BELGIAN COLLABORATIVE AGRICULTURE MONITORING AT PARCEL LEVEL FOR SUSTAINABLE CROPPING SYSTEMS

From 1st October 2014 to 31st March 2019

Cindy Delloye (UCL)

with contributions from Defourny Pierre, Wellens Joost, Piccard Isabelle, Gobin Anne, Kristof Van Tricht, Goffart Jean-Pierre, Curnel Yannick, Goffart Dimitri, Planchon Viviane, Baret Fred, Weiss Marie, Jingyi Jiang
4 years BELSPO project covering 3 crops over the whole Belgium

- 5 scientific partners led by UCL and 8 pilot/technical centers

Belgian Products at the belgian scale

Collaborative IT platform with … Pilot & Technical Centers Pionneers farmers

Agriculture Monitoring parcel level

3 crops
Partnership and collaborative system

First phase: learning phase

- Nitrogen advice
- Development monitoring & anomalies detection
- Yield estimation
- Heterogeneity map

Products based on data rich model

- Field data
- Feedback

NRT delivery

Logos: Carah, Cadco, Iwag, CIPF, Inagro, LCG, PCA, Hooghe Aaluwe
Partnership and collaborative system

Second phase: pioneers farmers integration

Products based on data rich model

Nitrogen advice

Development monitoring & anomalies detection

Yield prediction

Heterogeneity map

Field data
Feedback

Pioneers farmers

NRT delivery
First results

IMPROVEMENT OF THE NITROGEN ADVICE WITH SENTINEL IMAGES
Objective: use of Sentinel data to improve the accuracy of the actual Nitrogen recommendation

- Input data:
  - Crop type & variety
  - Soil characteristics
  - Crop residues use
  - Manure application frequency
  - Previous crop (type, yield)
  - Cover crop type, biomass
  - Cover crop ploughed/ not ploughed

Adjust the recommendation to the needs of the crops?

Is the last N dosis required?

Estimated the current N status of the crop (winter wheat and potato)

From Sentinel

Total N dosis *Requaferti*

Complementary dosis *White book*
Estimation of the N status
Empirical model

Empirical relation

$N_{canopy}$

Date effect?
Estimation of the N status
Radiative transfer model (1)

\[ C_{ab,\text{canopy}} \leftrightarrow N_{\text{canopy}} \]

Relation N vs Chlorophyll

**Leaf level (trial, INRA France)**

- \[ y = 0.0002x^{1.8729} \]
- \[ R^2 = 0.59 \]

**Canopy level (field, Belgium)**

- \[ y = 0.0313x^{1.1796} \]
- \[ R^2 = 0.56 \]

Is the last N dose required?
Estimation of the N status
Radiative transfer model (2)

Inversion of the RTM
**Prospect model** (Jacquemoud & Baret, 1990)

\[ C_{ab,canopy} \leftrightarrow N_{canopy} \]

Relation Chl measured and estimated from RTM

Leaf level (trial, INRA France)

\[ y = 0.7802x + 12.9 \]

\[ R^2 = 0.43 \]

Canopy level (field, Belgium)

Field from organic farm
remove \( \rightarrow \) RRMSE = 5%

\[ R^2 = 0.28 \]

RMSE= 6.86 (15.1 %)
bliais= 4.32
Winter wheat (N= 38 )
Previous crop (Requaferti input)
Crop type map 2015

Classifier comparison

K-nearest neighbours
Random Forest (100 trees)

Input: DMC/Deimos
- 8 March 2015
- 14 April 2015
- 4 June 2015
- 11 July 2015

Equal CAL/VAL data

OA = 83%
OA = 85%

Similar accuracies in this test, but random forest allows to add more input data

Previous method
Current method

Adding SAR data (and more optical)

→ structural information to classification in addition to biophysical information from optical data

Especially interesting for early crop mapping

OA = 91%

DMC

<table>
<thead>
<tr>
<th>Date</th>
<th>8/03</th>
<th>14/04</th>
<th>4/06</th>
<th>11/07</th>
<th>1-7/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Sentinel 1

<table>
<thead>
<tr>
<th>Date</th>
<th>Feb-Mar</th>
<th>May-Jun</th>
<th>Sep</th>
<th>OA</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/03</td>
<td>35%</td>
<td>59%</td>
<td>73%</td>
<td>84%</td>
</tr>
<tr>
<td>14/04</td>
<td></td>
<td></td>
<td></td>
<td>86%</td>
</tr>
<tr>
<td>4/06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-7/08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Classification

**DMC & Sentinel-1**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Confidence (%)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>82%</td>
<td>99%</td>
</tr>
<tr>
<td>Barley</td>
<td>66%</td>
<td>92%</td>
</tr>
<tr>
<td>Rape seed</td>
<td>55%</td>
<td>57%</td>
</tr>
<tr>
<td>Maize</td>
<td>66%</td>
<td>94%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>62%</td>
<td>93%</td>
</tr>
<tr>
<td>Beets</td>
<td>69%</td>
<td>86%</td>
</tr>
<tr>
<td>Flax</td>
<td>69%</td>
<td>85%</td>
</tr>
<tr>
<td>Grassland</td>
<td>71%</td>
<td>94%</td>
</tr>
<tr>
<td>Forest</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>Built-up</td>
<td>73%</td>
<td>79%</td>
</tr>
<tr>
<td>Water</td>
<td>54%</td>
<td>72%</td>
</tr>
</tbody>
</table>

**Sentinel-2 and Sentinel-1 classifications in progress**

**Combined confidence (%)**

(RF probability X valid data %)
First results

CROP DEVELOPMENT MONITORING & ANOMALY DETECTION
Development monitoring during the season with the Green Area Index (GAI) and meteo data.
Anomaly detection

Example on the maize (Hooibeekhoeve “Tolhuis Tongerlo”): heterogeneity due to water excess is clearly visible on Sentinel-2 fCover image time series

7 June 2016
10 July 2016
20 July 2016
6 August 2016
26 August 2016

8 Sept 2016
25 Sept 2016
5 Oct 2016

fCover

0
12.5
25
37.5
50
62.5
75
87.5
100

1 July 2016
First results

YIELD ESTIMATION
Yield estimation based on Aquacrop Integration of fCover from Sentinel-2

- Simple and robust model to estimate the biomass and yield (Requaferti input)
- Based on several factors including meteo data and development cycle of the crop

Regional follow-up of the crop with DHP

Leaf expansion

Senescence

02%
35%
55%
77%
88%
Yield estimation based on Aquacrop
First results

Maize

Potato

Winter wheat

Error = 1,6 ton/ha

Error = 0,9 ton/ha

Error = 0,9 ton/ha
Development of products of interest requested by the partners
Product requested by the PC/TC
Intra field heterogeneity map (1)

RapidEye, 5m (visual & fAPAR)

31 Aug 2015

Sentinel-2, 10m (visual & fAPAR)

22 Aug 2015

Example: potato field in Gembloux

Segmentation results

→ Similar zones
Biophysical variables (fAPAR, GAI) retrieved from Sentinel-2 images show a good potential to map intra-field heterogeneity.

Research is ongoing on this product.
Product requested by the PC/TC
Water damage detection

- VITO R&D results on using UAV and Sentinel-2 for water detection on a potato field managed by Jacob Van den Borne:

- UAV fCover < 60% → crop lost or severely damaged

Flanders: 15% lost or severely damaged

Per province:
- Antwerpen: 35%
- Limburg: 19%
- Vlaams-Brabant: 13%
- Oost-Vlaanderen: 12%
- West-Vlaanderen: 11%

Flemish agricultural regions:
- Kempen: 26%
- Vlaamse Zandstreek: 11%
- Duinen en Polders: 8%

Adjustment of the threshold for Sentinel-2 → <50%
Thank you for your attention