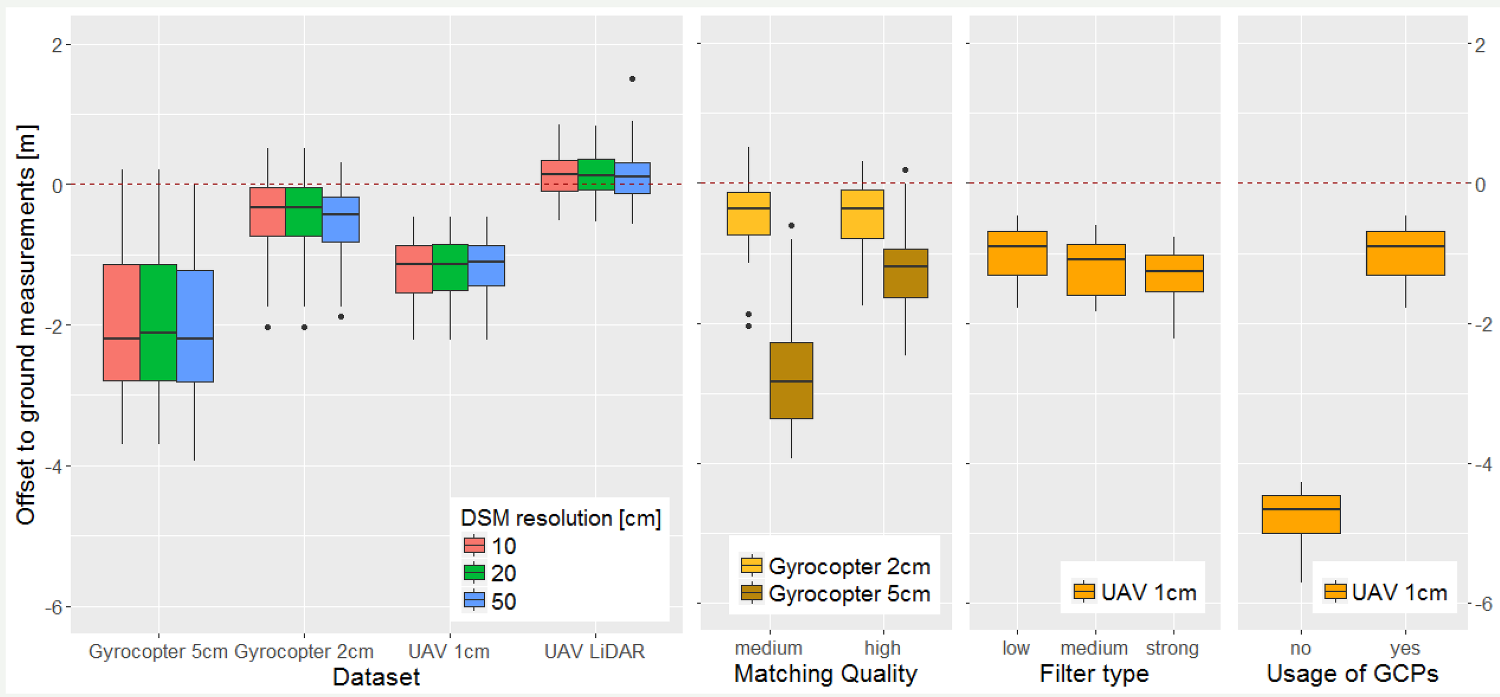

Figure 3: Results for the derivation of tree height with different datasets, matching quality, filter types and with and without the usage of GCPs. The photogrammetric datasets are named by platform and GSD.

Crown radius

RMSEs varied between 0.41m and 0.65m (RMSE%: 7.85% - 12.45%) whereas MEs were between -0.07m and -0.11m (ME%: -1.34% to -2.11%). For photogrammetric point clouds, best results were achieved with a high point cloud density and low point cloud filtering.

	Standard 50cm	Standard 20cm	Gyrocopter 5cm	Gyrocopter 2cm	UAV 1cm	UAV LiDAR
RMSE	0.65	0.65	0.59	0.41	0.44	0.49
ME	-0.10	-0.08	-0.07	-0.09	-0.09	-0.11

Table 2: Best results for crown radius for the different datasets. RMSE and ME in meters [m].

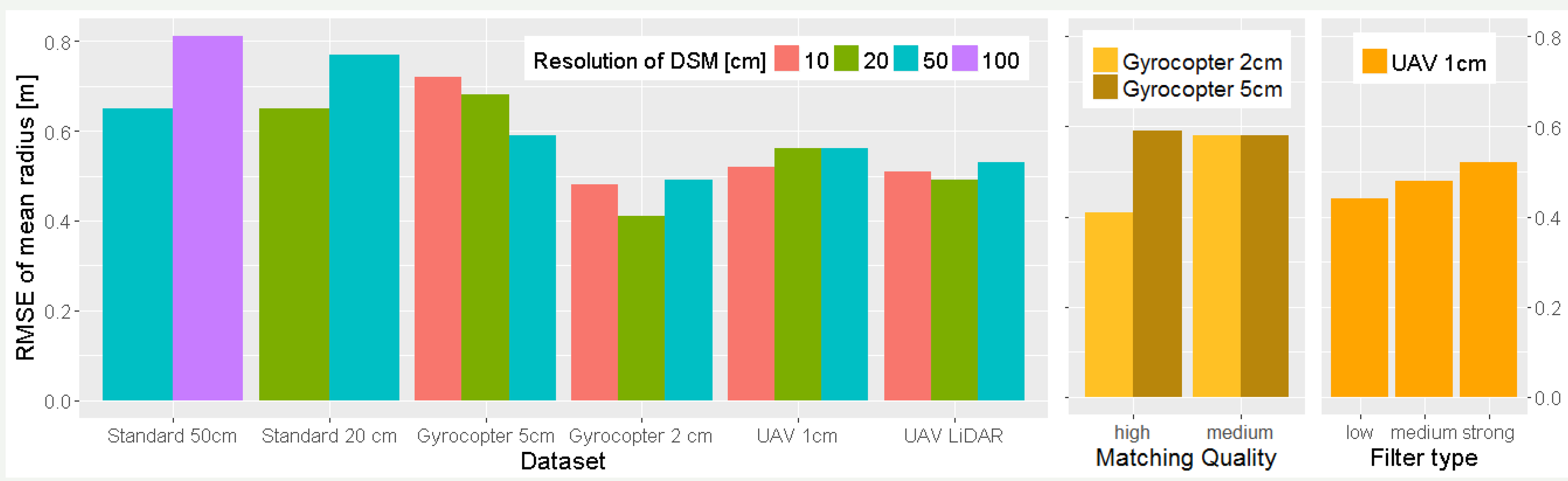

Figure 4: Results for the derivation of crown radius with different datasets, matching quality and filter types. The photogrammetric datasets are named by platform and GSD.

CONCLUSION

Overall, the results are promising with regards to the achieved accuracy and showed, that the applied methods were reasonable for detecting tree height and mean crown radius. The accuracy of photogrammetric based data differed as a function of point cloud quality and absolute orientation accuracy. The geometric resolution of the DSMs played only a secondary role for calculation accuracy. The developed methods have the potential to supplement future research directed towards the derivation of other single tree based parameters.

Gefördert durch:

Bundesministerium für Ernährung und Landwirtschaft

aufgrund eines Beschlusses des Deutschen Bundestages

FNR

Förderkennzeichen: 220 231 14

Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg