In-season potato crop nitrogen status monitoring from satellite and meteorological data

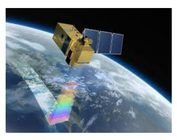
D. Goffart, F. Ben Abdallah, Y. Curnel, V. Planchon, P. Defourny, J.-P. Goffart
d.goffart@cra.wallonie.be

Context : splitting of N fertilizer application and Sentinel-2 images

Scope of the paper

- Application of a reduced N rate at planting (for example 70% of the total recommended N rate)
- Between 20 and 50 days after emergence, N status monitoring :
  - Decision on the need to apply supplemental N based on the **Nitrogen Nutrition Index** (NNI)
  - While applied, modulation of N supplement based on **N uptake** and targeted final yield

- **Sentinel-2** satellites = free access multispectral images, 10-20m spatial resolution, 5 days revisit time, full parcel images

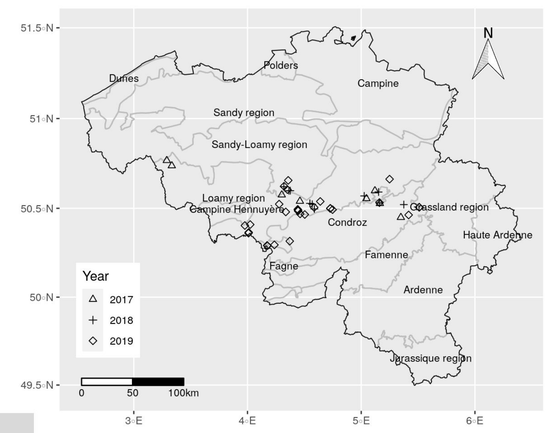


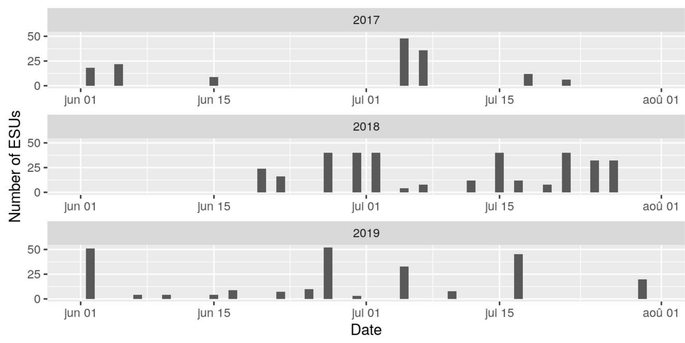
+ meteo data

*D. Goffart, F. Ben Abdallah, Y. Curnel, V. Planchon, P. Defourny, J.-P. Goffart (2021). **In-season potato crop nitrogen status assessment using satellite and meteorological data.** *Published in Potato Research*

Field data

- 3 years with contrasted meteo conditions (2017, 2018, 2019)
- Loamy, sandy-loamy, stony-loamy soils
- Total biomass samples in farmers fields (148 sampling units)
- Mainly 2 variety (Bintje, Fontane)
- Nitrogen content (NIR analysis)





Sentinel-2 data

Number of elementary sampling units (ESUs) by date covered by Sentinel-2 cloud free images

⇒ Restrictions on usable field data

Methodology

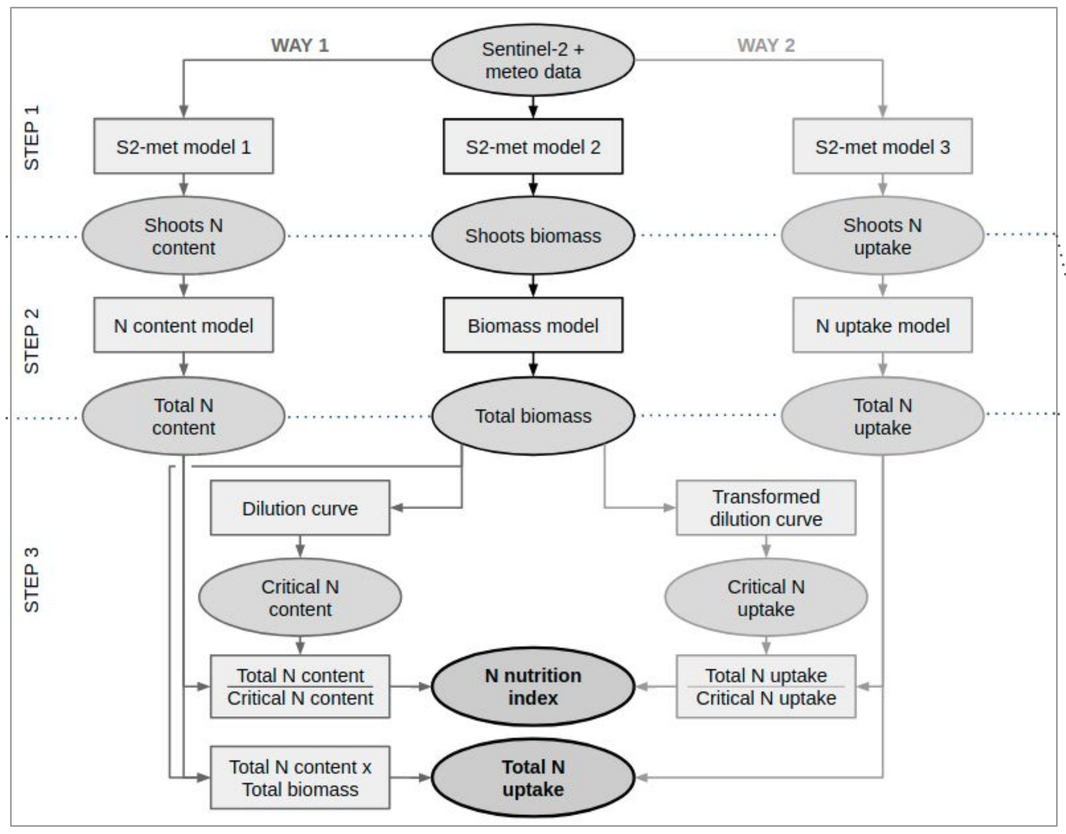
- **Meteo** :
  - Degree Days from planting date
  - Water balance from planting date
- **Sentinel-2** :
  - Selection of 16 Vegetation Indices (VIs) from remote sensing
  - Leaf Area Index (LAI) and Fraction of Vegetation Cover (FCOVER)
- **Performance evaluation** of each 1 to 5 variables combinations with RMSE from cross-validation procedure (multiple linear regression and random forest models)

- Simple linear regression established with field data

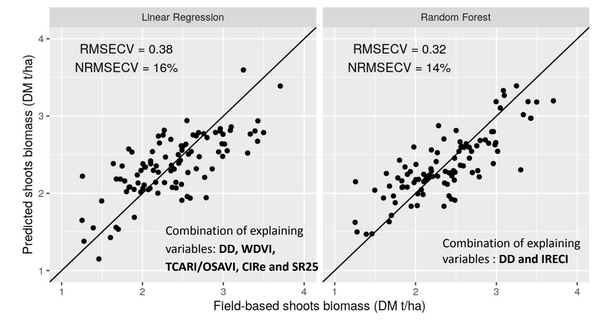
- Predicted values from cross-validation of step 1 best models
  → application of step 2 developed models
  → Total N content, total biomass and total N uptake values

- Comparison of NNI and Total N uptake obtained through way 1 and 2, for both model types (linear regression and Random forest)

Workflow for N status assessment



Results

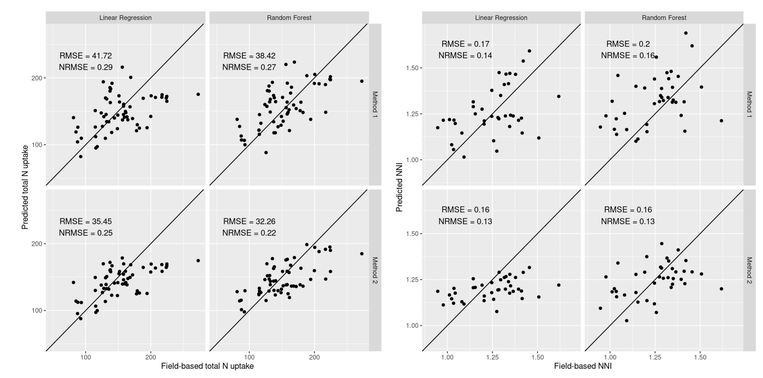


- For the three explained variables, several combinations of VIs, BVs and weather data allow similar performances ⇒ several options for practical use

- Adding variety as explanatory variable :
  - No effect on biomass and N uptake prediction
  - Slight effect on N content prediction

- "Year-fold" cross validation :
  - Demonstrate higher robustness of linear regression models
  - Bad results for N content for both model types (linear regression and Random forest)

- Best predictions through way 2 for N uptake and NNI



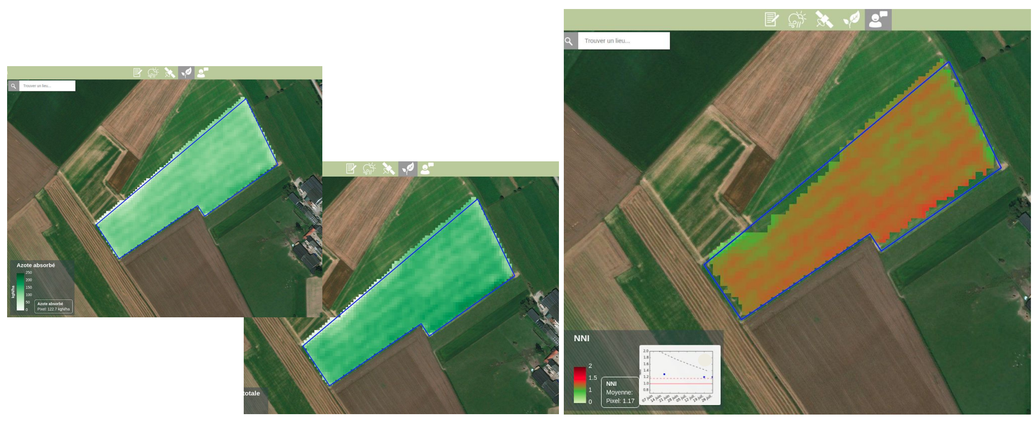
Discussion and conclusion highlights

- Integration of DDs in models appears to be highly useful variable to reach relevant multi-year models.
- Several relevant combinations of variables (VIs, BVs or meteo data-based) : choice must be governed by the ease and speed of data acquisition and processing, the rapid, ready availability of VIs and/or BVs, and the highest spatial resolution at field scale.
- Results relevant to way 2 (NNI and total Nuptake as targeted variables)
- NNI of 1 or more on explored potato fields : reality for Belgian potato cropping conditions but potential limitations for our models.
- NNI calculation currently limited to Bintje cultivar; current development for Fontane, Challenger and Innovator cultivars.
- Multiple linear models more robusts, dataset too limited for use of Random Forest models.
- A model can be incorporated into decision support system (DSS)

Transfer of the results to the BELCAM platform

Choices :

- Multiple linear regression using VIs and DDs
- NNI and direct total N uptake estimation



Work in progress

- 2022 validation field campaign : possibility of an increased model robustness in the Belgian context.
- 2023 field campaign through a collaboration with ULiège Gembloux Agro-Bio Tech to experiment the N status monitoring

Perspectives

- Combination with other data acquisition methods (drones, on-board sensors, etc.), given the risks of limited S2 data acquisition during cloudy periods.
- Go further in the recommendation by developing a relevant method to estimate and map the supplemental N to apply based on N uptake and N need. The actual N need could be defined by predicting the expected final yield through a dynamic crop growth model.
- Increase the robustness of the models under wider soil-climate and cropping conditions at Northwestern Europe level by validating them on wider data sets obtained from other institutions (other varieties and varied cropping practices).

Wallonie recherche CRA-W
Walloon Agricultural Research Centre
To address today's questions and to prepare tomorrow's challenges
www.cra.wallonie.be
Funded by
UCLouvain
belspo