T. Lorée[1], G. Morin[2], J. Guil[2], H. Squividant[3], T. Morvan[1]

[1] SAS, INRAE, Institut Agro, 35000 Rennes, France
[2] Chambres d'agriculture de Bretagne, 56500 Bignan, France
[3] SAS, Institut Agro, INRAE, 35000 Rennes, France

WS-CI: a web service for predicting the biomass and nitrogen uptake of intercropping cover crops

Introduction

Cover crops are an effective tool for decreasing nitrogen leaching in agrosystems, and their biodegradation after destruction provides nitrogen for the following crop, but in highly variable amounts depending on their biomass and the amount of nitrogen that they took up. Remote sensing data from Sentinel-2 satellites show great potential for addressing this variability through the development of predictive models based on vegetation indices and parameterised using field measurements of variables of agronomic interest (Dusseux et al., 2022).

Objectives

- Develop reference values for the biomass and nitrogen uptake of intercropping cover crops in Brittany
- Use the data collected for predictive modelling
- Create an open-source web service to estimate nitrogen uptake by cover crops in a field and predict its dynamics

Obtaining reference values for the biomass and nitrogen uptake of cover crops

Two sampling campaigns were performed by INRAE and Brittany's Regional Chamber of Agriculture in the autumn/winter of 2022/2023 and 2023/2024. To increase data quality and the reliability of data storage, a dedicated web service was created to collect data and information about the fields. We collected 272 elementary sampling units (Verrelst et al., 2015) (Figure 1), each of which consisted of 5 measurements of biomass in a square with 20 m sides (Figure 2).

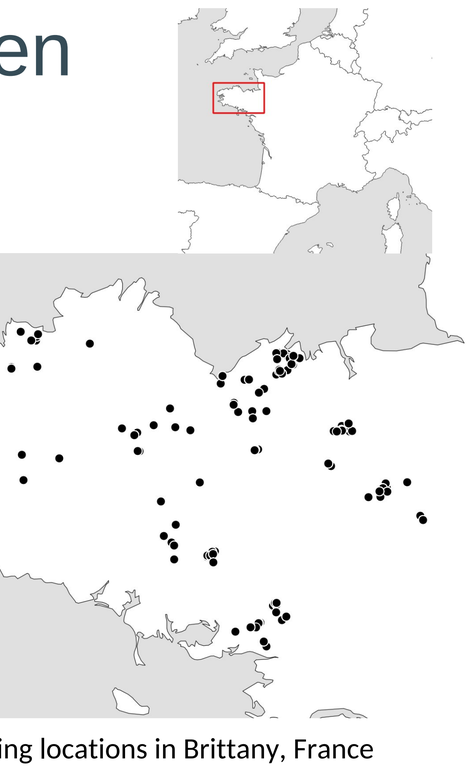

Figure 1. Sampling locations in Brittany, France

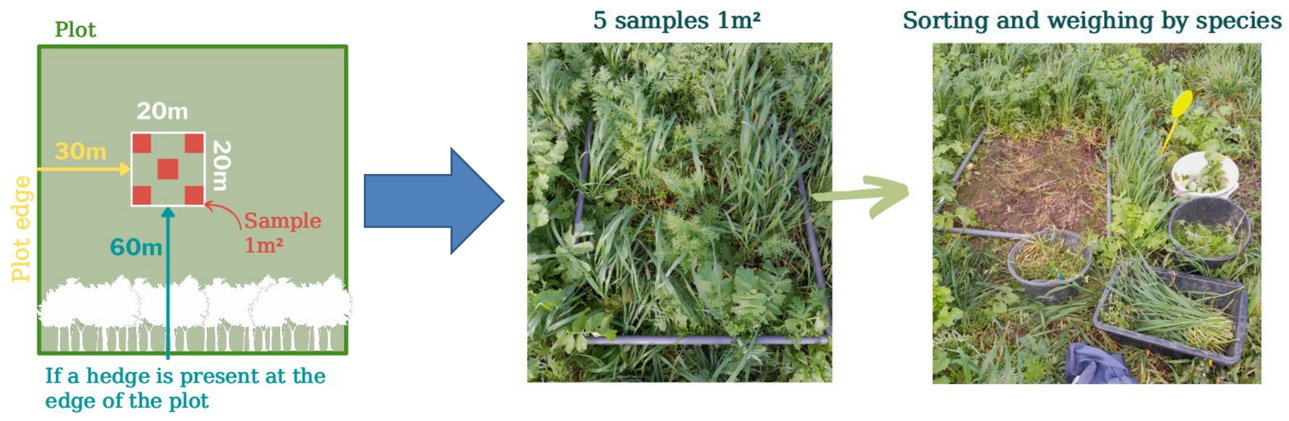

Figure 2. Sampling of an elementary sampling unit

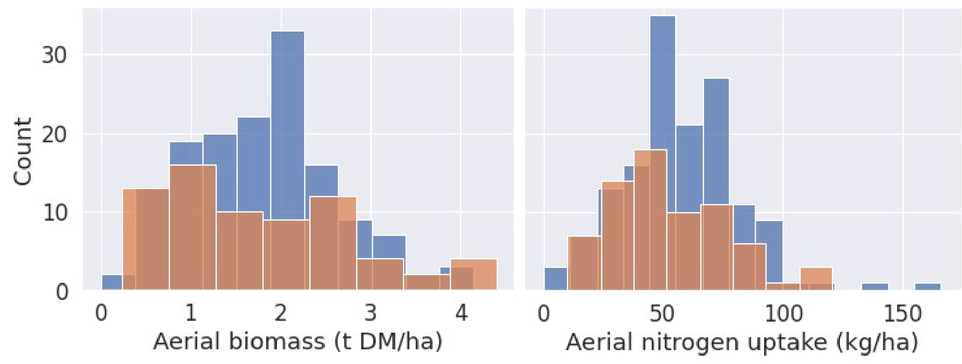

Figure 3. Distributions of aerial biomass (t dry matter ha^{-1}) (left) and its nitrogen uptake (kg N ha^{-1}) (right) in 2022/2023 and 2023/2024

- Cover crops developed more in 2022/2023 than in 2023/2024
- The main species were phacelia, oats and fodder radish

Modelling

Approach

- We calculated 152 vegetation indices selected from the literature. The 20 best spectral bands or indices were selected based on testing their correlations with field data, and then all possible pairs of the 20 bands or indices with different combinations were assessed using linear regressions (Verrelst et al., 2015).
- Data from 2022/2023 were divided into a training set and a testing set. Data from 2023/2024 were used to assess model accuracy for a different context (different weather during the year, different development patterns).

Results

- The model predicted nitrogen uptake well for 2023/2024
- The combination of NIRV (Grayson et al., 2017) and NDVI*band 6 (Rouse et al., 1974) were the most robust indices for predicting nitrogen uptake for 2023/2024

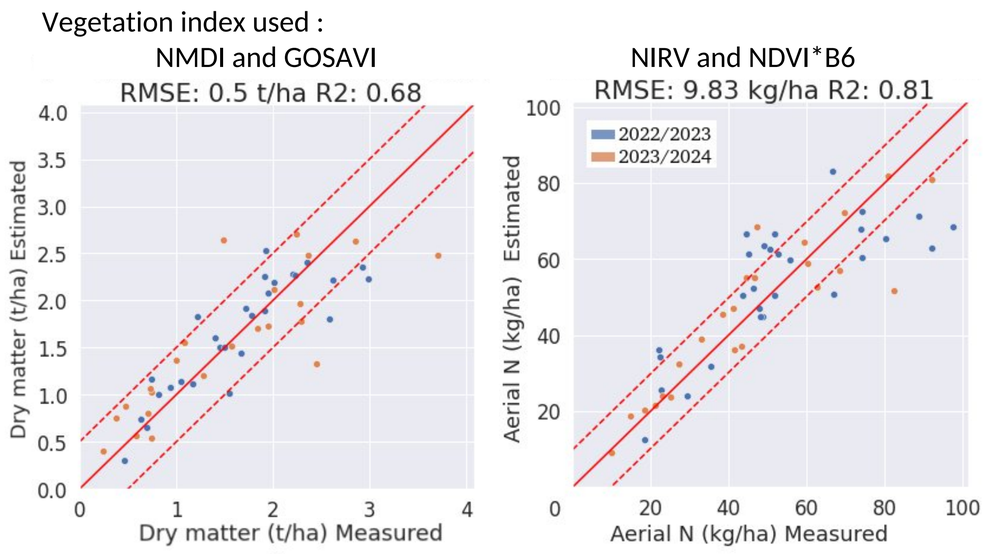

Figure 4. Model selected to predict aerial biomass (left) and its nitrogen uptake (right). The R^2 and RMSE refer to those for data from 2023/2024.

Web service

- Based on the models (Figure 4), a web service was created to predict the aerial biomass of cover crops and their nitrogen uptake at the field scale (Figure 5).
- The web service is coded in Python using the web framework Flask and interoperability standards: OGC API Processes, OGC API Environmental Data Retrieval and Web Coverage Service (which allows users to download Sentinel-2 data for each field).
- Nitrogen uptake by aerial biomass is predicted for all of the Sentinel-2 data available for autumn/winter. For simplicity, the web service indicates only the peak nitrogen uptake and the date of this peak (Figure 6).

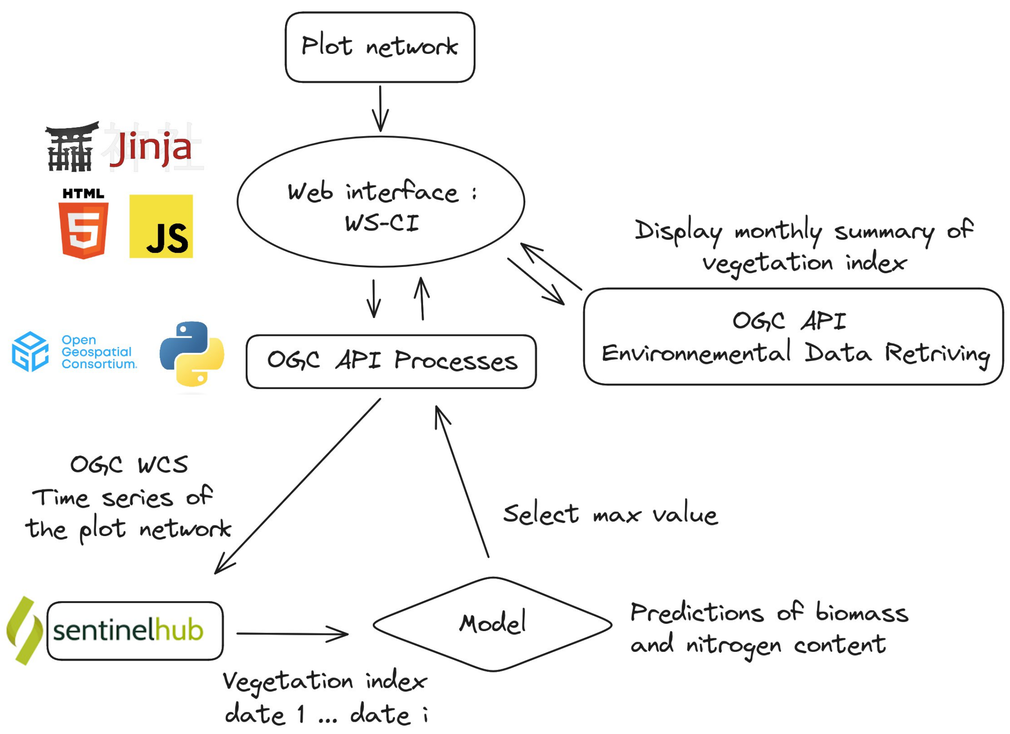

Figure 5. Structure of the web service

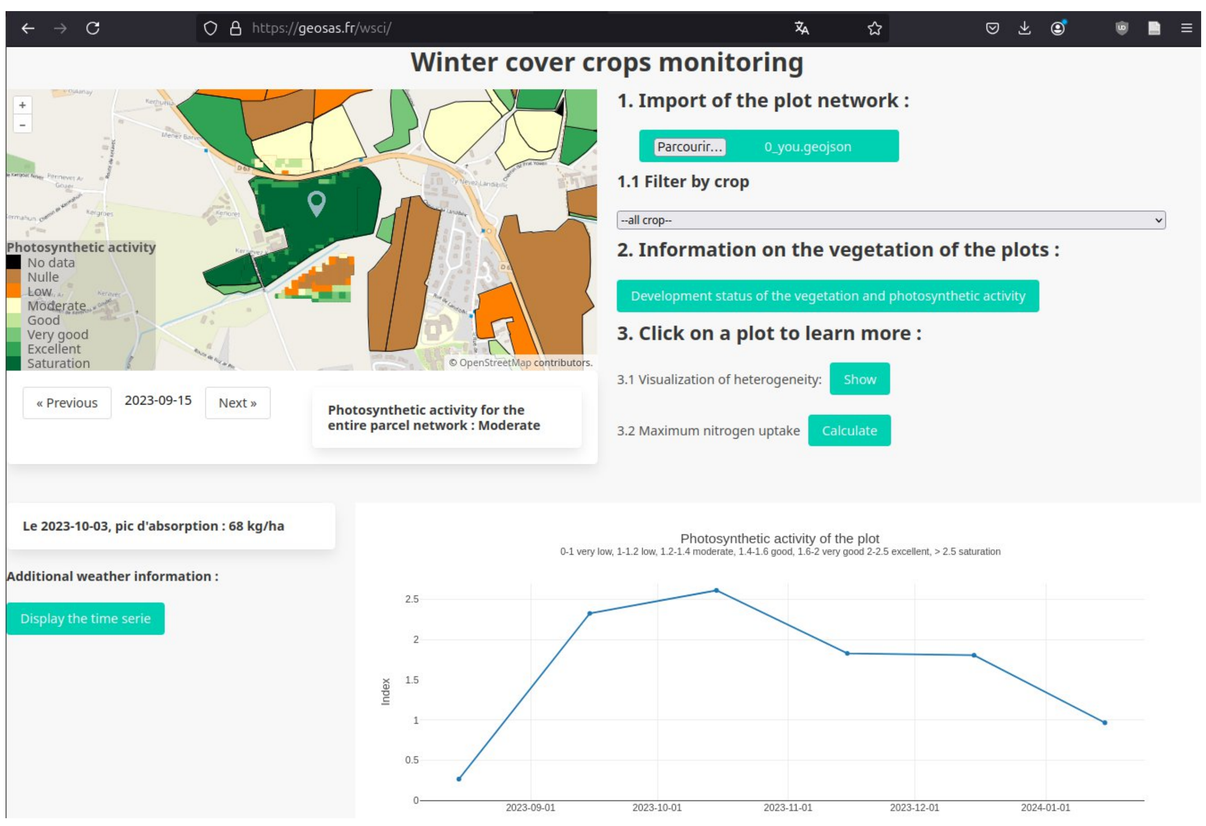

Figure 6. Screen capture of predicted nitrogen uptake of a field's cover crop by the web service (https://geosas.fr/wsci)

Discussion and perspectives

- Multiple modelling approaches were tested: statistics, machine learning, time-series integration, and coupling a mechanistic model to a time series. We chose linear regression due to its high accuracy for both years, simplicity of use, calculation speed and it is less limited by sparse time series (cloud-free image).
- Generating models based on the predominant species seems more effective but would require a larger database and presents challenges for the generalization of the web service.
- Using interoperability standards allows web services to be created that other projects can easily adopt. Its main advantage was its ability to download months of Sentinel-2 data for a small area in approximately 20 seconds.

References

Dusseux P, Guyet T, Pattier P, Barbier V, Nicolas H, 2022. Monitoring of grassland productivity using Sentinel-2 remote sensing data. International Journal of Applied Earth Observation and Geoinformation, Volume 111
Grayson Badgley et al., Canopy near-infrared reflectance and terrestrial photosynthesis.Sci. Adv.3,e1602244(2017)
Rouse, J.W., Haas, R.H., Schell, J.A., & Deering, D.W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. In Third Earth Resources Technology Satellite-1 Symposium, Vol. 1, NASA SP-351, pp. 309-317
Verrelst J, Rivera JP, Veroustraete F, Muñoz-Marí J, G.P.W. Clevers J, Camps-Valls G, Moreno J, 2015. Experimental Sentinel-2 LAI estimation using parametric, non-parametric and physical retrieval methods – A comparison. ISPRS Journal of Photogrammetry and Remote Sensing, 108, 260-272

POSTER ID : 308