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Estimating Grassland Biomass - Potentials and Limitations of Point Cloud Analysis

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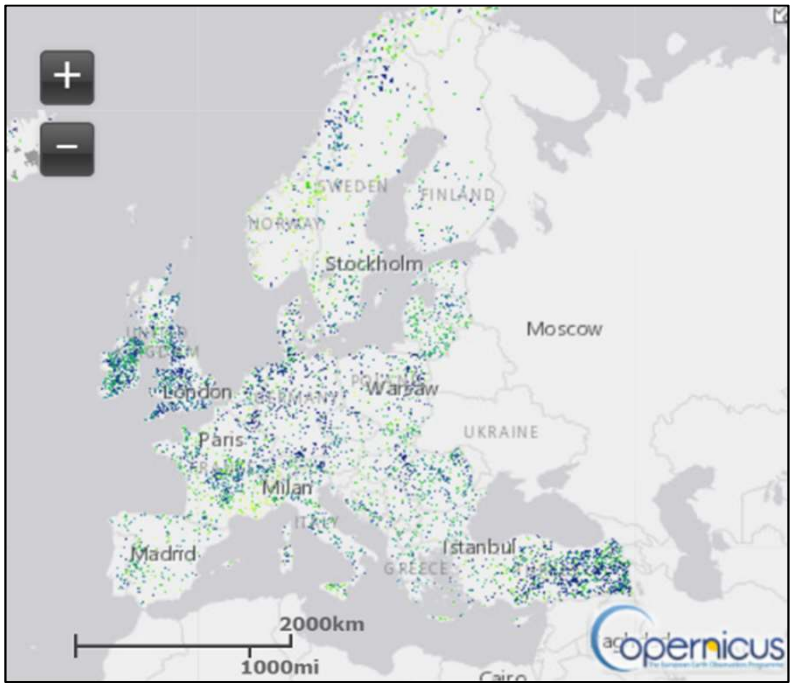
Section Grassland Science and Renewable Plant Resources

Background

- 72 Mio ha of grassland within the EU
- Quantifying above ground biomass is important for management and the understanding of ecological processes
- Continuous estimation of biomass yield over large areas is still challenging



(https://land.copernicus.eu/)

Background

- Grassland canopies are highly heterogenous and biomass yield can change within a few cm distance
- High fraction of senescent material or patches of upstanding grasses can further hamper biomass estimation
- Allometric relationships between grassland height and biomass are traditionally used for biomass estimation

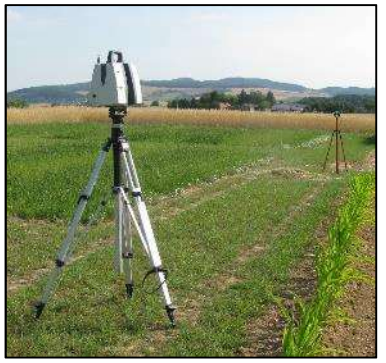
Background

- Remotely sensed information about grassland canopy height exceeds traditional methods, when:
  - Information is needed on larger scales
  - Information is needed in high temporal repetition

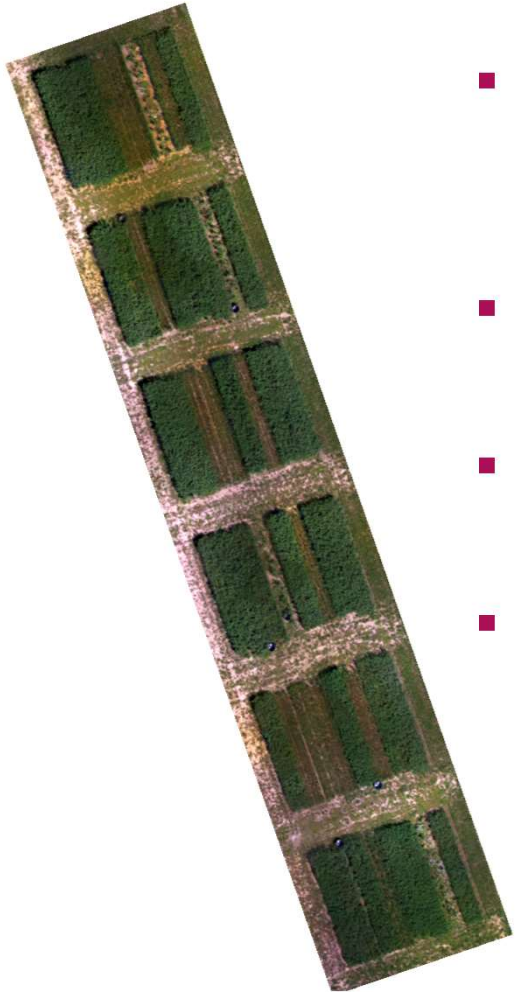
<u>Several techniques exists:</u>

Photogrammetric (SfM)

Active Laser Pulses (TLS)

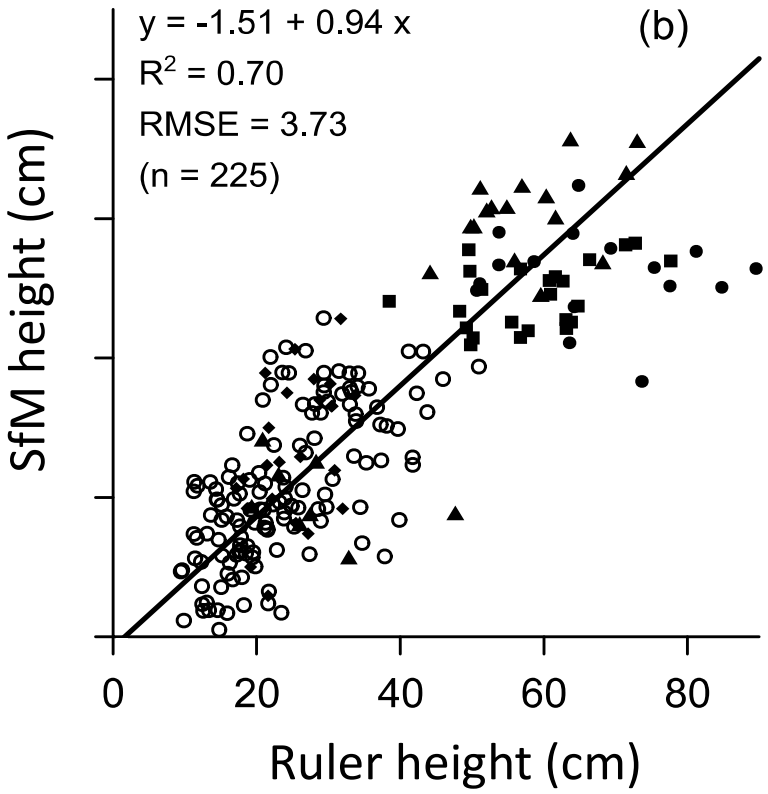


DMY predicted by SfM



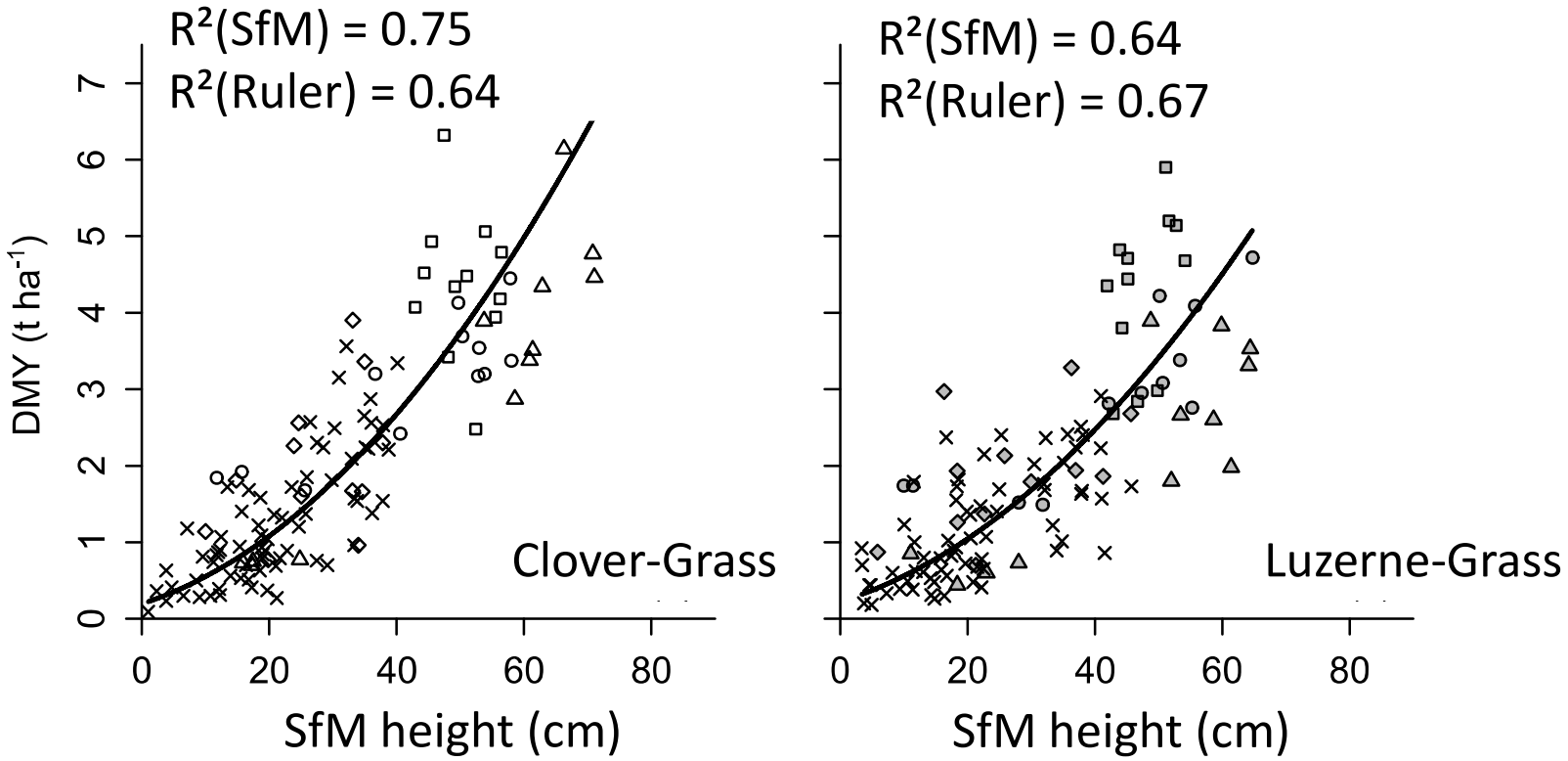
- Experiment with 2 forage grass mixtures (Clover-Grass, Luzerne-Grass) and its single species in 4 repetitions
- Canopy height was measured at 50 random points per plot using a ruler
- Drone pictures of the whole experiment were taken before each sampling
- Using SfM approach, canopy height was derived from images

DMY predicted by SfM



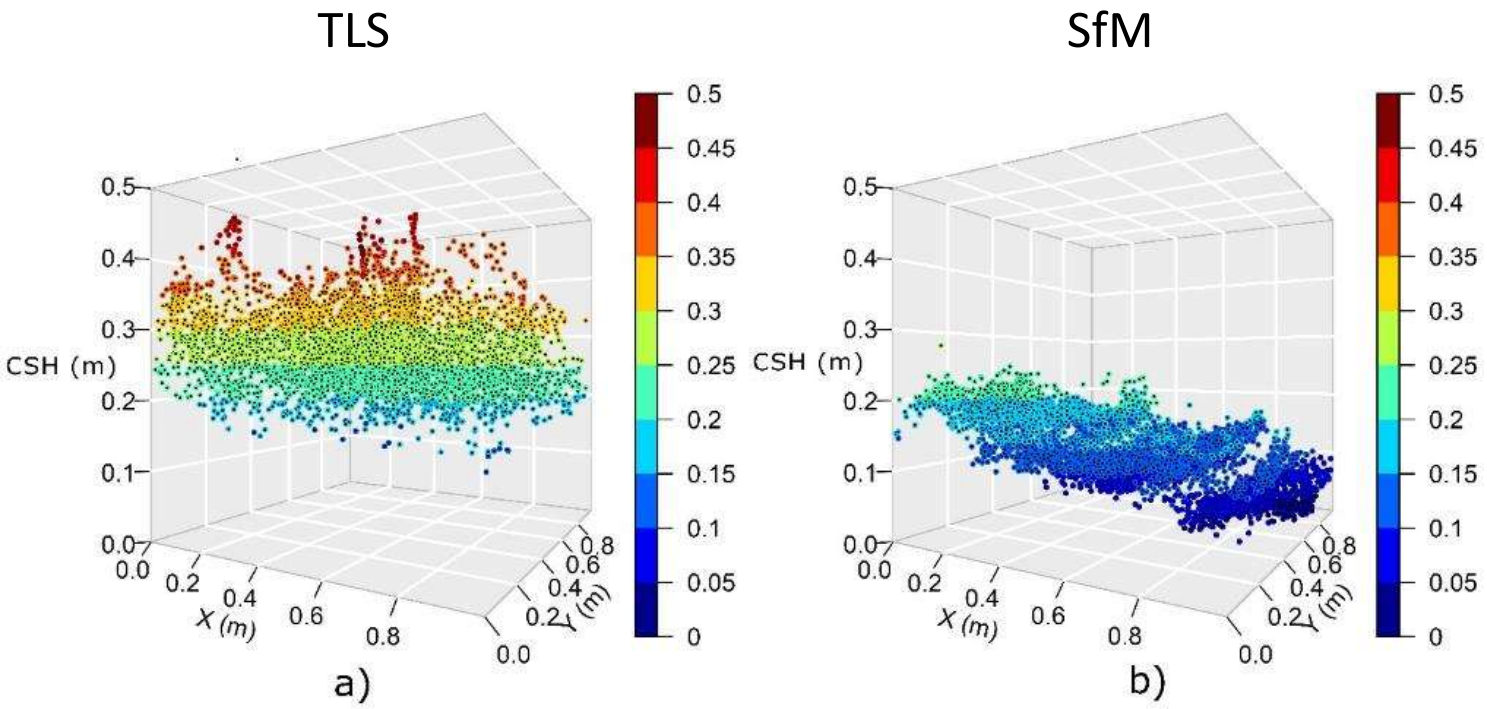
- Drone height and ruler height are highly correlated
- ➢ Drone derived height can be used to replace traditional height measurements

DMY predicted by SfM



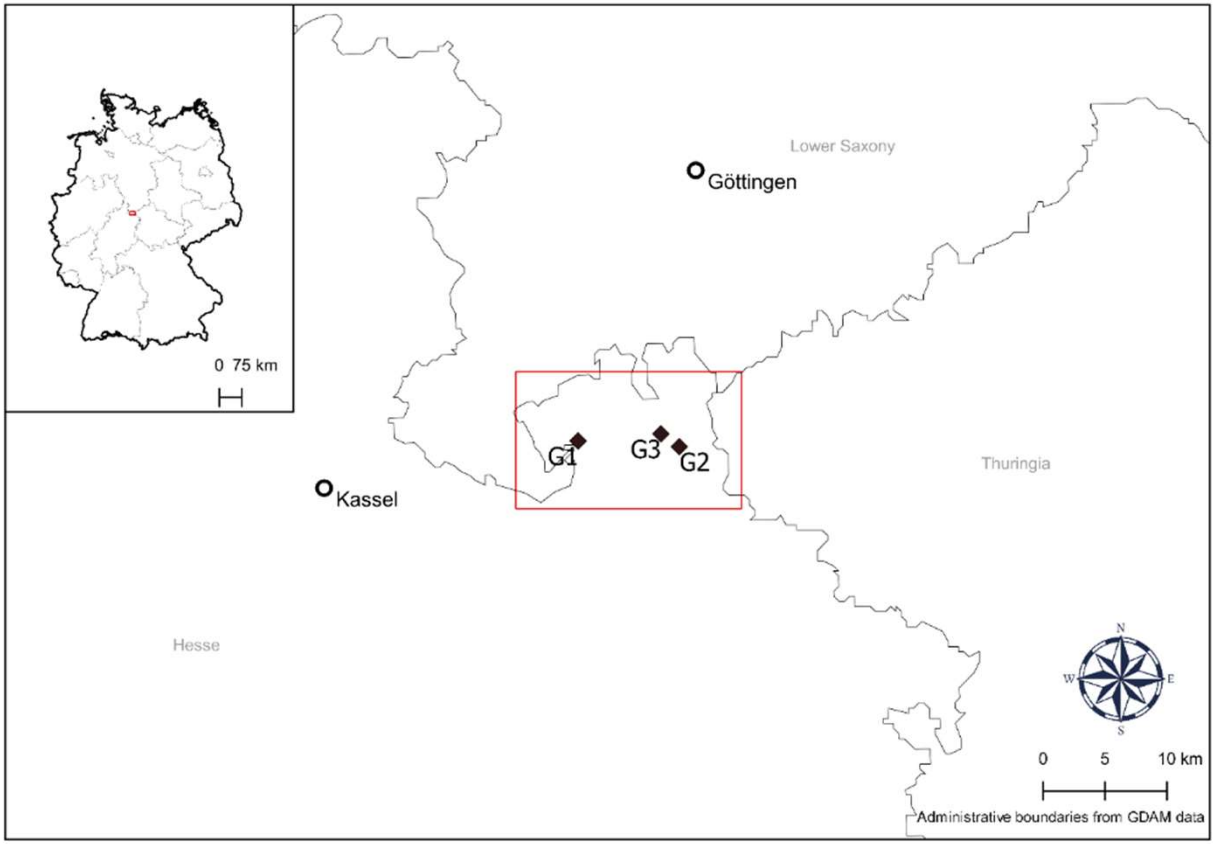
- For both typical grassland mixtures, drone based DMY estimations can be used instead of traditional methods

Point clouds differences (TLS vs. SfM)



- Differences in point cloud perception of grassland canopy depending on applied method

DMY predicted by TLS and SfM



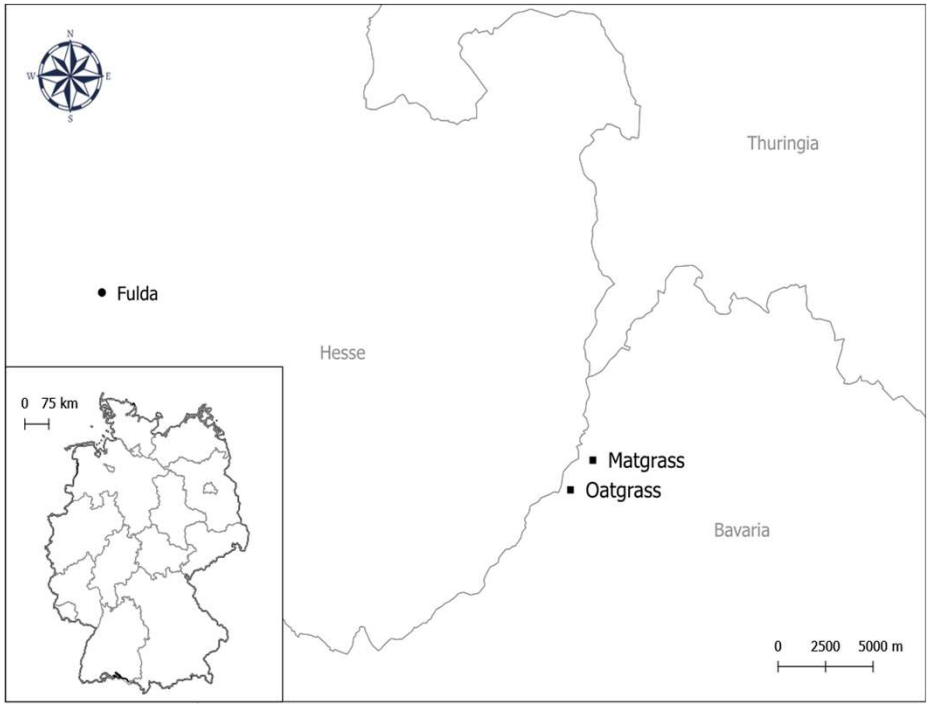
- 3 grassland sites with different management regime (1-4 cuts)

DMY predicted by TLS and SfM

Grassland-Harvest	DMY predicted by TLS		DMY predicted by SfM	
	adj.R^2	nRMSE (%)	adj.R^2	nRMSE (%)
G1-H1	**0.59*****	**17.8**	0.53***	18.8
G1-H2	0.05^{ns}	25.9	0.14$^{\cdot ns}$	15.9
G1-H3	**0.83*****	**15.0**	0.62***	22.7
G1-H4	**0.58*****	**24.2**	0.55***	24.9
G2-H1	**0.34****	**16.0**	NA	NA
G2-H3	**0.60*****	**11.6**	0.40**	14.1
G2-H4	**0.25***	**19.5**	0.06^{ns}	21.7
G3-H1	**0.35***	**16.3**	0.15*	18.5

- TLS always performed slightly better than SfM in predicting DMY in different grassland classes continuously over the growing season

DMY estimation using TLS highly diverse grasslands



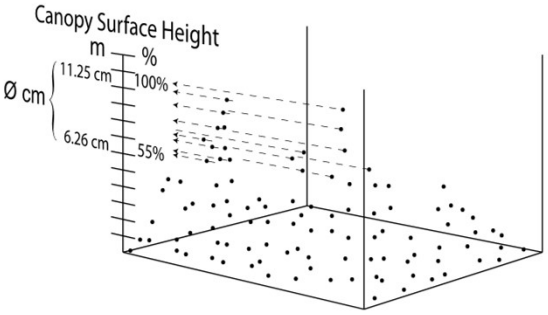
- 2 grassland types:

  Nardus stricta [Matgrass], *Trisetum flavescens* [Oatgrass]

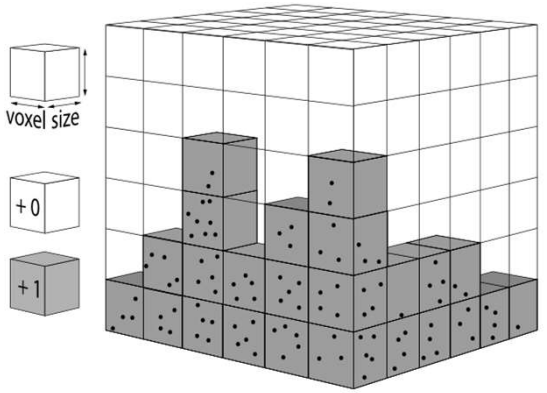
- Highly diverse grassland, which are endangered due to invasion of *Lupinus polyphyllus*

DMY predicted by TLS - Various Methods

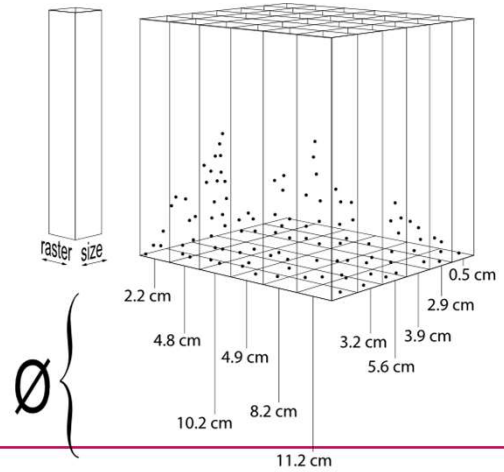
Canopy Surface Height



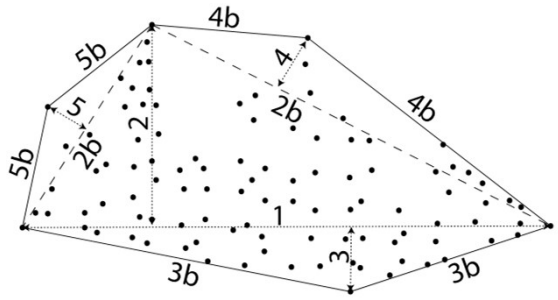
Voxel



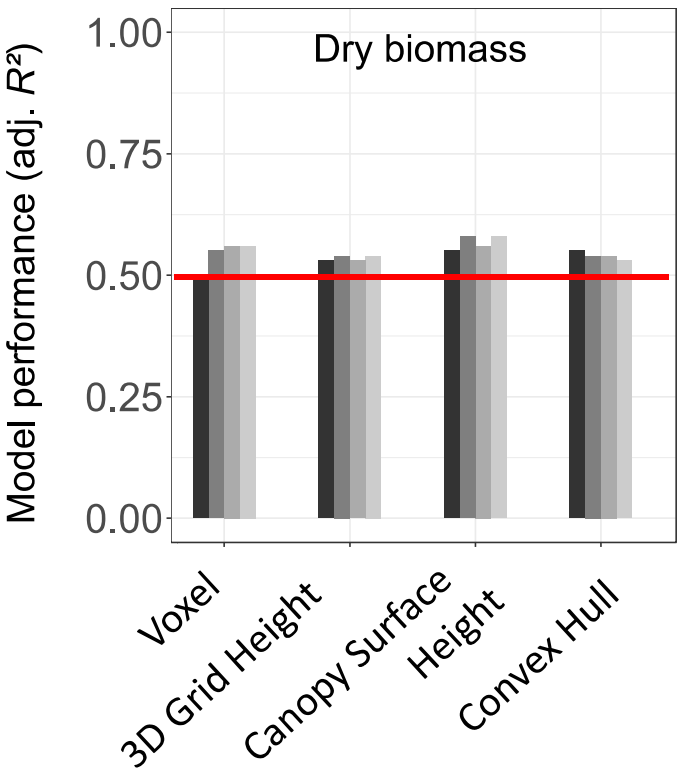
3D Grid Height

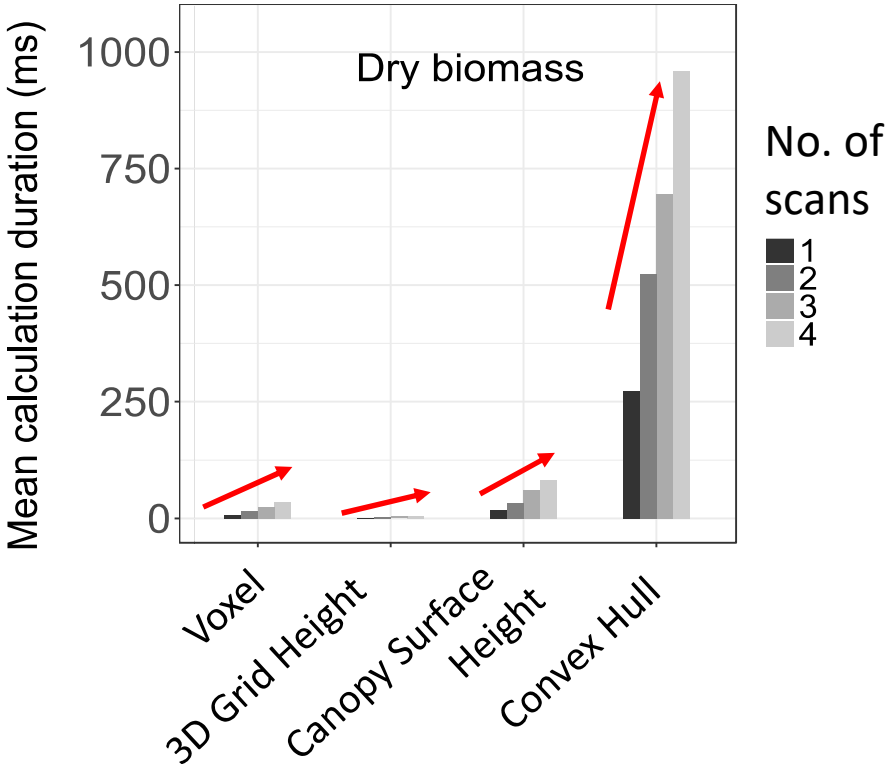


Convex Hull



DMY predicted by TLS - Various Methods





- All methods are equally good
- No. of scans did not improve performance, but increased processing time

Conclusion

- Point cloud analysis is a suitable approach for estimating biomass yield in grasslands
- In comparison to traditional field methods prediction accuracies of point cloud analysis performing similar or better
- SfM approaches have a good potential for large scale biomass estimations
- TLS data delivers a more detailed representation, however large scale application is limited
- Prediction accuracy needs to be improve → other parameter extracted from the point clouds need to be tested
- Effect of vegetation density needs to be considered → fusion with other sensor techniques (spectral) may help

Team

Esther Grüner

Damian Schulze-Brüninghoff

Jayan Wijesingha

Thank you for listening.

References

- The results of the presentation are based on the following publications:
  - Grüner et al. Evaluation of the potential of RGB sensor to predict biomass yield in heterogenous temperate grassland (planned submission to *Agronomy*)
  - Wijesingha et al. Evaluation of 3D point cloud-based models for the prediction of grassland biomass (in revision at *International Journal of Applied Earth Observations and Geoinformation*)
  - Schulze-Brünninghof et al. Methods for LiDAR-based estimation of extensive grassland biomass (in revision *Computers and Electronics in Agriculture*)