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LEAF AREA INDEX RETRIEVAL IN SHANXI PROVINCE OF CHINA USING SENTINEL-1 DATA

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Context

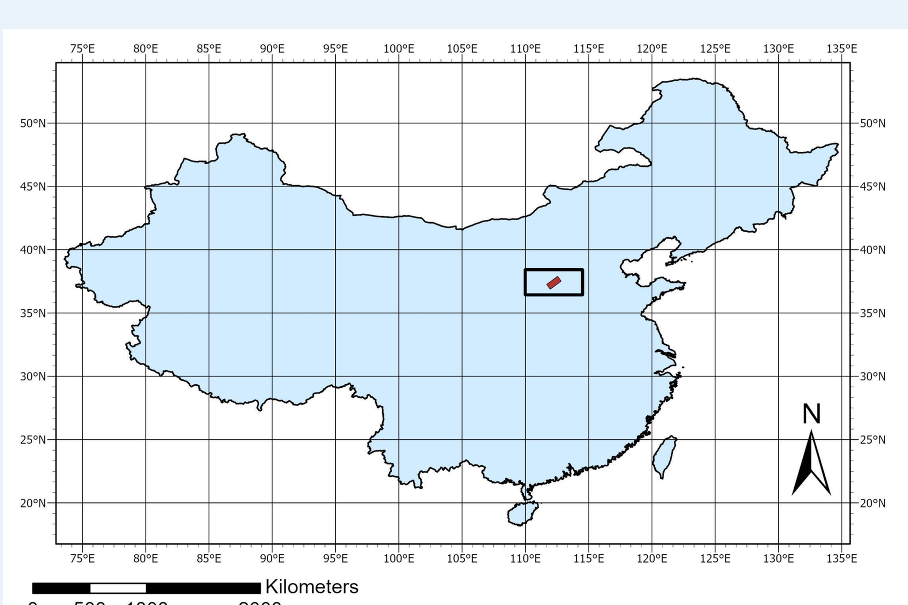
- Leaf area index (**LAI**) is a key variable for agricultural monitoring
- The most accurate LAI estimation methods exploit optical data (e.g., [1]) and are rendered ineffective in the case of frequent cloud cover
- Synthetic aperture radar (**SAR**) can allow the remote estimation of LAI at the parcel-level, on a large scale, regardless of cloud cover [2]
- SAR-to-optical regression methods have shown promising results for NDVI monitoring [3]

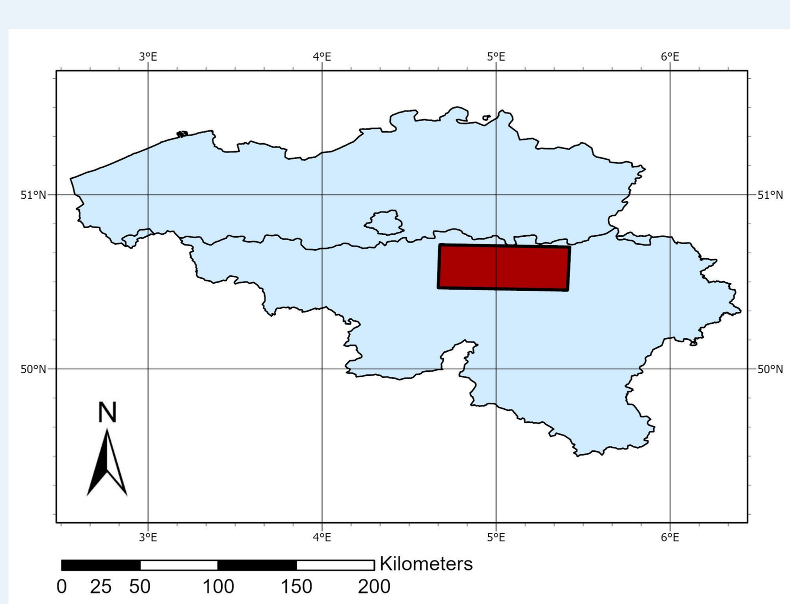
Objectives

1. Development of a reliable SAR-to-optical **LAI estimation** method for **maize** based on recurrent neural network and dual-pol **SAR** data
2. Assessment of its temporal and spatial (Belgium and China) **transferability**

Data

- Two geographically distinct regions: Shanxi province of **China** and Hesbaye region of **Belgium**





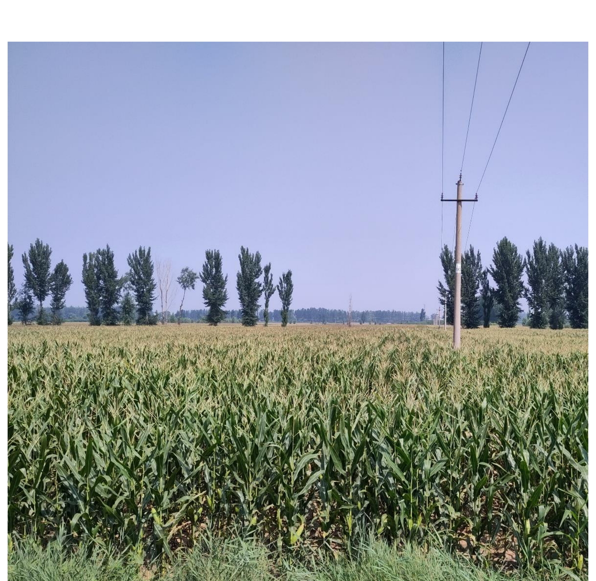
- **Field-average** values

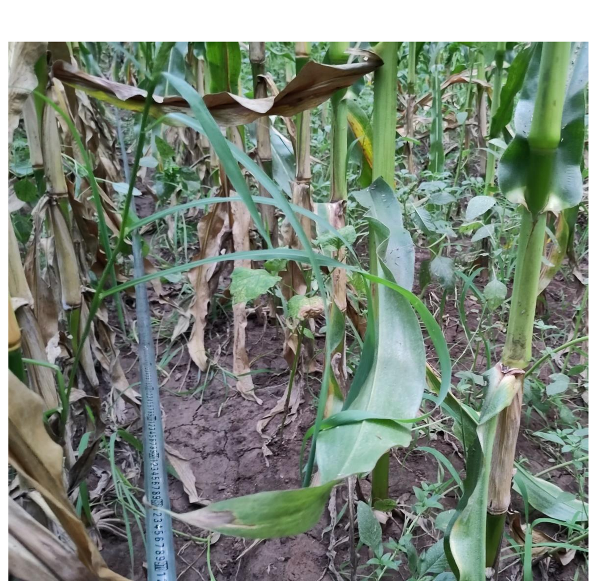
Training & testing

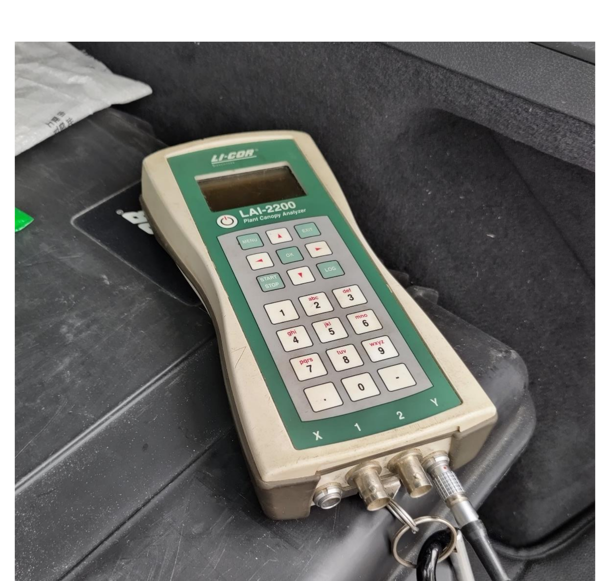
- SAR backscatter data (σ^0_{VH}, σ^0_{VV}, θ) from **Sentinel-1**, from 2019 to 2023
- **LAI** derived from **Sentinel-2** optical imagery [1], from 2019 to 2023

External validation

- **LAI** measured **in situ** in 5 sites in the Shanxi province of China in 2023 (ongoing)







Methods

Model

- **Recurrent neural network**
- Time series (May to mid-October) of field-average values

Dense layer* (64)
↓
Bidirectional GRU (128)
↓
Dense layer* (64)
↓
Dense layer* (32)
↓
Dense layer (1)

*batch normalizations, ReLU activations, and dropouts

Features (Sentinel-1)

- Mean, std, min, and max for VV and VH
- VV/VH ratio
- Incidence angle
- Dual Pol Radar Vegetation Index (dpRVI)

Labels (Sentinel-2)

- LAI derived from Sentinel-2
- Interpolated with a nearest neighbor algorithm on Sentinel-1 DSC acquisition grid
- Label masked if > 5 days apart from nearest Sentinel-1 acquisition

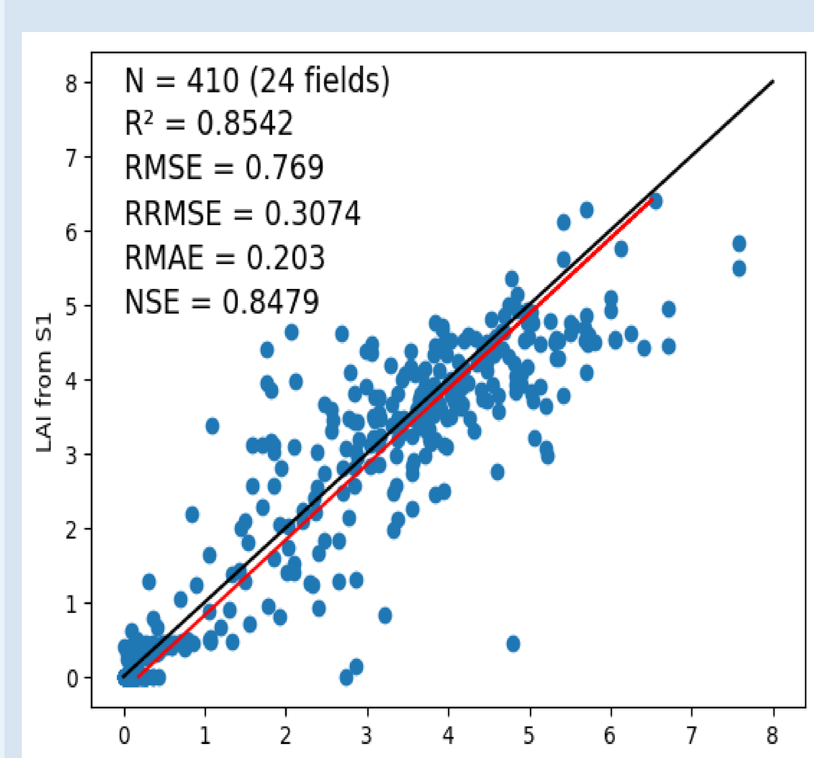
Training and validation

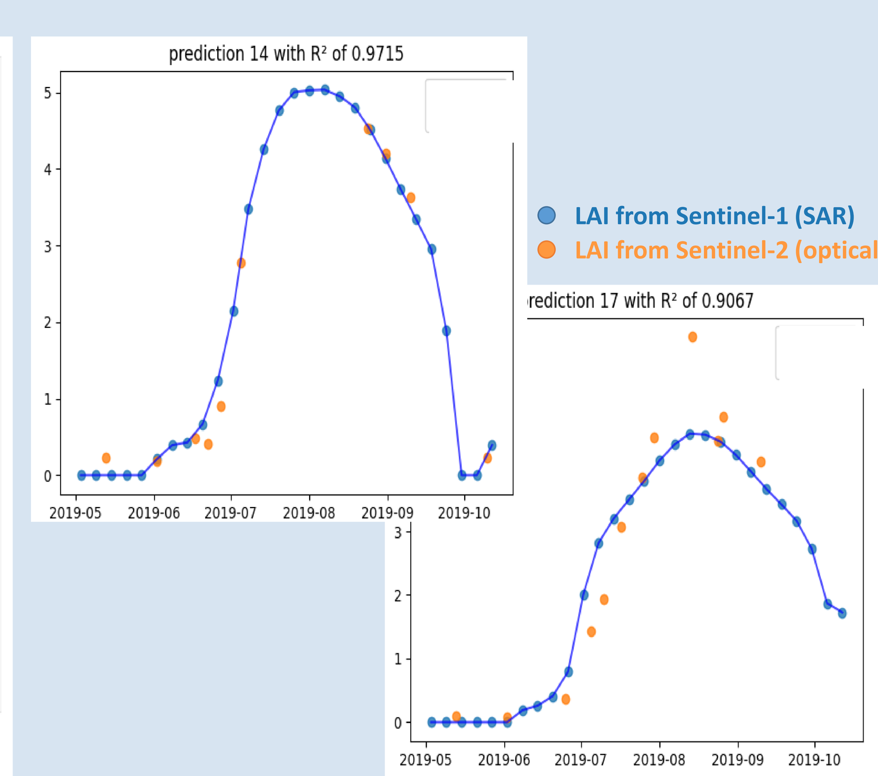
- 10-to-1 train/test split
- External validation against LAI measured in situ with Licor LAI-2000

Results

- **Field campaign** in Shanxi still **ongoing**
- **Preliminary study** conducted on 231 maize fields in **Belgium** with Sentinel-1 and -2 images from **2019**

LAI estimation results for Hesbaye region, Belgium, in 2019





References

(1) Delloye, C., Weiss, M., & Defourny, P. (2018). Retrieval of the canopy chlorophyll content from Sentinel-2 spectral bands to estimate nitrogen uptake in intensive winter wheat cropping systems. Remote Sensing of Environment, 216, 245-261.

(2) Bouchat, J., Tronquo, E., Orban, A., Neyt, X., Verhoest, N. E., & Defourny, P. (2022). Green area index and soil moisture retrieval in maize fields using multi-polarized C-and L-Band SAR data and the water cloud model. Remote Sensing, 14(10), 2496.

(3) Garioud, A., Valero, S., Giordano, S., & Mallet, C. (2021). Recurrent-based regression of Sentinel time series for continuous vegetation monitoring. Remote Sensing of Environment, 263, 112419.