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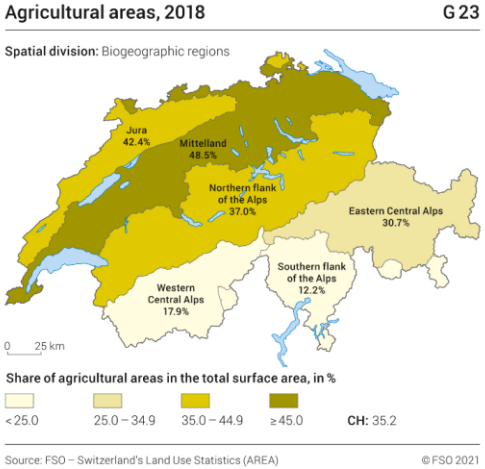
Earth Observation of Agroecosystems team

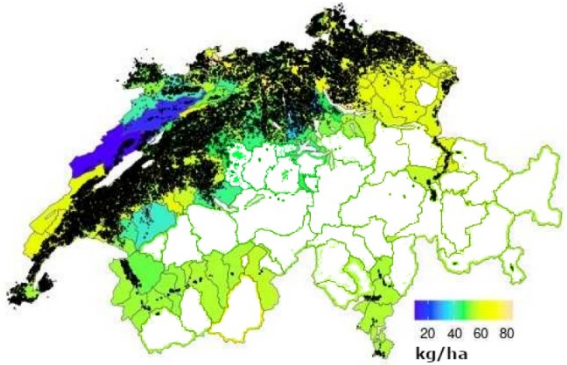
Improving large-scale hybrid LAI retrieval with local soil data and noise

Sélène Ledain, Anina Gilgen, Helge Aasen

COST Action 22136
Workshop in Sofia, Bulgaria

How can we monitor fields across Switzerland?

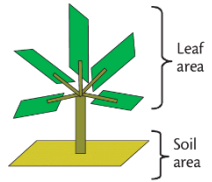




Black dots represent winter wheat fields in 2021.
Color indicates average yield for municipalities with significant winter wheat cultivation (unpublished data).

Leaf Area Index (LAI) as a indicator for biomass, crop cover, soil erosion...

- Retrieved from remote sensing data using radiative transfer models (RTM)
- Potential of satellite data to cover large areas at high resolution



$$LAI = \frac{\text{Leaf area}}{\text{Soil area}}$$

Objectives

«Global» LAI model using RTMs (ProSAIL) and ML (hybrid retrieval)

- For Switzerland
- Use soil samples to improve LAI retrieval at low values/bare soil

agronomy

MDPI

Article

RTM Inversion through Predictive Equations for Multi-Crop LAI Retrieval Using Sentinel-2 Images

Michele Croci [1,2], Giorgio Impollonia [1,2], Andrea Marcone [1], Giulia Antonucci [1], Tommaso Letterio [3], Michele Colauzzi [1], Marco Vignudelli [4], Francesca Ventura [4], Stefano Anconelli [3] and Stefano Amaducci [1,2,*]

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Abstract: Near-real-time, high-spatial-resolution leaf area index (LAI) maps would enable producers to monitor crop health and growth status, improving agricultural practices such as fertiliser and water management. LAI retrieval methods are numerous and can be divided into statistical and physically based methods. While statistical methods are generally subject to high site-specificity but

Validation of sentinel-2 leaf area index (LAI) product derived from SNAP toolbox and its comparison with global LAI products in an African semi-arid agricultural landscape

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[a]Earth Observation, South African National Space Agency, Pretoria, South Africa; [b]Schools of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa; [c]Laboratory of Remote Sensing, Spectroscopy and GIS, School of Agriculture, Aristotle University of Thessaloniki, Thessaloniki, Greece; [d]Scuola di Ingegneria Aerospaziale, Sapienza Università di Roma, Rome, Italy

ABSTRACT

This study validated SNAP-derived LAI from Sentinel-2 and its consistency with existing global LAI products. The validation and intercomparison experiments were performed on two processing levels, i.e., Top-of-Atmosphere and Bottom-of-Atmosphere reflectances and two spatial resolutions, i.e., 10 m, and 20 m. These were chosen to

ARTICLE HISTORY

Received 8 January 2020
Accepted 5 May 2020

Data

Sentinel-2: 10m resolution, 13 bands, 2017 to 2023

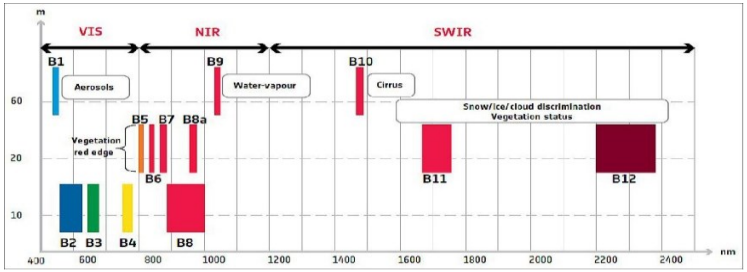
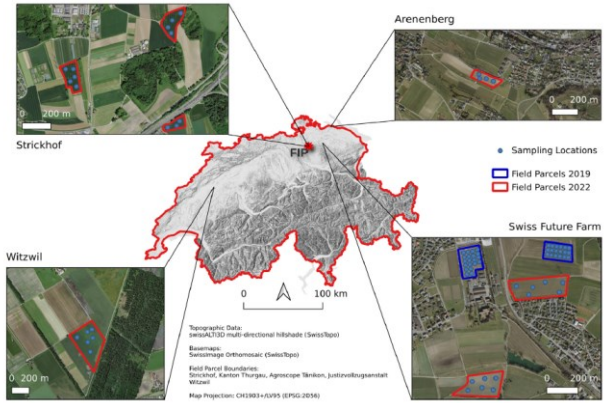


Image credit: ESA

In situ LAI measurements (224 observations)



Graf et al., 2023

Methodology overview

1. Sample bare soil spectra

Using GEE with S2 data across Switzerland

2. Prepare parameter inputs for RTM

LAI	Cab	Car	…	ALA
1	50	13	…	35
…	…	…	…	…
2.4	67	8	…	49
…	…	…	…	…
4.8	80	4	…	52

~50k combinations

Using values for winter wheat *(Danner et al., 2019)*

3. Simulate S2 spectra with RTM

- Pass subset of table with a single soil spectra
- ProSAIL model
- Get S2 top of canopy reflectance

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Methodology overview (cont.)

1. *Sample bare soil spectra*
2. *Prepare parameter inputs for RTM*

3. *Simulate S2 spectra with RTM*

4. ***Compare no soil vs soil***
   - Train a neural network (NN) on look-up table (LUT)
   - Compare model performances (RMSE and R^2)

Synthethic test data:
Use RTM to LUT of size 10k
Once with soil and once without

Validation set

5. ***Investigate effect of noise***
   - Add gaussian noise to data
   - Test 5 gaussian models at different levels (1, 3, 5, 10, 15, 20% noise)

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Methodology overview (cont.)

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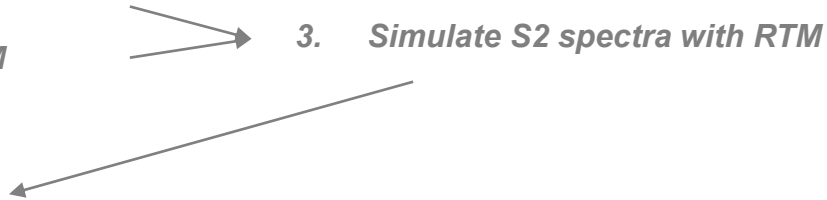

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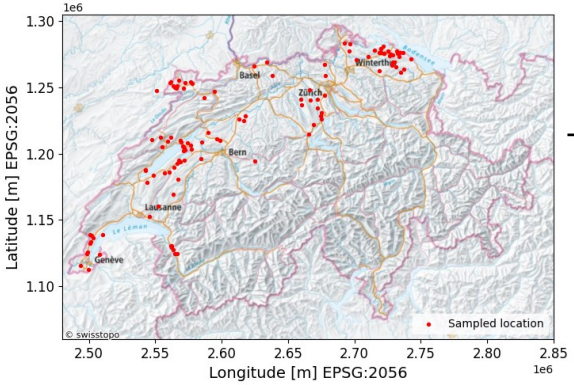
Sampling bare soil



Filter agricultural land → Remove clouds, snow, shadows → Remove vegetation and crop residue [1]

Using S2 Scene Classification Layer

NDVI < 0.25
NBR2 < 0.075

Yearly mean bare soil composites → Sample representative spectra → Interpolate to 1nm resolution

K-means clustering into 5 groups. Sample from each cluster

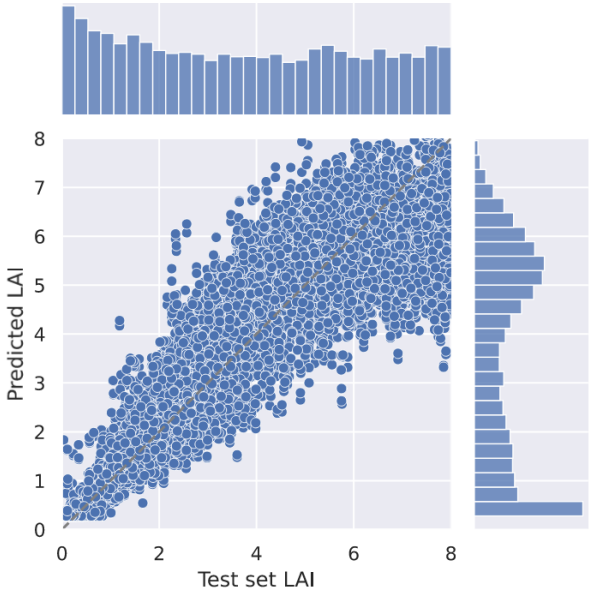
Monotonic cubic spline interpolation

1. Based on work by Felix Stumpf

Effect of integrating soil spectra

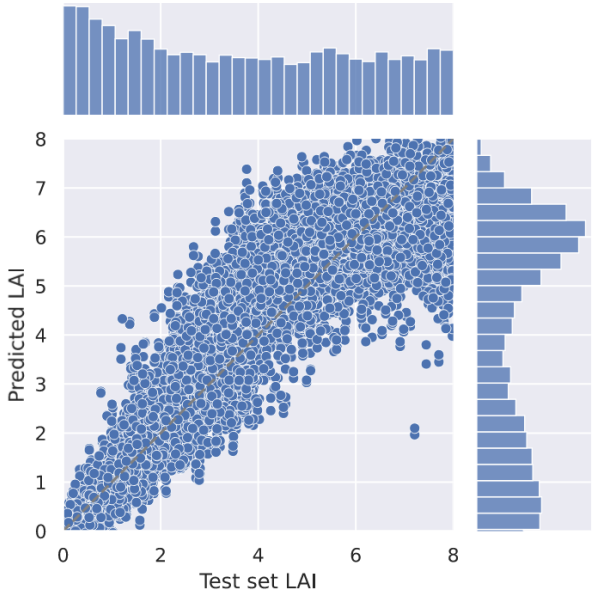
- All models trained with the same architecture (1 hidden layer, 16 nodes, 100 epochs)

Default RTM



RMSE: 0.987
R2: 0.834
RMSE LAI<3: 0.642

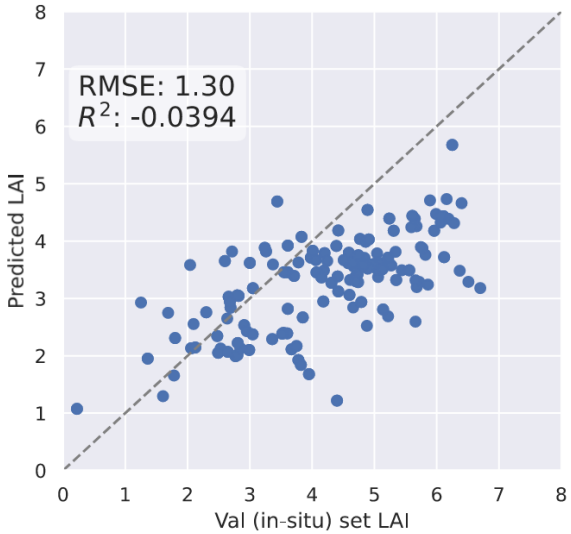
With added soil in RTM



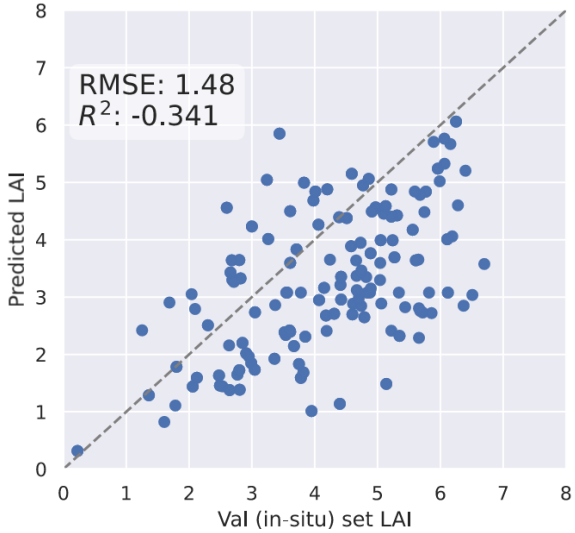
RMSE: 0.949
R2: 0.847
RMSE LAI<3: 0.622

Effect of integrating soil spectra (cont.)

Default RTM



With added soil in RTM



→ Bigger spread in predictions when soil is included

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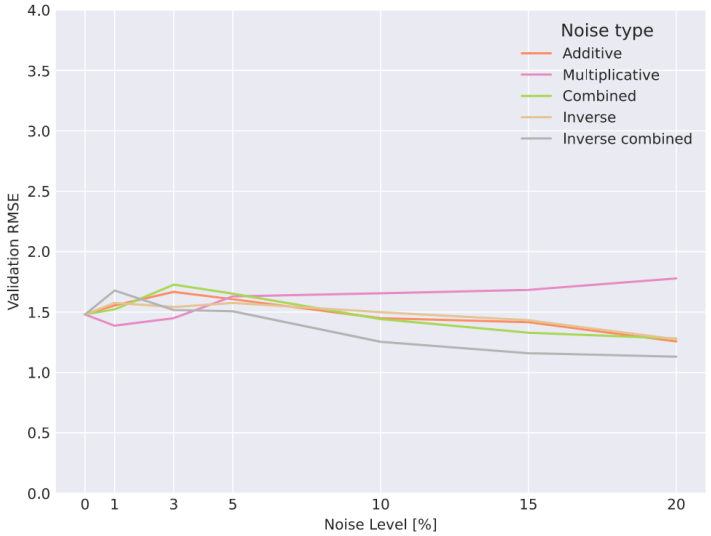
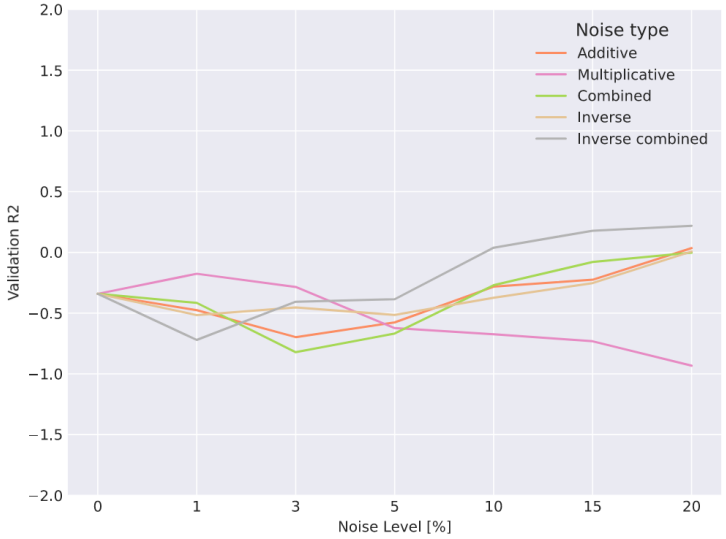
Effect of adding noise to the data

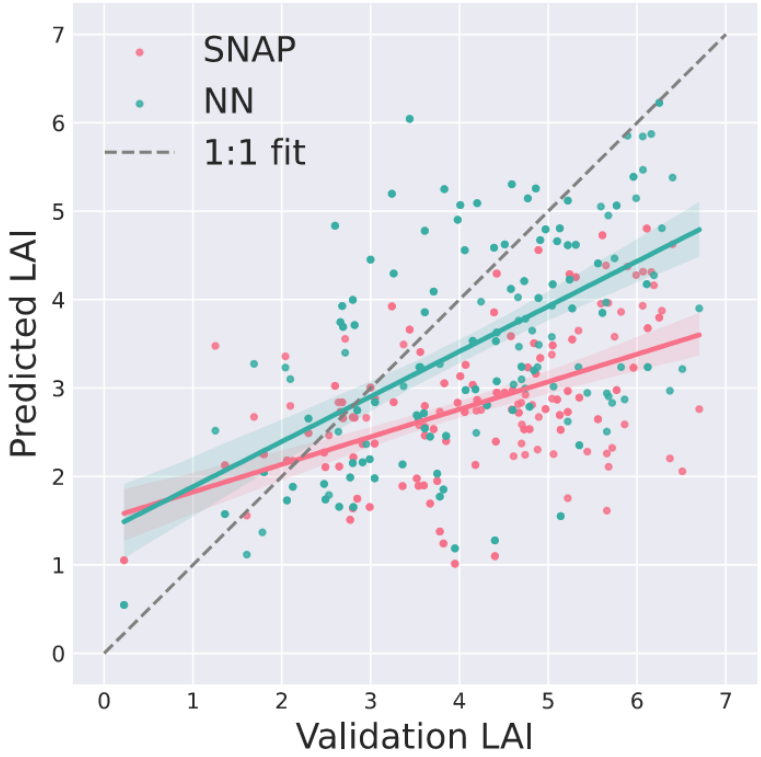




Any experience with best practices for adding noise to satellite data?

Comparison to SNAP
Sentinel-2's global LAI product

Specifically for winter wheat



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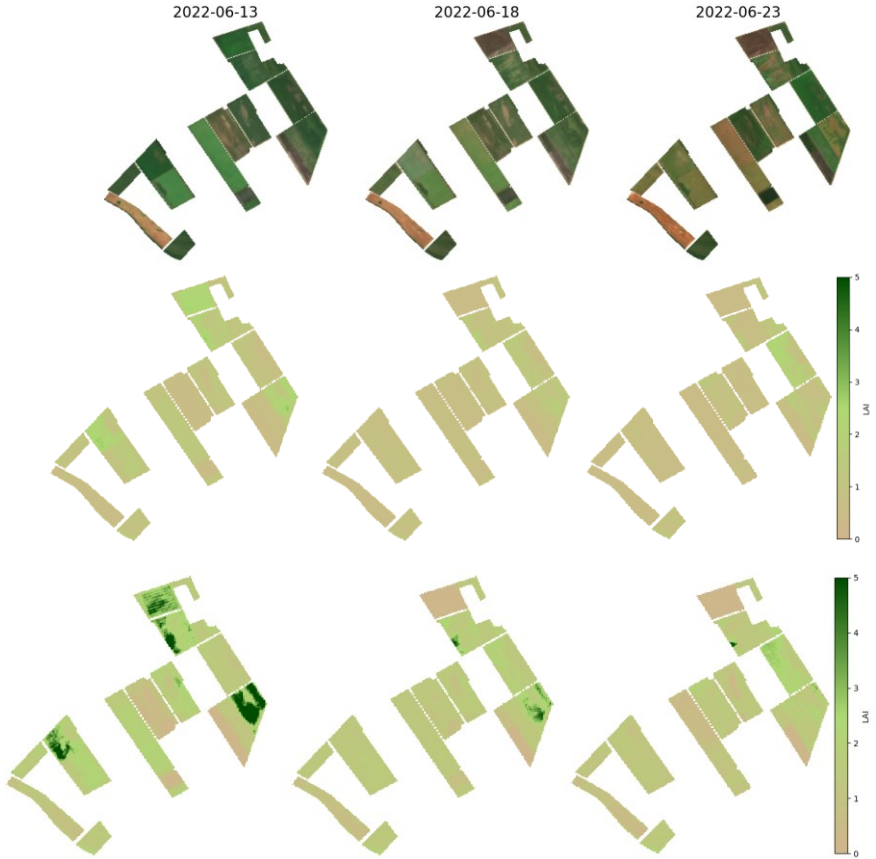
Comparison to SNAP (cont.)



Outlook

Data

✓ Sampling and inclusion of bare soil in RTM
? Upsampling of bare soil from S2 to hyperspectral
? Robustness of validation set

Model

✓ Outperforms SNAP on validation set
? Hyperparameter tuning

Application

✓ Pipeline to develop wheat LAI model
? Performance on other crops
? Relation to biomass, crop cover, soil erosion…

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Thank you for listening!

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PANGEOS for funding and organising

Questions? Ideas?

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