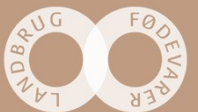


Usages of UAV and multispectral images in Danish field trials

By Mette Kramer Langgaard, department of Crop Innovation, SEGES

SEGES



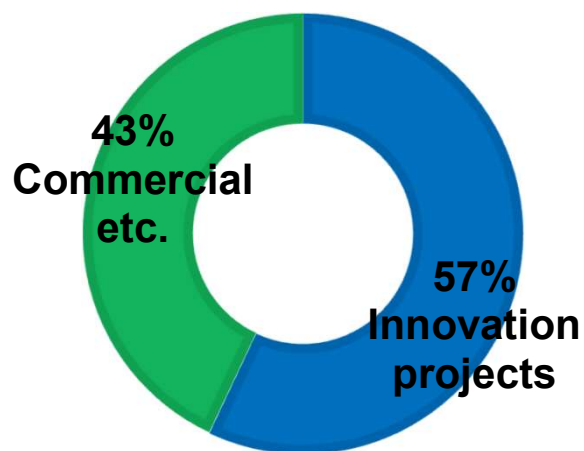
SEGES – The Danish knowledge center of Agriculture

Provide Danish farmers with the best tools for running their businesses more profitably in the most sustainable way that takes account of the environment, animal welfare and public interest.

Close partnership with universities, government departments, municipalities and businesses etc.

- Employ around 650 people
- Annual turnover of ~ 1 billion DKK

Department of Crop Innovation:



Why are multispectral images from UAV of interest to Danish farmers



The Danish field trials

SEGES perform more than 1,000 field trials every year

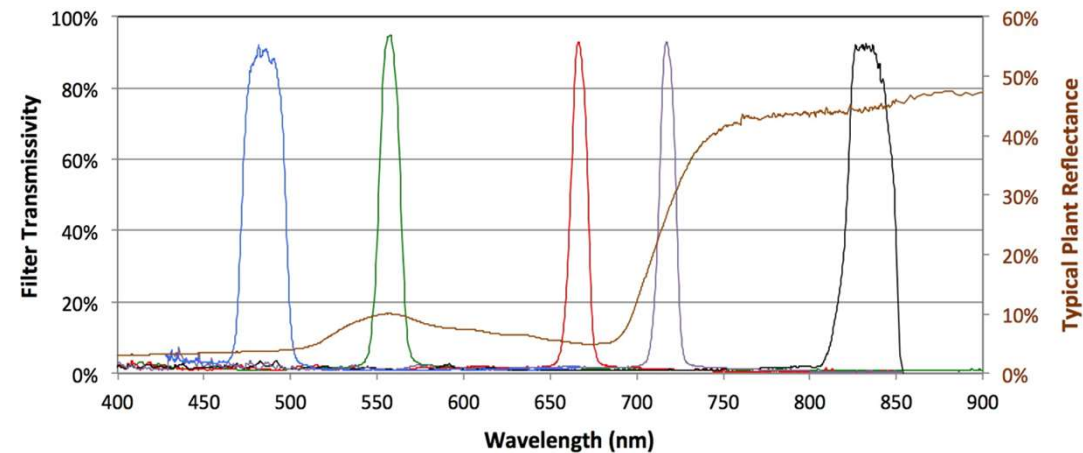
- In 2018 and 2019: 259 and 470 flights with UAV

Equipment:

- MicaSense RedEdge-M Multispectral Camera
(resolution 2-3 cm depending on flight height)
- At least a DJI Phantom 4 Pro drone

Stitching program: Solvi

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The Danish field trials

Vegetation index calculated

$$\text{NDVI} = (\text{Infrarød}_{840} - \text{Rød}_{668}) / (\text{Infrarød}_{840} + \text{Rød}_{668})$$

$$\text{NDRE} = (\text{Infrarød}_{840} - \text{Red Edge}_{717}) / (\text{Infrarød}_{840} + \text{Red Edge}_{717})$$

Nordic Field Trial System Version: 1.1.7198.10875

Trial documentation

070011919-003. Increasing N levels for winterwheat with plantsamling

Field Trial results can only be used under specific conditions - read about it [here](#)

| P02: Før 2. behandling | | | |
|------------------------|--------------------------|--------------------------|-----------------|
| 08-04-2019 ST. 31 | | | |
| NDVI, std. afv. | NDRE-REFLEKTANS Drone | NDVI-REFLEKTANS Drone | NDRE, std. afv. |
| 0,085 | 0,342 | 0,677 | 0,047 |
| 0,081 | 0,368 | 0,721 | 0,047 |
| 0,084 | 0,363 | 0,709 | 0,049 |

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An aerial multispectral image of a field, likely corn, showing distinct color bands and patterns that indicate varying levels of nitrogen treatment. The colors range from dark green to bright yellow and red, representing different vegetation indices. The field is divided into rectangular plots by narrow paths or roads.

UAV and multispectral images in field trials treated with increasing amount of nitrogen (fertilizer)

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The objectives

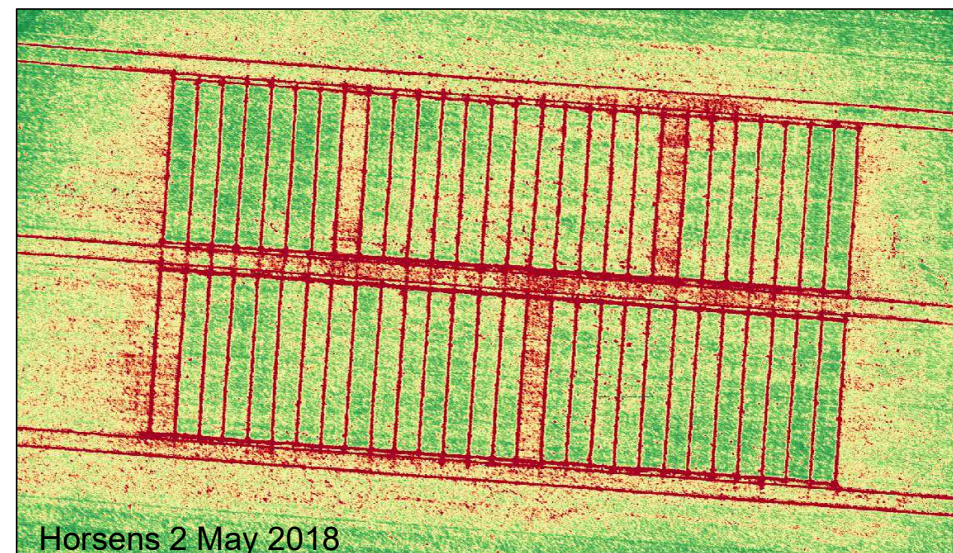
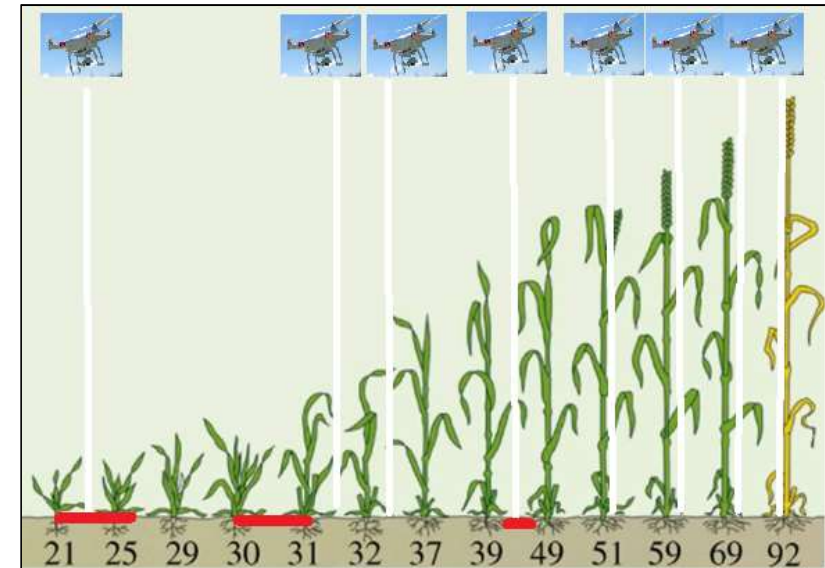
1. The relationship between biomass (NDRE and NDVI) and nitrogen (N) uptake in winter wheat.
2. When it is possible to measure a difference between N treatments in winter wheat during the growth season.
3. Which vegetation index (NDVI or NDRE) performs the best in relation to N uptake in winter wheat

Method

- 6 field trials in 2018 in winter wheat (3 in 2019)
- 9 treatments from 0 to 300 kg N pr. ha (4 replicates)
 - First N application – late Marts/beginning of April
 - Second N application – mid/late April
 - Third N application – mid/late May
- 6 to 7 flights (Growth stage 24 to 87)
- Plant cuts in BBCH 31, 32 to 34 and 49 to 57.

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Drone measurements in 2018



Results

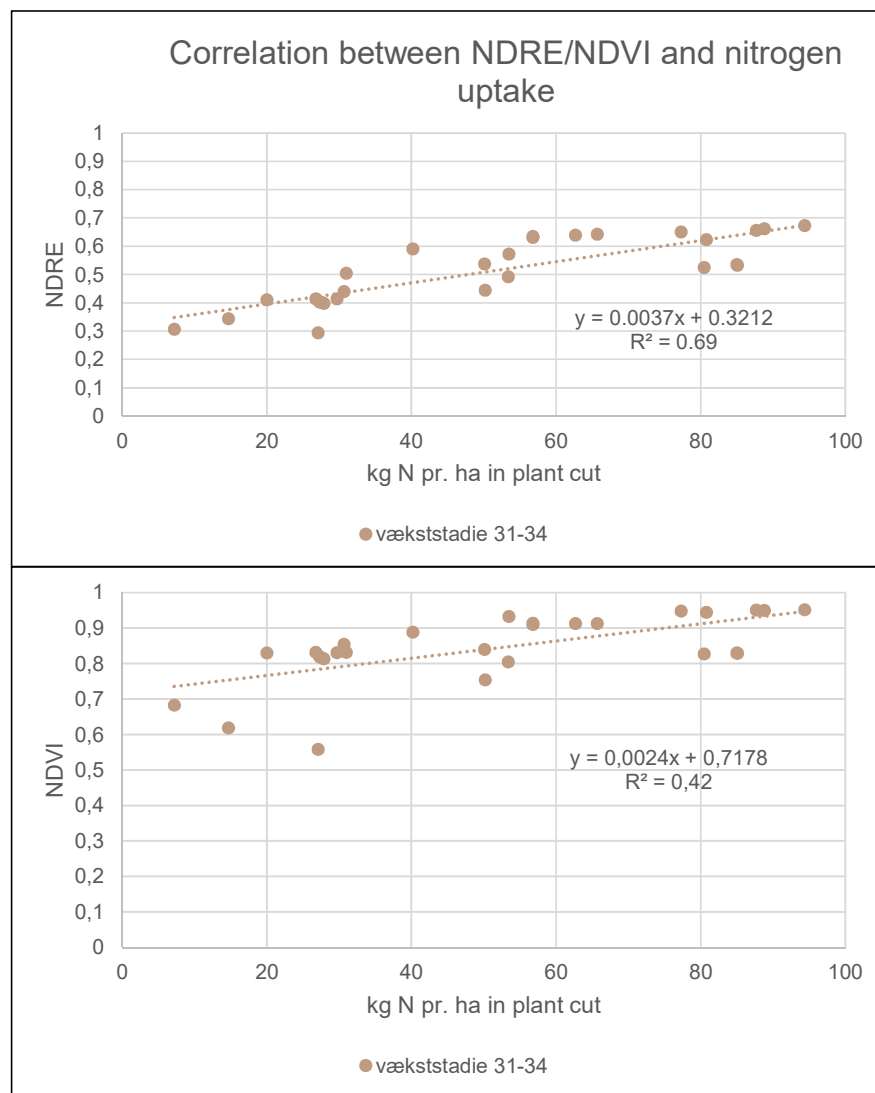
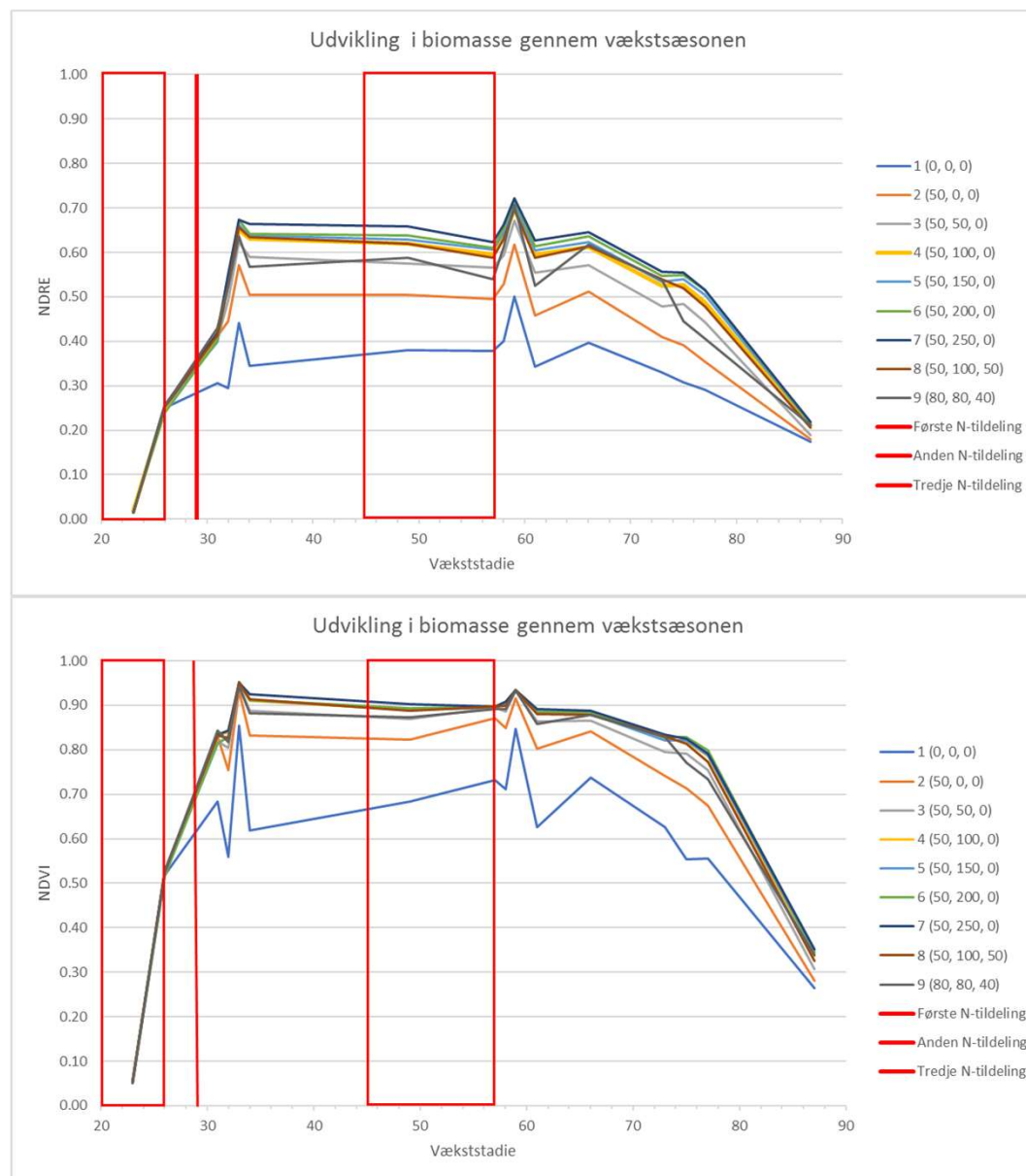


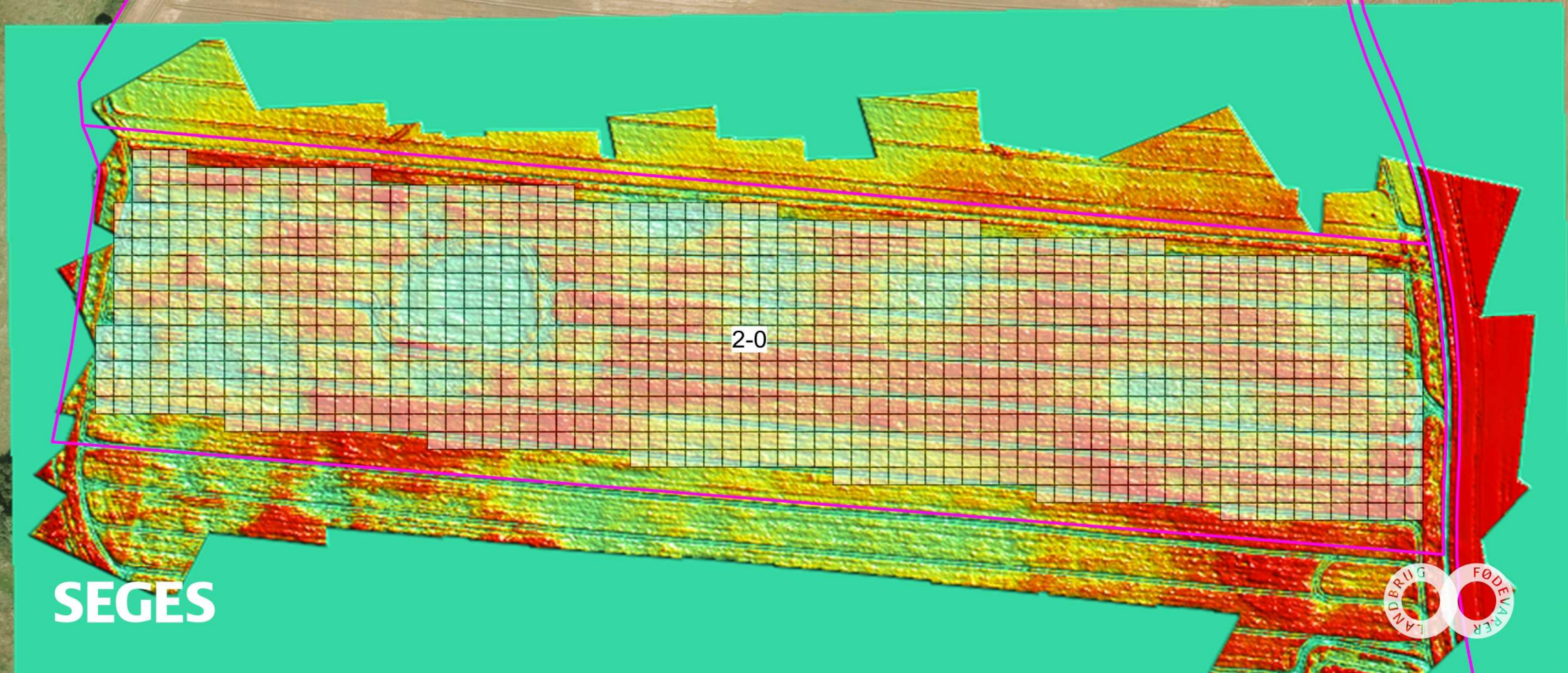
Figure. NDRE/NDVI as a function of nitrogen uptake in winter wheat from growth stadium 31-34 (data from 003,004 and 005).

Results

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Upscaling results from drone to satellite



The objectives

1. The relationship between satellite and drone measured biomass (NDRE)
2. The effect of multispectral camera used and time of measurements

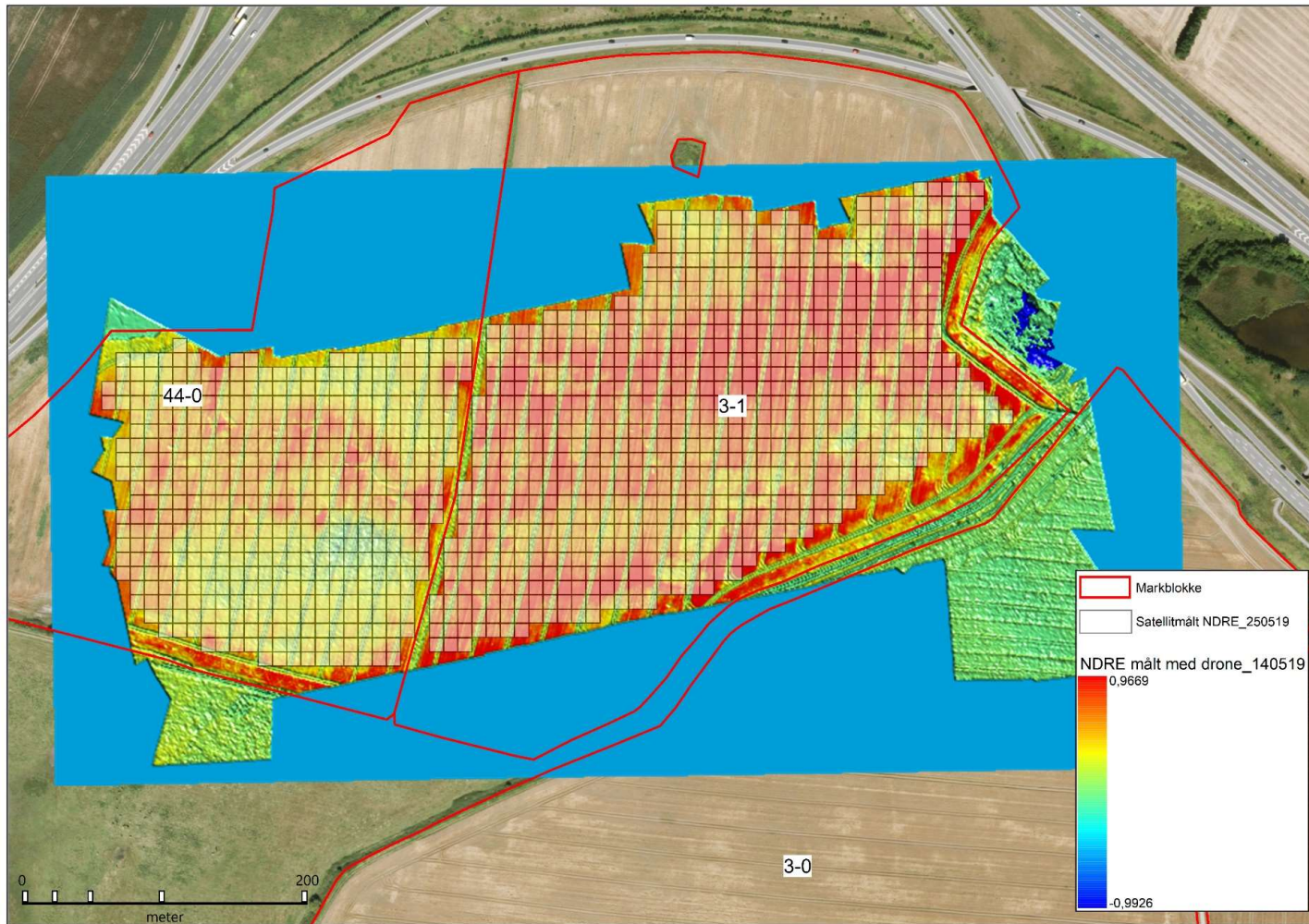
Method

| Field number | Crop | Date of drone images | Growth stadium | Date of satellite images | Area analysed ^{**}) |
|--------------|---------------|------------------------------------|----------------|---|--|
| 3-1 and 44-0 | Winter wheat | 6 Marts 10 April 14 May | 29 31 37 | 11 Marts ^{*)} 13 April 25 May | 12.7 ha (1265) 13.5 ha (1351) 16.2 ha (1620) |
| 5-0 and 6-0 | Winter wheat | 28 February 6 Marts 11 April | 29 29 31 | 27 February 11 Marts ^{*)} 13 April | 15.6 ha (1556) 22 ha (2204) 11.6 ha (1159) |
| 3-0 | Winter rape | 6 Marts 10 April 14 May | 19 57 65 | 11 Marts ^{*)} 13 April 3 May ^{*)} | 14.9 ha (1493) 14 ha (1408) 13.5 ha (1353) |
| 2-0 | Spring barley | 14 May | 25 | 25 May | 10.8 ha (1041) |

^{*)} Raster images downloaded from Sathub without removing cloud. Subsequently, images were checked for clouds in CropSat (sinus clouds can occur).

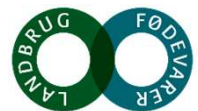
^{**}) number of measuring points (10 x 10 meters polygons) used in the analysis.

Method



Drone images (GeoTiff): 1 x 1 meter resolution

Satellite images: GeoTiff converted to vector
(10 x 10 meters resolution)



Results

| Field number | Crop | Date of drone images | Growth stadium | Date of satellite images | Area analyzed **) | Relationship between drone and satellite***) | R ² | Mean difference in NDRE |
|--------------|---------------|----------------------|----------------|--------------------------|-------------------|--|----------------|-------------------------|
| 3-1 and 44-0 | Winter wheat | 6 Marts | 29 | 11 Marts ^{*)} | 12,7 ha (1265) | $y = 0.8032x - 0.0494$ | 0.88 | - 0.14 |
| | | 10 April | 31 | 13 April | 13,5 ha (1351) | $y = 0.8084x - 0.044$ | 0.85 | - 0.15 |
| | | 14 May | 37 | 25 May | 16,2 ha (1620) | $y = 0.8907x - 0.1305$ | 0.26 | - 0.22 |
| 5-0 and 6-0 | Winter wheat | 28 February | 29 | 27 February. | 15,6 ha (1556) | $y = 0.7724x - 0.0645$ | 0.85 | - 0.17 |
| | | 6 Marts | 29 | 11 Marts ^{*)} | 22 ha (2204) | $y = 1.063x - 0.1453$ | 0.86 | - 0.12 |
| | | 11 April | 31 | 13 April | 11,6 ha (1159) | $y = 0.941x - 0.1067$ | 0.80 | - 0.14 |
| 3-0 | Winter rape | 6 Marts | 19 | 11 Marts ^{*)} | 14,9 ha (1493) | $y = 0.9247x - 0.146$ | 0.59 | - 0.18 |
| | | 10 April | 57 | 13 April | 14 ha (1408) | $y = 0.8742x - 0.1116$ | 0.22 | - 0.20 |
| | | 14 May | 65 | 3 May ^{*)} | 13,5 ha (1353) | $y = 0.7042x - 0.0895$ | 0.19 | - 0.26 |
| 2-0 | Spring barley | 14 May | 25 | 25 May | 10,8 ha (1041) | $y = 0.4418x - 0.021$ | 0.53 | - 0.34 |

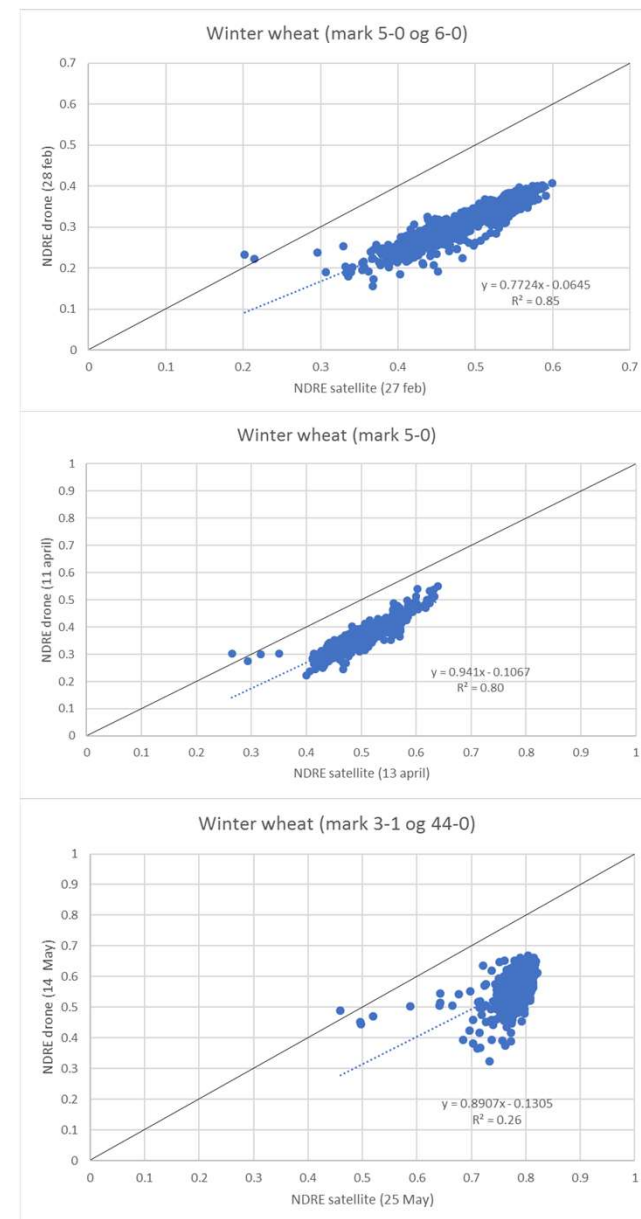
^{*)} Raster images downloaded from Sathub without the layer removing cloud. Subsequently, images were checked for clouds in CropSat (sinus clouds can occur).

^{**)} number of measuring points (10 x 10 meters polygons) used in the analysis.

^{***)} NDRE measured with drone (y) and NDRE measured with satellite (x)

Measurements from around 9, 12 AM and 3 PM were significantly different ($p < 0,001$) but with a mean difference in NDRE at **0,02-0,03** (SD = 0,02).

Mean difference in NDRE between measurements from two cameras of same type were **0.0002 – 0.017** (SD = 0.01-0.02).



Conclusion

- Biomass measurements (NDRE and NDVI) during the growth season can be used to calculate nitrogen uptake in winter wheat.
- In 2018 NDRE was more sensitive in relation to nitrogen uptake compared to NDVI.
- There is a relationship between NDRE measured with drone and NDRE measured with satellite which mean that results from field trials measured with drone can be scaled up to satellites and incorporated in a field management program like CropManager.
- Multispectral camera used and time of measurements had small and insignificant effect on biomass measurement in relation to use in practice.