JECAM Belgium site

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with the collaboration of BELCAM project team

JECAM/GEOGLAM Science Meeting
Brussels, Belgium
16-17 November, 2015

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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

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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

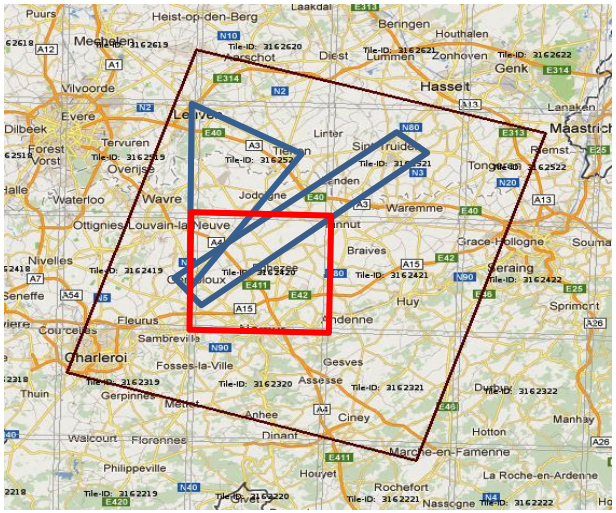
5 SPOT4 TAKE5
20m

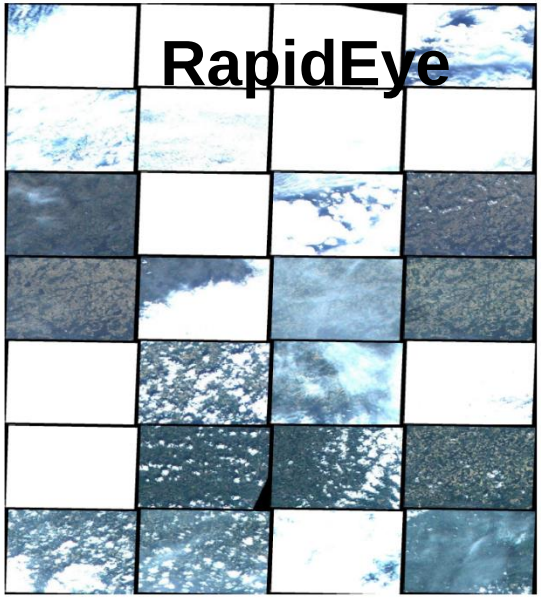
2013

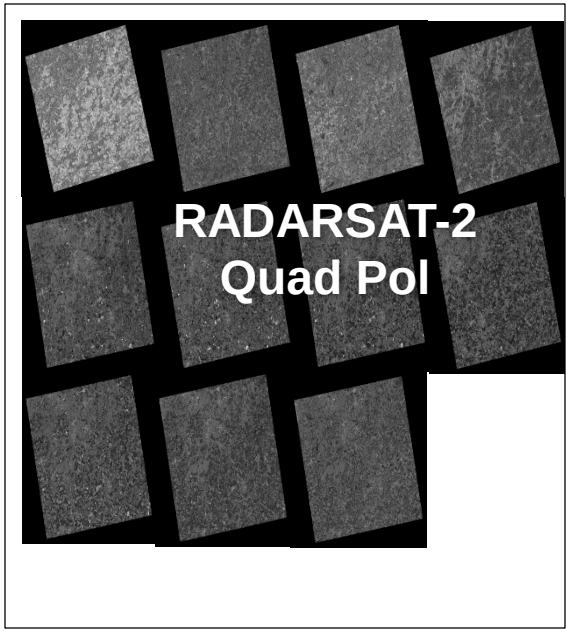
8 RapidEye
5m

6 TerraSAR-X
5m

2014





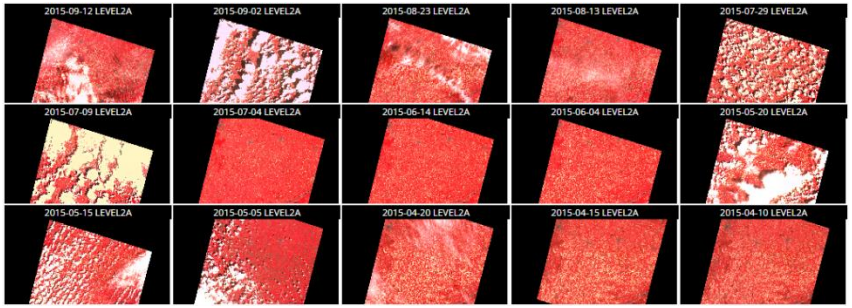


6 RADARSAT-2
10m

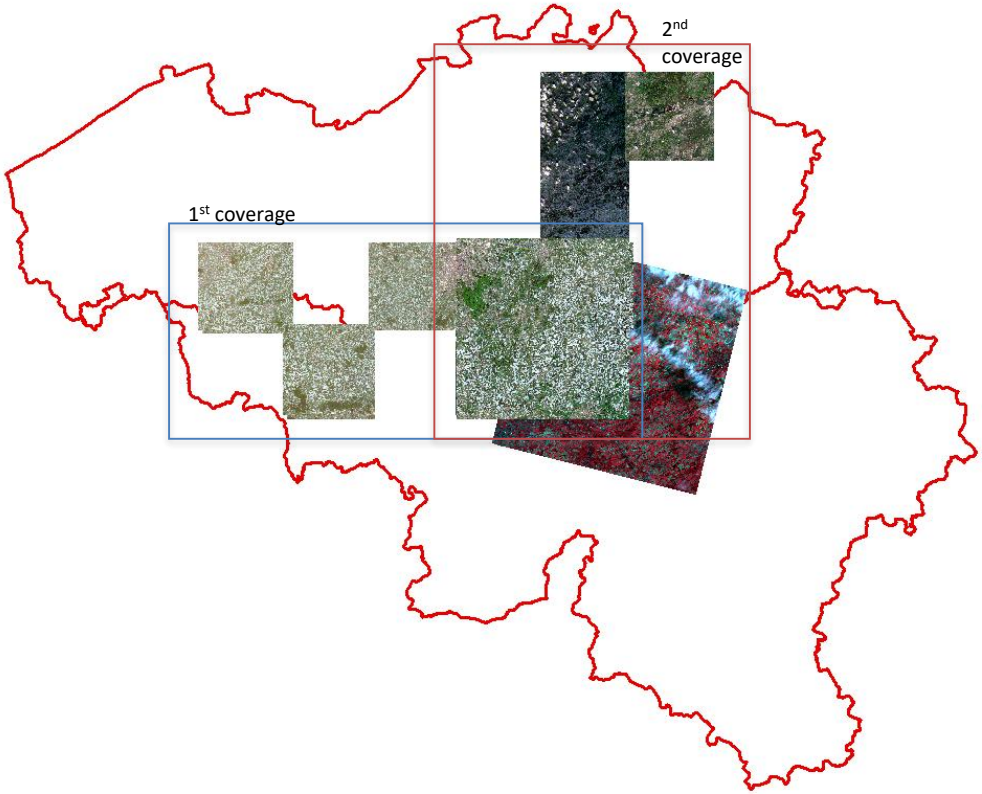
15 SPOT5 TAKE5
20m

10 RapidEye
5m

2015



SPOT4 TAKE5 Datum	Visual interpretation of 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
Septembre 11/09	(F: 0% - W: 2 tiles 5%)
October 26/10 – 01/11	Not received yet

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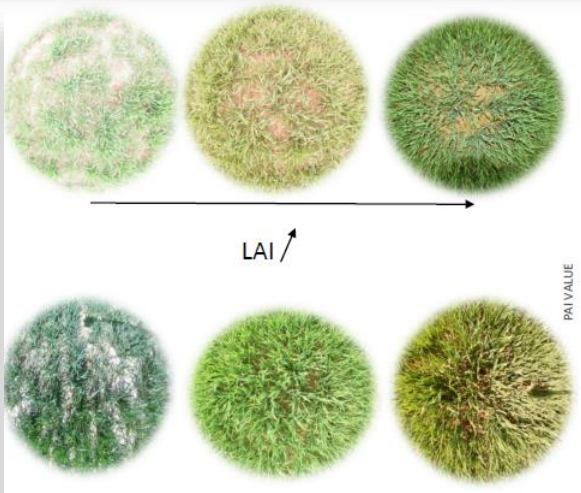
Field Data – 2013/14/15

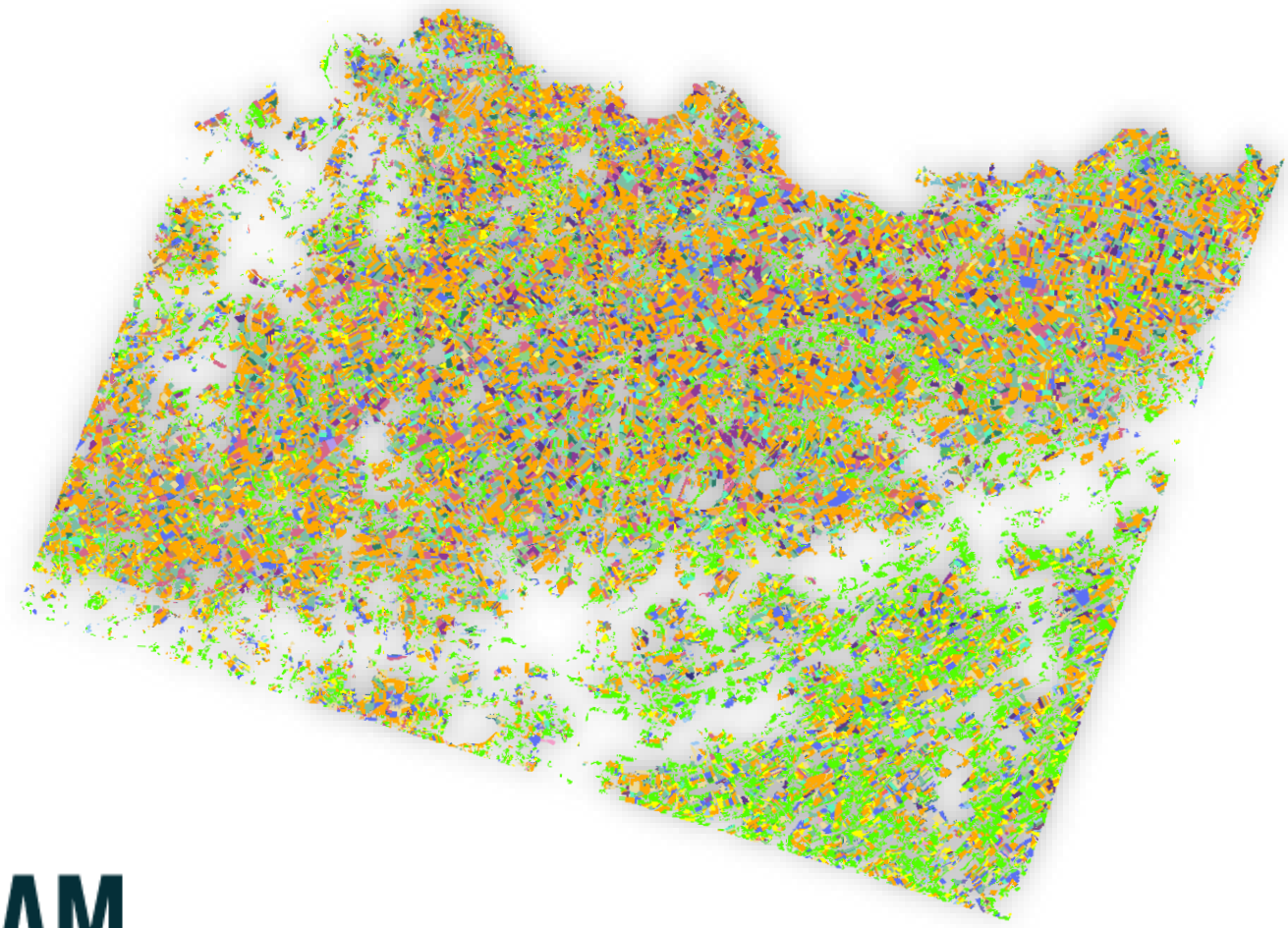
LAI quantification

- 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



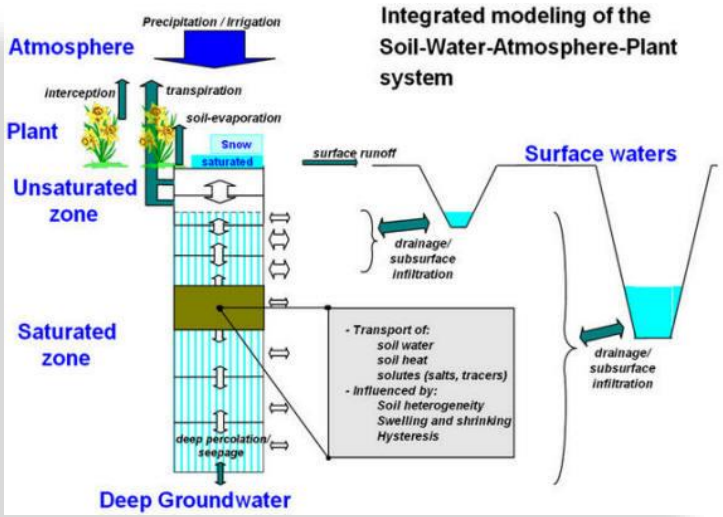
Results: Leaf Area Index from RADARSAT-2

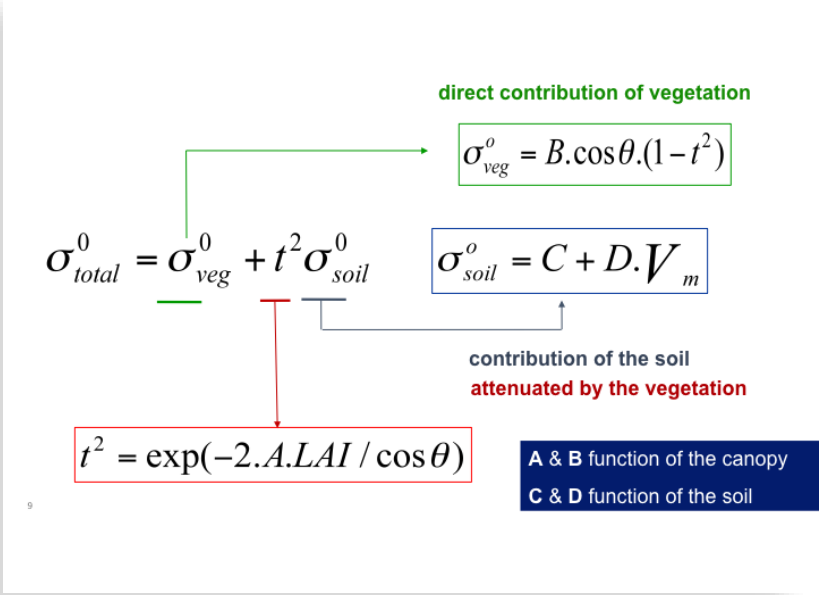
- Water Cloud Model

  combined with soil moisture estimate simulated by SWAP model

  using hourly rainfall data from a very dense meteorological network

- Empirical relationships





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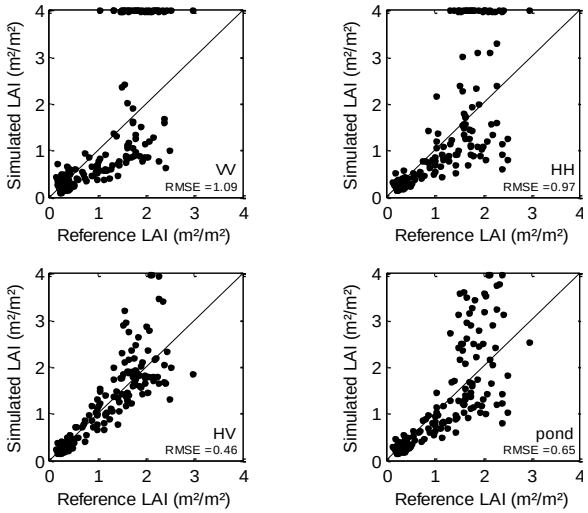
Maize: good performances of cross-polarization with WCM

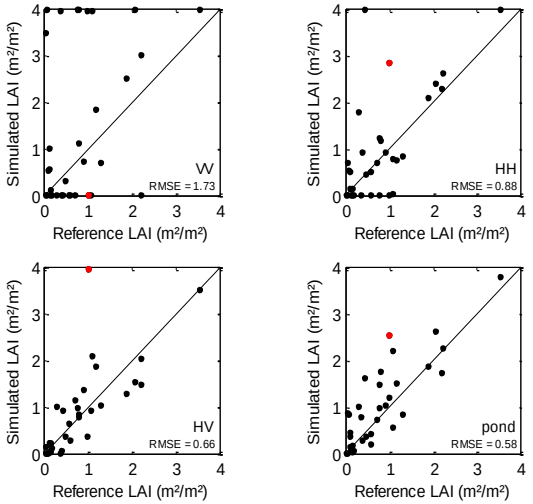
Flevoland (n=180)



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

RMSE=0.46 m²/m²

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



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)

RMSE=0.66 m²/m²

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

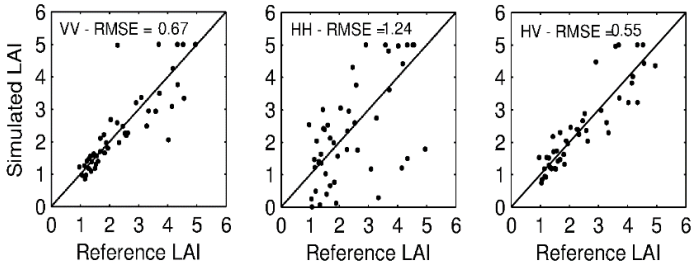
Thanks to: - 3 existing sources of information, i.e. meteo data, soil database, optical images

- 1 hydrological model, i.e. SWAP

Winter Wheat : good performances of WCM for VV or HV polarization according to the crop phenological phase

Water Cloud Model: Calibration and Inversion of 3 subsets of 2013 RS-2 time series

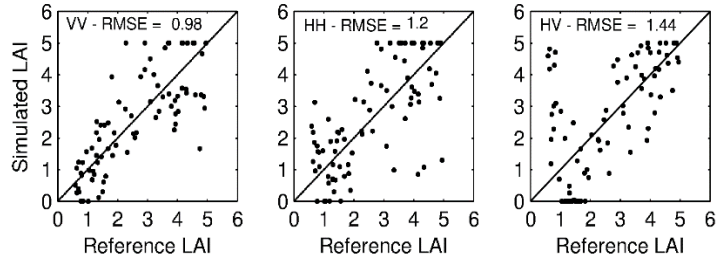
- **Vegetative phase - 4 acq – n=49**



HV : RMSE = 0.55 m²/m²

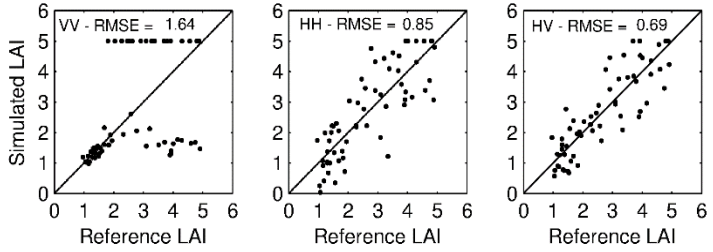
VV : RMSE = 0.67 m²/m²

- **Whole growing season - 7 acq – n=83**



VV : RMSE = 0.98 m²/m²

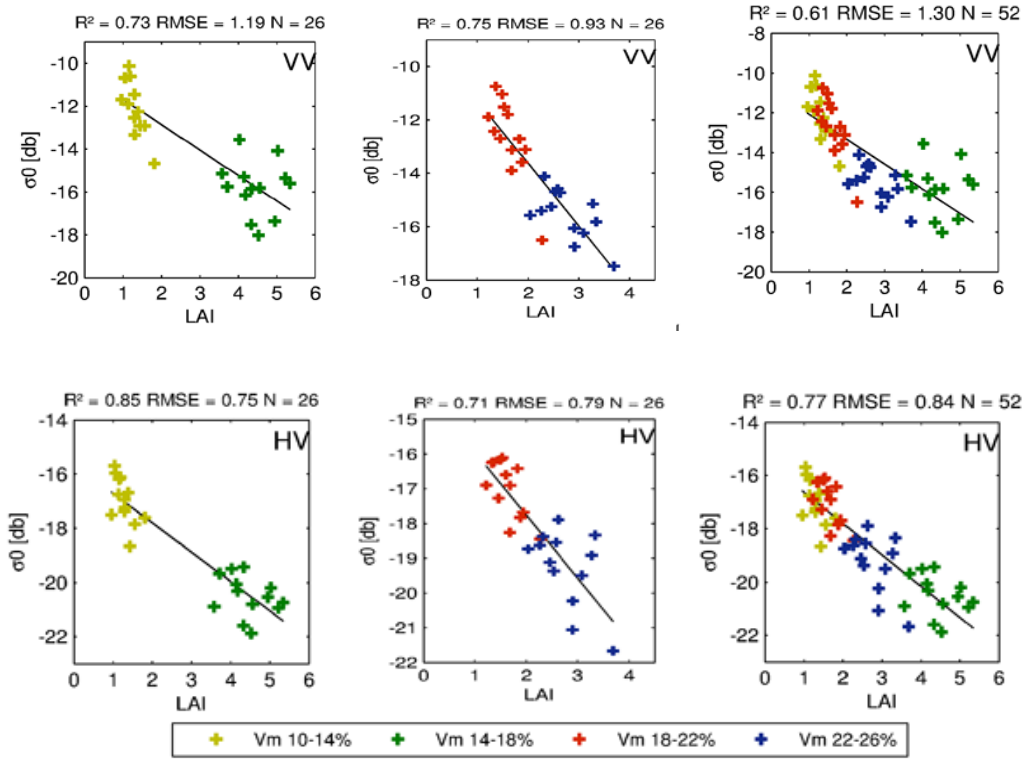
- **Whole growing season - θ>38 - 5 acq - n=61**



HV RMSE = 0,69 m²/m²

Winter Wheat : good performances of empirical linear relationship based on VV or HV polarization

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



RMSE=0.61 m²/m²

RMSE=0.77 m²/m²

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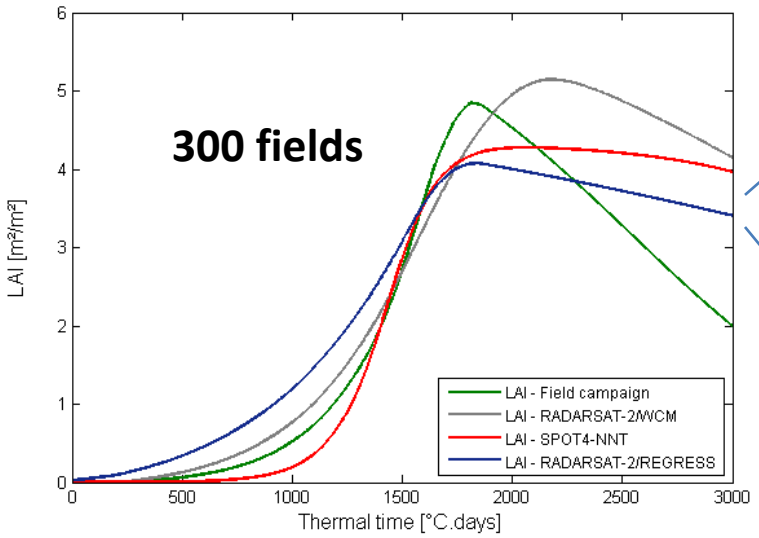
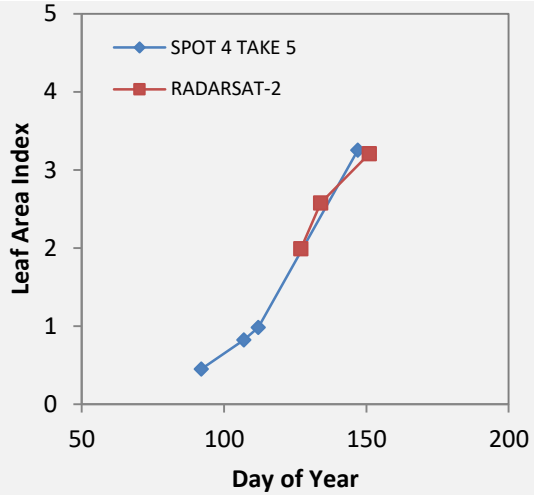
Good synergy with optical imagery

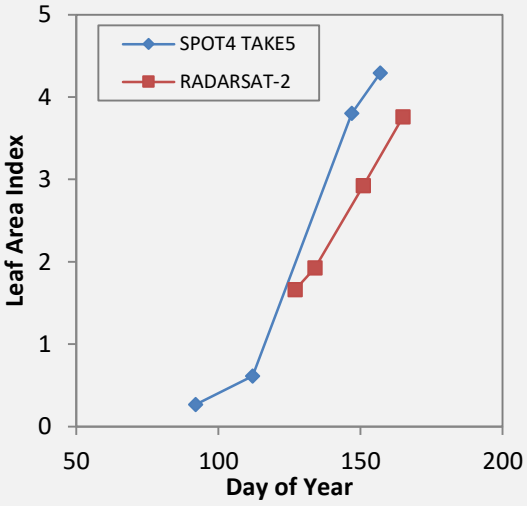
- LAI retrieval RADARSAT-2 → linear regression (vegetative phase)
- LAI retrieval RADARSAT-2 → Water Cloud Model (vegetative phase)
- LAI retrieval SPOT4 →Neural network (Li et al., 2015)



1 field



1 field



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)

BELCAM project (5 partners)

2015-2019 supported by BELSPO

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 ?

belspo

UCL Université catholique de Louvain Earth and Life Institute - Geomatics

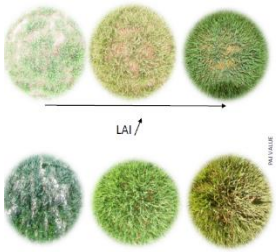
Université de Liège

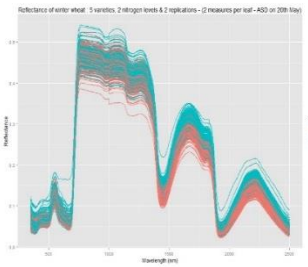
vito vision on technology

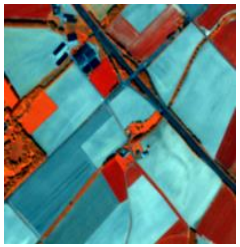
cra-w

INRA SCIENCE & IMPACT

Products developed







From field level to farmers and regional levels

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

CANEYE

BV-NET algo

PLSR model
Partial Least Square

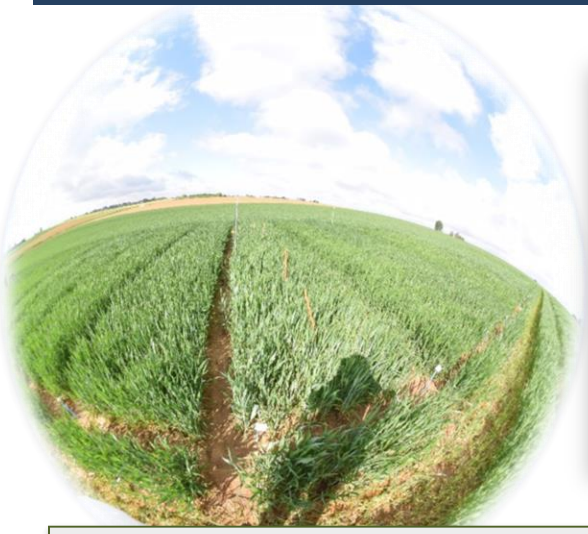
Canopy Structural Dynamic Models

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)

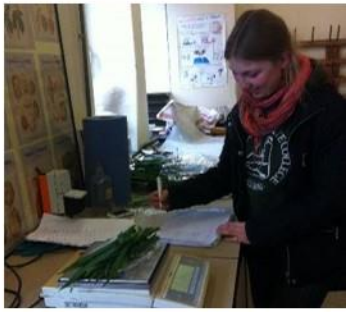
Empirical PLSR model & algorithm development

Nitrogen status

Remote Sensing data

- UAV flights (RGB, NIR, RE)
- Satellite imagery : RapidEye, SPOT5TAKE5

Thanks for your attention



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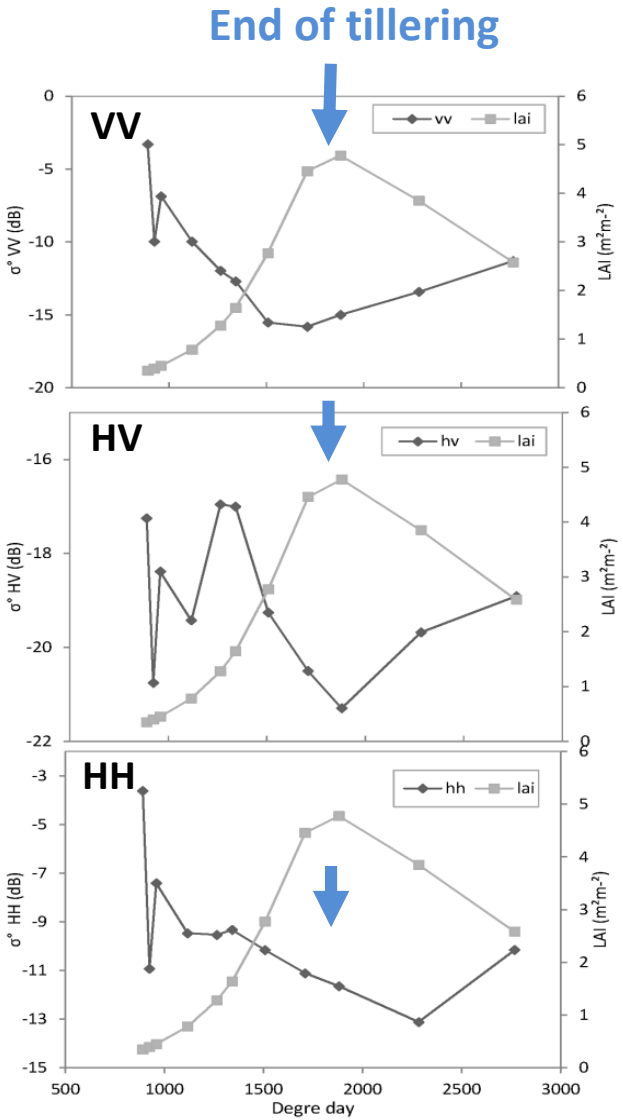
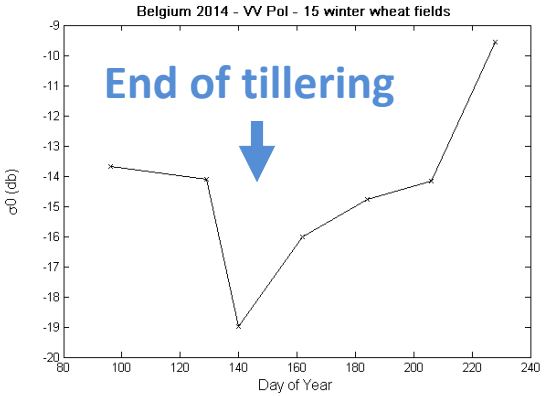
Results : SAR temporal behavior over winter wheat fields

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





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

Focus on vegetative phase

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Soil Moisture: Similar calibrations

(Beriaux, 2012)

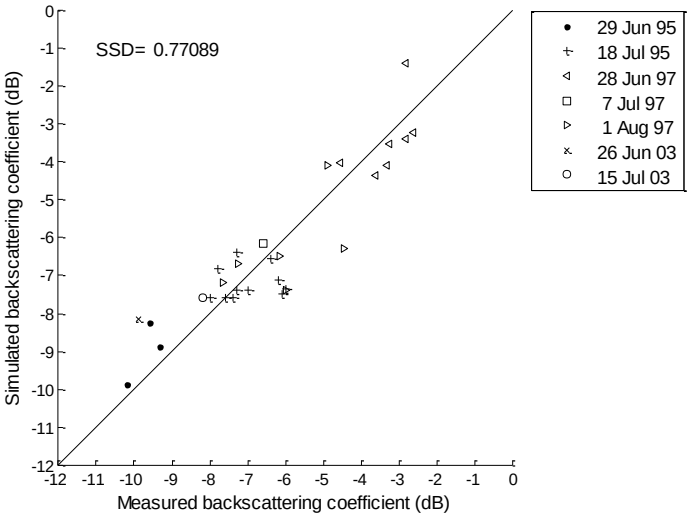
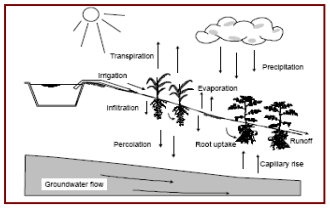


Figure 16. WCM calibration using volumetric soil moisture measured on the ground (n=30).

SWAP



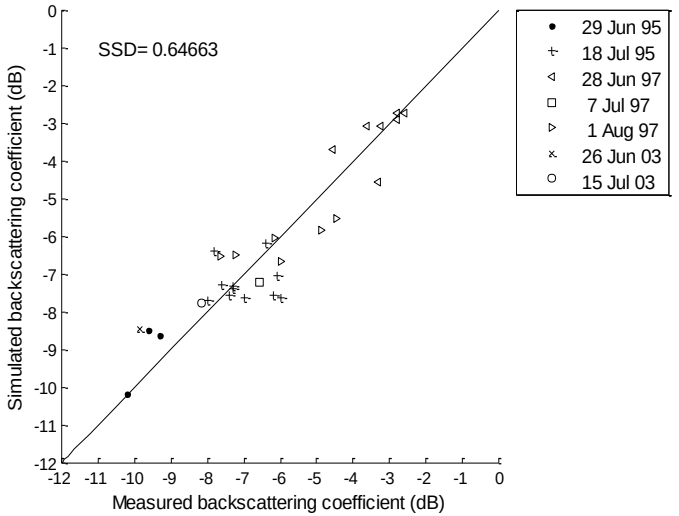


Figure 17. WCM calibration using volumetric soil moisture derived from SWAP simulation (n=30).

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