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

Several techniques exist:

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
Drone height and ruler height are highly correlated

Drone derived height can be used to replace traditional height measurements
For both typical grassland mixtures, drone based DMY estimations can be used instead of traditional methods.
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**

<table>
<thead>
<tr>
<th>Grassland-Harvest</th>
<th>DMY predicted by TLS</th>
<th>DMY predicted by SfM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>adj.R²</td>
<td>nRMSE (%)</td>
</tr>
<tr>
<td>G1-H1</td>
<td>0.59***</td>
<td>17.8</td>
</tr>
<tr>
<td>G1-H2</td>
<td>0.05 ns</td>
<td>25.9</td>
</tr>
<tr>
<td>G1-H3</td>
<td>0.83***</td>
<td>15.0</td>
</tr>
<tr>
<td>G1-H4</td>
<td>0.58***</td>
<td>24.0</td>
</tr>
<tr>
<td>G2-H1</td>
<td>0.34**</td>
<td>16.0</td>
</tr>
<tr>
<td>G2-H3</td>
<td>0.60***</td>
<td>11.6</td>
</tr>
<tr>
<td>G2-H4</td>
<td>0.25*</td>
<td>19.5</td>
</tr>
<tr>
<td>G3-H1</td>
<td>0.35*</td>
<td>16.3</td>
</tr>
</tbody>
</table>

- 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

3D Grid Height

Voxel

Convex Hull
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.
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*)
- Schulze-Brünninghof et al. Methods for LiDAR-based estimation of extensive grassland biomass (in revision *Computers and Electronics in Agriculture*)