



DRONE-BASED ASSESSMENT OF AUTUMNAL RAPE GROWTH

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Rose, May 2019.

Structure

- I. Autumnal Rape Growth & Multispectral Data
- II. Drone-Based Data Acquisition
 - Data Quality: Information Content & Stability
 - Time Slots for Data Acquisition
- III. Comparison with the Satellite-Based Approach
- IV. Summary



Bukowiecki, November 2017.

Contributor to N-Balance Surplus

- One of the Major Crops in Germany (> 10 % of Arable Land¹)
- 100 kg N/ha Mean N Surplus of Winter Oilseed Rape² (WOSR) (Legal Limit: 3-Year-Average of 50 kg N·ha⁻¹)

¹German Federal Statistical Office; URL: <https://www.destatis.de/DE/Presse/Pressemitteilungen>, last visit: 2019-04-05, 12:20.

²Henke et al., 2007.



Rose, May 2019.

Optimizing N Management

- Algorithm for Site-Specific N Fertilization of WOSR³
 - **Autumnal Canopy N** as Predictor for the Optimal N Fertilization Rate⁴
 - **Multispectral Measurements** (Vegetation Indices) to Characterize WOSR-Growth⁵

³Pahlmann et al., 2017.

⁴Henke et al., 2009.

⁵Müller et al., 2008.



Pahlmann, November 2010.

Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor



Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor
- Satellite (Sentinel 2, MSI)



Return Interval	2 – 3 Days
Bands	12 Bands
Resolution	10 – 60 m

Picture source: <https://bit.ly/2OGm8wx> , last visit: 2017-07-03, 12:00.

Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor
- Satellite (Sentinel 2, MSI)
- Dronal Approach (eBee+, Parrot Sequoia)



Weight	700 g
Endurance	50 min
Max. Wind Speed	45 km·h ⁻¹

Picture source: <https://www.sensefly.com/uploads/contentElements/ebec-plus-responsive.jpg>, last visit: 2017-07-03, 12:00.

Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor
- Satellite (Sentinel 2, MSI)
- Dronal Approach (eBee+, Parrot Sequoia)

Bands	Green, Red, Red Edge, Near Infrared
Resolution	Centimetre Range
Min. Sun Irradiance	3000 lx ($> 24 \text{ W}\cdot\text{m}^{-2}$)



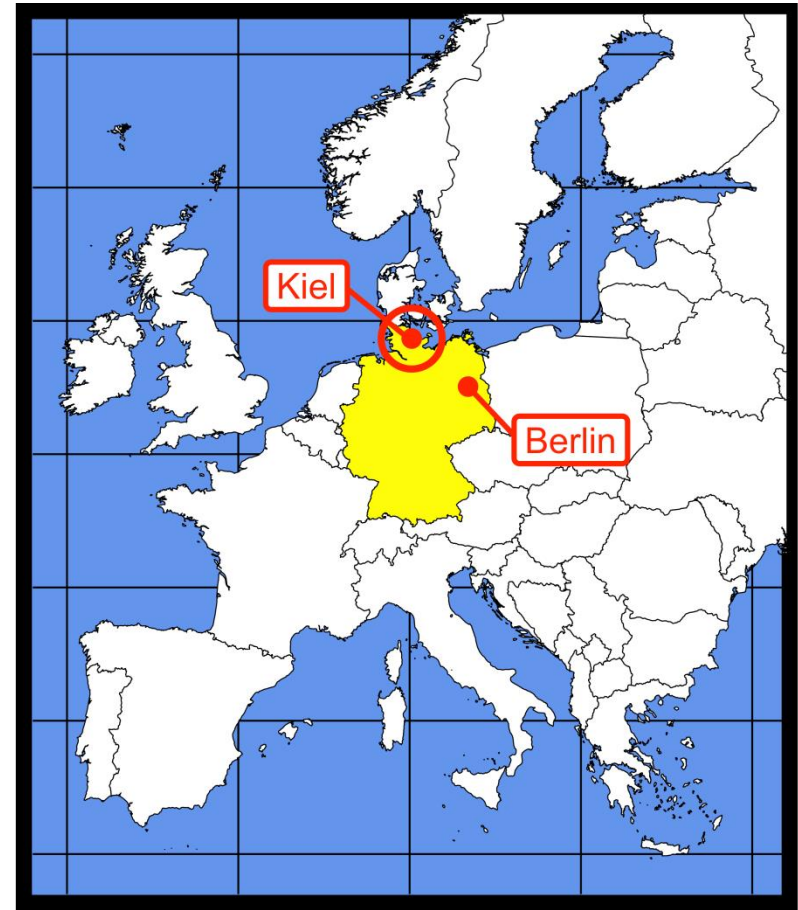
Picture source: https://www.parrot.com/files/s3fs-public/resize_produits_home_locale_0.png, last visit: 2019-05-03, 8:45.

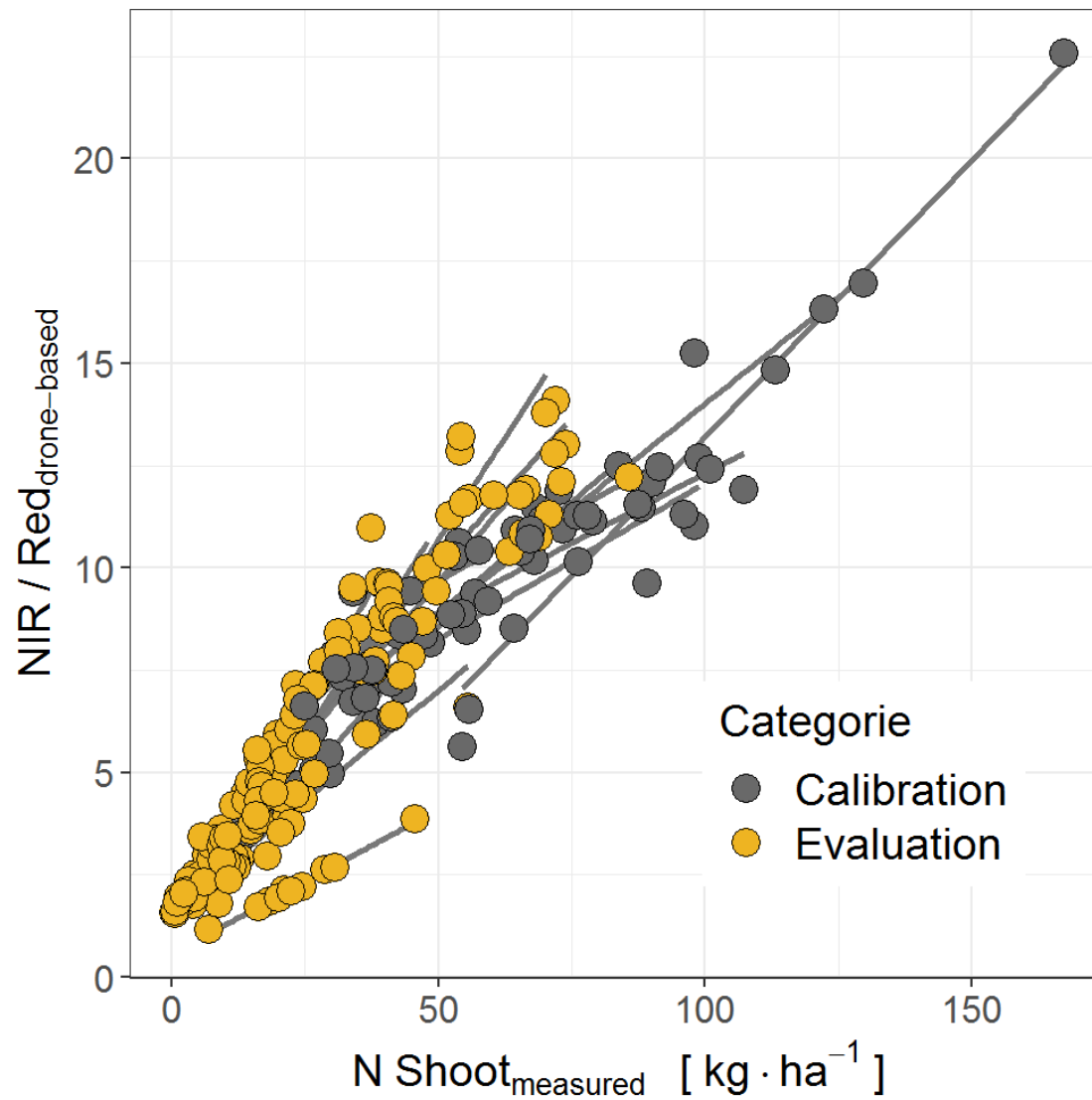
Work on Field Trials & Farms

Autumn 2017 & 2018:

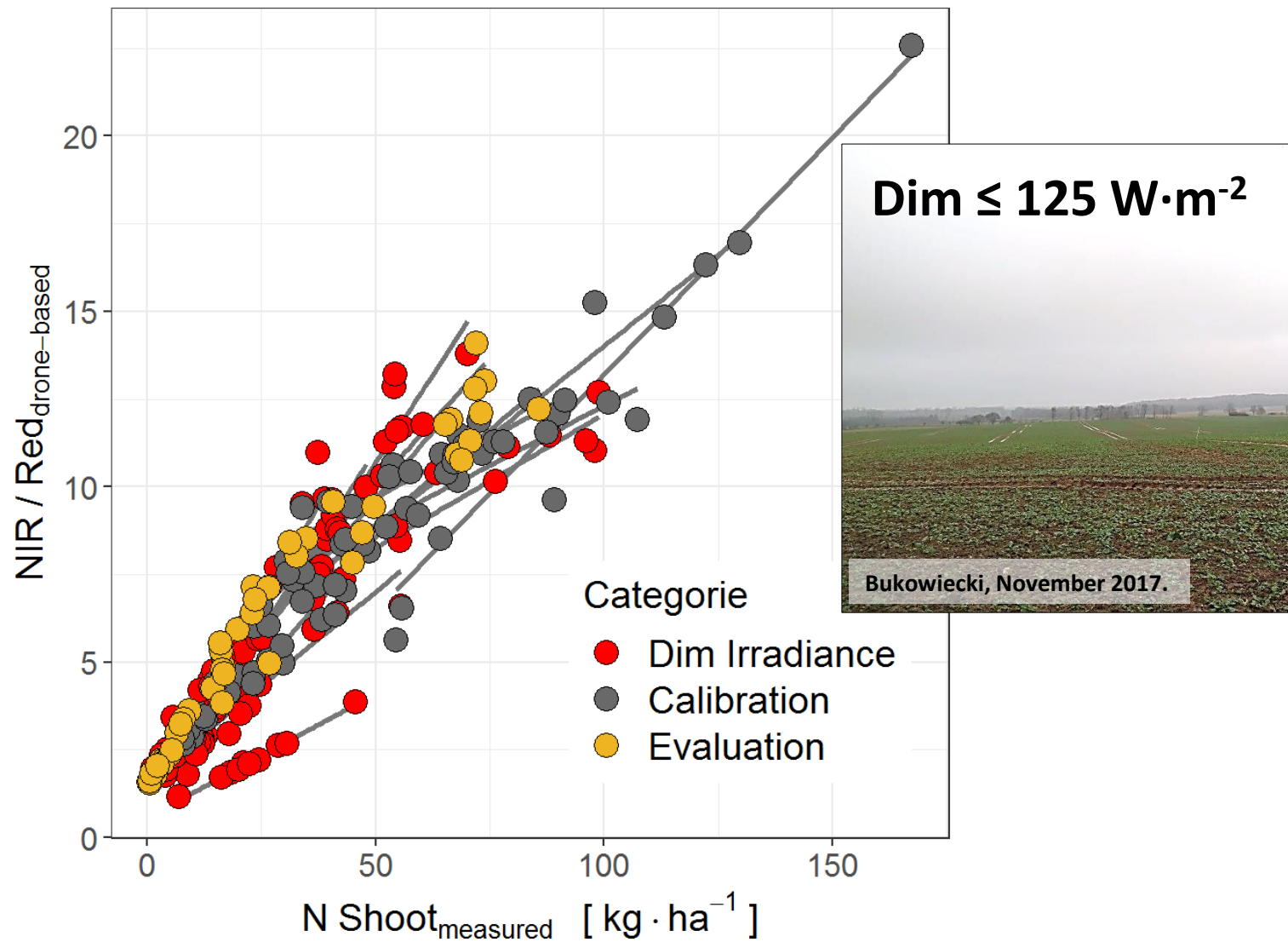
18 Sampling Dates:

- Multispectral Flight
- Destructive Sampling of N Shoot
- Calculation of Vegetation Indices
- Correlation with N Shoot
(Calibration Data: 2018,
Evaluation Data: 2017)



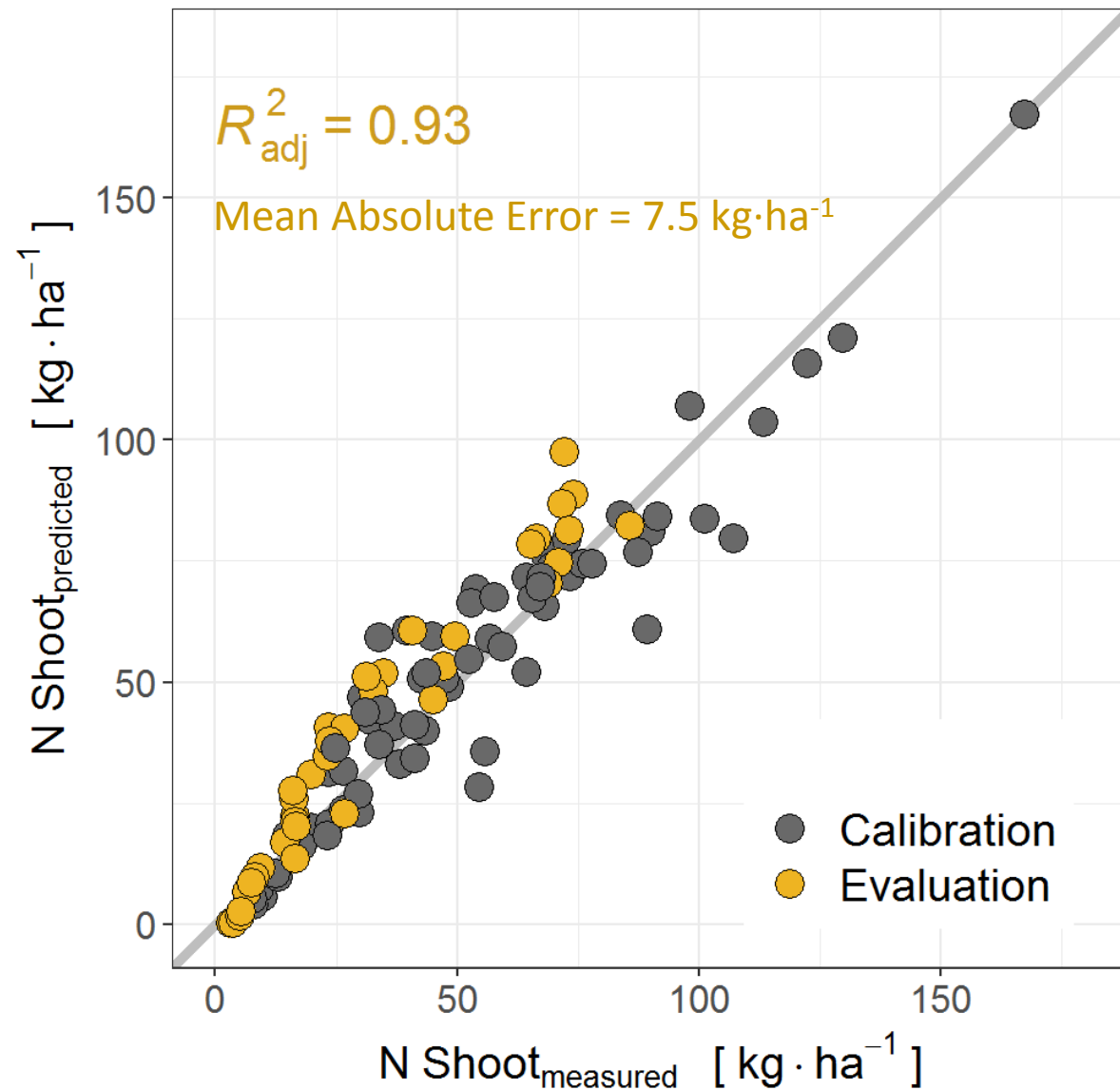


Correlation of Measured N Shoot and Drone-Based Vegetation Index (Near Infrared/Red).



Correlation of Measured N Shoot and Drone-Based Vegetation Index (Near Infrared/Red).

⁶Data from Sunshine log of Sequoia Camera or, if not available, from Deutscher Wetterdienst (<ftp://ftp-cdc.dwd.de/pub/CDC>, 2019-05-03, 15:45).



Correlation of Measured and Drone-Based N Shoot (Vegetation Index: Near Infrared/Red, Data⁶ > 125 $\text{W} \cdot \text{m}^{-2}$).

⁶Data from Sunshine log of Sequoia Camera or, if not available, from Deutscher Wetterdienst (<ftp://ftp-cdc.dwd.de/pub/CDC>, 2019-05-03, 15:45).

Weather-Related Time Slots: Drone

- Relevant Time Slot for N Shoot-Mapping:
Early November – Mid December (First Freezing)
- Requirements to Be Fulfilled
for at Least 3 Consecutive Hours:



- No Precipitation
- Wind Speed $< 12 \text{ m}\cdot\text{s}^{-1}$
- Irradiance $\geq 125 \text{ W}\cdot\text{m}^{-2}$

→ 2017: 12 Days & 2018: 8 Days

Picture sources: <https://www.sensefly.com/uploads/contentElements/ebec-plus-responsive.jpg>, last visit: 2017-07-03, 12:00,
https://www.parrot.com/files/s3fs-public/resize_produits_home_locale_0.png, last visit: 2019-05-03, 8:45.

Preliminary Conclusion

- Drone-Based Multispectral Data Sensitive to Autumnal N Uptake
- Calibration Samples Required at Dim Irradiance Conditions ($< 125 \text{ W}\cdot\text{m}^{-2}$)
- Data Acquisition by Drone in Autumn Possible (During Relevant Time Period at Least 8 Flight Days per Year)



Rose, July 2017.

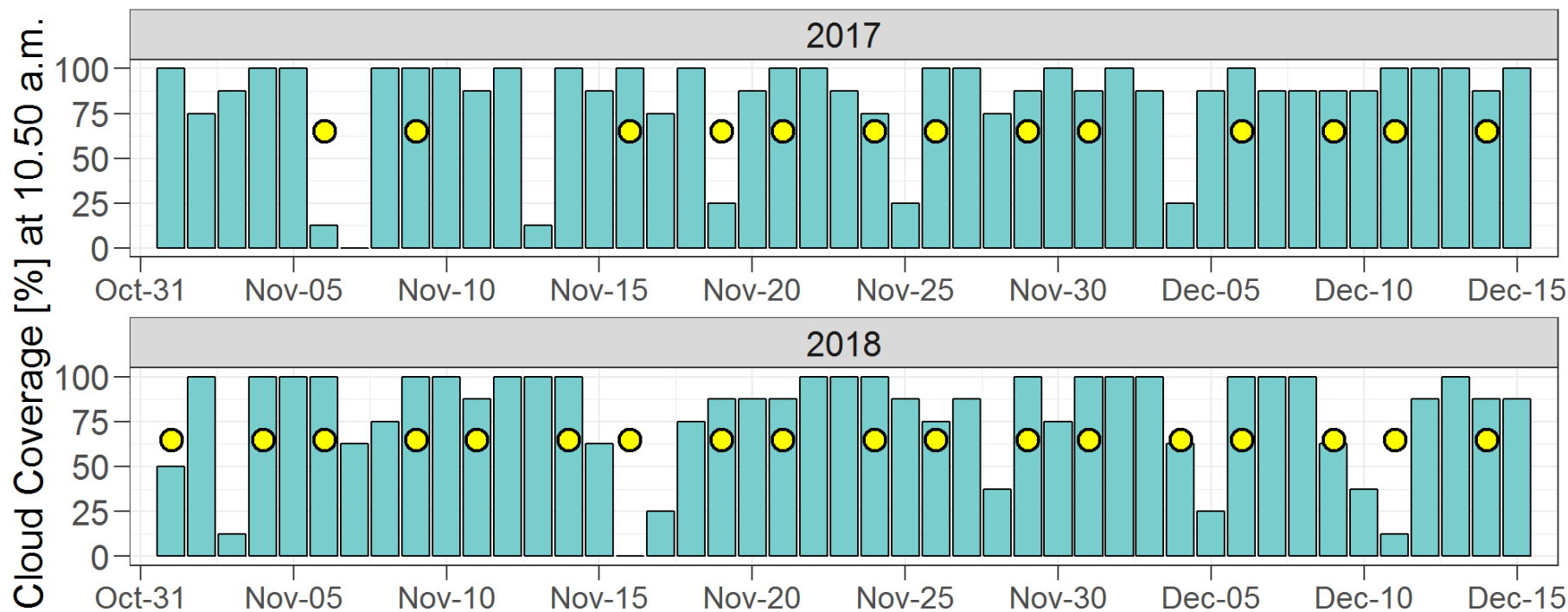
Weather-Related Time Slots: Satellite

- Relevant Time Slot for N Shoot-Mapping:
Early November - Mid December (First Freezing)
- Requirements to Be Fulfilled During Data Acquisition
(Return Interval 2 - 3 Days, at ~10:50 a.m.):



- Cloudless Sky

Picture source: <https://bit.ly/2OGm8wx> , last visit: 2017-07-03, 12:00.



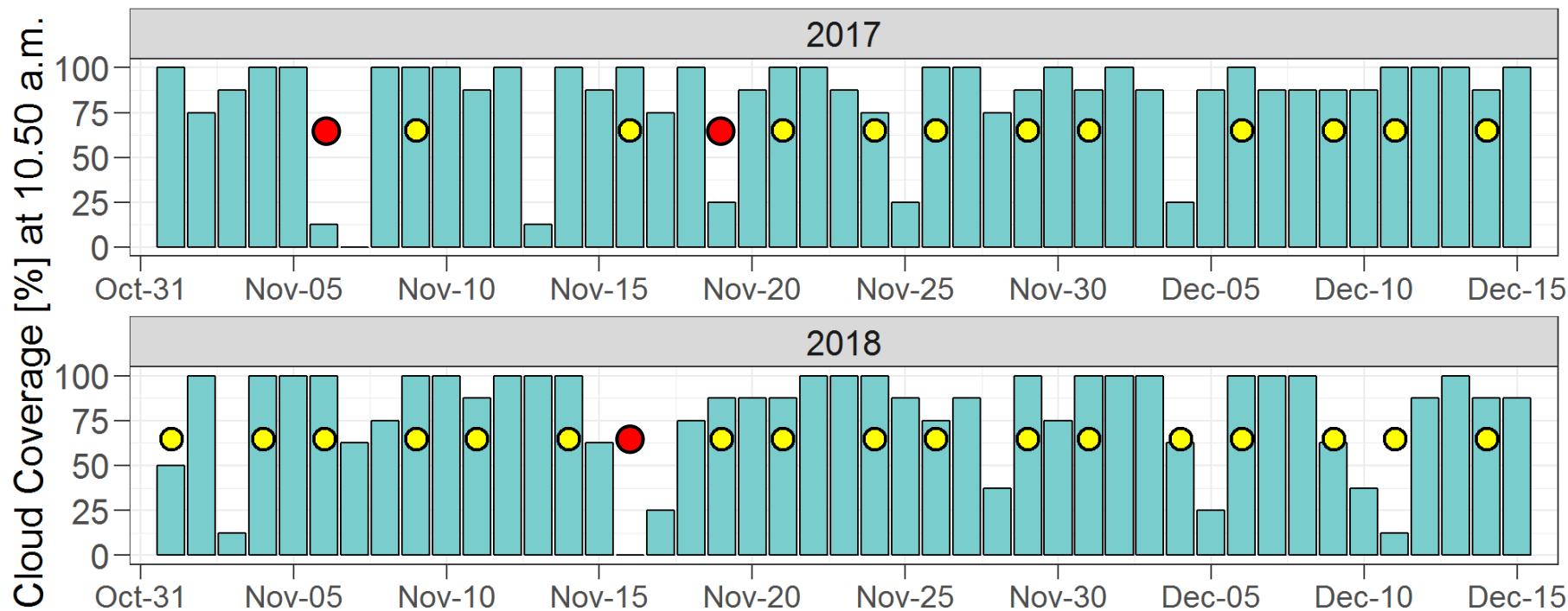
Cloud Coverage⁶ as Bar Graphs During the Relevant Period for N Shoot-Mapping at the Overpass Dates and -Time of the Sentinel Satellites (~10.50 a.m.)⁷, Depicted as Yellow Points.

→ Only Nov-16-2018 Definitely Cloudless

→ Other Time Slots Possible, but Not Guaranteed

⁶Data from Deutscher Wetterdienst (<ftp://ftp-cdc.dwd.de/pub/CDC>, 2019-05-03, 15:45) &

⁷Data from ESA (<https://scihub.copernicus.eu/dhus/#/home>, 2019-05-06, 13:00).



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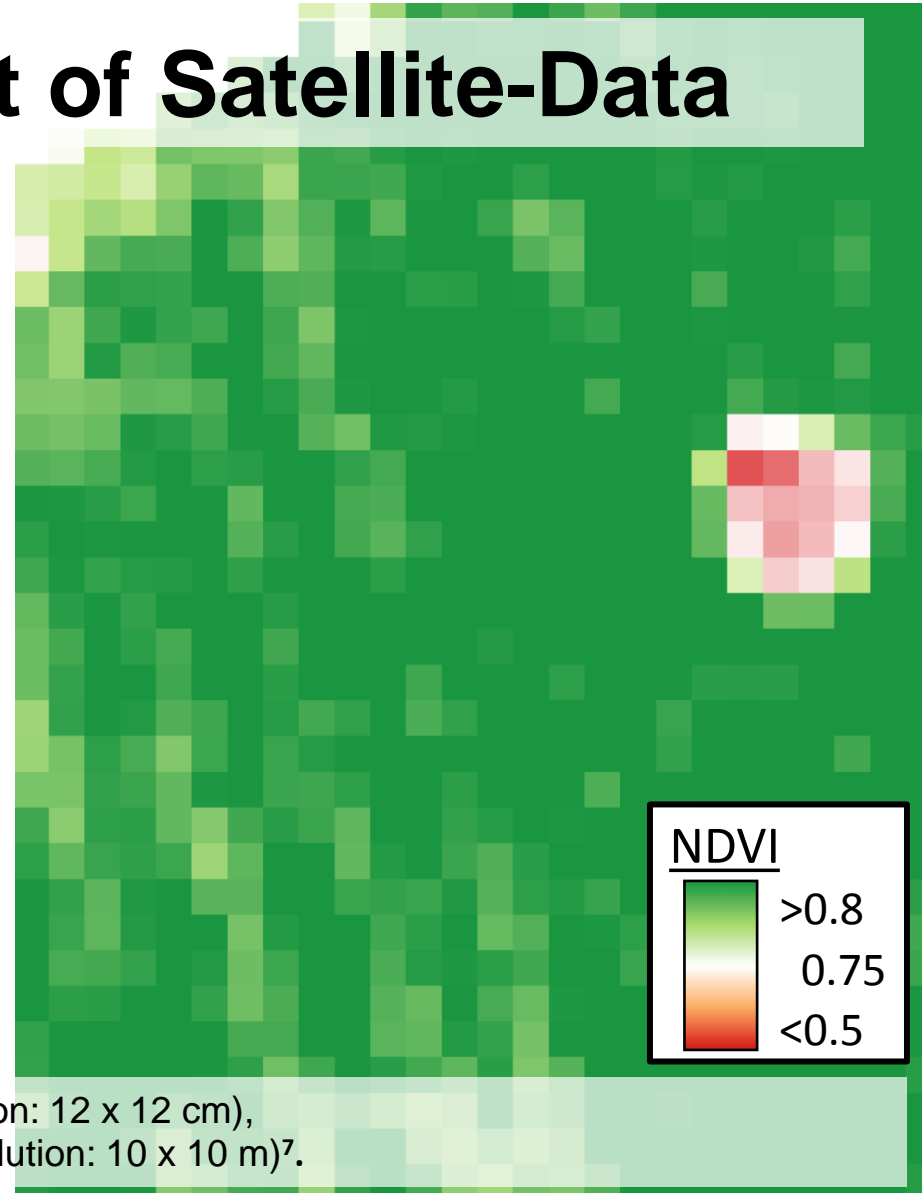
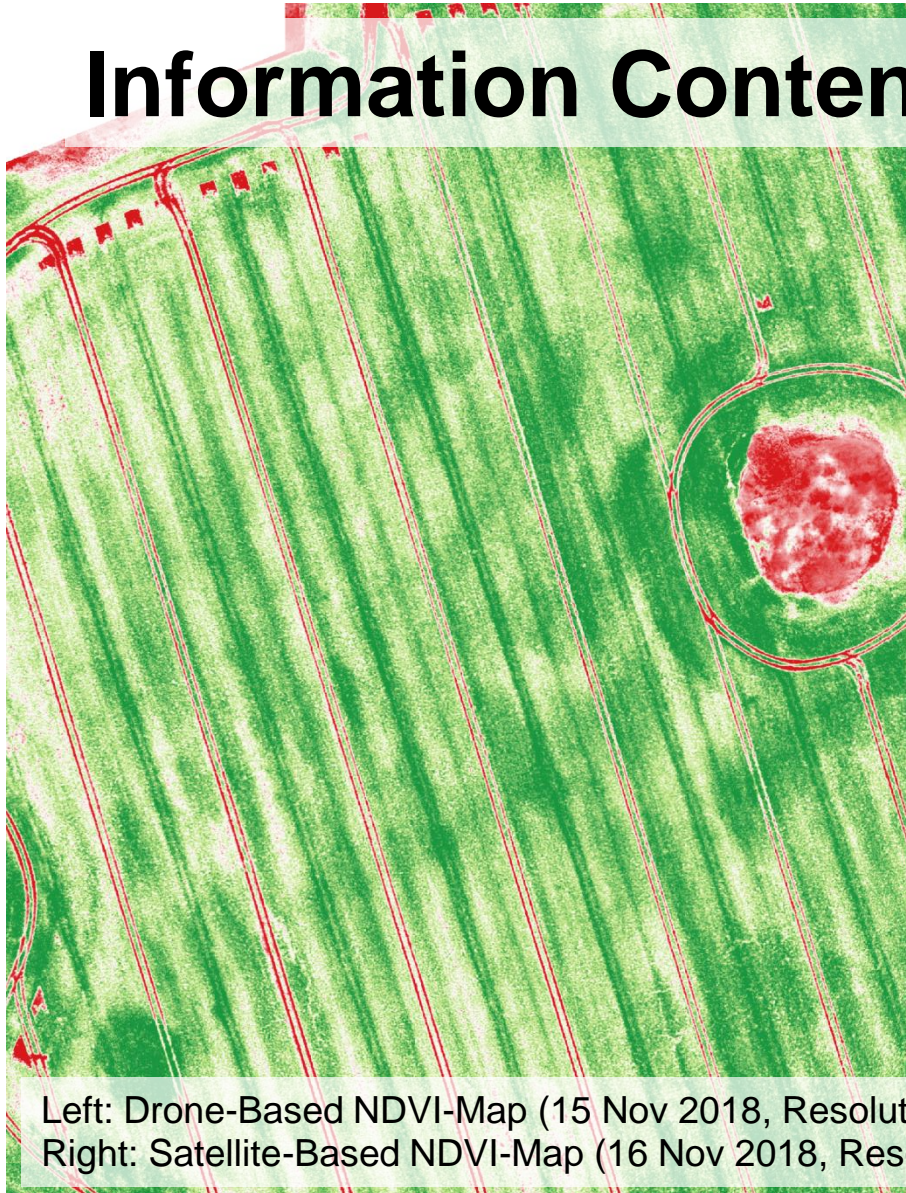
→ Only Nov-16-2018 Definitely Cloudless

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Information Content of Satellite-Data



Left: Drone-Based NDVI-Map (15 Nov 2018, Resolution: 12 x 12 cm),
 Right: Satellite-Based NDVI-Map (16 Nov 2018, Resolution: 10 x 10 m)⁷.

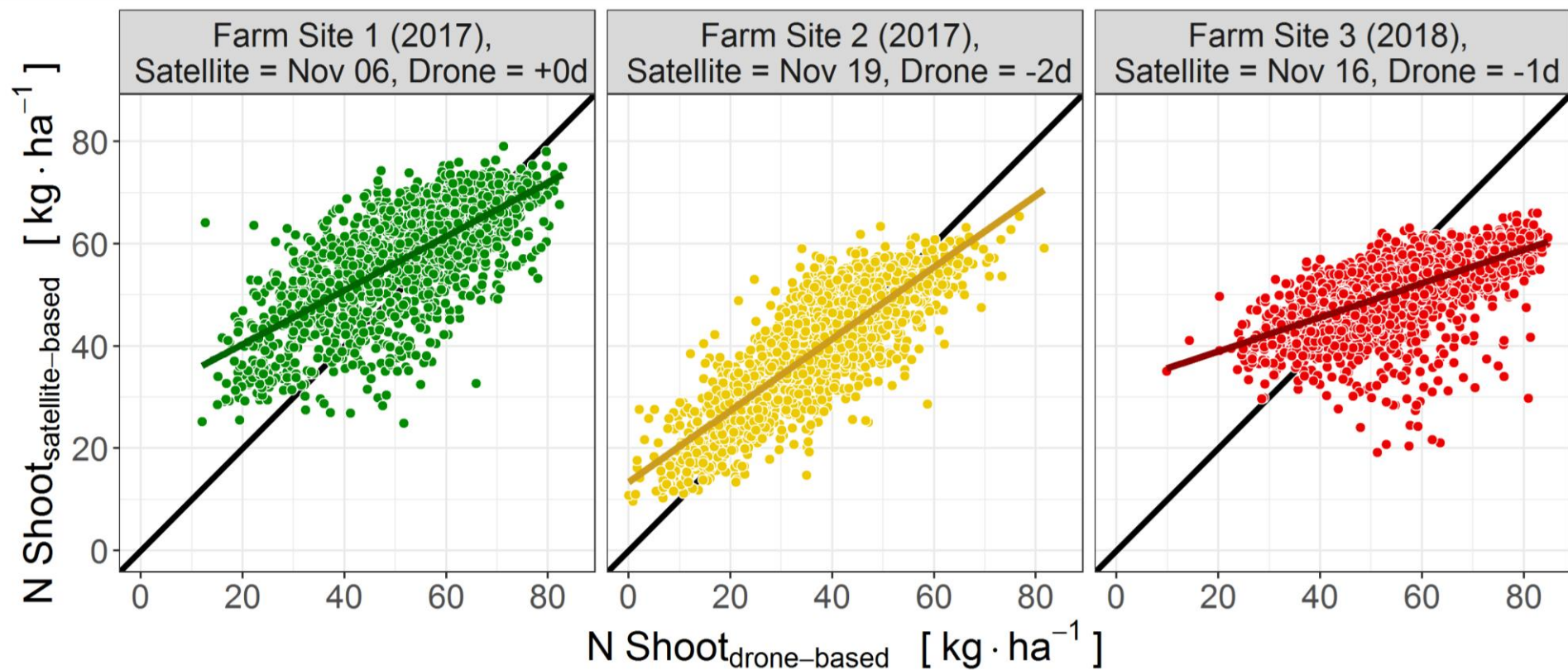
⁷Data from ESA (<https://scihub.copernicus.eu/dhus/#/home>, 2019-05-06, 13:00).

Information Content of Satellite-Data: Drone-Based Calibration

1. Drone-Based Maps of N Shoot ($> 125 \text{ W}\cdot\text{m}^{-2}$)
2. Drone- & Satellite Data in Same Grid (10 x 10 m)
3. Calibrate Satellite Data with Drone Data
 $\rightarrow N \text{ Shoot}_{\text{Satellite}} = a \times \exp(b \times \text{NDVI}_{\text{Satellite}})$
4. Predict $N \text{ Shoot}_{\text{Satellite}}$ & Compare with $N \text{ Shoot}_{\text{Drone}}$

Left: Drone-Based NDVI-Map (15 Nov 2018, Resolution: 12 x 12 cm),
Right: Satellite-Based NDVI-Map (16 Nov 2018, Resolution: 10 x 10 m)⁷.

⁷Data from ESA (<https://scihub.copernicus.eu/dhus/#/home>, 2019-05-06, 13:00).



R²_{adj}	0.50	0.72	0.39
MAE	10.0 kg N·ha ⁻¹	7.6 kg N·ha ⁻¹	6.9 kg N·ha ⁻¹
ΔRange	-16.7 kg N·ha ⁻¹	-25.9 kg N·ha ⁻¹	-28.1 kg N·ha ⁻¹

Satellite Data from ESA (<https://scihub.copernicus.eu/dhus/#/home>, 2019-05-06, 13:00).

Summary

- Data Acquisition in Autumn Remains Challenging
- Drone-Data Convinces (Sensitive to N Uptake, Available Time Slots for Data Acquisition)
- Alternative / Complementary Use of Satellite-Data Questionable (Data Availability, Information Content Requires Further Examination)



References

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