Opportunities for high-resolution remote sensing to monitor grasslands

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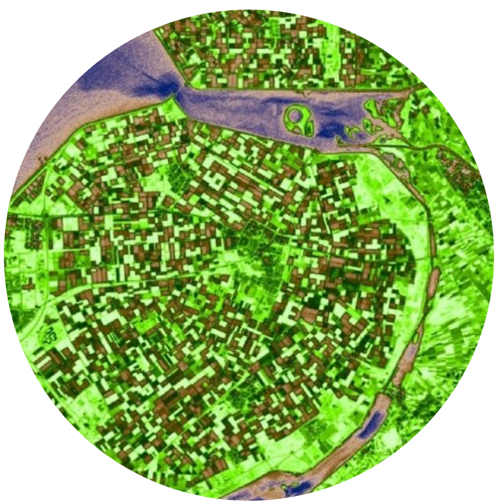

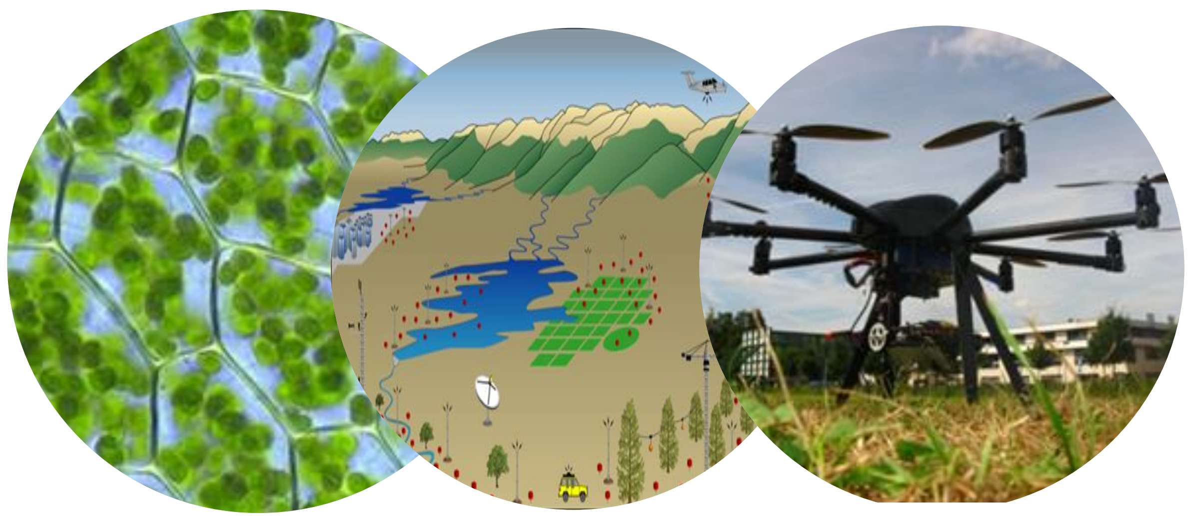

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spectors

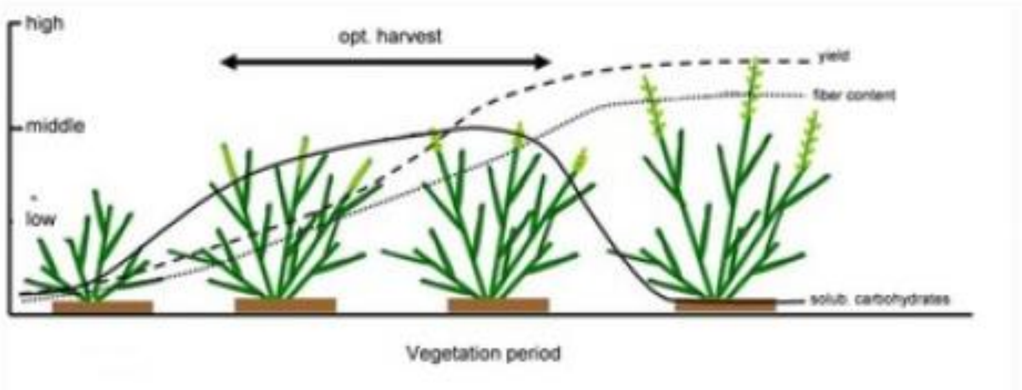
Management of production grasslands

- Dairy farming: high-production grasslands-> 5 cuts/year
- Developments towards precision management
- Need for spatio-temporal information:
    - When to harvest
    - Where to harvest
- Relevant grassland traits:
    - Quantity: biomass, height, …
    - Quality: protein (~N), …

Lolium perenne dominant grassland species for production

Remote sensing of grasslands

- Several studies: retrieval of grassland traits
  - Mainly statistical models: VIs + multi-variate
- Weather (temperature + rainfall) driver of production and composition
  - One general retrieval model over growing season possible?
- Requirements for precision management:
  - Continuous monitoring: combi of satellite and UAV
  - Forecasting?



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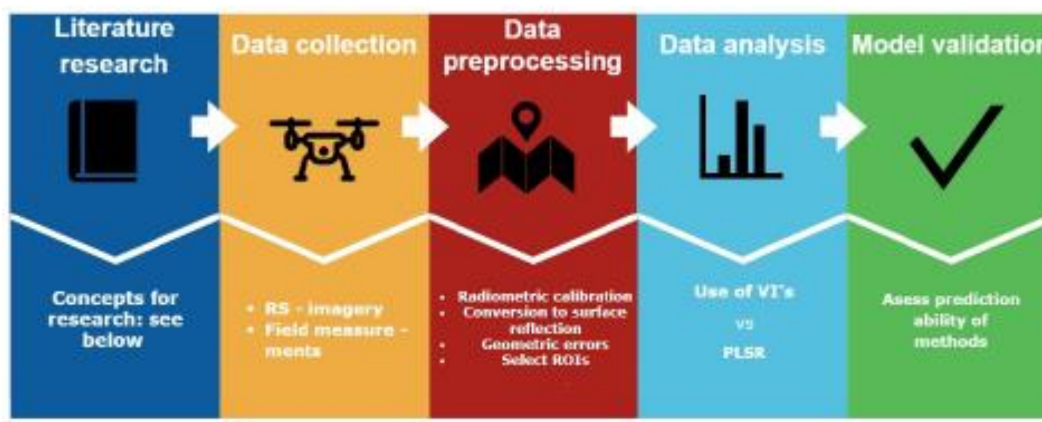
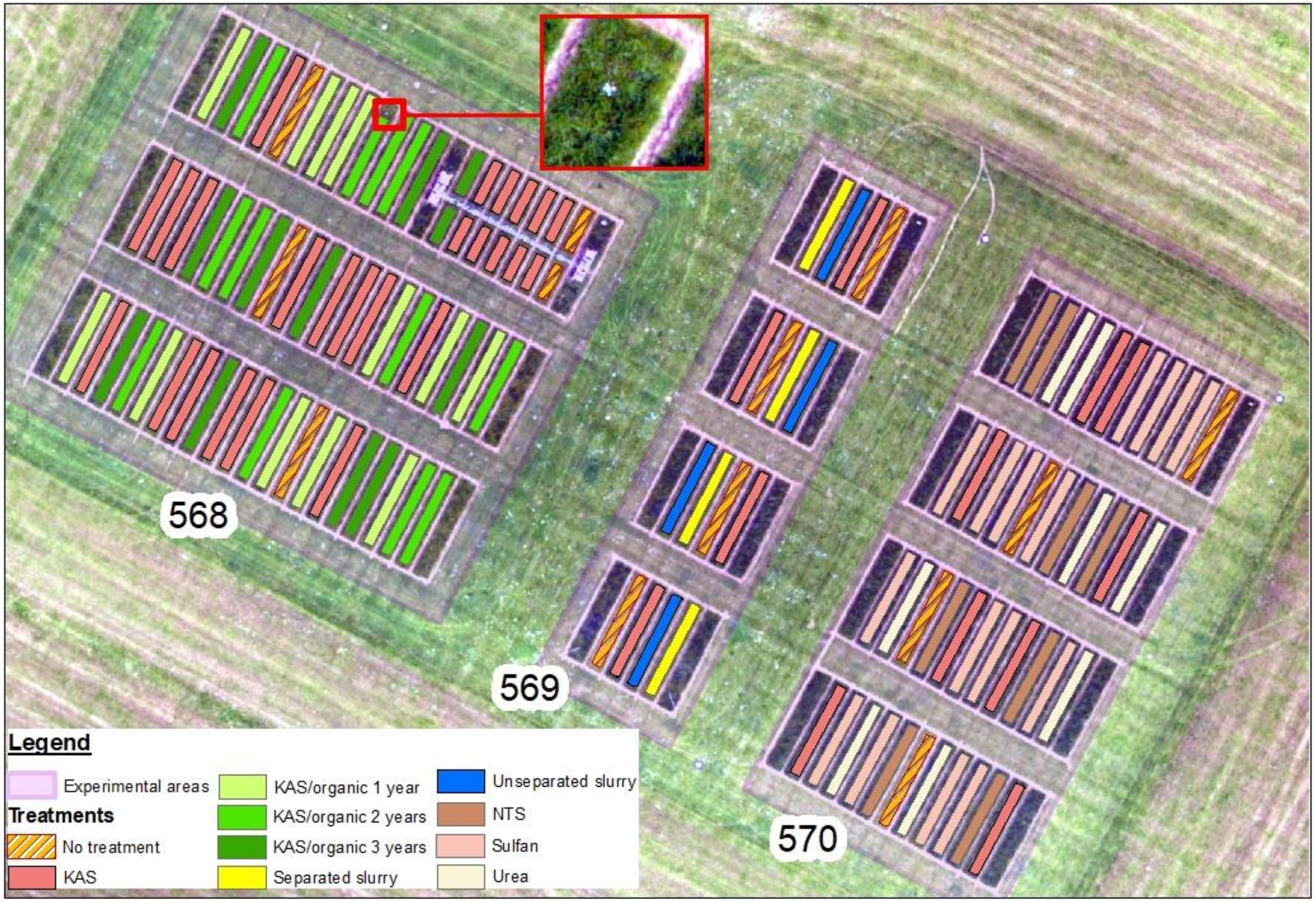
Research Objectives

- Identification of relevant spectral regions within VNIR for monitoring of grassland traits (biomass and proteins) over the growing season
- Development of grassland trait retrieval models which are scale-able:
    - Over time: robust for varying weather conditions
    - Over different platforms: from UAV to satellite
- To support future precision management and grass growth models



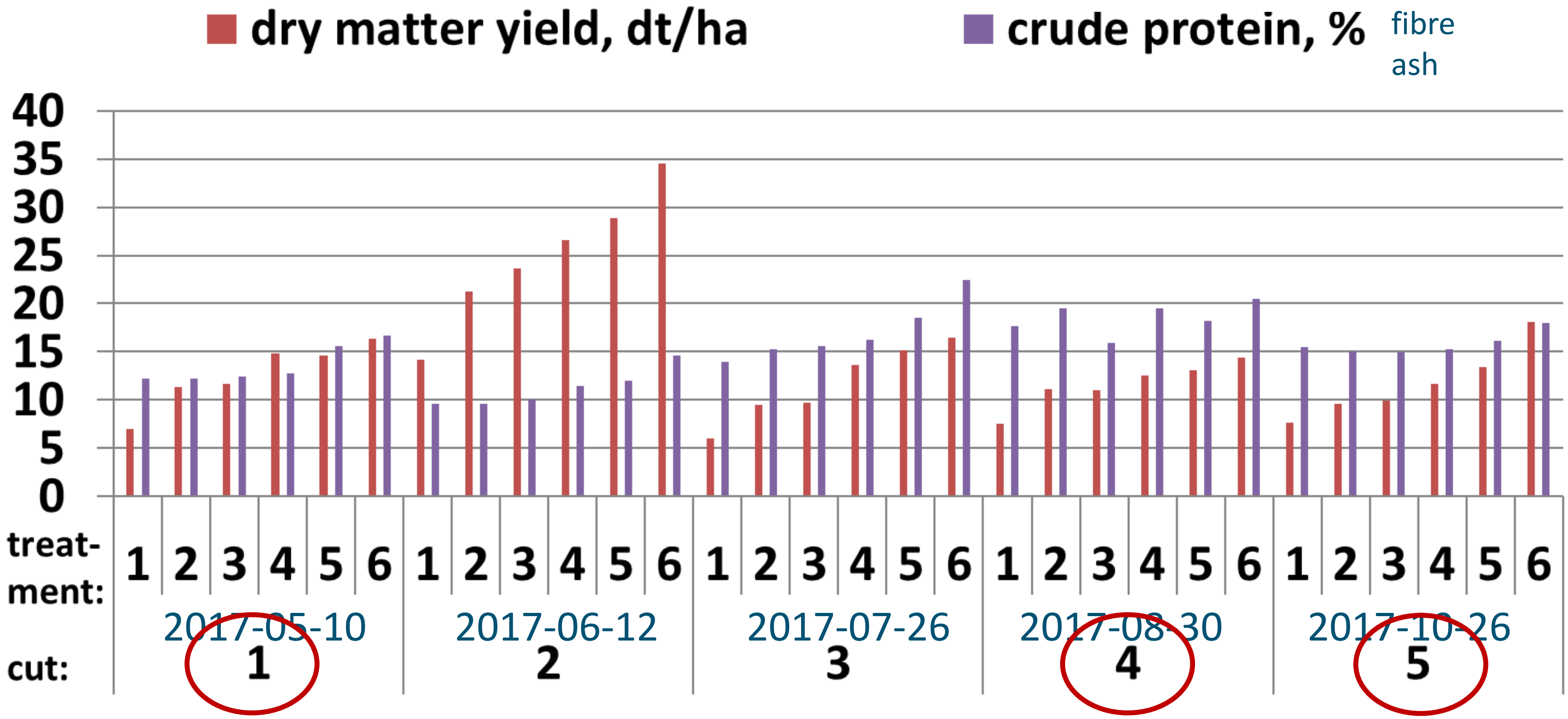
Grassland fertilization experiment



Long-term grassland experiment
Landwirtschaft Kamer Haus Riswick
Kleve, Germany (situation 2017)
Background: RGB Hymsy, Aug 30, 2017

Grassland traits for 2017

height
fresh yield
dry matter content
dry matter yield
nitrogen content
nitrogen yield
protein
fibre
ash



weather

Temp: 9.3 °C
Rain: 28 mm
Period: 50 days

Temp: 18.1 °C
Rain: 20 mm
Period: 35 days

Temp: 14.1 °C
Rain: 110 mm
Period: 58 days

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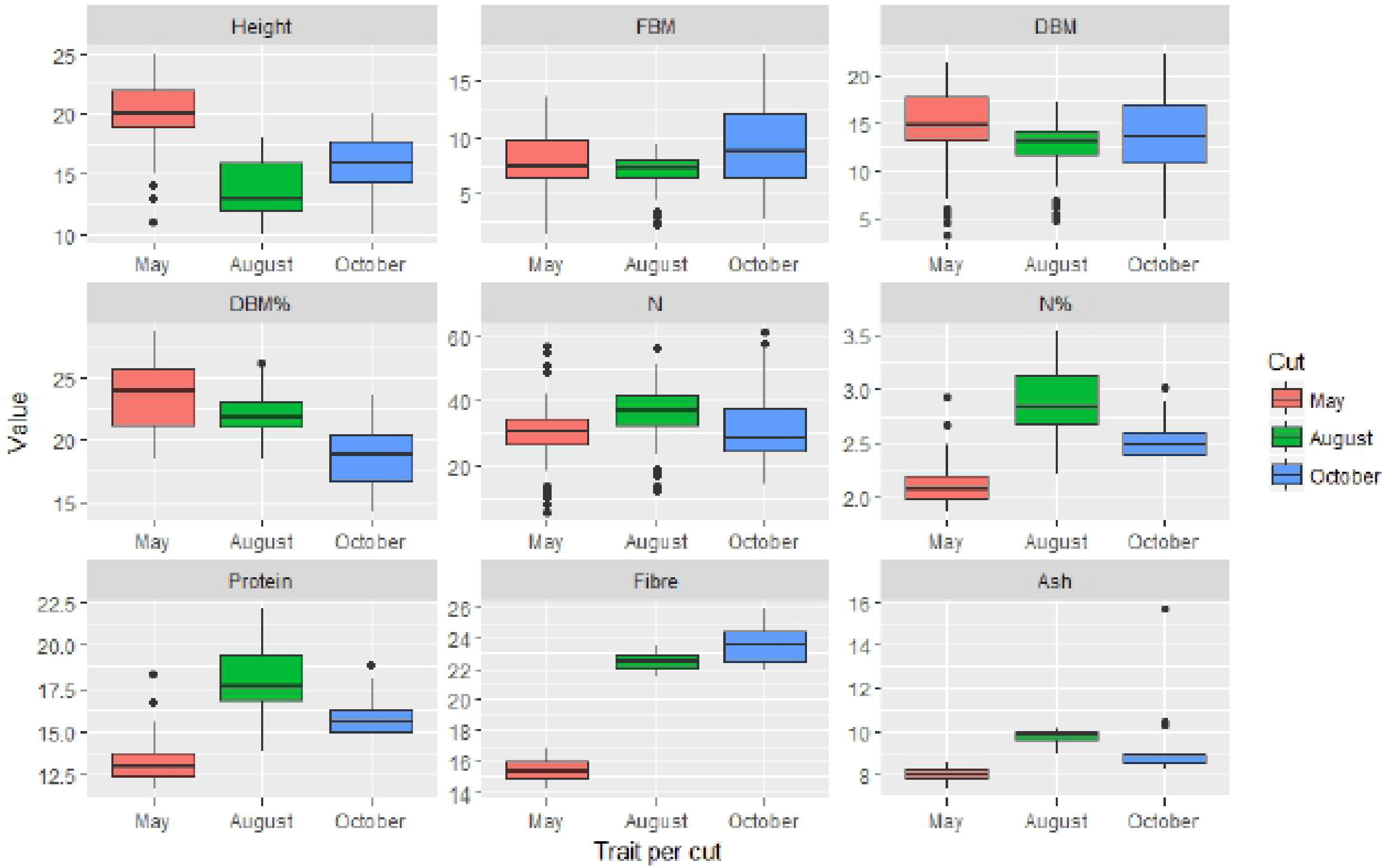
Mean trait variation over season



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UAV based imaging spectroscopy

- Octocopter Aerialtronics
- Comparison two camera’s
- Sunny conditions + 8 GCPs
- Reference panel

Processing steps according to camera specific processing chain:

- Radiometric correction
- Empirical Line Correction
- Structure from Motion
- Ortho per band + DSM

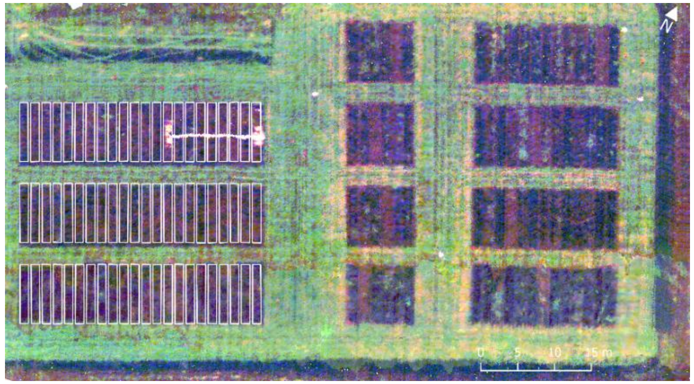
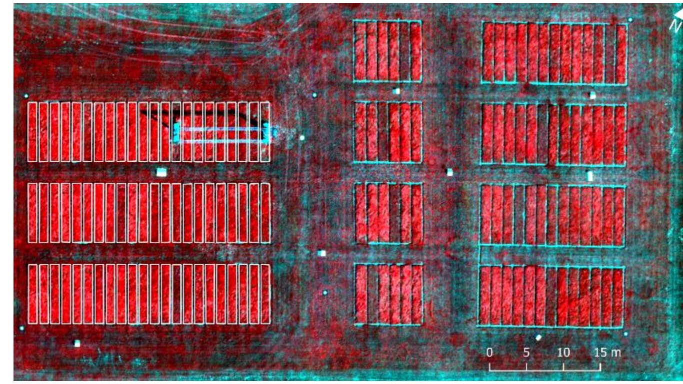
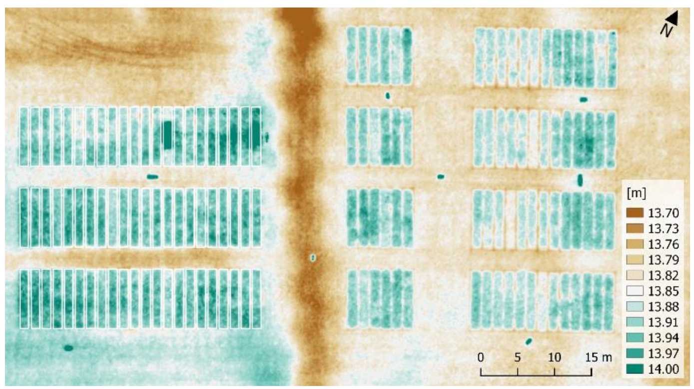
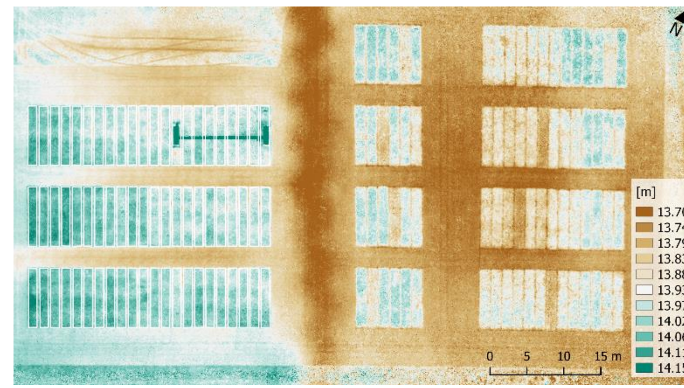
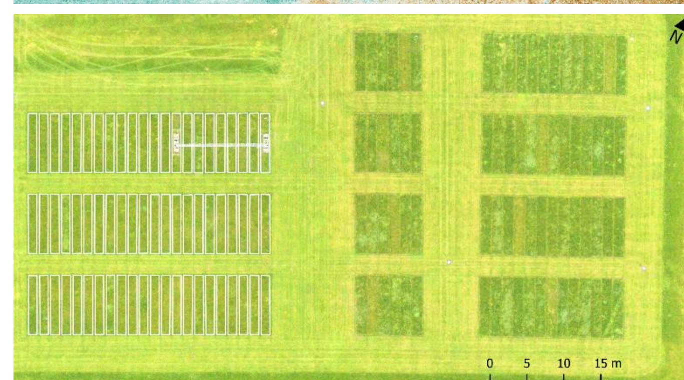
Statistical analysis:

- Selection of pixels from ROI per plot
- Calculation of VIs and PLS
- Training and validation (40%) set

Rikola camera
1Mpix frame camera with adjustable spectral filter
Fabry-Perot interferometry filter
30 bands selected in range of 550-900 nm; FWHM 10 nm
GPS: accuracy 4m
Weight: 600 g
Processing:
Roosjen et al. (2016)

Hyperspectral Mapping System (HYMSY)
Pushbroom spectrometer:
Photonfocus SM2-D1312 + Specim ImSpector V10 2/3”
450-950nm; FWHM 9nm; 20 lines/s
Consumer RGB camera
GPS/INS accuracy: 4m / 0.25°
Weight: 2 kg
Processing: Suomalainen et al. (2015)

HRW Grassland experiment Aug 30 2017

	@Rikola Frame|FPI 0.031m; 400-900nm [sel. 30 bands]	@HYMSY Pushbroom 0.140 m; 0.012 m 450-900 nm; [5 nm]
False colour composite		
DSM		
Ultra-high resolution orthomosaic		

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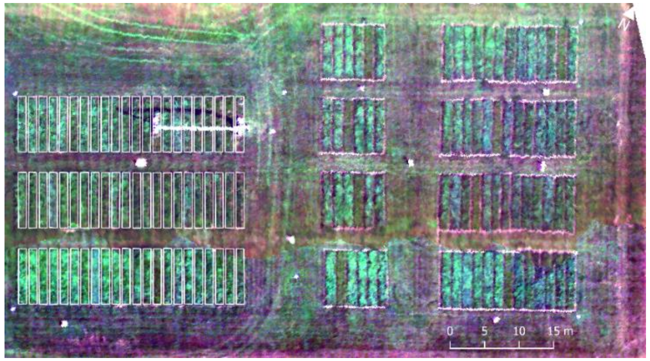
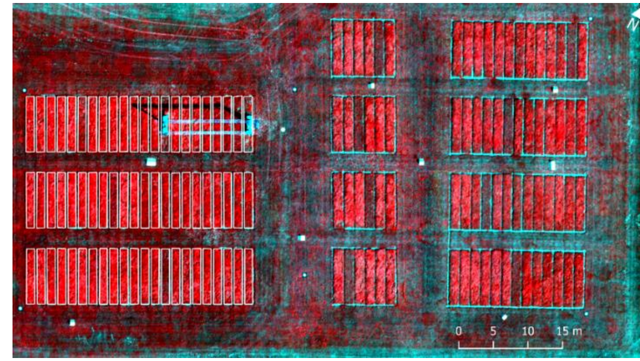
Sensor comparison [30-Aug-2017]

@HYMSY [0.140m]

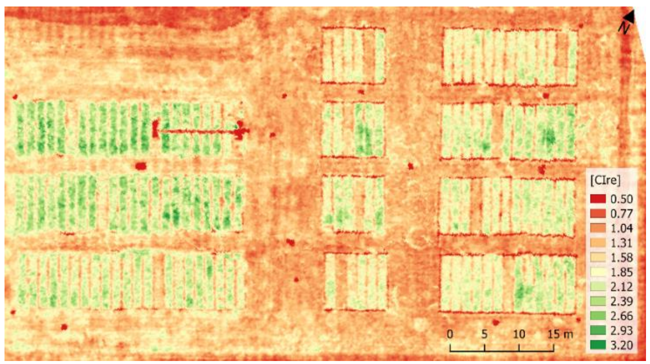
@Rikola FPI-system [0.031m]

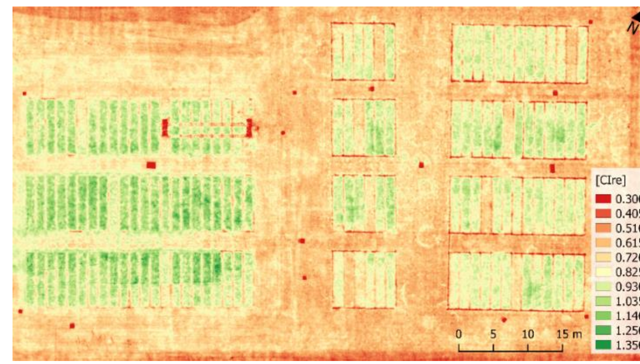
Composite



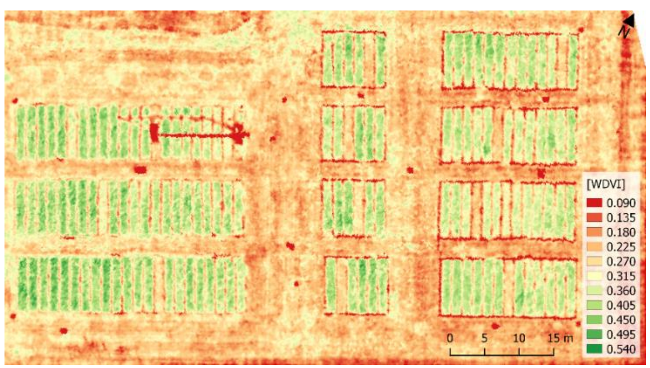


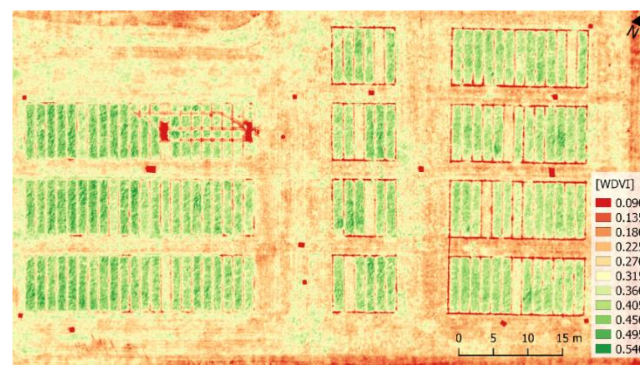
CI red-edge (~CCC)





WDVI (~FBM)





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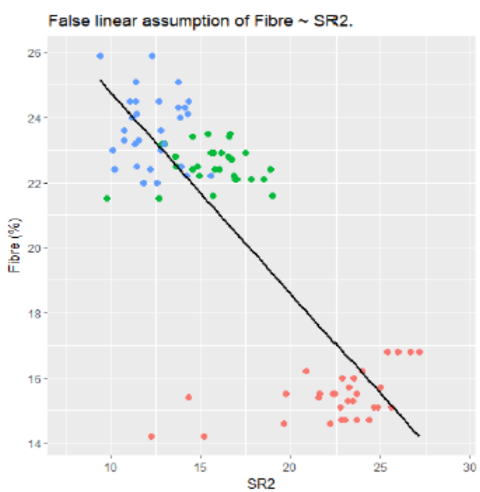
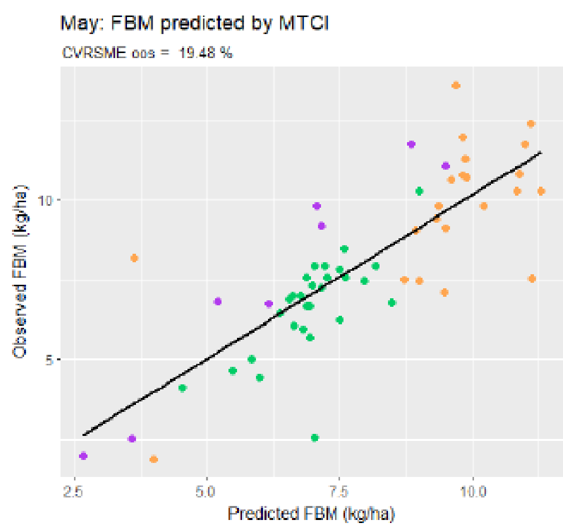
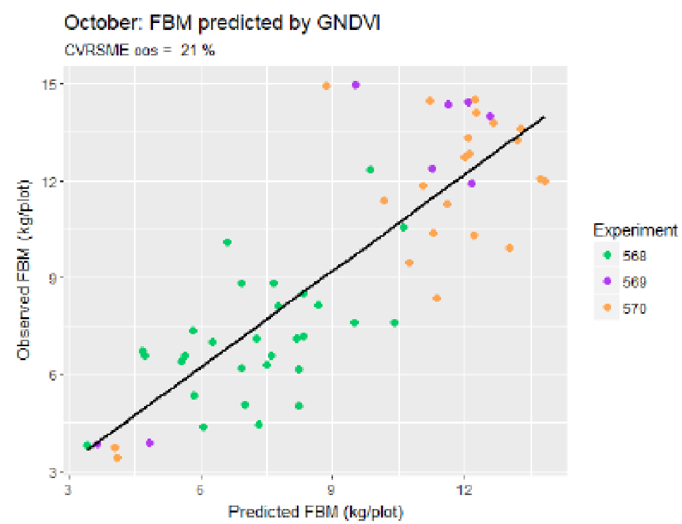
Evaluation of VIs for trait retrieval (HYMSY)

Color code	R-squared value
	=> 0.7
	=> 0.6 & < 0.7
	=> 0.4 & < 0.6
	=> 0.1 & < 0.4
	< 0.1

	May		August		October		All	
Ranking	Calibration	Validation	Calibration	Validation	Calibration	Validation	Calibration	Validation
Height	LCI	MTCI	SR2	SR2*	TCARI/OSAVI	LCI	GNDVI	GNDVI
FBM	MTCI	MTCI	MCARI/OSAVI	TCARI/OSAVI	TCARI/OSAVI	TCARI/OSAVI	MTCI	MTCI
DBM	NDRE	GNDVI	MCARI/OSAVI	MCARI/OSAVI	TCARI/OSAVI	TCARI/OSAVI	LCI	LCI
DBM%	$CI_{red-edge}$	MTCI	TCARI/OSAVI	TCARI/OSAVI	GNDVI	TCARI/OSAVI	REP	SIPI
N	GNDVI	MTCI	NDVI3	NDVI3*	MCARI/OSAVI	TCARI/OSAVI	MTCI	MTCI
N%	MTCI	MTCI	/	MTCI	SR2	TCARI/OSAVI	NDVI3	NDVI3
fiber	MTCI	MTCI	NDVI3	TCARI/OSAVI	/	/	SR2	SR2
Ash	$CI_{red-edge}$	MTCI*	NDVI3	/	MCARI/OSAVI	MCARI/OSAVI	NDVI3	SR2







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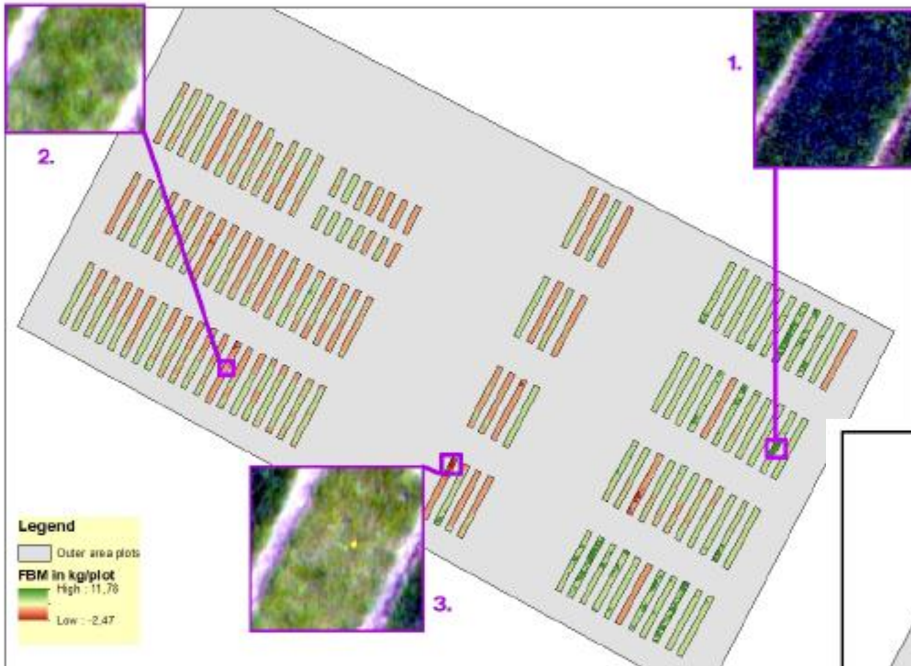
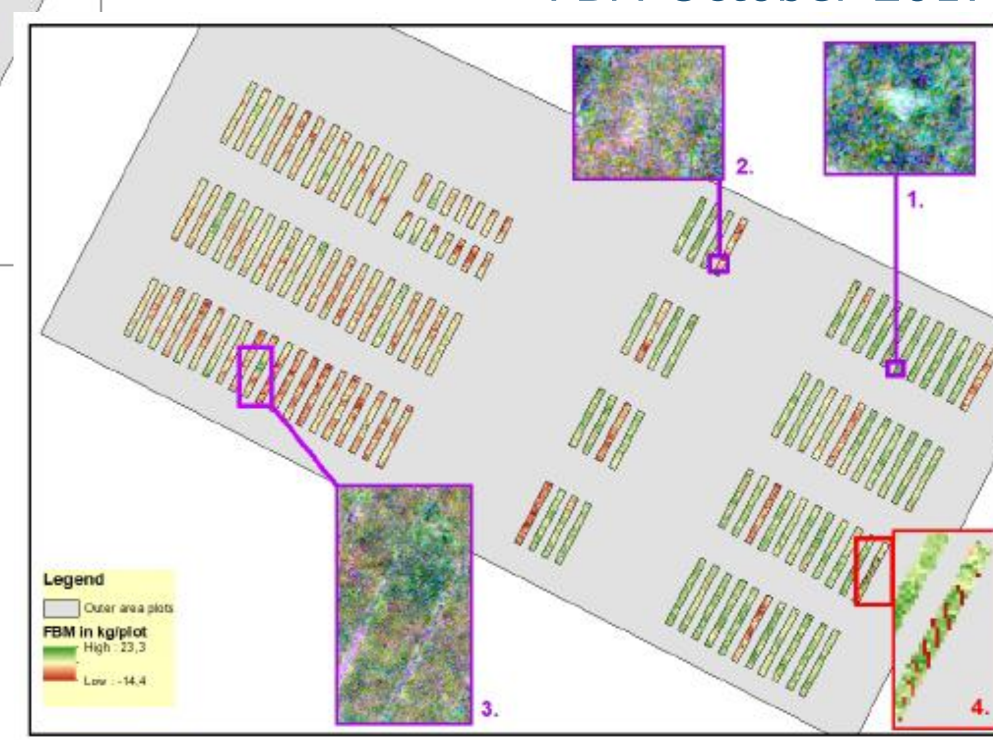
Grass trait maps Fresh Biomass (HYMSY)



FBM May 2017

FBM October 2017



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Rain: 28 mm
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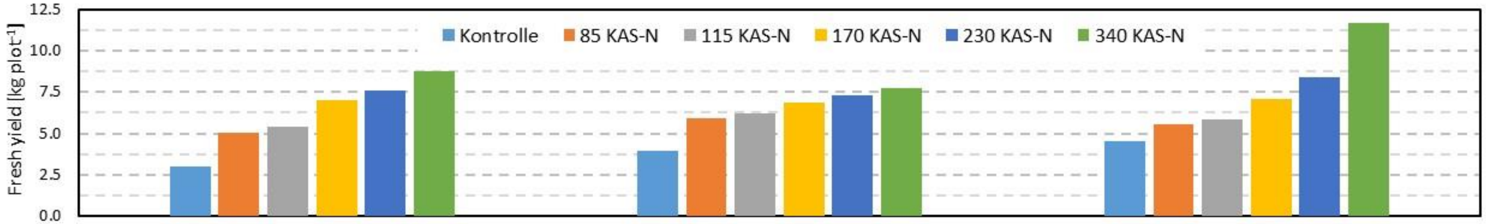
@HYMSY [time-series]

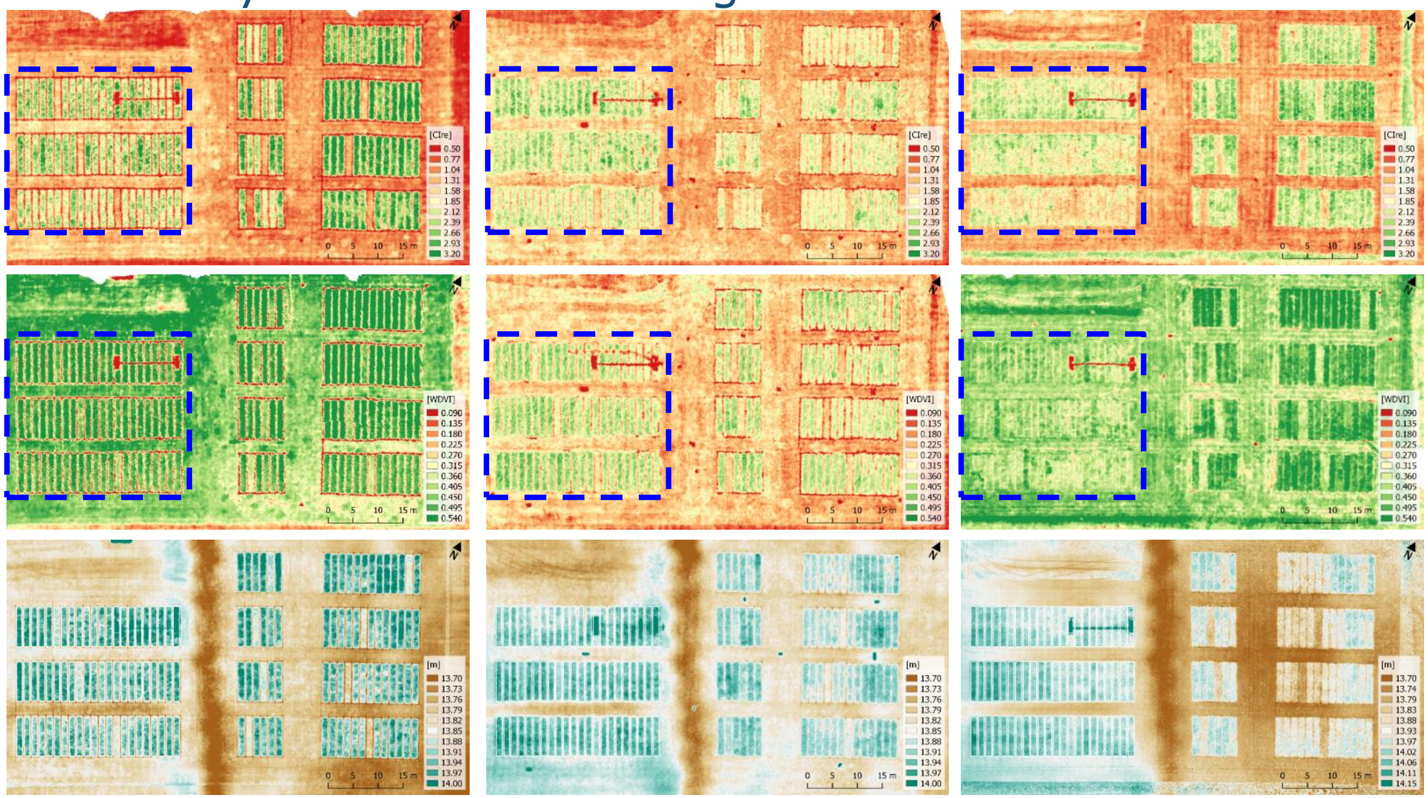


09-May-2017 | 30-Aug-2017 | 26-Oct-2017

CI red-edge [0.14 m]

WDVI [0.14 m]

DSM [0.012 m]



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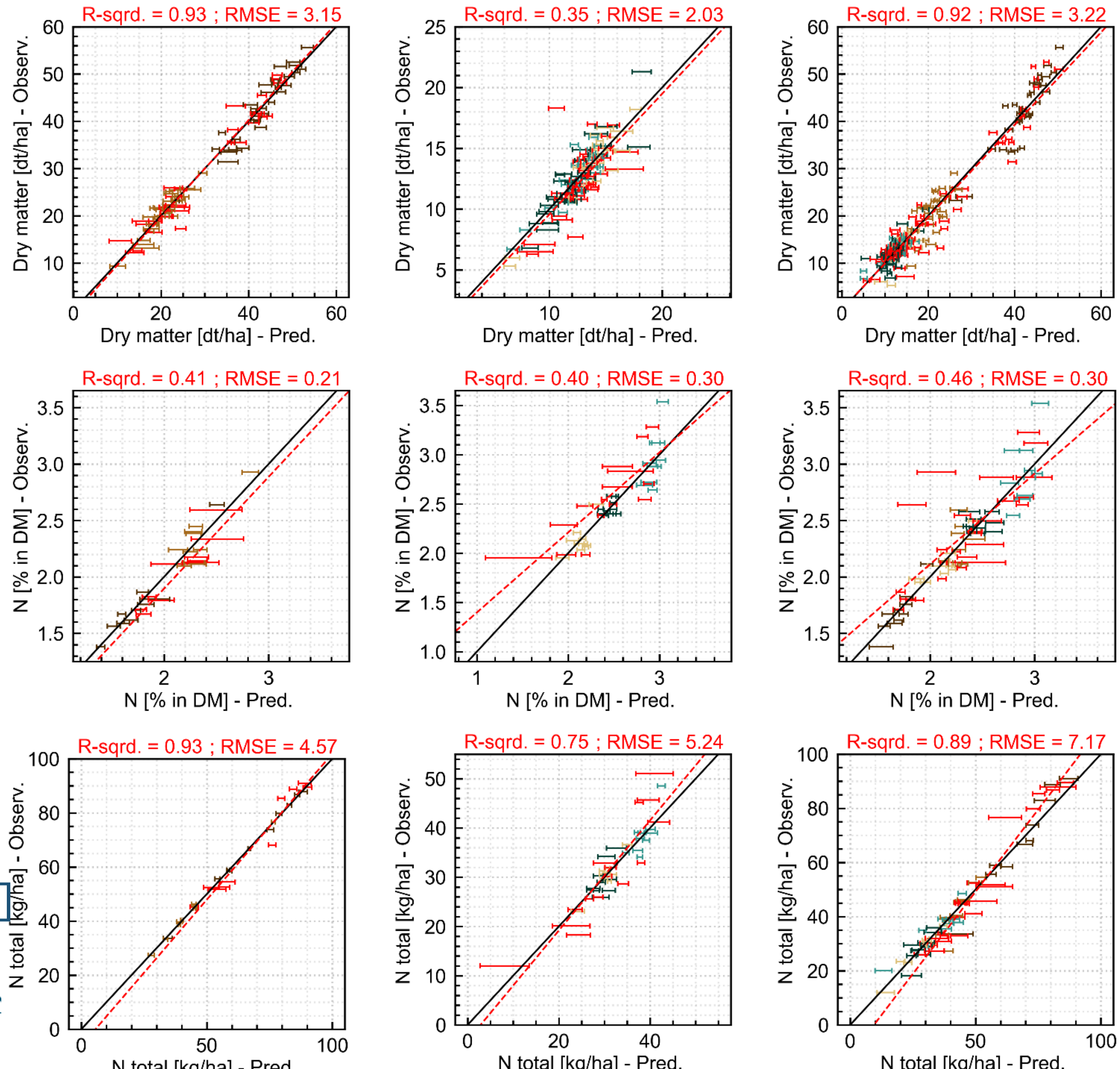
@HYMSY and PLSR – Traits estimates

[2014   [2017   [2014-

[Dry matter]

[N %]

[N kg ha^{-1}]



In the meantime in Tasmania!

Pasture Biomass: Canopy Height or Vegetation Indices?

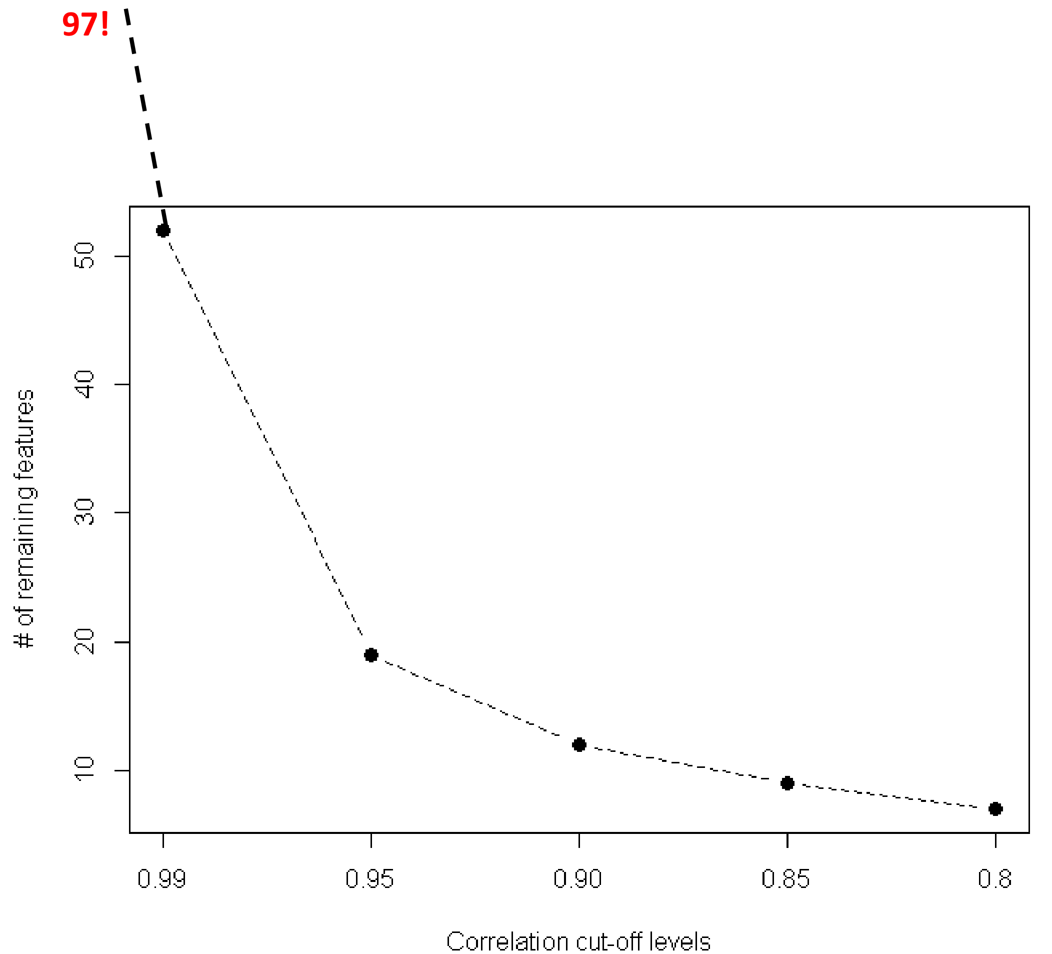
- Perennial Ryegrass: 900 samples biomass/spectra /canopy height collected in Tasmania - AUS.
- Data Collection Period: 1 year.
- Instrument: FieldSpec Handheld 2 / Plate Meter / MicaSense Parrot Sequoia.
- Research Goal: Plate Meter vs. Vegetation Indices (VIs) ?
- Applied Goal: Pasture Biomass sensor.

Dairy Australia

How similar are Vegetation indices?

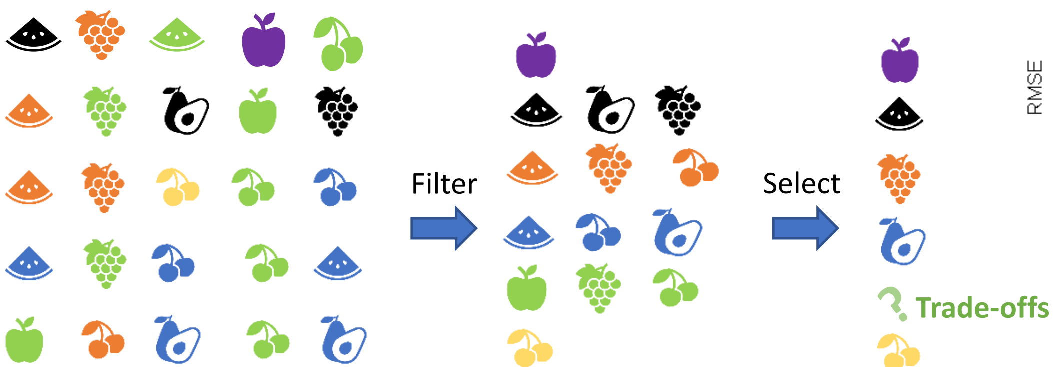
- Examining 97 indices more than 80% present a high degree of correlation.

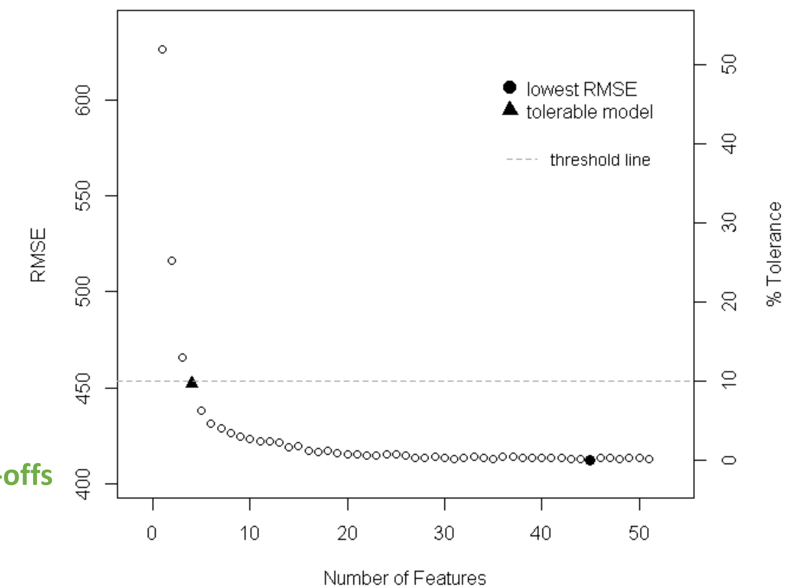
  In other words, they are **redundant**!
- We can filter out indices which are extremely similar.
- Next question is: which group of indices work better?
- What is the trade-off by not including one less index?



Vegetation Indices: which ones? Trade-offs.

- **Workflow for selection of VIs:**
  Start: 97 VIs.
  End: 4 VIs .
  Trade-off: 10% RMSE of minimal RMSE.





Findings

- There is no single silver bullet index. There are indices which perform as well or better than RPM (~ 450 kg.DM.ha^{-1})
- A group of indices do a better job explaining pasture biomass.
- Adding a lot of **redundant** indices does not improve your ability to predict biomass.
- Depending on the level of accuracy desired, a small number of indices is sufficient (4 VIs ~350 kg.DM.ha^{-1}).

G.T. Alckmin *, L. Kooistra , A. Lucieer, R. Rawnsley. *FEATURE FILTERING AND SELECTION FOR DRY MATTER ESTIMATION ON PERENNIAL RYEGRASS: A CASE STUDY OF VEGETATION INDICES.*

Conclusions

- Grassland traits show large variation over season: variation in best VI based retrieval model
- Multi-variate PLS model provides best retrieval model over whole season: but portability between seasons
- HYMSY and Rikola comparable: Rikola higher detail and spectrally and geometrically more stable (to be continued)

Outlook:

- Extend to complete Rikola dataset and combine with grassland production model -> Spectors: Marston

- Scaling to larger dataset (Ger, NL, Aust) -> PhD Gustavo

- Scaling to satellite products -> Spectors: Tom

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Thank you for your attention

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