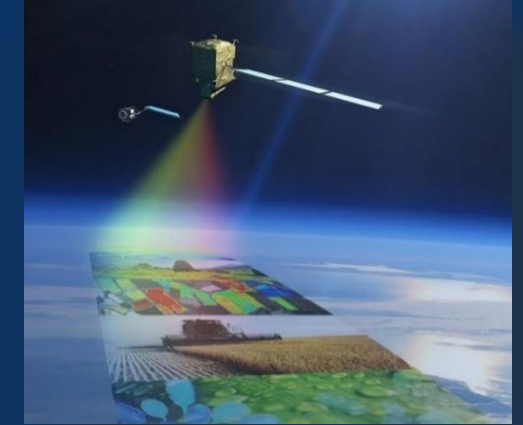# Measuring fluorescence & reflectance across spatial scales – Results from the LIAISE field campaign in July 2021

*Bastian Siegmann, Juan Quiros, Egor Prikaziuk, Patrick Rademske, Julie Krämer, Juliane Bendig, Christiaan van der Tol & Uwe Rascher*

Institute of Bio- and Geosciences
Plant Sciences (IBG-2)

# Solar-induced chlorophyll fluorescence (SIF) is the most direct measure of photosynthetic activity
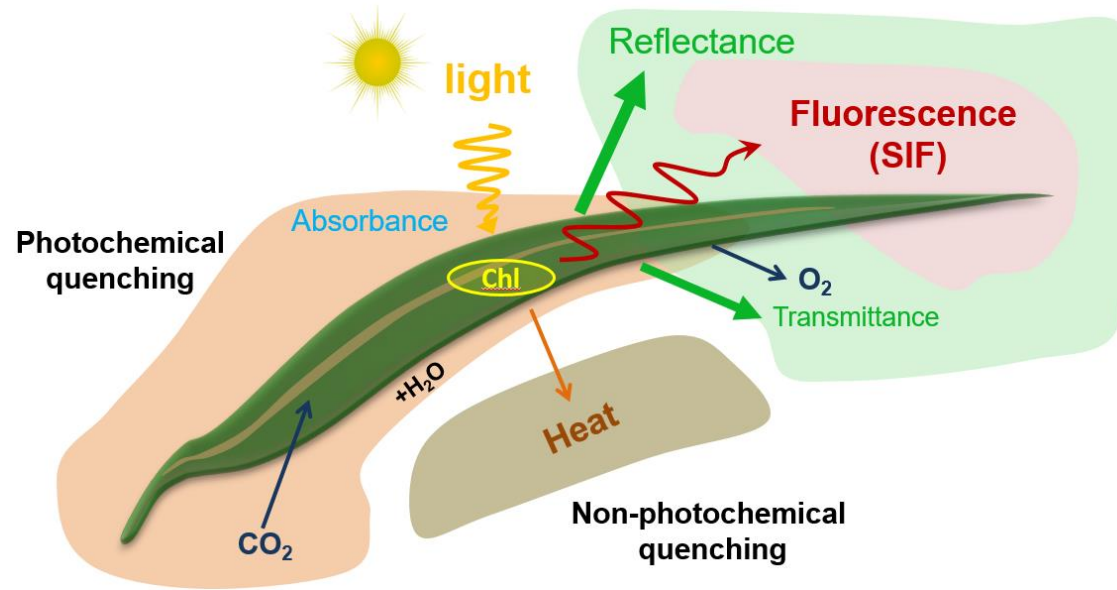


➢ SIF can be measured from different scales at different spatial and temporal resolutions

➢ Several effects challenge the correct physiological interpretation of retrieved canopy SIF

Bandopadhyay et al. (2020)
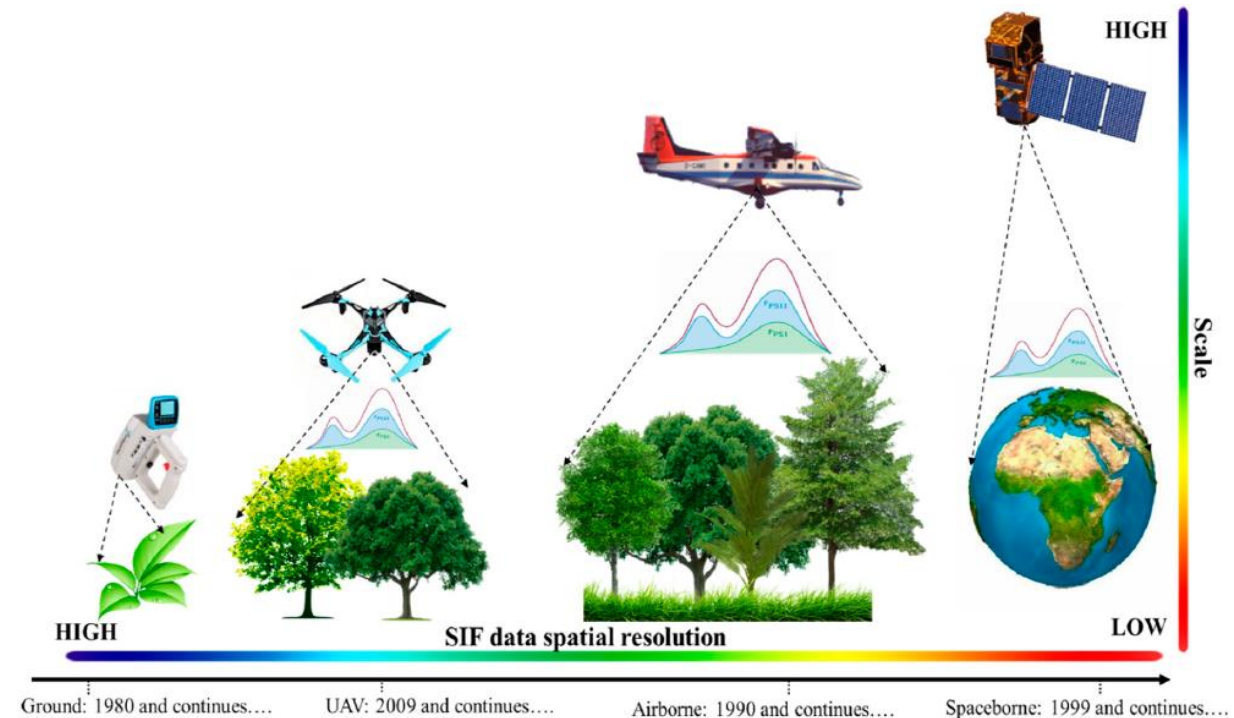
# Overview about SIF and reflectance measurements across spatial scales

- SIF and reflectance point measurements at leaf level (alfalfa, apple trees and maize) – *ASD + Fluowat & Polypen*

- SIF and reflectance point measurements in close distance above the canopy (alfalfa, apple trees and maize) – *stationary/mobile FloX*

- SIF and reflectance image data at canopy level recorded from 20-30 m above ground (alfalfa, apple trees and maize) – *RGB, MicaSense RedEdge dual & SIF-Dual camera*

- SIF and reflectance image data at canopy level recorded from 1430 m above ground (GLORI, FULL and VERDU pattern) – *HyPlant*
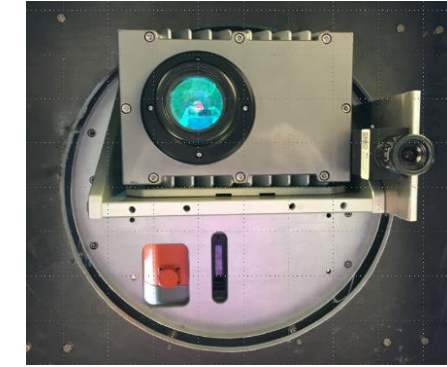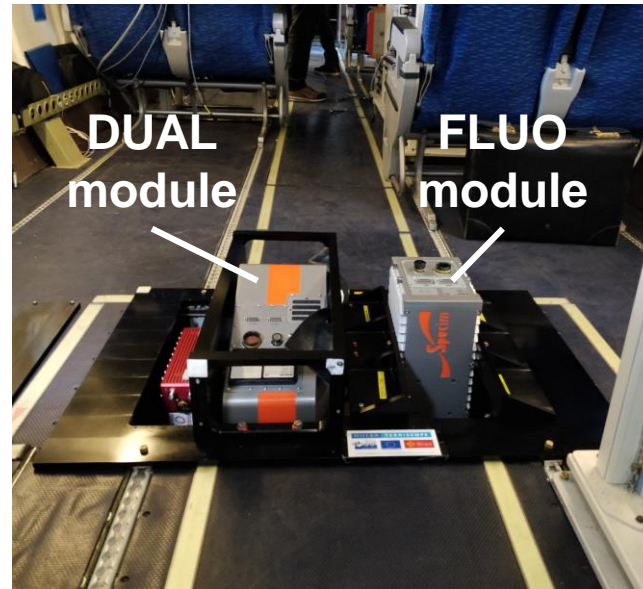
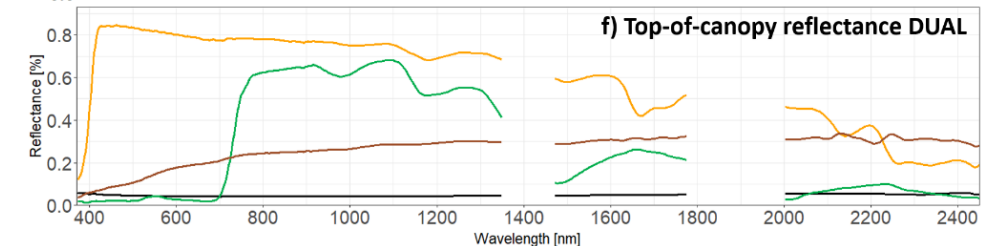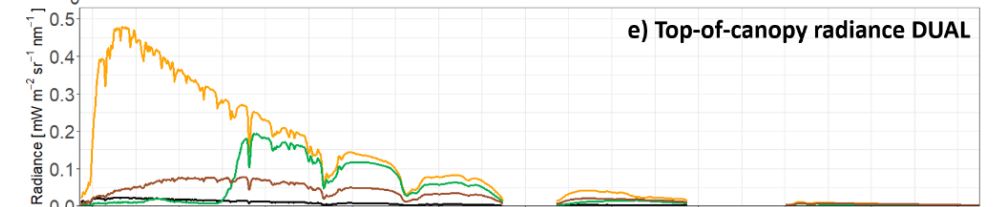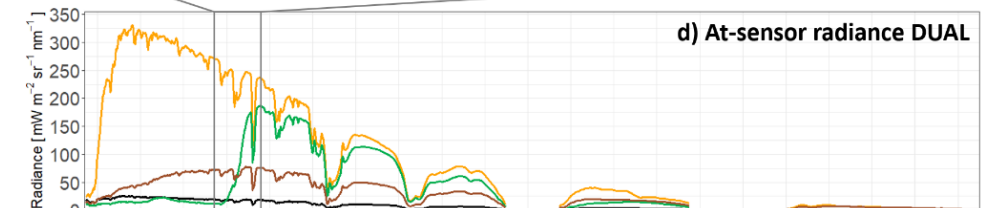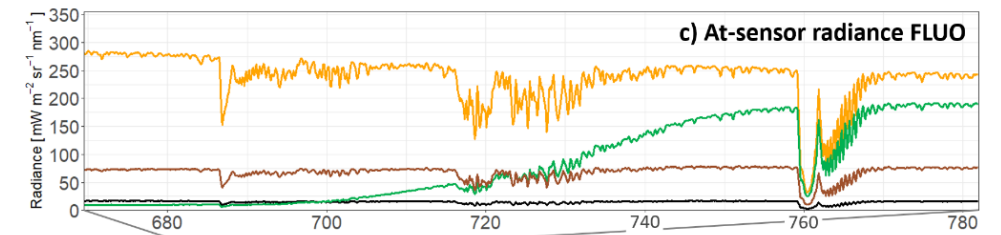| Leaf - Level | Canopy - Level | UAV - Level | Aircraft - Level | Satellite - Level |
|---|---|---|---|---|
| Fluowat | FloX | SIF Dual-camera | HyPlant | Sentinel-5P |

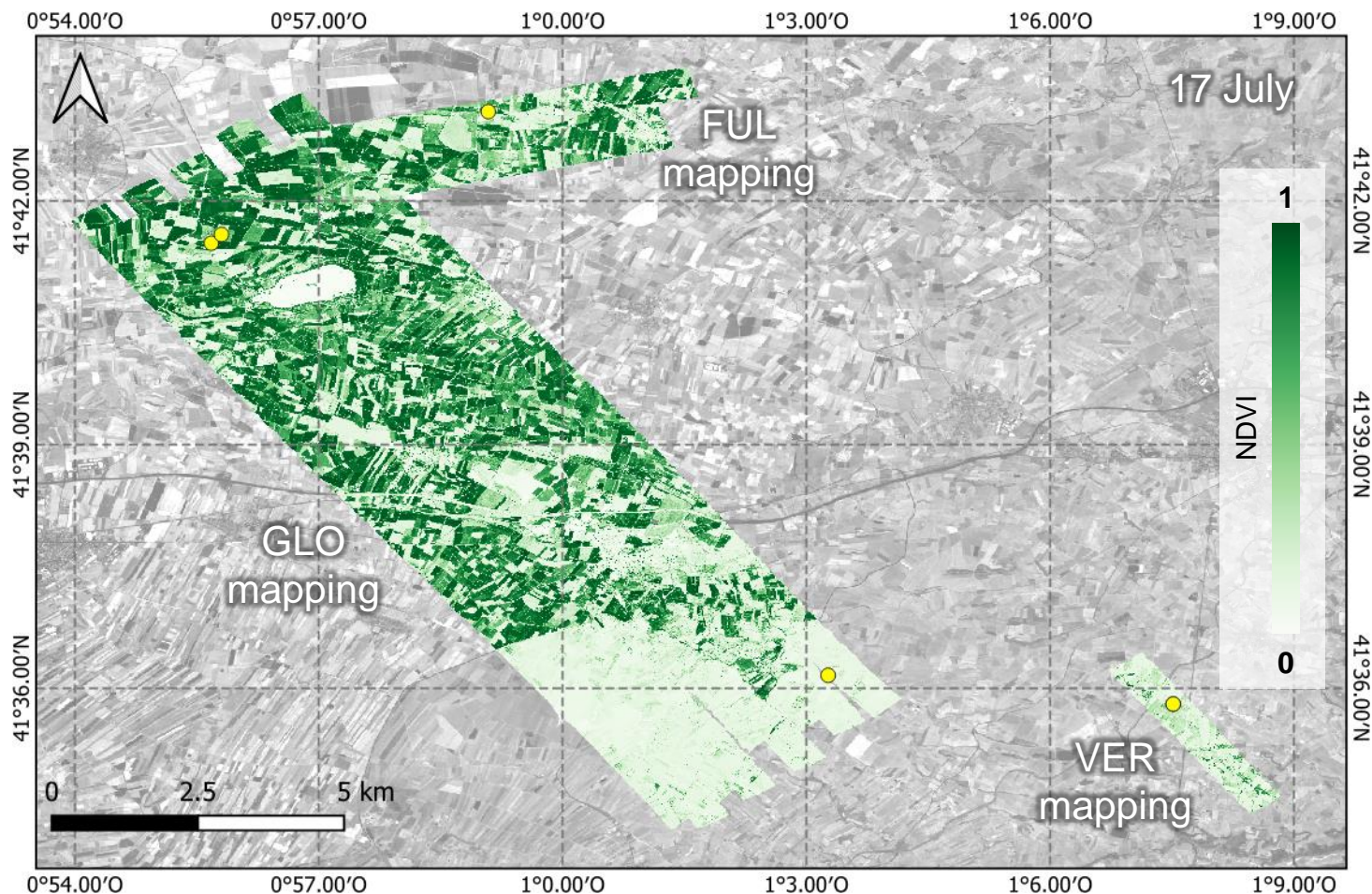# Measuring SIF from the ATR42 (HyPlant)



> **HyPlant 3**

- DUAL module (380 – 2500 nm)
    VIS/NIR: 3-4 nm FWHM, 1.7 nm SSI
    SWIR:    13 nm FWHM,  5.5 nm SSI

- FLUO module (670 – 780 nm)
    0.25 nm FWHM, 0.11 nm SSI

# HyPlant DUAL Mosaics – TOC reflectance & indices



- 15 July – 15:29-16:48 CEST
- 16 July – 15:01-16:18 CEST
- 17 July – 13:27-14:49 CEST
- 20 July – 15:00-16:15 CEST
- 21 July – 15:10-16:26 CEST
- 22 July – 13:32-14:50 CEST
- 27 July – 13:12-14:26 CEST

- 7(8) flight days = 91 flight lines - both sensors and two spat. resolutions (1.7 and 10 m)
  - Each flight day → GLO(RI) mapping, FUL mapping, VER(DU) mapping

# HyPlant FLUO Mosaics – $SIF_{760}$ and $SIF_{687}$ + uncertainties
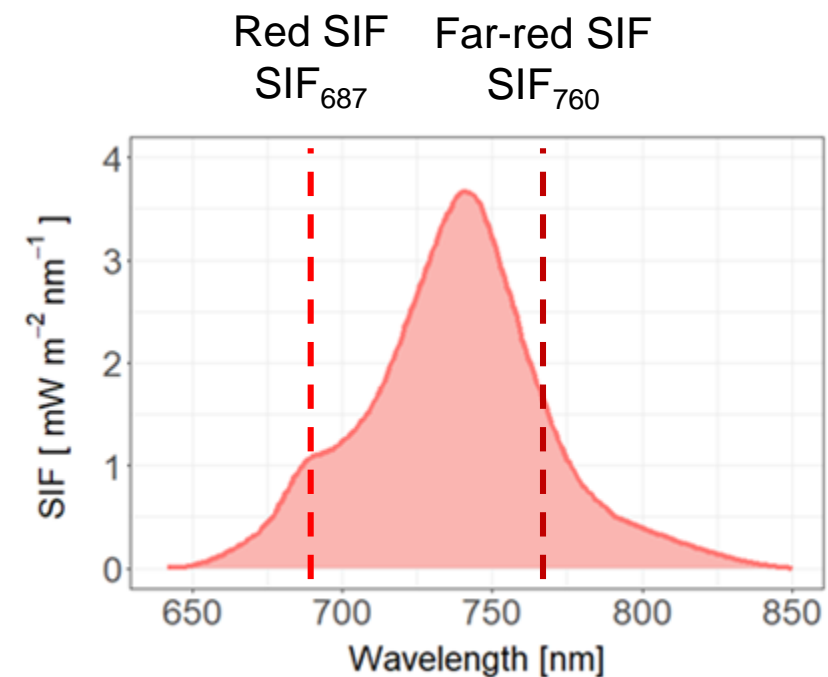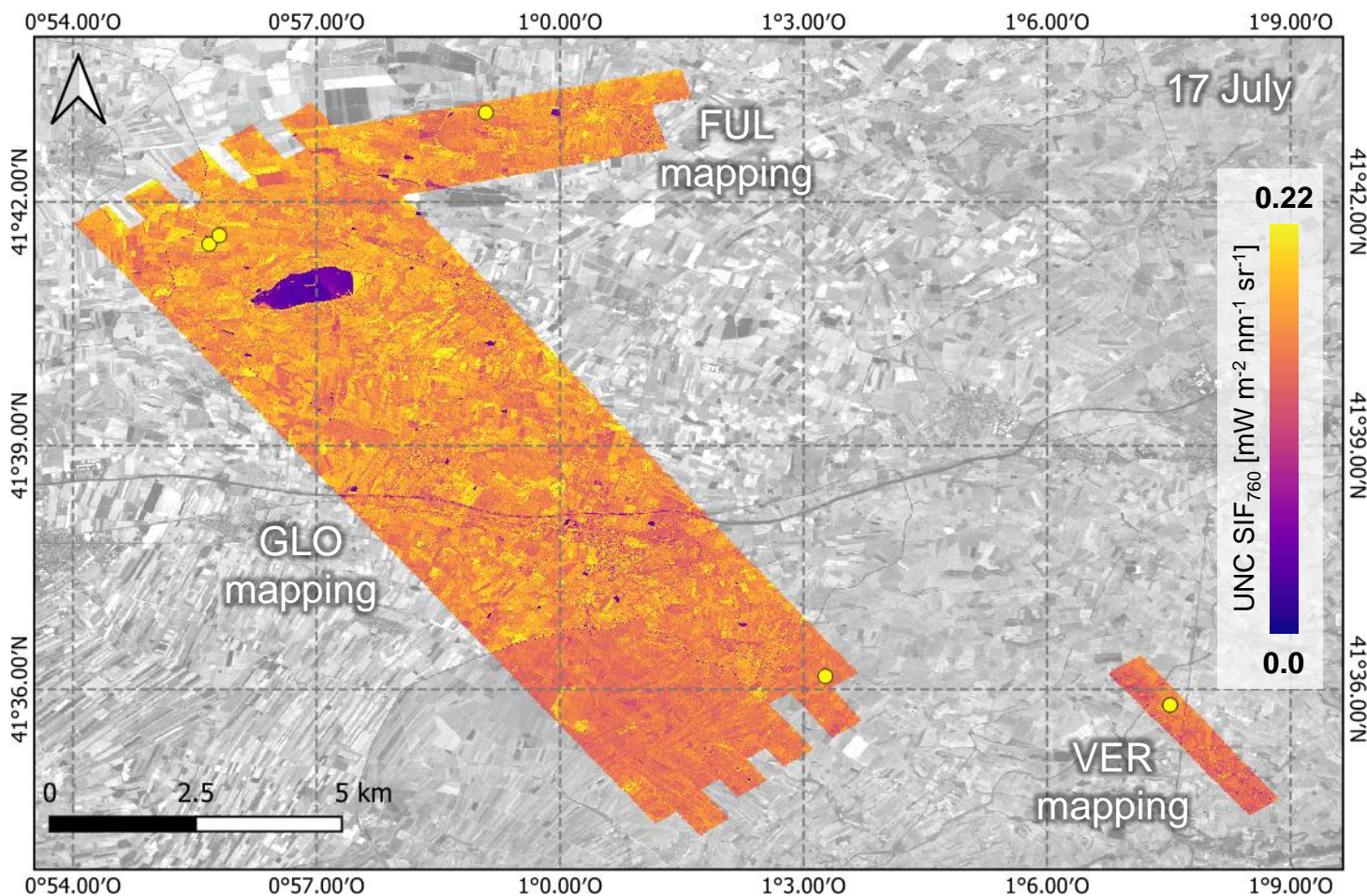


➢ 7(8) flight days = 91 flight lines - both sensors and two spat. resolutions (1.7 and 10 m)

• Each flight day → GLO(RI) mapping, FUL mapping, VER(DU) mapping
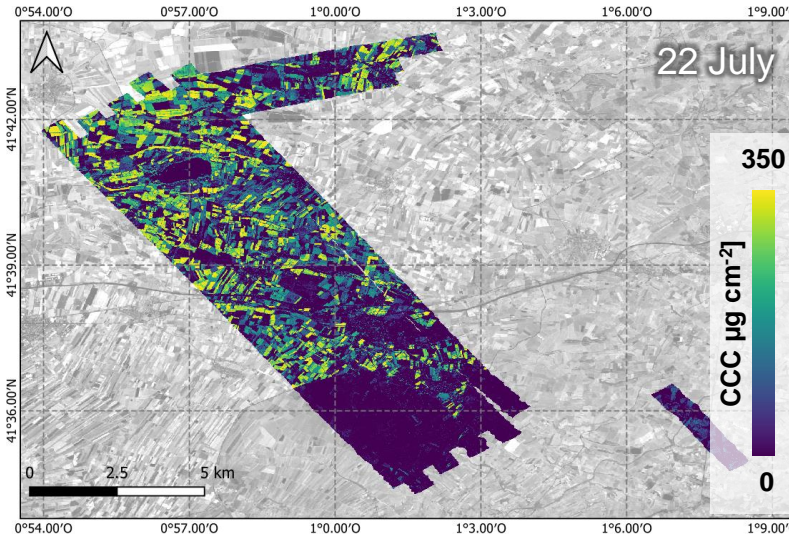
# Quality of HyPlant TOC reflectance and SIF data


a) Measurement setup
b) Gravel
c) Asphalt
d) Grass
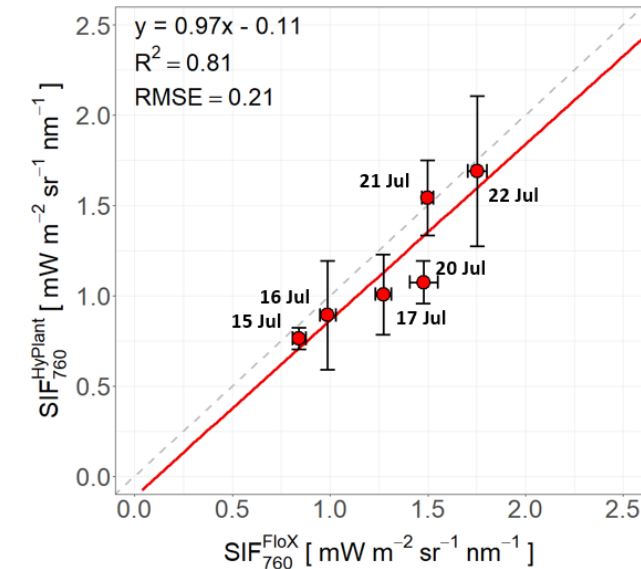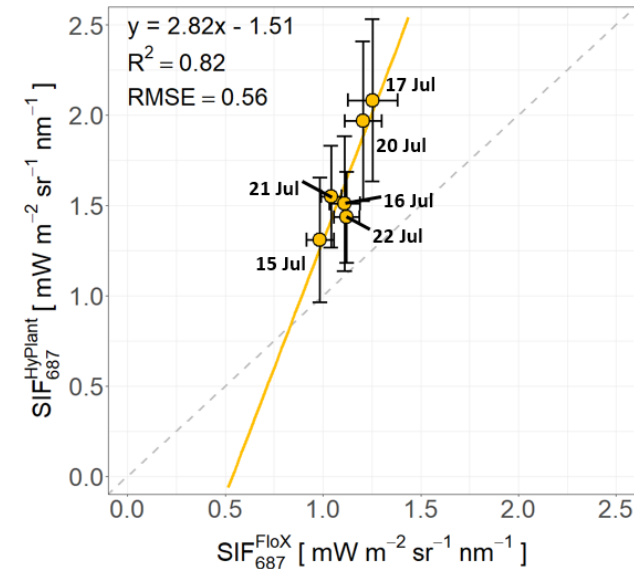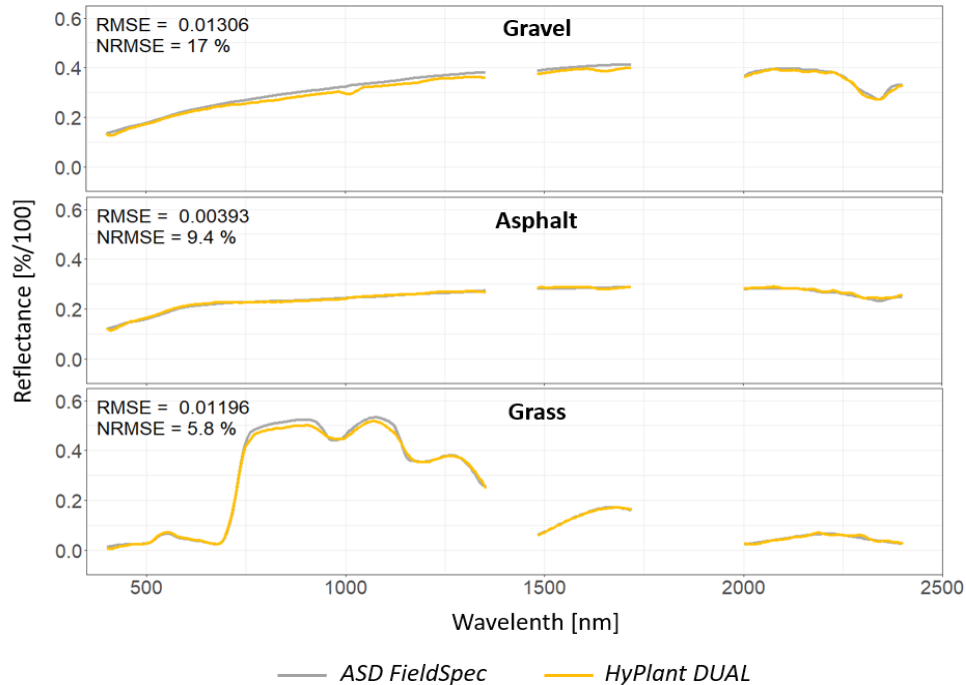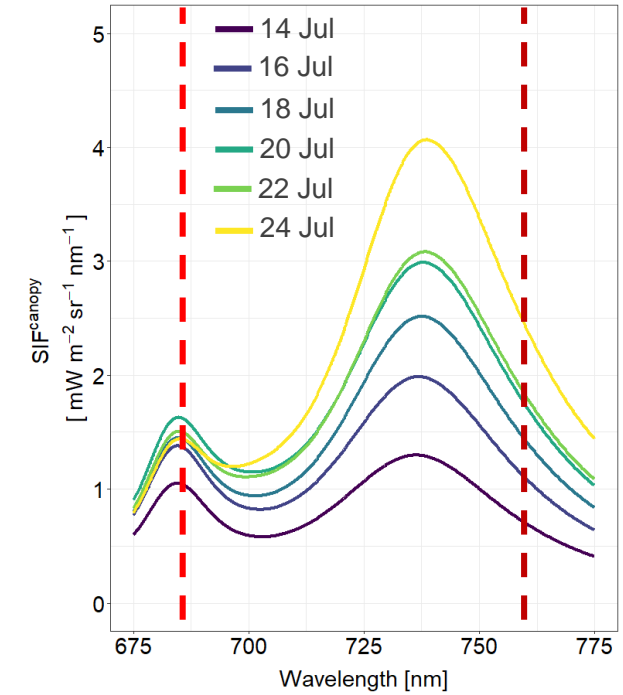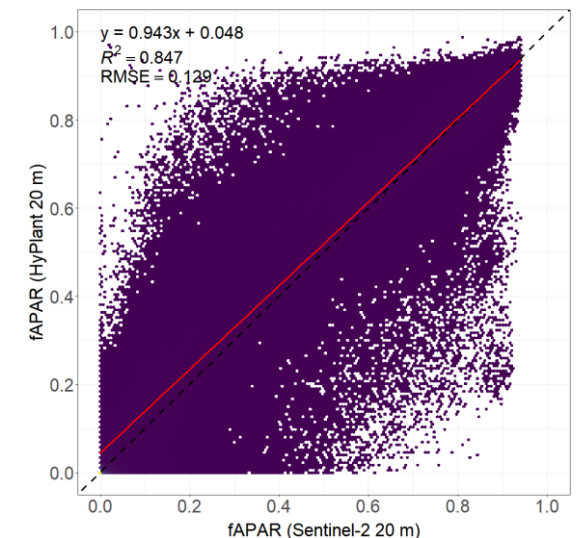
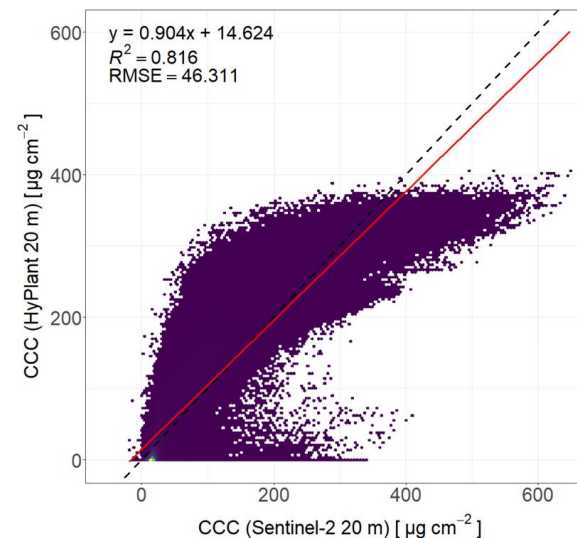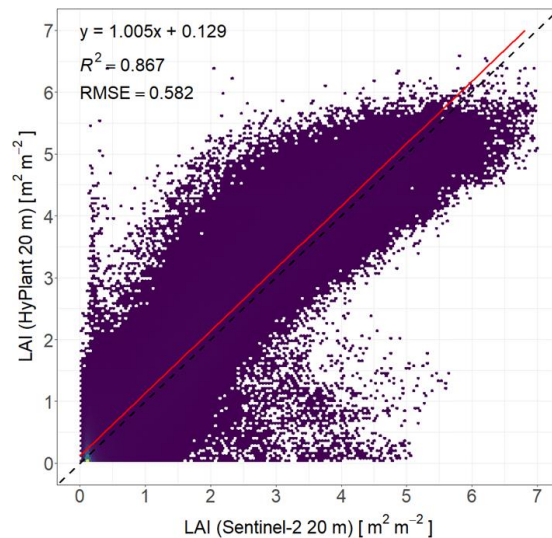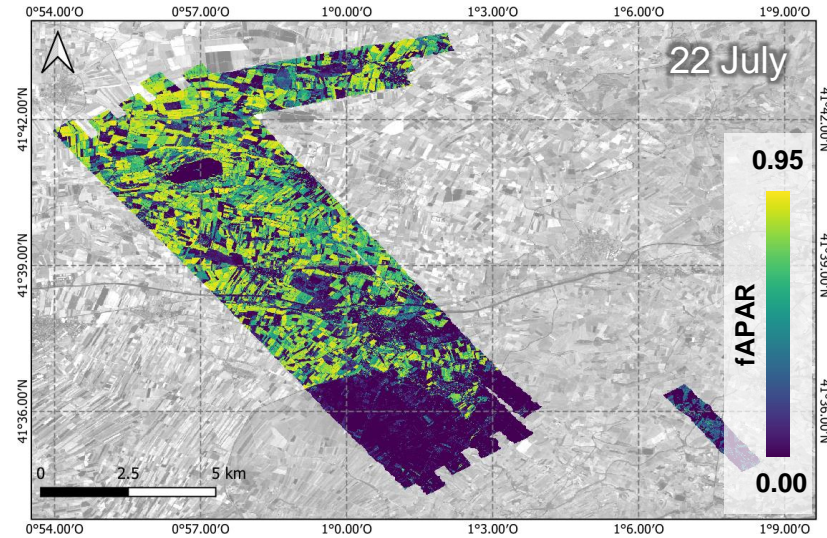# Vegetation parameters derived from HyPlant vs. Sentinel-2



**Leaf area index (LAI) - HyPlant**
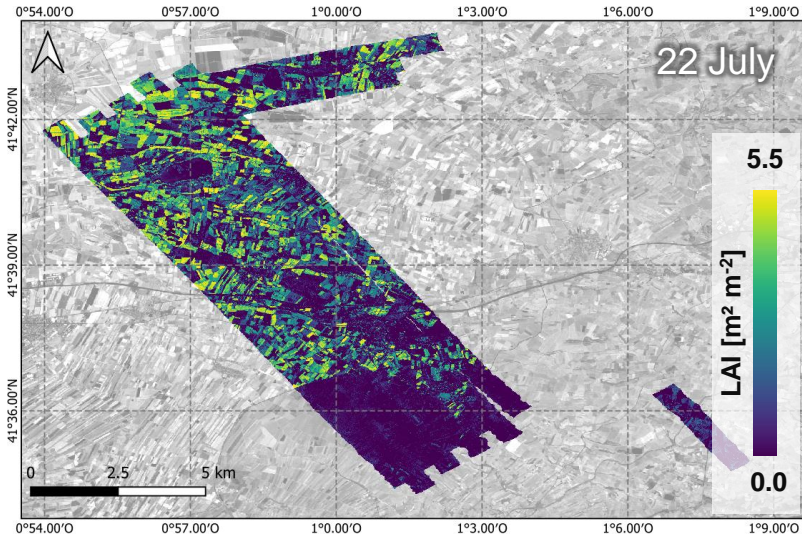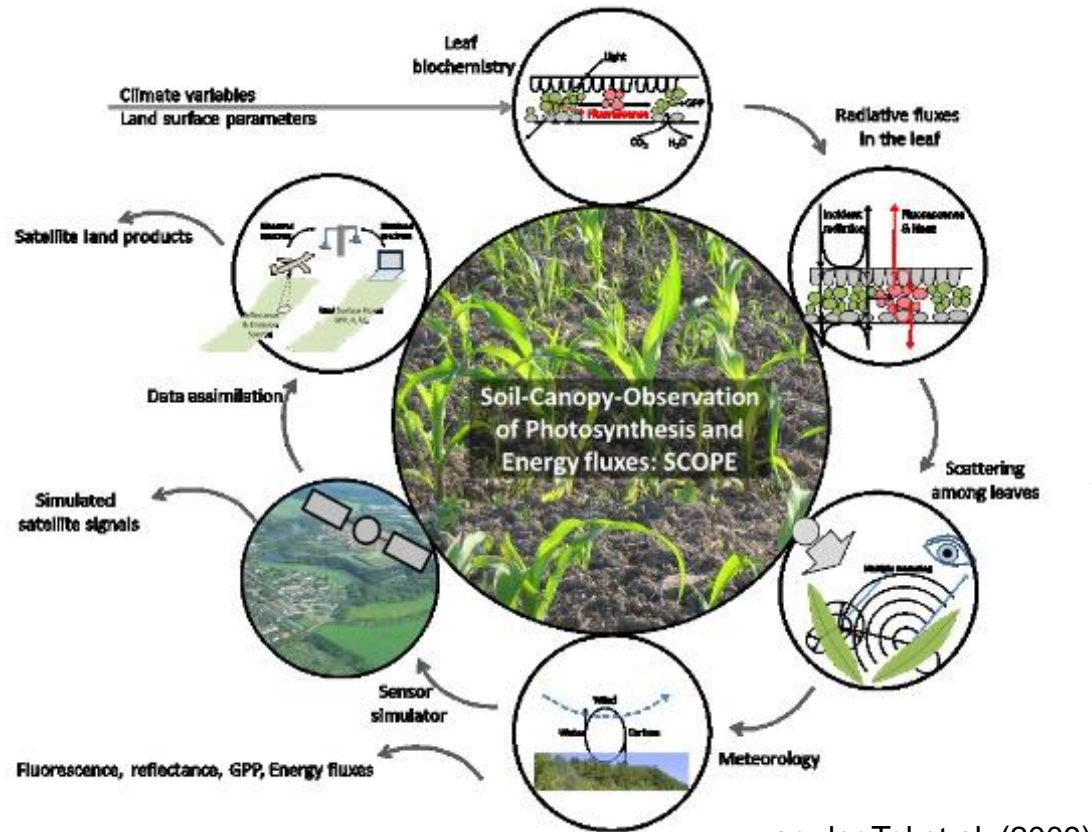
**Canopy chlorophyll content (CCC) - HyPlant**

**Fraction of absorbed photosynthetically active radiation (fAPAR) - HyPlant**
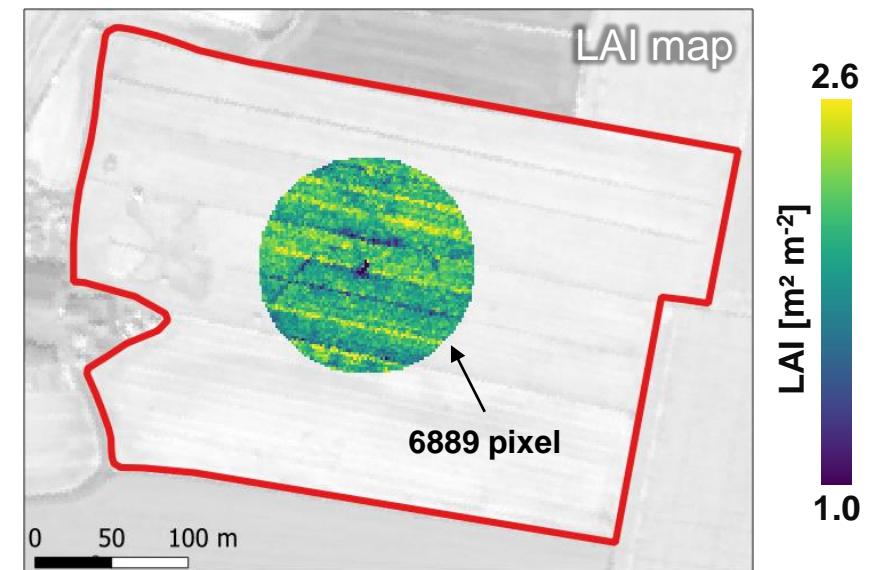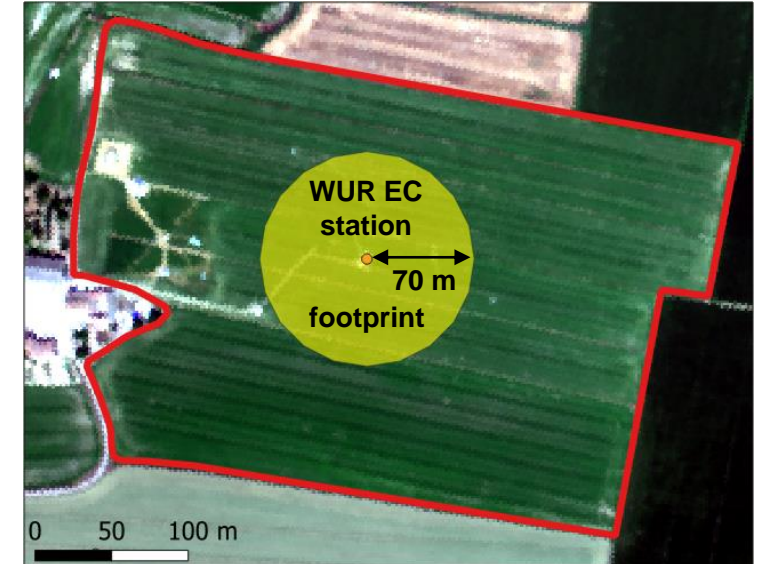
# Estimation of energy fluxes from HyPlant image data of the alfalfa field at La Cendrosa



**Soil Canopy Observation, Photochemistry and Energy fluxes (SCOPE) model**
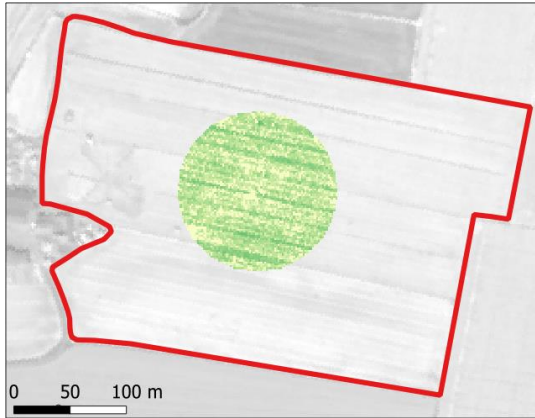
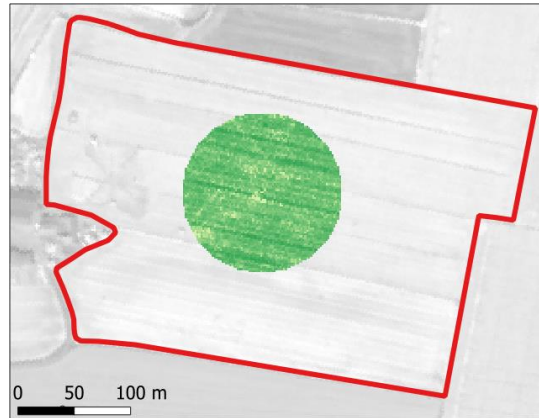van der Tol et al. (2009)

**HyPlant**

LAI
LCC
Cw

**Meteo data**

temp.
pressure
humidity
radiation
…

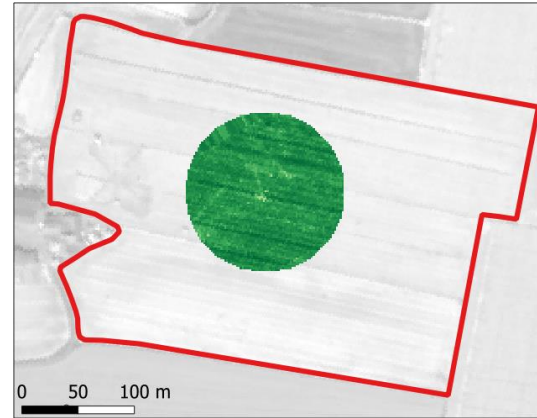**Alfalfa La Cendrosa – 22 July**

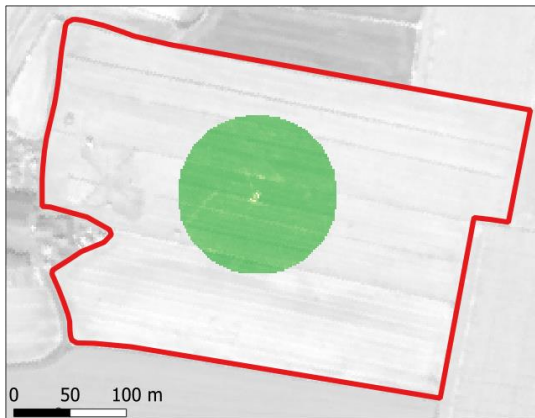# Estimation of net radiation



**15 Jul – 16:02 CEST**

**16 Jul – 15:33 CEST**

**17 Jul – 14:00 CEST**

**20 Jul – 15:32 CEST**

**21 Jul – 15:42 CEST**

**22 Jul – 14:04 CEST**

Rn [W m$^{-2}$]

565     695

**Rn (EC) vs. Rn (Scope & HyPlant)**

$y = 0.76x + 167.98$

$R^2 = 0.83$

$RMSE = 20.88$

Net radiation (Scope) [W m$^{-2}$]

Net radiation (EC) [ W m$^{-2}$ ]

# Estimation of latent heat flux



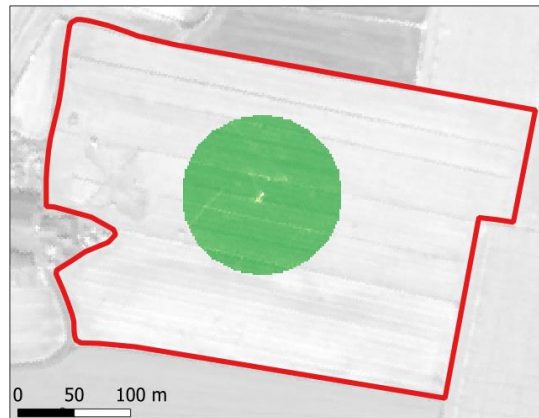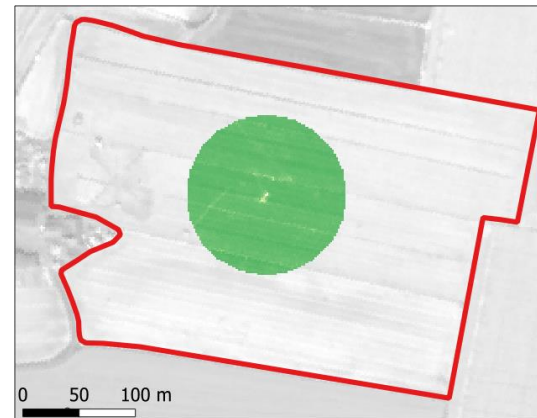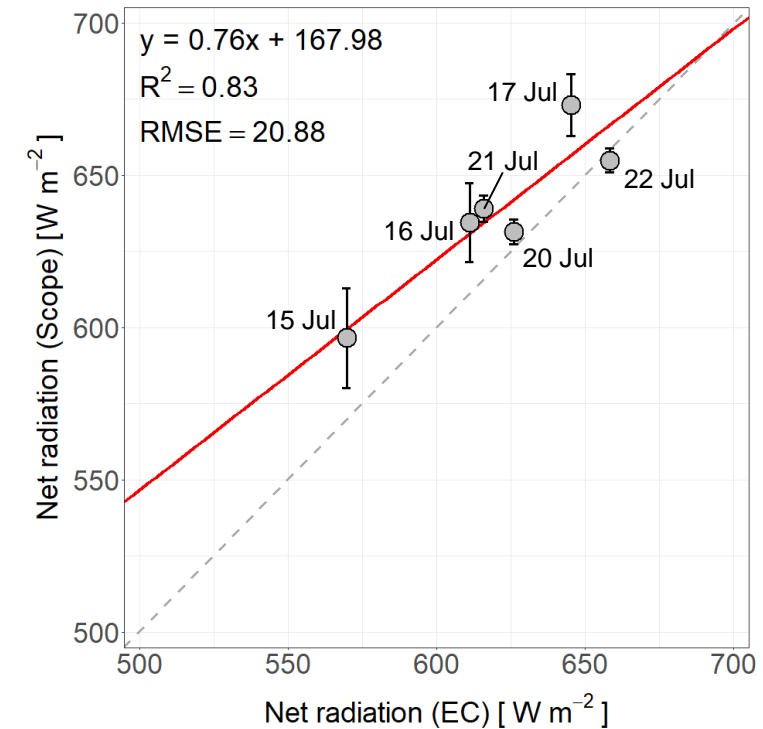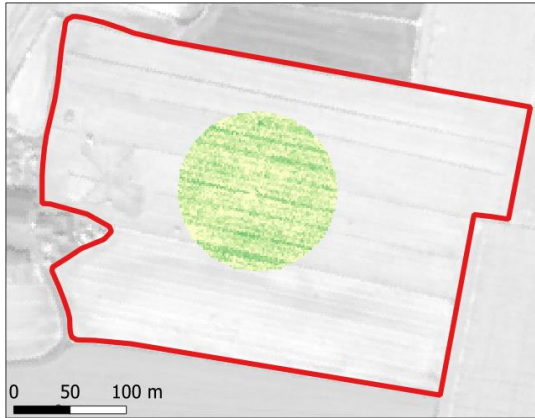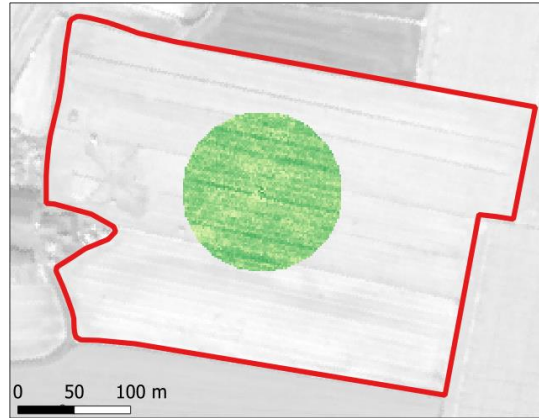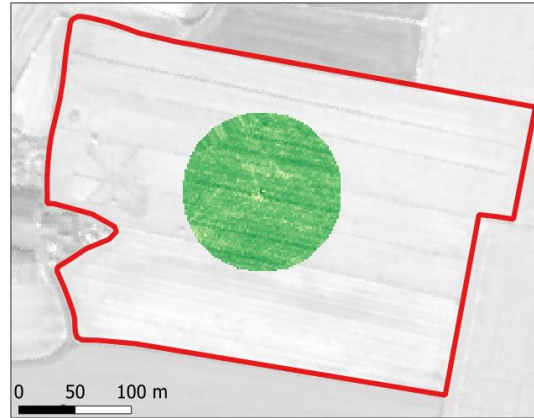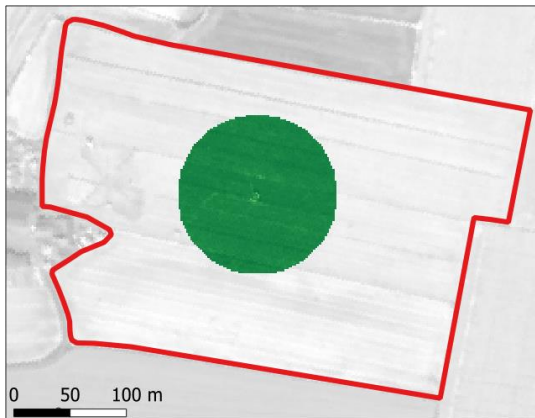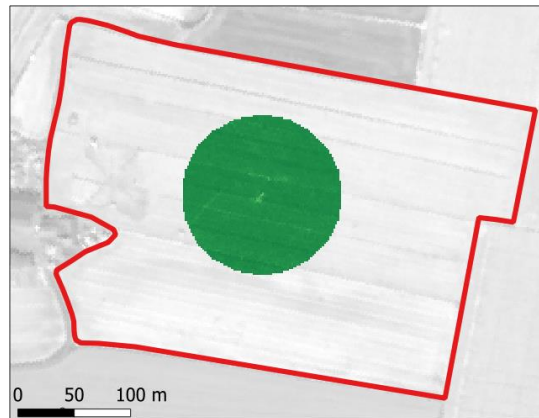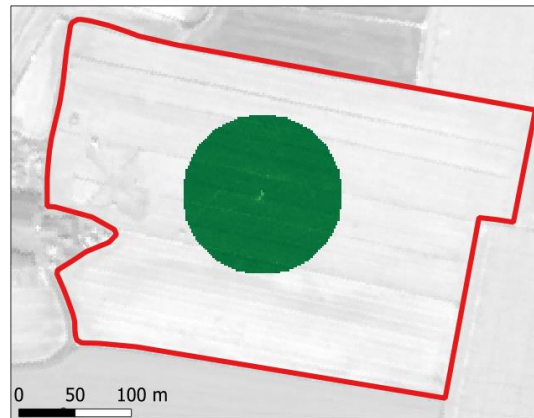15 Jul – 16:02 CEST
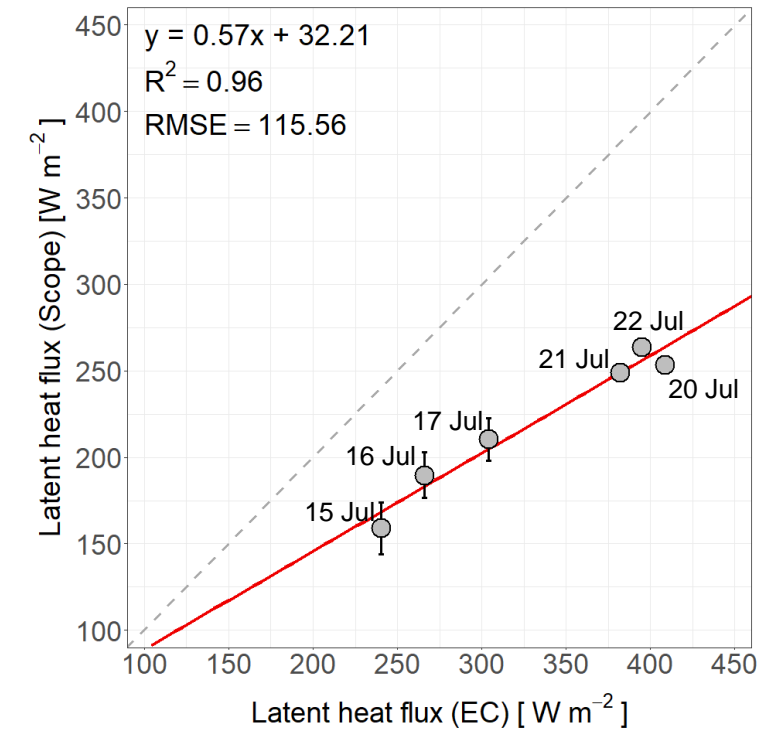16 Jul – 15:33 CEST
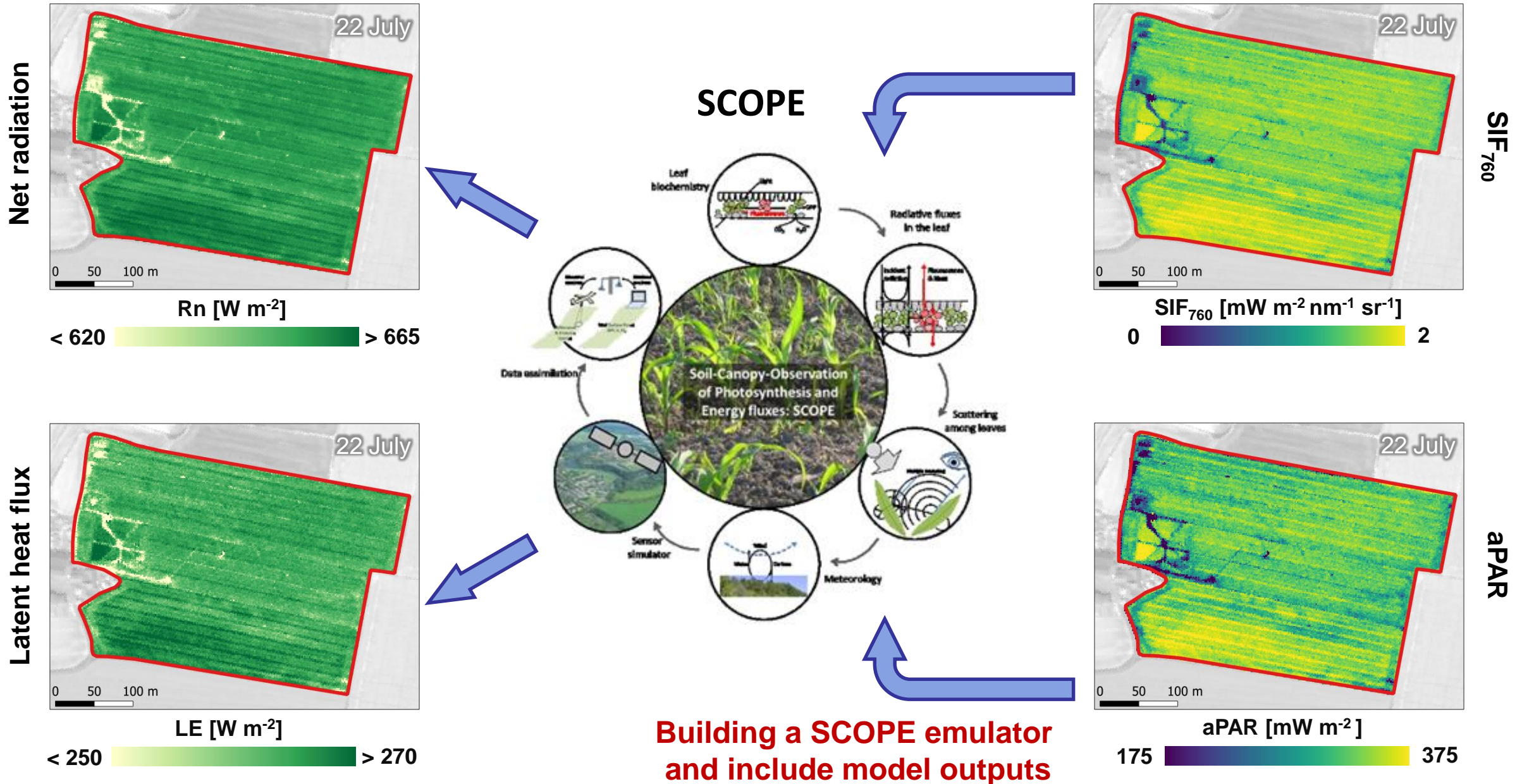17 Jul – 14:00 CEST
20 Jul – 15:32 CEST
21 Jul – 15:42 CEST
22 Jul – 14:04 CEST

LE (EC)
vs.
LE (Scope & HyPlant)

$y = 0.57x + 32.21$
$R^2 = 0.96$
RMSE = 115.56

LE [W m$^{-2}$]

135    270

# Estimation of latent heat flux, SIF and aPAR with Scope



**Net radiation**

22 July

Rn [W m$^{-2}$]

< 620    > 665

**SIF$_{760}$**

22 July

SIF$_{760}$ [mW m$^{-2}$ nm$^{-1}$ sr$^{-1}$]

0    2

**SCOPE**

Soil-Canopy-Observation of Photosynthesis and Energy fluxes: SCOPE

**Latent heat flux**

22 July

LE [W m$^{-2}$]

< 250    > 270

**aPAR**

22 July

aPAR [mW m$^{-2}$]

175    375

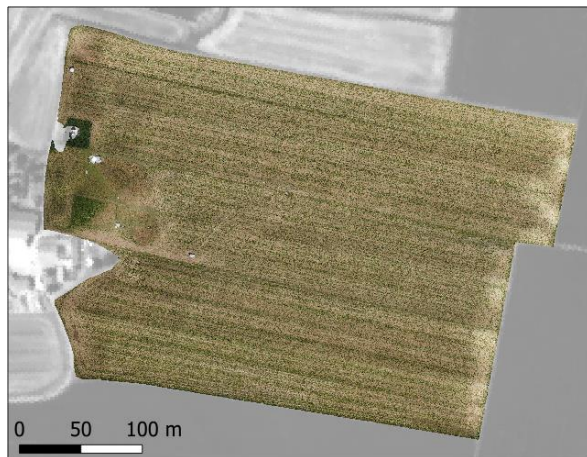**Building a SCOPE emulator and include model outputs**

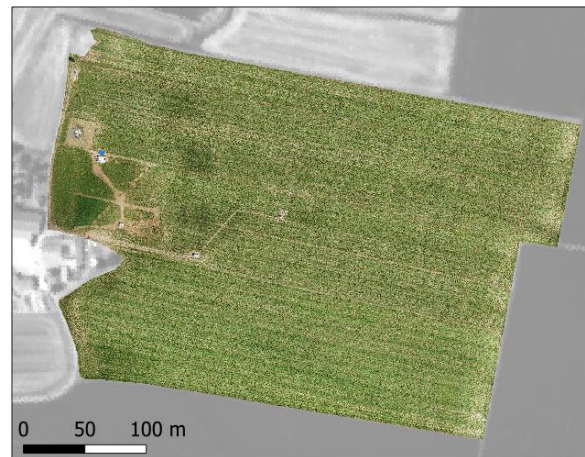# UAV data recorded during LIAISE (Saja Salattna)

➢ Data acquisition with three different sensor packages

- Sony α7 (RGB)

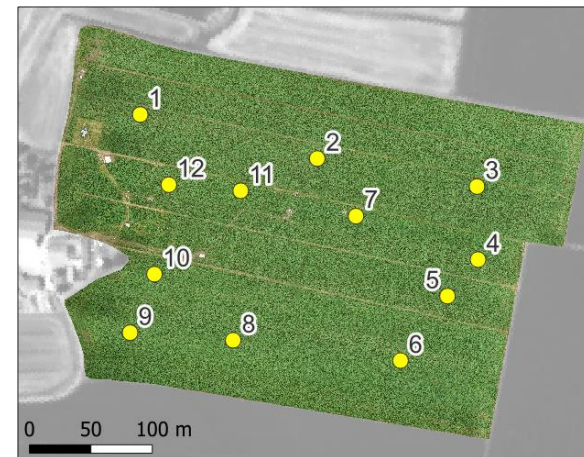- MicaSense RedEdge MX dual (multispectral) camera
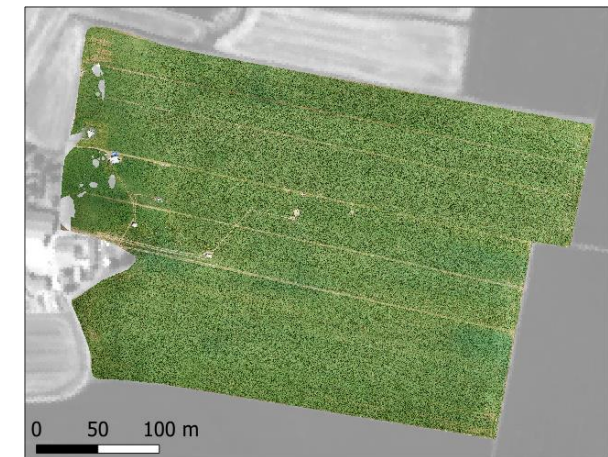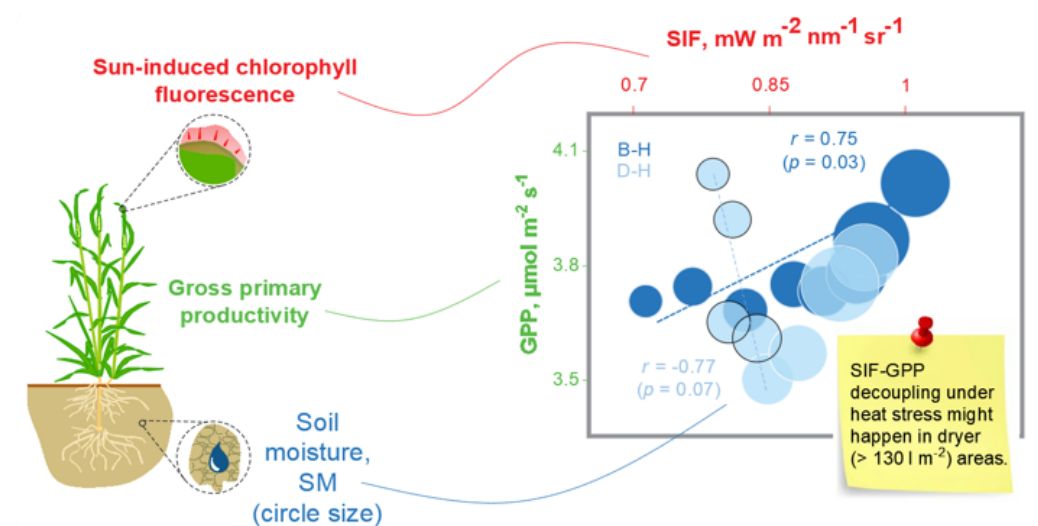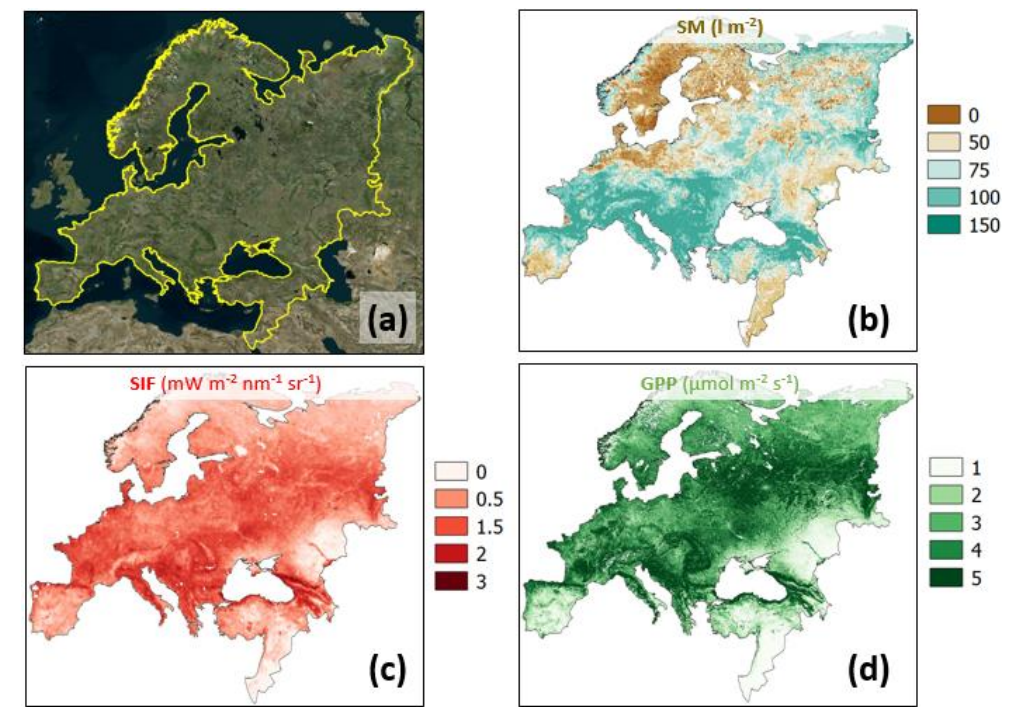
- SIF dual camera



14 July        19 July        26 July        28 July

# (Spatial) relationship of SIF with soil moisture and GPP (Juan Quiros)



Quiros et al. (under review)
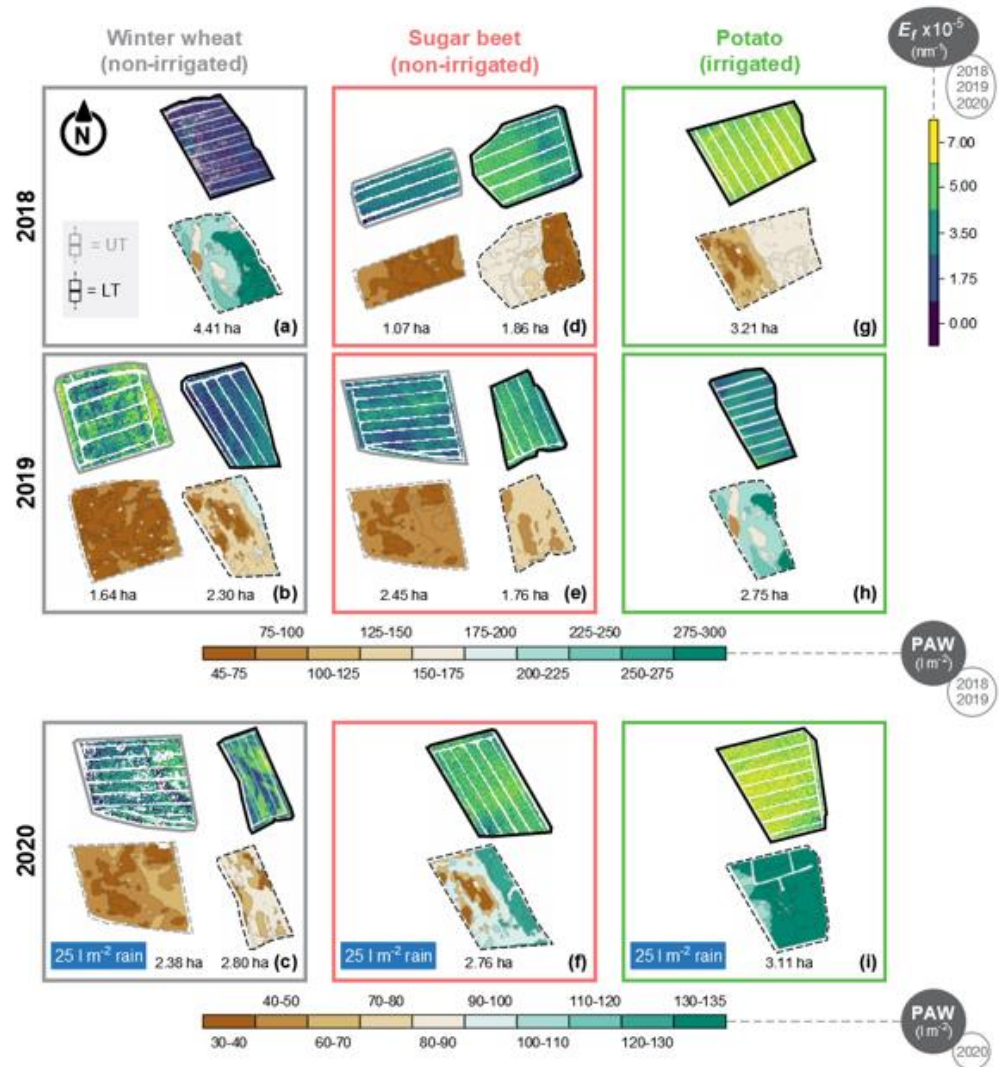
# Summary and outlook

➢ HyPlant top-of-canopy reflectance, reflectance index and SIF maps + data acquisition report uploaded to the LIAISE DB

➢ Retrieval of vegetation parameters (e.g. LAI, LCC, fAPAR) from HyPlant DUAL data in progress (can also be made uploaded to the LIAISE DB)

➢ First ET retrieval results from HyPlant DUAL data (SIF still needs to be included), analysis will be extended to UAV and satellite data

➢ Relationship between airborne SIF and soil moisture will be investigated as soon as the GLORI and/ or NASA soil moisture maps are available

❖ Is there a land use/cover map of the LIAISE study area for 2021available? (e.g. based on a multi-temporal Sentinel-2 classification)
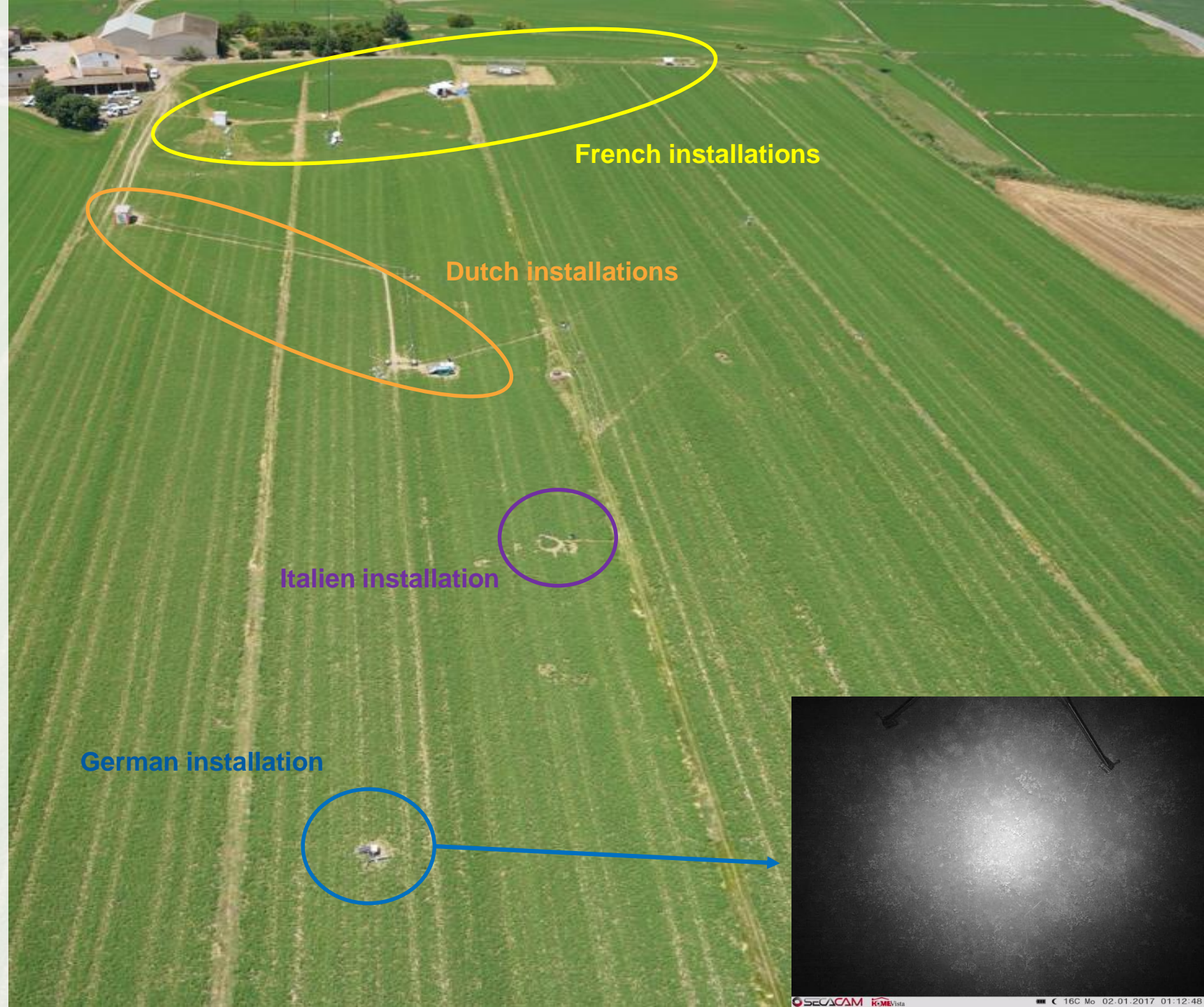
# Thanks for your attention!

**French installations**

**Dutch installations**

**Italien installation**

**German installation**

**Dr. Bastian Siegmann**

Forschungszentrum Jülich
Institute of Bio- and
Geosciences (IBG-2)
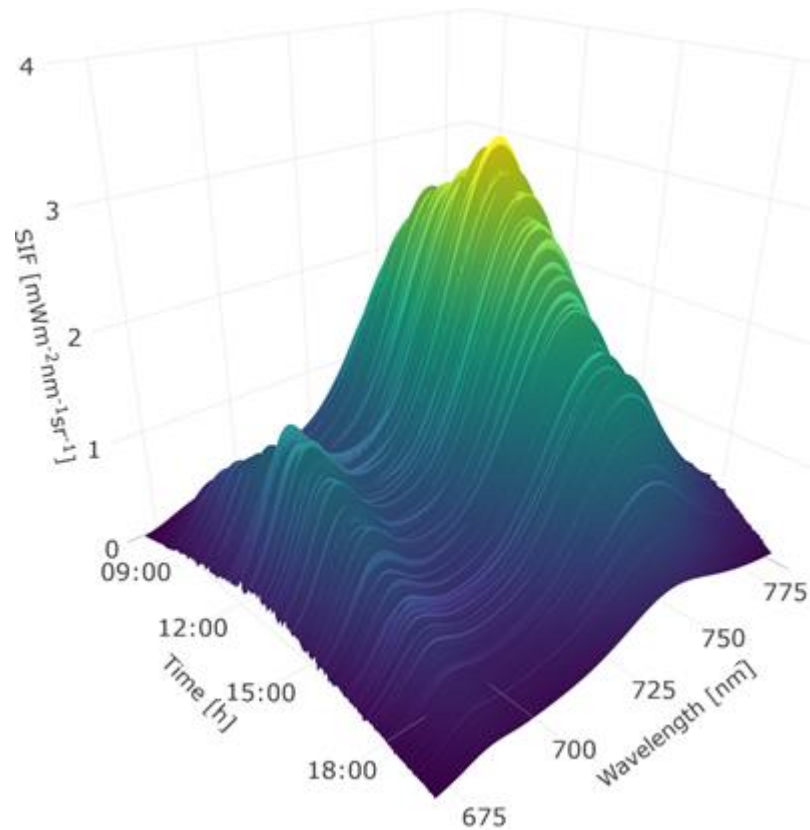b.siegmann@fz-juelich.de

&

University of Twente
Faculty of Geo-Information
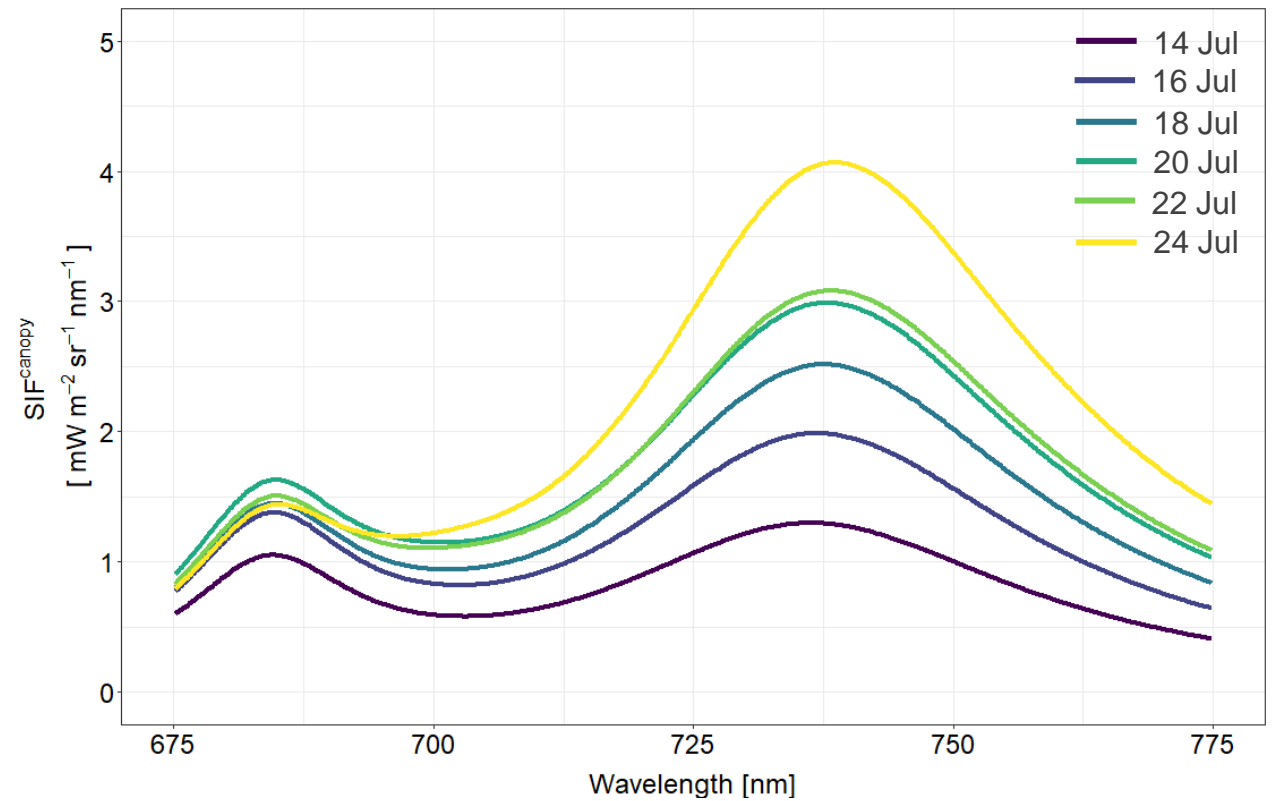Science and Earth Observation
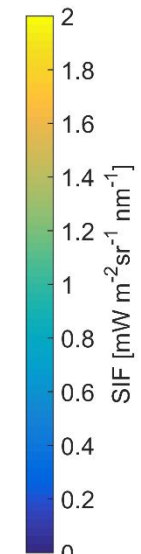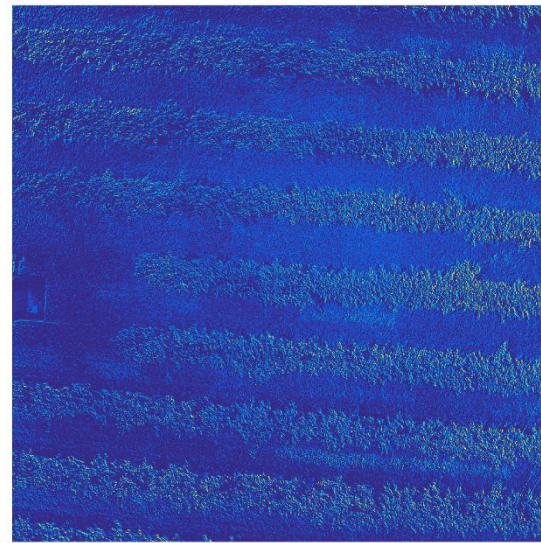b.siegmann@utwente.nl
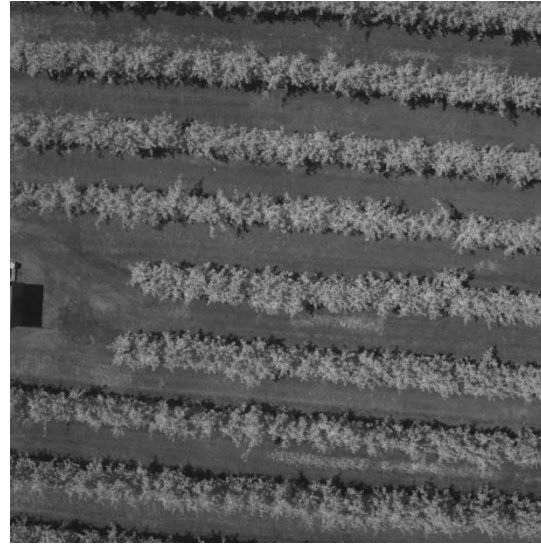
# SIF canopy close-range measurements



**SIF diurnal course
21 July 2021**

**SIF time-series
14-24 July 2021**

# SIF UAV measurements – Dual-camera system
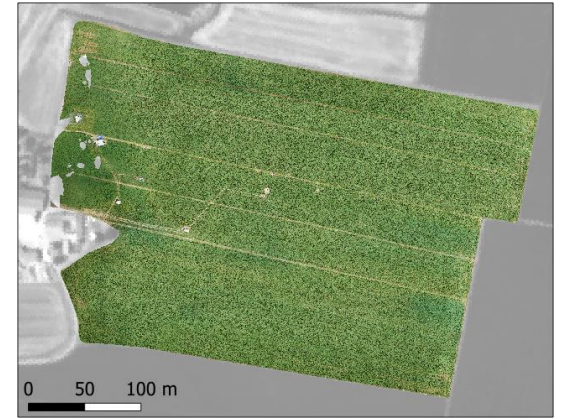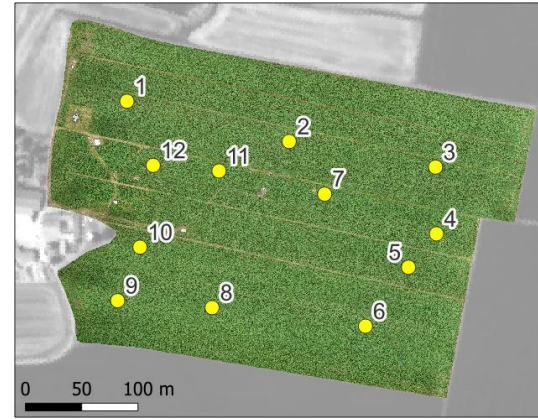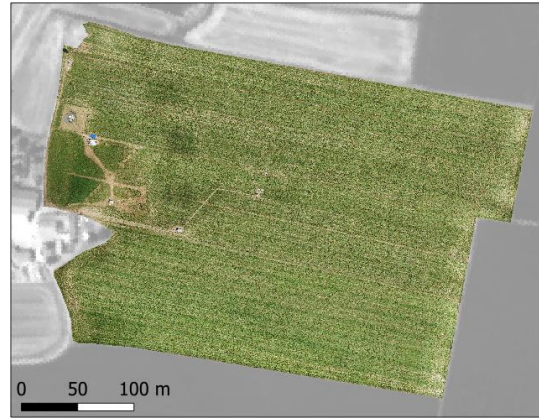
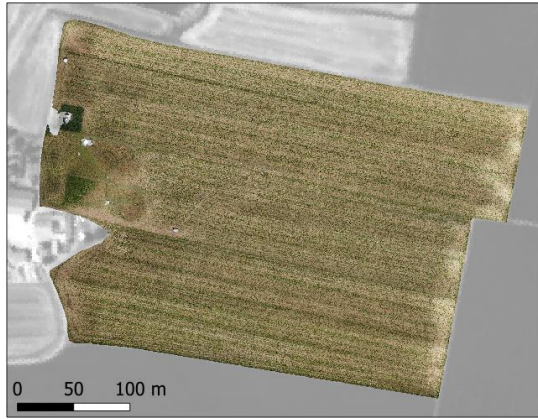| | 14 July | 19 July | 26 July | 28 July |
|---|---|---|---|---|
| True color composite | | | | |
| Color infrared composite | | | | |
| NDVI | | | | |