PRISMA & EnMAP comparison in the context of wheat nitrogen status assessment

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Objectives

- Assessing the **added value of hyperspectral data** for estimating wheat **nitrogen content**
- Comparing **EnMAP** and **PRISMA** data in the context of nitrogen status assessment
- Developing a robust methodology to provide accurate crop nitrogen concentration

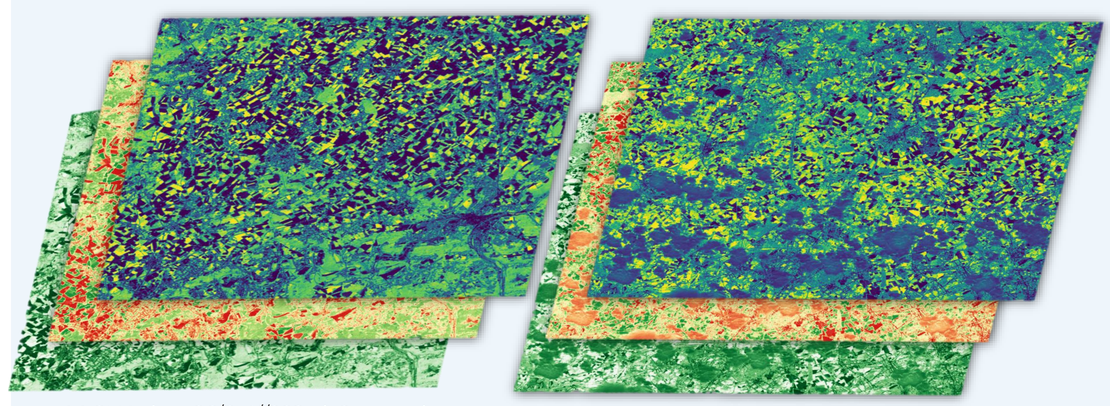
Context

- Study part of **SPAGHYTI** project, led by Constellr
- Development of two applications based on satellite hyperspectral imagery to deliver relevant information to Walloon farmers: **wheat nitrogen status assessment** and (a)biotic stresses monitoring

Methods

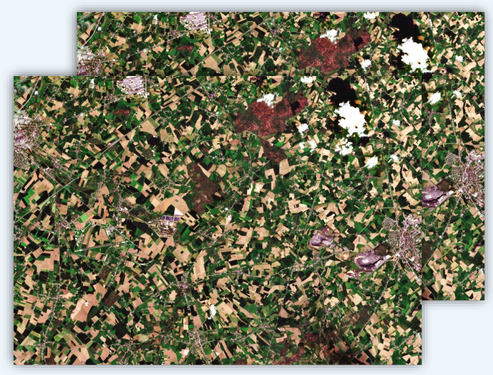
- For both EnMAP and PRISMA acquisition, **Normalized Difference Index (NDI)** $\frac{Band\ 1 - Band\ 2}{Band\ 1 + Band\ 2}$ and **Simple Ratio Index (SRI)** $\frac{Band\ 1}{Band\ 2}$ have been computed for all possible combinations of spectral bands.
- The estimation of **Canopy Nitrogen Concentration** (CNC) is based on Sentinel-2 MSI data selected to be the closest with EnMAP and PRISMA acquisitions date. CNC estimation relies on **the inversion of the radiative transfer model** PROSAIL (PROSPECT-3 coupled with SAIL-4) with an artificial neural network (Delhoye et al., 2018).
- As the CNC output came with a 10m resolution, the product has been **smoothed** using an EnMAP and PRISMA-like **point spread function** (PSF). The **PSF of Landsat-8** was chosen because of its similar spatial resolution with EnMAP and PRISMA data. Assuming a gaussian PSF, we used a full width half maximum value (FWHM) of 51.05 m (Radoux et al., 2016). The product has been **resampled** to **30m resolution** product. CNC values are expressed in kg per ha.
- **CNC and NDI/SRI** values have been aggregated at the **parcel level** and their relationship has been assessed using the **Pearson correlation** formula.
- For each 30km x 30km hyperspectral image footprint, all **winter wheat fields** were extracted from the **Walloon SIGEC** (Système Intégré de Gestion et de Contrôle).

Satellite data



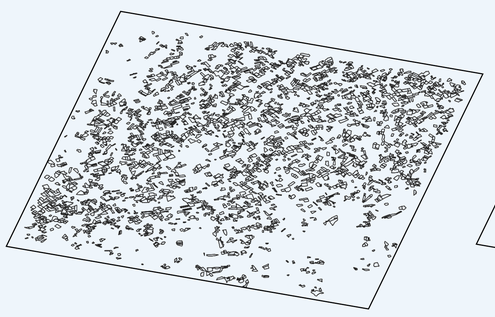
PRISMA data 06/014//2023 (30-m res.)

EnMAP data 04/21/2023 (30-m res.)

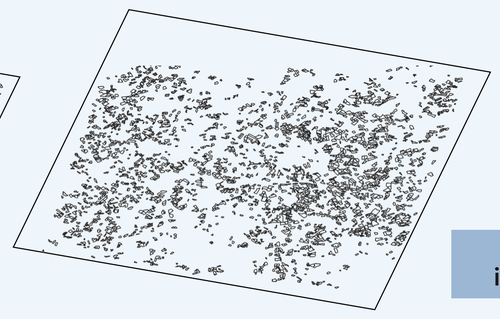


Sentinel-2 MSI data data 04/15/2023 & 06/01/2023 (10-m res.)

Field data



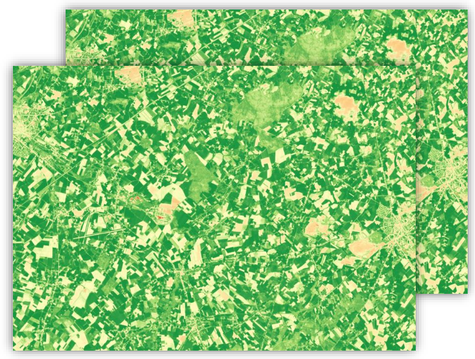
Winter wheat fields under PRISMA footprint number: 2659, mean area: 4,62 ha, std: 6,23 ha



Winter wheat fields under EnMAP footprint number: 1279, mean area: 5,27 ha, std: 4,03 ha

Canopy Nitrogen Content estimation

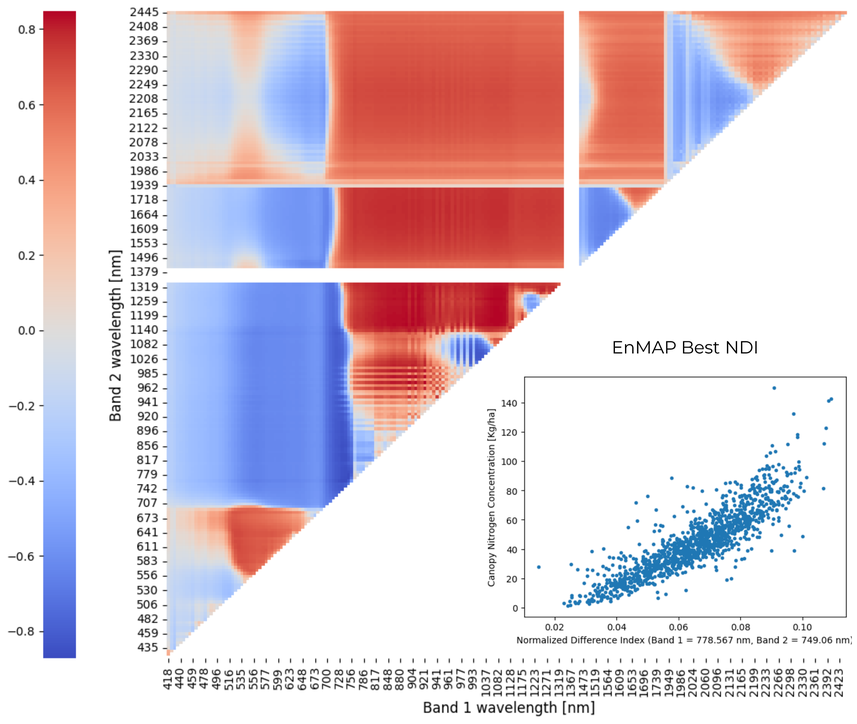
Mean CNC and indices at parcel



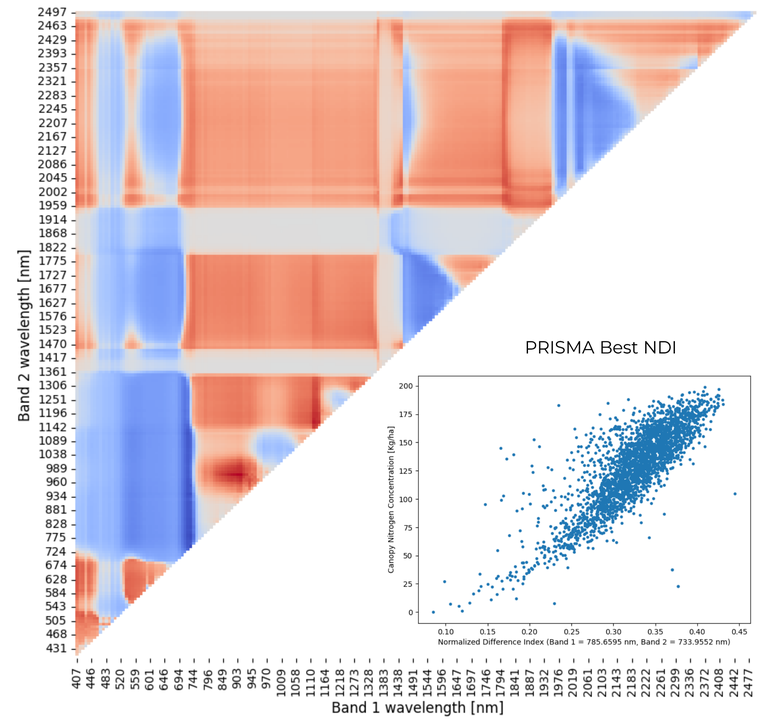
Canopy Nitrogen Concentration (10-m res.) [Kg/ha]

Heatmaps correlation matrices

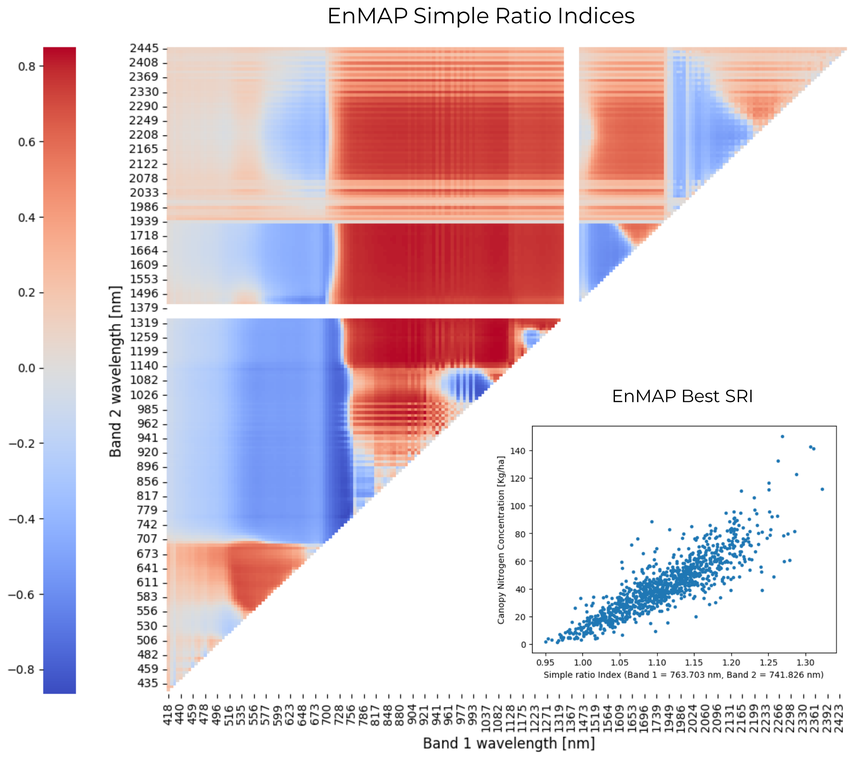
EnMAP Normalized Indices



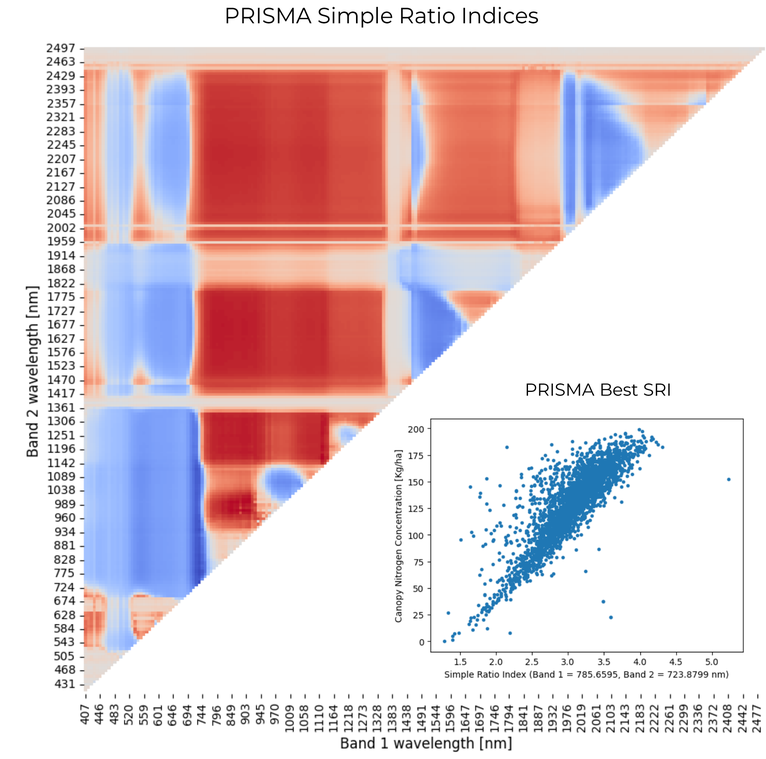
PRISMA Normalized Indices



EnMAP Simple Ratio Indices



PRISMA Simple Ratio Indices



	Band 1 (nm)	Band 2 (nm)	R	R^2	RMSE	RRMSE
EnMAP (NDI)	778	749	0.87	0.76	49.96	1.11
PRISMA (NDI)	786	734	0.83	0.68	132.58	1.03
EnMAP (SRI)	764	742	0.87	0.76	46.71	1.09
PRISMA (SRI)	786	724	0.83	0.69	129.72	1.01

These preliminary results demonstrate the **potential of hyperspectral imagery** for **CNC retrieval**. The **most correlated indices** are derived from spectral bands within the Sentinel-2 spectrum, but other indices showed similar correlation coeffcient with CNC. While the **red-edge region** appears to be the **most sensitive** to **nitrogen concentration**, heatmaps exhibit numerous other sensitive spectral bands. The results obtained from a **simple linear regression** suggest that there is a room for improvement regarding the accuracy of CNC estimation.

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Radoux, Julien, Guillaume Chomé, Damien Christophe Jacques, François Waldner, Nicolas Bellemans, Nicolas Matton, Céline Lamarche, Raphaël D'Andrimont, et Pierre Defourny. « Sentinel-2's Potential for Sub-Pixel Landscape Feature Detection ». *Remote Sensing* 8, nº 6 (juin 2016): 488. https://doi.org/10.3390/rs8060488.

Delloye, Cindy, Marie Weiss, et Pierre Defourny. « 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 (1 octobre 2018): 245-61. https://doi.org/10.1016/j.rse.2018.06.037.

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