Upscaling winter wheat above-ground biomass measurements using multispectral imagery and 3D data from unmanned aerial vehicle

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I. UPSCALING ICOS MONITORING PROGRAM WITH UAV IMAGERY

Field measurements in the ICOS *(Integrated Carbon Observation System)* program are spatially limited

→ Monitored gas fluxes may have a large footprint

Case of Above-Ground Biomass (AGB)

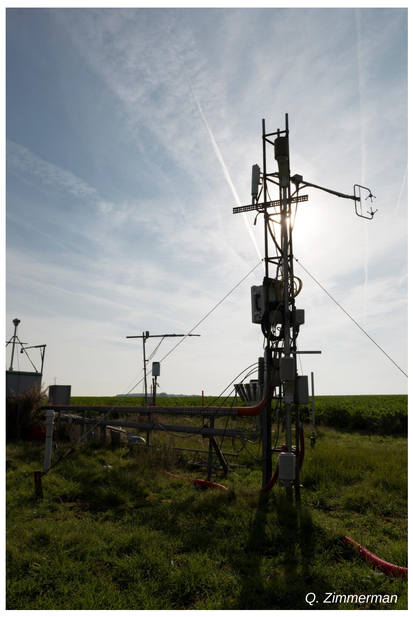
→ Field sampling time consuming

→ Spatially limited

Can UAV imagery time series be (part of) a solution?

→ Cost effective and final user-controlled systems

→ Higher spatial (0.1 m imagery) and temporal resolution than other remote sensing technique (e.g. satellite or other airborne imagery)



ICOS candidate station of Lonzée (Belgium, Wallonia)

- Four years rotation crop (winter wheat in 2017)
- One of the first European site devoted to production crops
- 3 m high mast
- Intensive biomass monitoring, soil respiration, NDVI (*Normalized Difference Vegetation Index*) and PRI (*Photochemical Reflectance Index*), nitrogen, volatile organic compounds fluxes, N_2O fluxes

II. ACQUISITION AND PREPROCESSING OF UAV IMAGERY

Octocopter drone

- X frame type, PixHawk controller
- High spatial resolution consumer grade RGB camera (Sony RX100)
- Multispectral camera (Parrot Sequoia)

Acquisition of time series

- 8 flights from 14th of February to the 7th of July 2017
- Production of reflectance maps (*green, red, NIR and Red-Edge*, derived from Sequoia camera)
- Two straight-forward vegetation indices (Normalized Difference Vegetation Index - **NDVI** and Green NDVI - **GNDVI**)
- Production of Crop Height Model maps (RX100)

III. MODELING AND MAPPING ABOVE-GROUND BIOMASS (AGB) WITH UAV IMAGERY

AGB field reference data

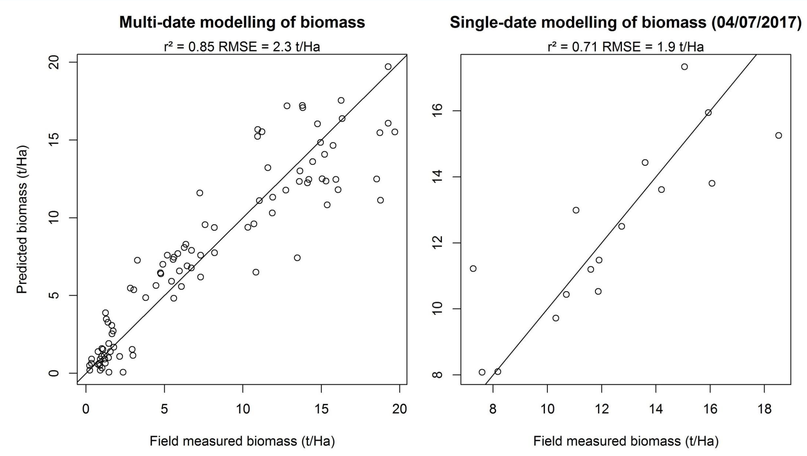
- Sampling approach: use of data monitored by the ICOS program and by field research conducted in experimental fields within the area of interest
- Field measurement: Crop samples were collected (destructive), dried and weighted in order to compute a reference AGB normalized per unit area (t / Ha)

AGB modelling with UAV data

- Each AGB field estimation was associated with the imagery associated to the closest flight date
- Multiple linear regressions modelling:

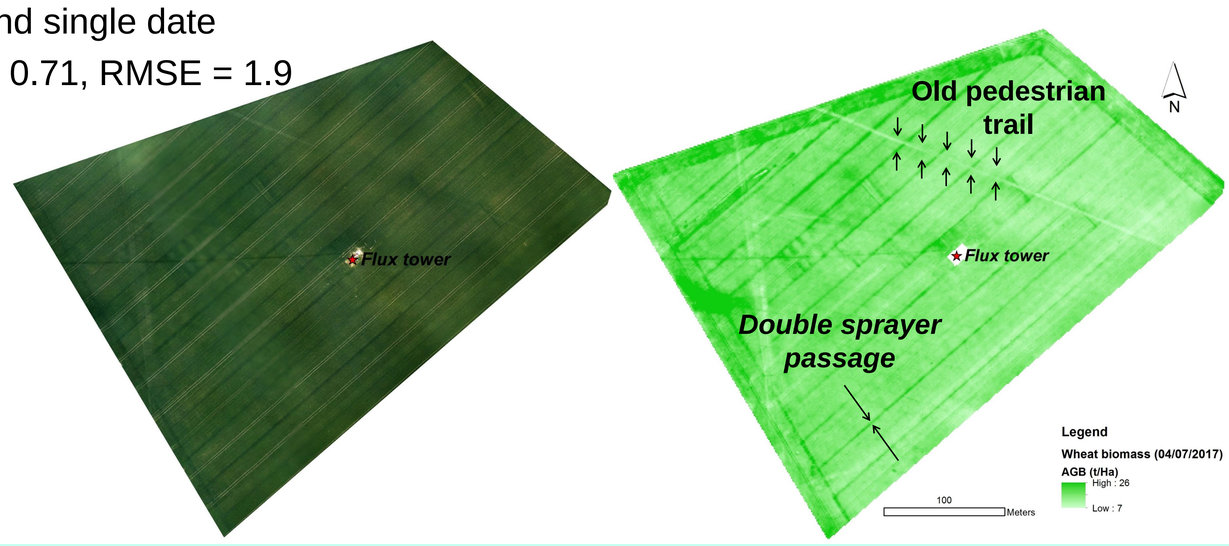
$$AGB = a + b * GNDVI + c * NDVI + d * CHM$$

- Good result for multidate (r^2 = 0.85, RMSE = 2.3 t/Ha, 96 obsv.) and single date approach (4th July, r^2 = 0.71, RMSE = 1.9 t/Ha, 16 obsv.)



Mapping AGB with UAV data

- Predicted AGB map displays a high spatial heterogeneity with some spatial patterns
- Low AGB values are found along two old pedestrian trails
- Higher AGB values for crop sprayed twice (in-between two tractor tracks)



IV. PERSPECTIVES

Upscaling AGB monitoring within entire footprint of the station with UAV imagery? → Clear potential of UAV imagery to monitor the AGB variation

Operational recommendation for UAV integration in ICOS AGB monitoring:

- The ICOS monitoring provides for this site only 20 AGB observations just before the harvest

→ need for specific (and more frequent) sampling strategy to enable UAV multitemporal AGB monitoring within the footprint of the flux tower

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