JECAM Belgium site

Aline Léonard, Cindy Delloye and Pierre Defourny

UCLouvain, Belgium

with the collaboration of BELCAM project team

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Belgium JECAM site: an intensive agriculture region in a fragmented landscape

- **Elevation** varies between 20 and 200 m, generally flat or slightly undulating
- **Soil drainage** is moderately well-drained
- **Crop types** are wheat, barley, potatoes, sugar beet, maize, alfalfa, etc.
- **Crop calendar**: Wheat / barley: March-August; Maize: April – September
- **Field size**: from 3 to 15 ha
- **Annual rainfall** of about 780 mm which is relatively well distributed over the year
Research Objectives: LAI retrieval from SAR

- Compare strategies to estimate winter wheat and maize LAI from C-band
  - by multi-year calibration of the Water Cloud Model
  - using empirical modeling
- Explore the different contribution of SAR polarization on LAI estimate
- Investigate the synergy between optical and SAR
Earth Observation Data Received/Used

- 11 RADARSAT-2
  - 10m

- 5 SPOT4 TAKE5
  - 20m

- 8 RapidEye
  - 5m

- 6 TerraSAR-X
  - 5m

2013

- 2014

Images of RapidEye, SPOT4 TAKE 5, and RADARSAT-2 Quad Pol are shown.
SPOT4 TAKE5
Datum
Visual interpretation of the cloud cover
10/04/2015 0%
15/04/2015 0%
20/04/2015 20%
5/05/2015 30%
15/05/2015 70%
20/05/2015 70%
4/06/2015 0%
14/06/2015 0%
4/07/2015 0%
9/07/2015 <50%
29/07/2015 <50%
13/08/2015 Haze; some clouds
23/08/2015 10%
2/09/2015 > 70%
12/09/2015 ~40%

Rapid Eye Date Visual interpretation of the cloud cover
May 13/05; 06/06 ~ 0%
June 30/06; 14/06 to 03/07 0% - 5%
July 17/07 0% - 15%
August 31/08 A lot of haze
September 11/09 (F: 0% - W: 2 tiles 5%)
October 26/10 – 01/11 Not received yet
Field Data – 2013/14/15

LAI quantification
• Field Data
  • LAI with **Digital hemispherical photography (DHP)** along the growing season
  • Phenological stages
  • 20 fields – 5 dates
Integrated Administration and Control System

Vectorial and annually updated GIS which contains crop type information on most of the agricultural parcels in the Walloon region.
Results: Leaf Area Index from RADARSAT-2

- Water Cloud Model combined with soil moisture estimate simulated by SWAP model using hourly rainfall data from a very dense meteorological network
- Empirical relationships
Maize: good performances of cross-polarization with WCM

Flevoland (n=180)

RMSE=0.46 m²/m²

Reference LAI versus simulated LAI, after Water Cloud Model inversion using VV, HH and HV polarizations using the AgriSAR 2009 data set (n=180)

JECAM site (n=34) (Beriaux, 2012)

RMSE=0.66 m²/m²

Reference LAI versus simulated LAI, after Water Cloud Model inversion using VV, HH and HV polarizations using the Belgium and Flevoland 2008/2009 data set (n=34)

Frequent retrieval of crop LAI from polarimetric SAR images is possible thanks to the WCM without requiring any specific in-situ measurements

Thanks to: - 3 existing sources of information, i.e. meteo data, soil database, optical images

- 1 hydrological model, i.e. SWAP
Winter Wheat: good performances of WCM for VV or HV polarization according to the crop phenological phase

- **Vegetative phase - 4 acq - n=49**
  
  \[
  \text{VV : RMSE} = 0.67 \text{ m}^2/\text{m}^2 \\
  \text{HH : RMSE} = 1.24 \\
  \text{HV : RMSE} = 0.55
  \]

- **Whole growing season - 7 acq - n=83**
  
  \[
  \text{VV : RMSE} = 0.98 \text{ m}^2/\text{m}^2 \\
  \text{HH : RMSE} = 1.2 \\
  \text{HV : RMSE} = 1.44
  \]

- **Whole growing season - \(\theta>38\) - 5 acq - n=61**
  
  \[
  \text{VV : RMSE} = 1.84 \\
  \text{HH : RMSE} = 0.85 \\
  \text{HV : RMSE} = 0.69
  \]
Winter Wheat: good performances of empirical linear relationship based on VV or HV polarization

- Using heterogeneous incidence angle
- Combining different ranges of soil moisture!
- But only for the vegetative phase

\[ R^2 = 0.73 \text{ RMSE} = 1.19 \text{ N} = 26 \]
\[ R^2 = 0.75 \text{ RMSE} = 0.93 \text{ N} = 26 \]
\[ R^2 = 0.61 \text{ RMSE} = 1.30 \text{ N} = 52 \]
\[ R^2 = 0.65 \text{ RMSE} = 0.75 \text{ N} = 26 \]
\[ R^2 = 0.71 \text{ RMSE} = 0.79 \text{ N} = 26 \]
\[ R^2 = 0.77 \text{ RMSE} = 0.84 \text{ N} = 52 \]

RMSE = 0.61 m²/m²
RMSE = 0.77 m²/m²

**JECAM**
Joint Experiment for Crop Assessment and Monitoring

**GROUP ON EARTH OBSERVATIONS**
Good synergy with optical imagery

- LAI retrieval RADARSAT-2 → linear regression (vegetative phase)
- LAI retrieval RADARSAT-2 → Water Cloud Model (vegetative phase)
- LAI retrieval SPOT4 → Neural network (Li et al., 2015)

Interpolation of LAI estimate over time using a canopy structure dynamic model (CSDM)
Conclusions

• LAI retrieval for maize and winter wheat was successful
• Importance of incidence angle and phenological phase
• Very promising results for optical-SAR synergy
• Great interest for a JECAM SAR experiment over multi-sites

Research Plans for Next Growing Season

• Same approach combining optical and SAR data
• Same type/quantity of EO data next year
• BELCAM project supported by BELSPO (2015-2019)
Research questions to move from research to operation

What are the **main sources of performances variability** for the biophysical variables retrieval from SAR and optical EO (LAI, biomass, chlorophyll and Nitrogen content)

Is there any simplified **mechanistic relationships** between crop yield and the EO-derived indicators

How to develop EO-derived products relevant to support farmers practices?
Products developed

In situ data
LAI, growing stages, biomass,…

Ancillary data from collaborative interactions
variety, sowing date, fertilisation, yield…

Remote sensing data
UAV flight, Spot5Take5, RapidEye, Sentinel-2A

From field level to farmers and regional levels

CANEYE
BV-NET algo
PLSR model
Canopy Structural Dynamic Models

Products
- Overall crop status (LAI, fAPAR, fCover)
- Annual field zoning
- Nitrogen status
- Yield prevision

Annual Nitrogen balance-sheet forecast
Retrieval of Nitrogen content: field experiment

### Winter wheat
- 1 field divided in 3 ESU
- 1 trial, 20 plots:
  - 5 varieties
  - 2 levels of Nitrogen
  - 2 replications

### Potato
- 2 fields
- 1 trial, 8 plots:
  - 1 variety
  - 4 fertilisation levels
  - irrigated/non irrigated

### Data collected (2 dates)
- **Field**:
  - Cropscan (5 wavelengths)
  - LAI DHP
  - Dualex & SPAD (chlorophyll meters)
- **In the lab**:
  - Biomass
  - Destructive LAI
  - ASD measurement (1 to 2500 nm)
  - Chlorophyll extraction (winter wheat)
  - Nitrogen content for 120 leaves (potato)

### Remote Sensing data
- **UAV flights** (RGB, NIR, RE)
- **Satellite imagery**: RapidEye, SPOT5TAKE5

### Empirical PLSR model & algorithm development

**Nitrogen status**
Thanks for your attention
Results: SAR temporal behavior over winter wheat fields

11 RADARSAT-2 images ➔ ascending pass direction.
➔ Acquired at 4 different beams 20 fields

End of tillering

7 TerraSAR-X
- Incidence angle: 39°
- 20 fields

Focus on vegetative phase
Soil Moisture: Similar calibrations

(Beriaux, 2012)

Figure 16. WCM calibration using volumetric soil moisture measured on the ground (n=30).

Figure 17. WCM calibration using volumetric soil moisture derived from SWAP simulation (n=30).