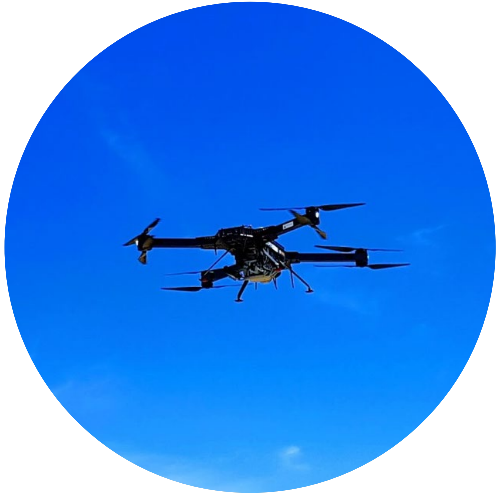
UAV-based and low-cost network approaches for Land Cal/Val

ESA Land Product Validation 2020

Benjamin Brede, Martin Herold (Wageningen University & Research)



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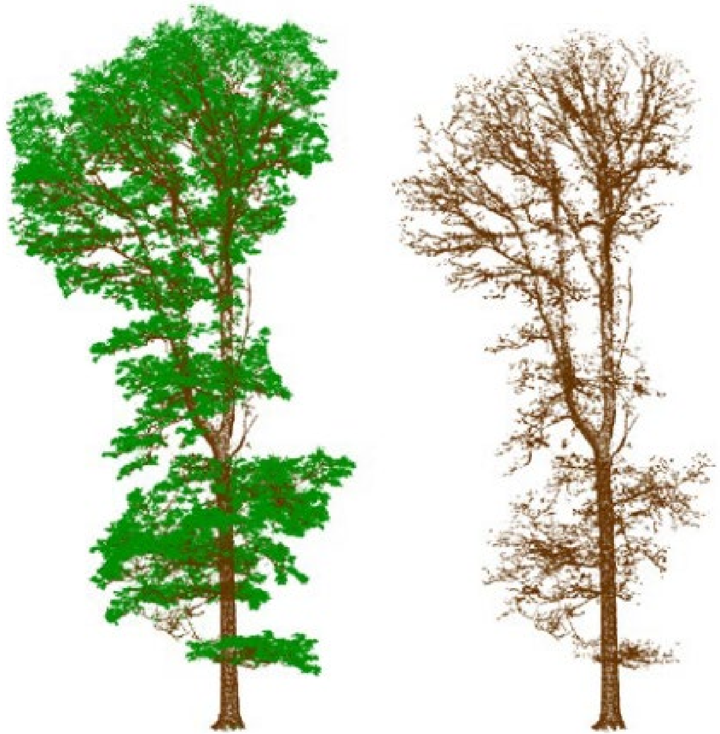
Overview

- LiDAR for permanent site characterisation
- LiDAR for LAI retrieval
- UAV for spatial scaling
- Low-cost sensors for temporal scaling

LiDAR for permanent site characterisation

- CEOS WGCV LPV AGB Product Validation Good Practices Protocol
    - TLS & UAV-LS for unbiased estimates of AGB especially for large trees
- Defoliation methods for leaf/wood separation developed



TLS-based leaf segmentation

Boni Vicari et al. (2019): DOI:10.1111/2041-210X.13144

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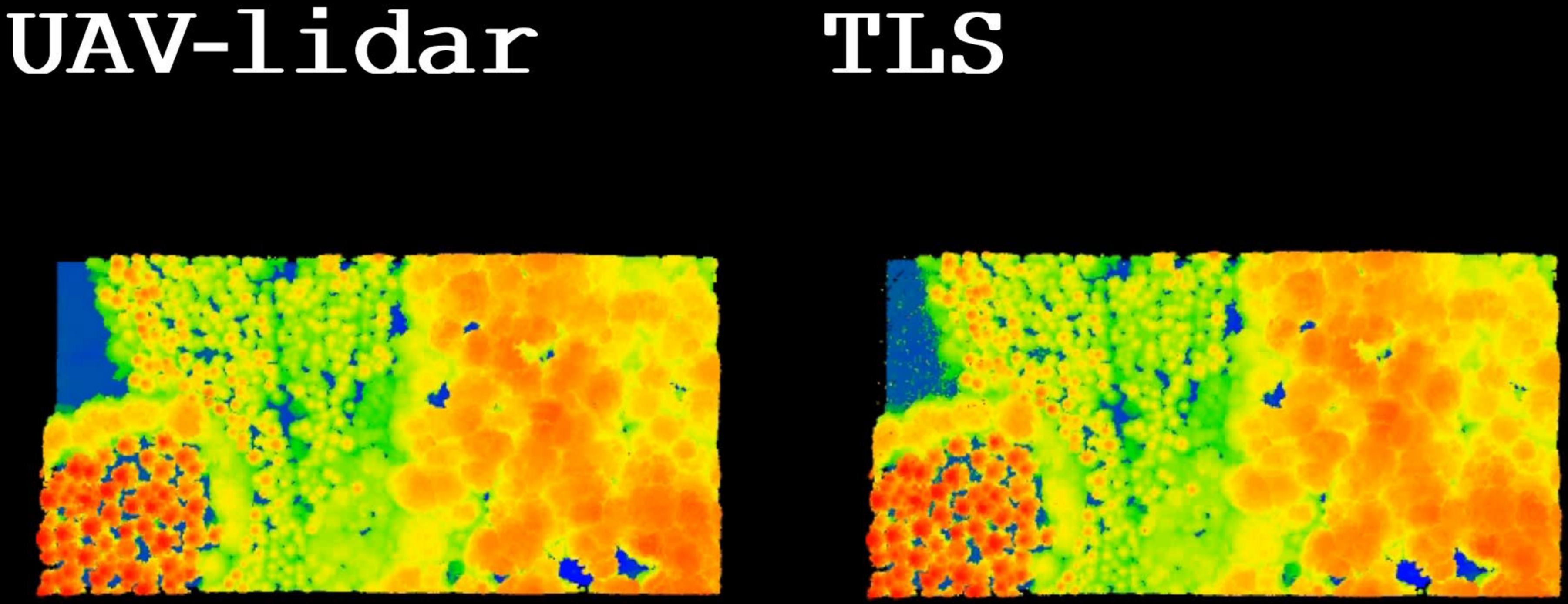
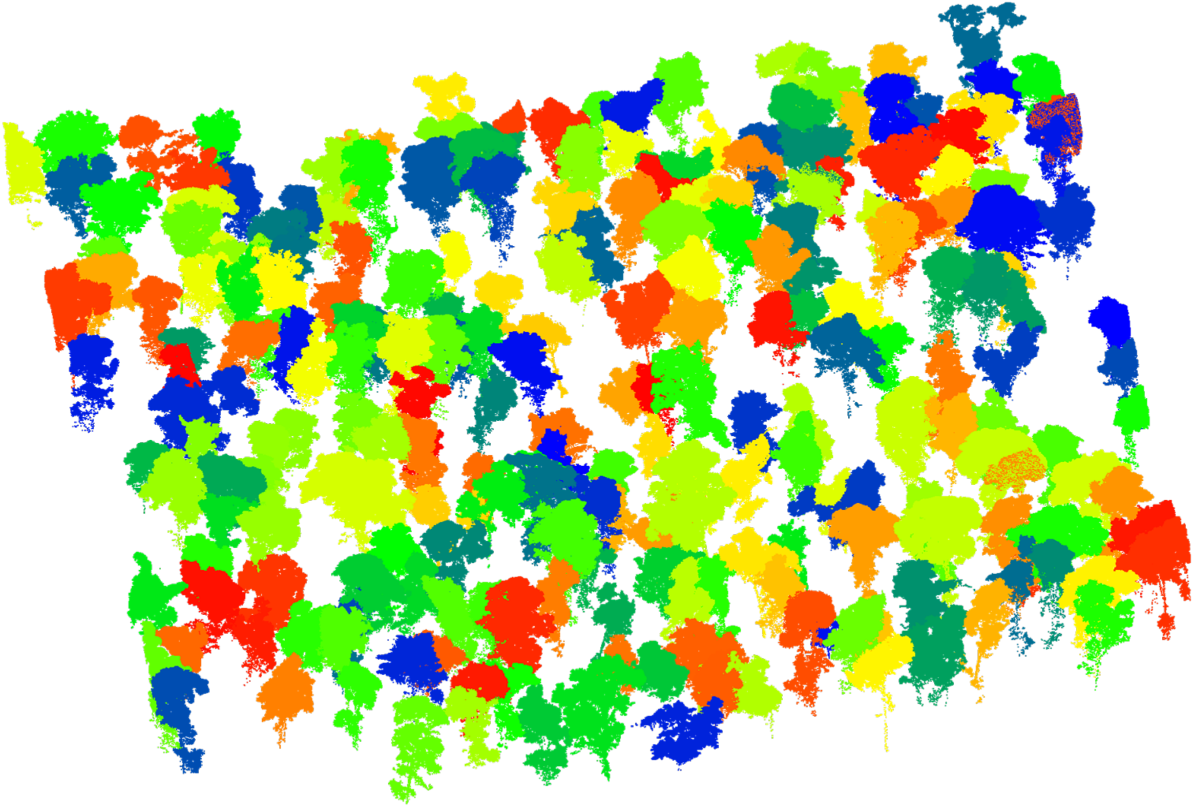

UAV-lidar
TLS

LiDAR for permanent site characterisation

- Automatic individual tree segmentation algorithms for plot-scale analysis

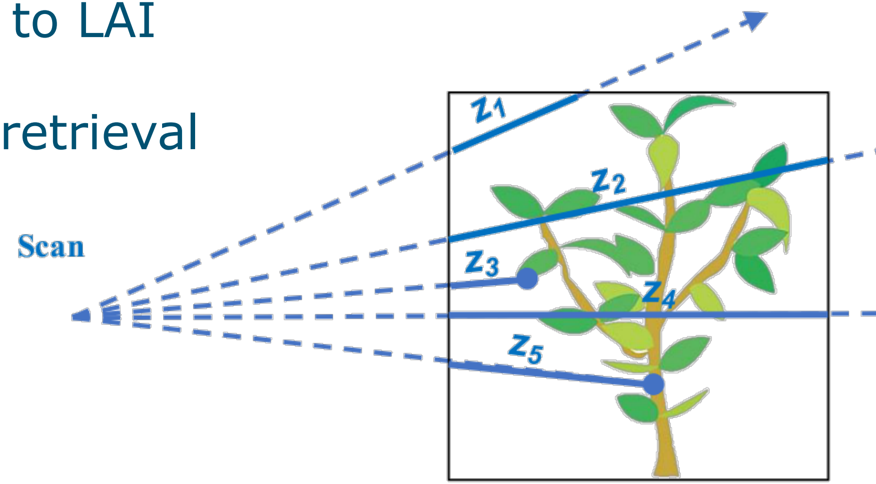


Tree segmentation UAV-LiDAR, Paracou

LiDAR for LAI retrieval

Theoretical basis for LiDAR LAI retrieval

- Wilson (1963): inclined point quadrat method; contact frequency linearly related to LAI
- Lovell et al. (2003): first TLS LAI retrieval
- Hosoi & Omasa (2004): first voxelised retrieval
- Pimont et al. (2018, 2019): theoretical uncertainties of LiDAR LAI estimators



Pimont et al. (2019)

Wilson (1963): DOI:10.1071/BT9630095
Lovell et al. (2003): DOI:10.5589/m03-026
Hosoi & Omasa (2004): DOI:10.1109/TGRS.2006.881743
Pimont et al. (2018): DOI:10.1016/j.rse.2018.06.024
Pimont et al. (2019): DOI:10.3390/rs11131580

UAV for spatial scaling

- Flexible platforms for multiple sensors
- Mapping at satellite footprint scale (hectares)

Roosjen et al. (2016)

WUR Hyperspectral Mapping SYstem (HYMSY)

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Roosjen et al (2016): DOI:10.3390/rs8110909

UAV for spatial scaling

LPV

- ✓ Empirical inversion (non-/linear)
- ✗ RTM inversion (e.g. PROSAIL) from
  - Nadir reflectance
  - Multi-angle reflectance (Roosjen et al., 2018)

Spectral methods (comparable to LAI retrievals from passive space-borne sensors)

- ✓ "Flying DHP" (Roth et al., 2018; Brown et al., 2020)
- ✓ UAV-LiDAR

Geometric-optical methods

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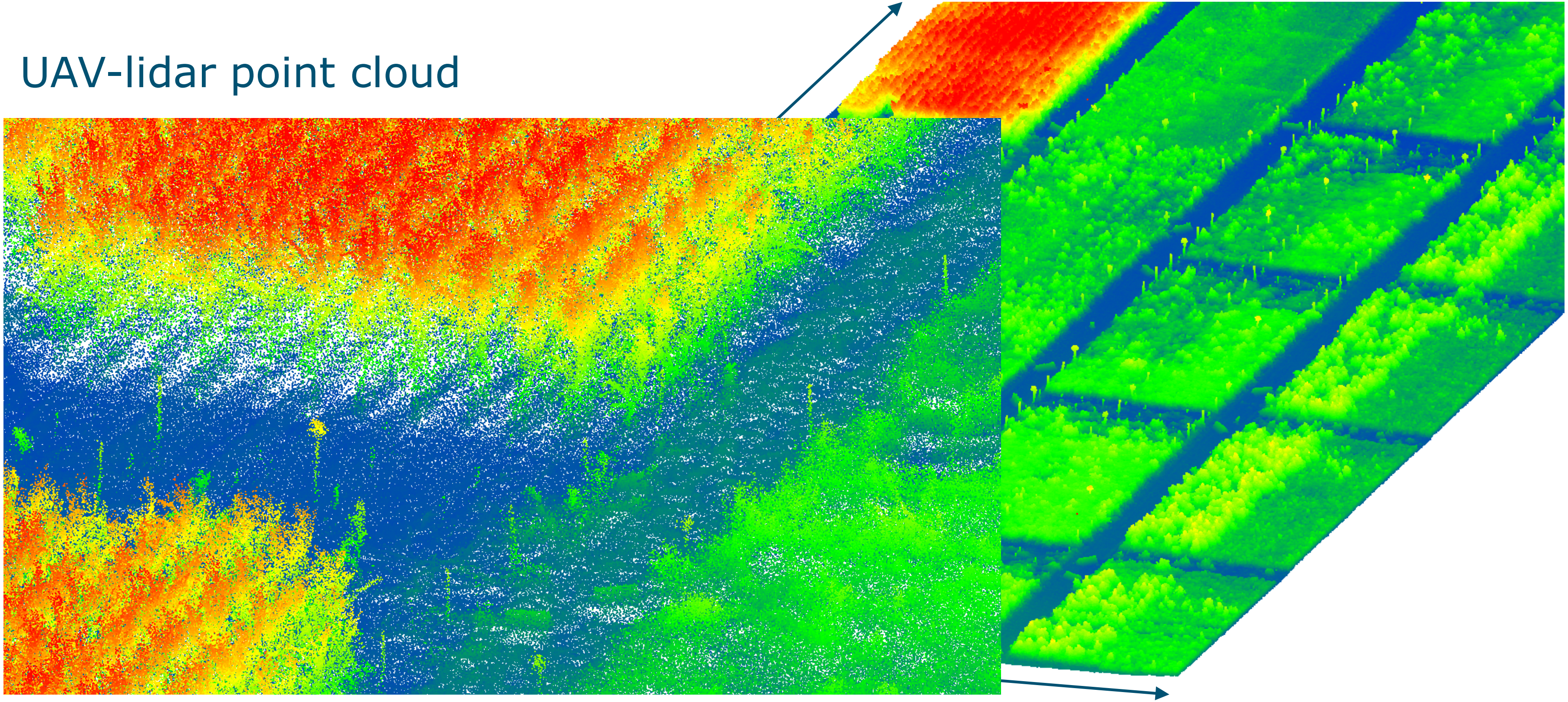
Roosjen et al (2018): DOI:10.1016/j.jag.2017.10.012
Brown et al. (2020): DOI: 10.1080/2150704X.2020.1802527
Roth et al. (2018): DOI:10.1016/j.isprsjprs.2018.04.012

UAV for spatial scaling

UAV-lidar point cloud



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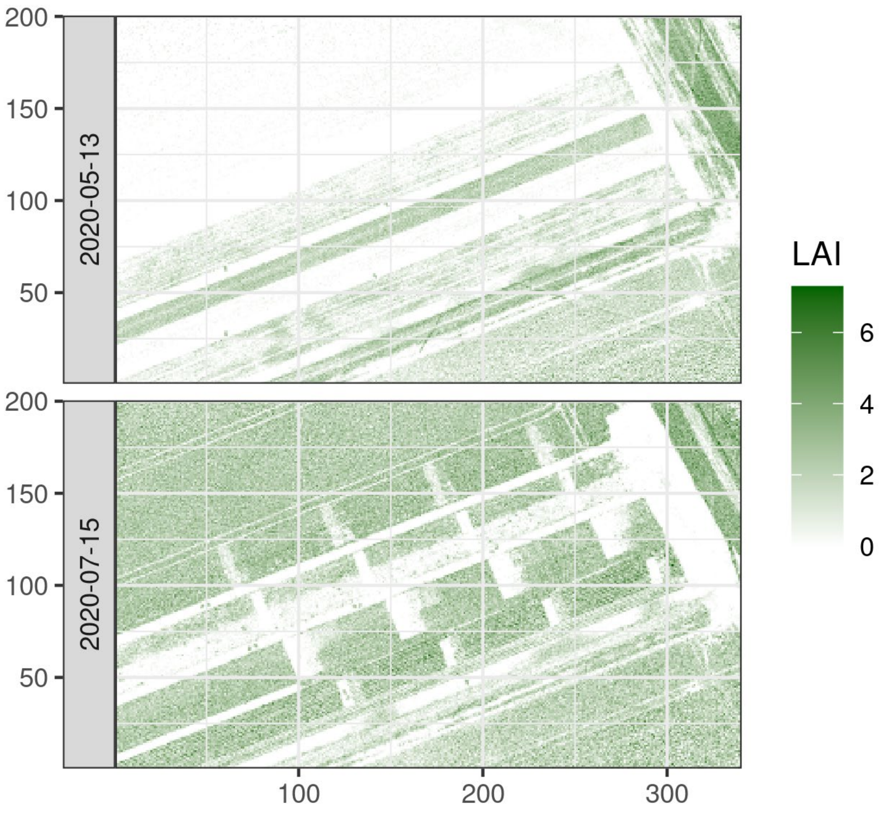
UAV for spatial scaling



- Crop experiment on WUR fields
- Field size: 1.2 ha
- Direct estimate of LAI from UAV-LiDAR based on Maximum-Likelihood principle (Pimont et al., 2018)
- Ground validation in progress

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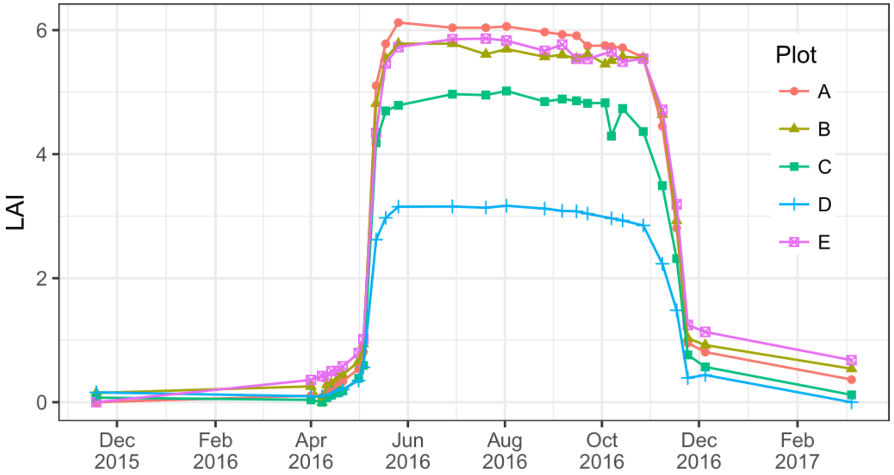
Low-cost sensors for temporal scaling

Needs/requirements for temporal validation:

- GCOS temporal requirement: 2-weekly average
- Copernicus Global Land Service: 10 days
- MODIS LAI v6: 4 days

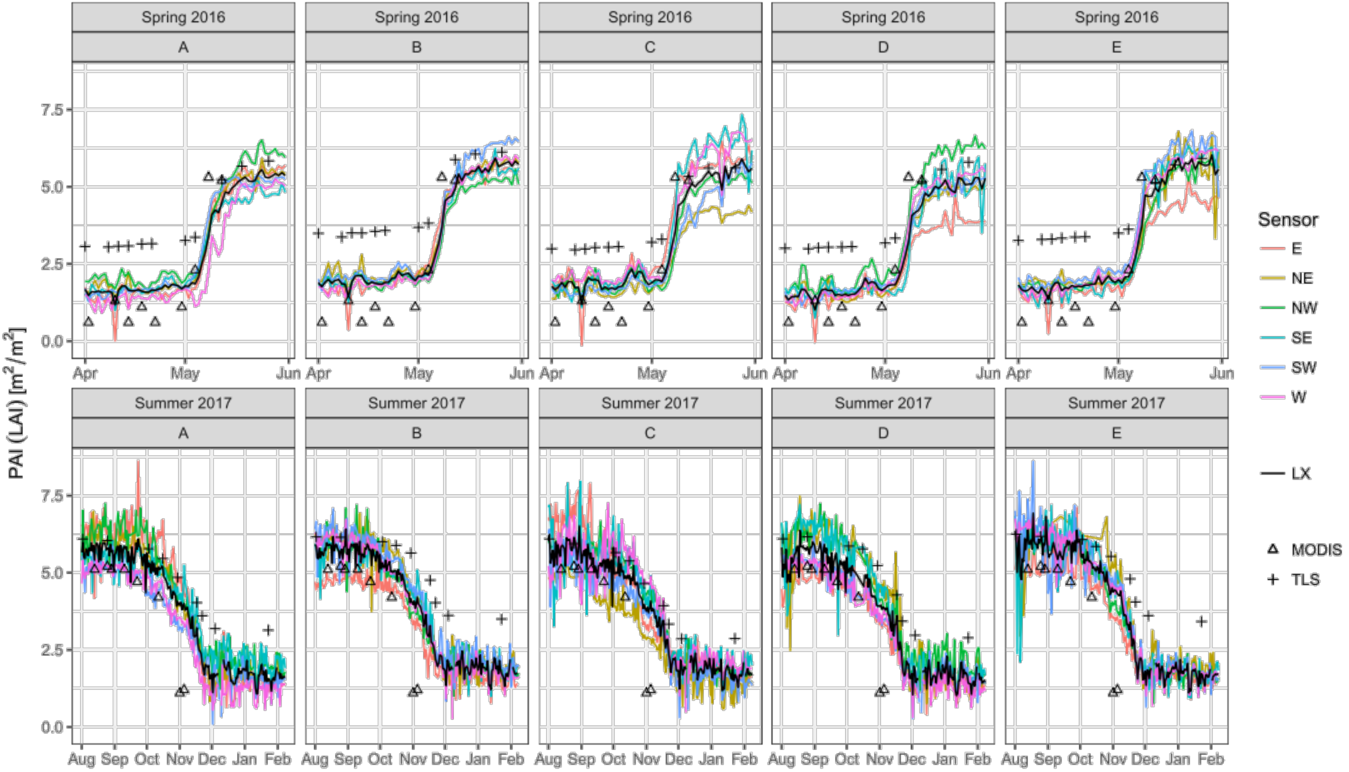


LAI based on TLS + litter traps

Brede et al. (2020)

Brede et al. (2020): DOI:10.3390/rs12060915

Low-cost sensors for temporal scaling



PASTIS57 in field
(opened housing)

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Brede et al. (2018): DOI:10.3390/RS10071032

Low-cost sensors for temporal scaling

LPV

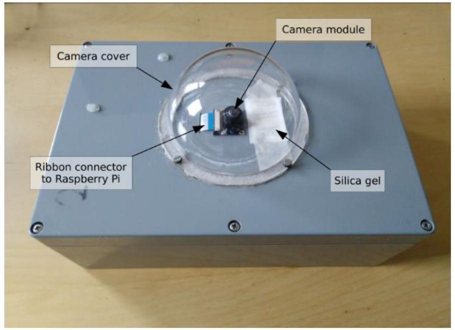
In-Situ Monitoring Sensors

- ✓ PASTIS57 (Lecerf et al., 2010; Brede et al., 2018)
- ✓ VEGNET (Culvenor et al., 2014) / LEAF
- ✓ TreeTalker TT (Valentini et al., 2019)
- ✓ Automated DHP (Brown et al., 2020)
- …

(Brown et al., 2020)

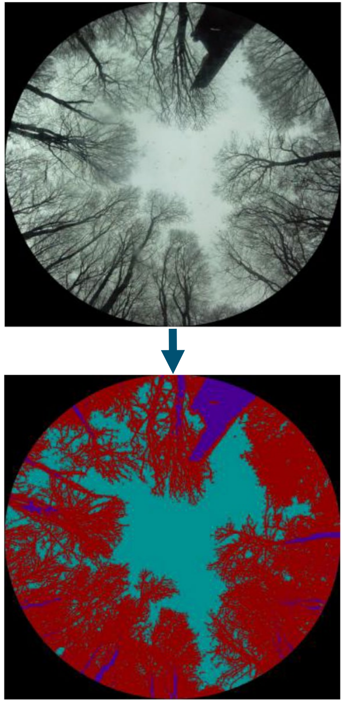
Lecerf et al. (2010): AGU, Fall Meeting 2010, abstract id. B52C-08
Brede et al. (2018): DOI:10.3390/RS10071032
Culvenor et al. (2014): DOI:10.3390/s140814994
Valentini et al. (2019): DOI:10.12899/asr-1847
Brown et al. (2020): DOI:10.1016/j.agrformet.2020.107944

Low-cost sensors for temporal scaling



PiLAI 1.0 (Vellekoop 2019)

PiLAI 2.0 (concept)



PiLAI 1.0 image & classification (Vellekoop 2019)

"Community" sensor:

- open source/codes
- Cost-effective components
- DIY community supported libraries
- Use wireless network technology (IoT)
- keep adoption thresholds low

Vellekoop (2019) https://edepot.wur.nl/517981

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Low-cost sensors for temporal scaling

- LEAF MkI - In-Situ Monitoring LiDAR
- NIR-LiDAR (905 nm)
- Comparable with 'traditional' methods?
- Comparable with other LiDAR (e.g. RIEGL VZ-400 @ 1550 nm)?

Recommendations

- Campaigns for site characterisation with TLS/UAV-LiDAR: use synergies with AGB
- Intercomparisons: LiDAR vs “traditional” sensors
  - LiDAR (UAV + IMS) vs traditional for forests
  - Destructive measurements as “gold standard” (litter traps for deciduous forest/harvest for crops)
- Intercomparisons: automated/low-costs vs traditional
- Include time series parameters: biophysical-based phenology

Acknowledgements

IDEAS-QA4EO project under ESA contract

Announcement

IGARSS 2021:
UAVs and low cost sensors for land calibration/validation

Take off! at Paracou, French Guiana

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