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Combined use of agro-meteorological model and multi-temporal Sentinel-1 data for monitoring corn biophysical parameters

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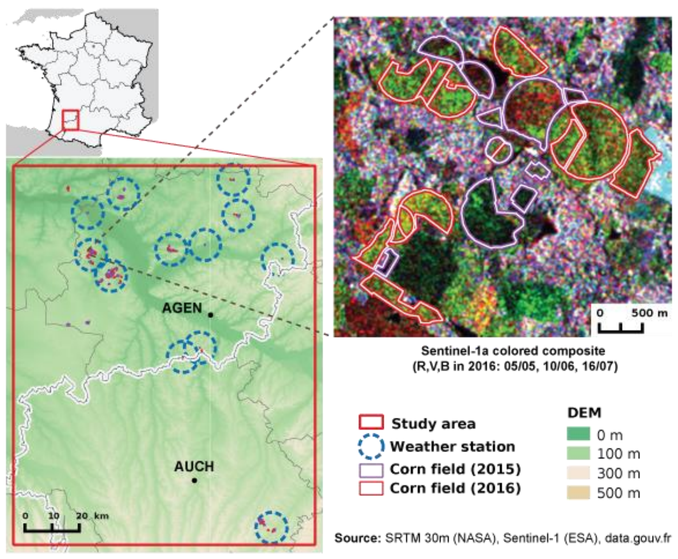
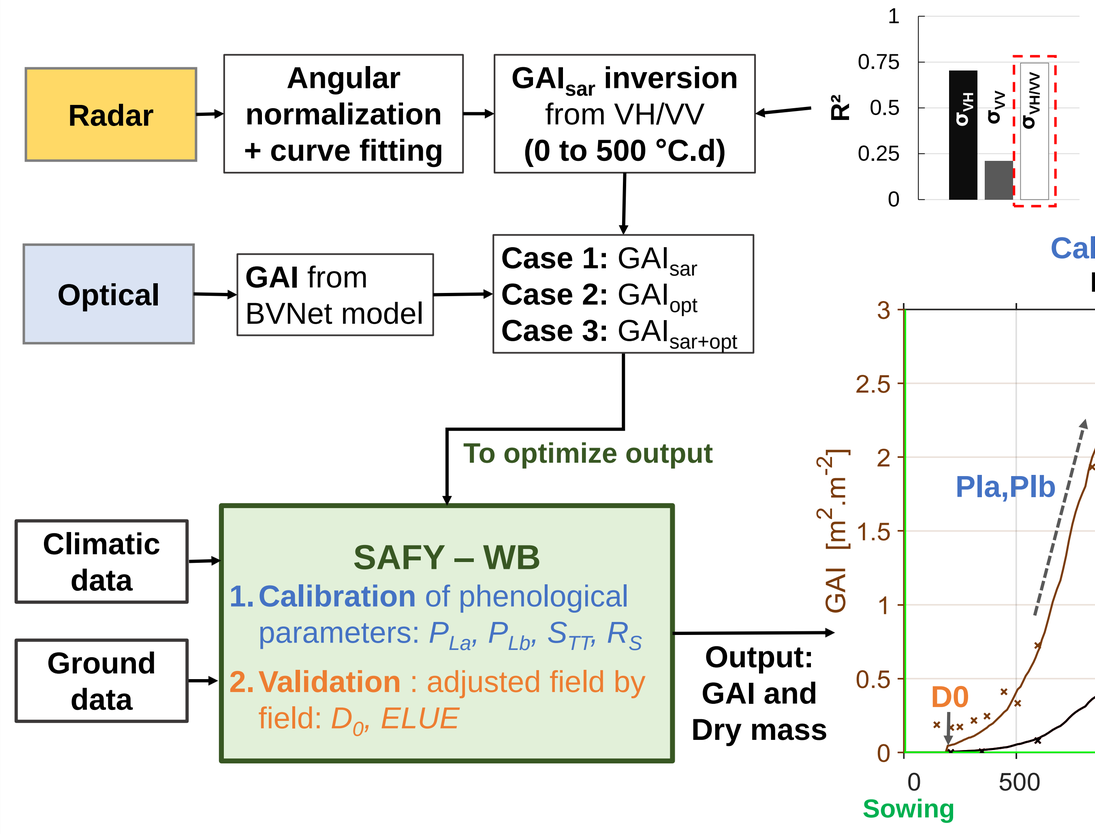
The objective of this study is to estimate corn biophysical parameters using an agro-meteorological model (SAFY-WB) constrained by satellite images acquired in the optical and microwave domains in 2015 & 2016.

The study area

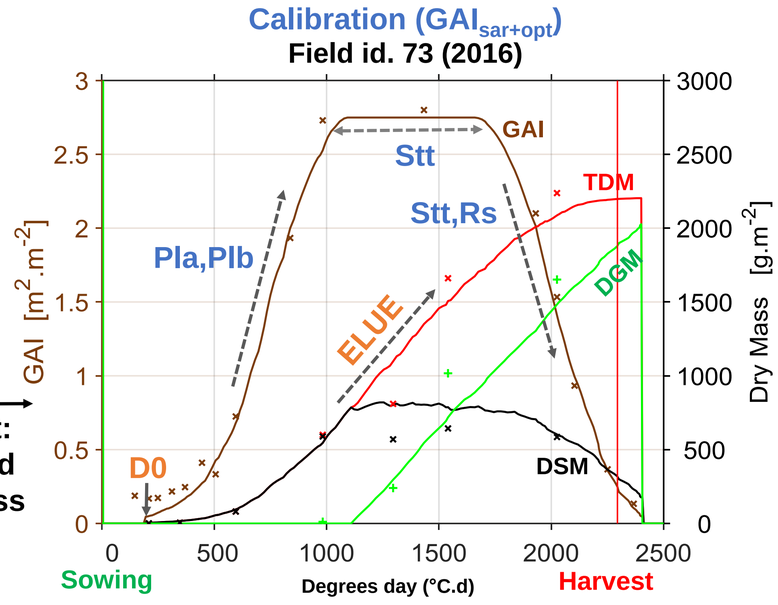


- **South west of France**
- **Surface:** 110*140 km²
- **Climate:** Temperate
- **Precipitation:** 700 mm.year^{-1}

Methodology



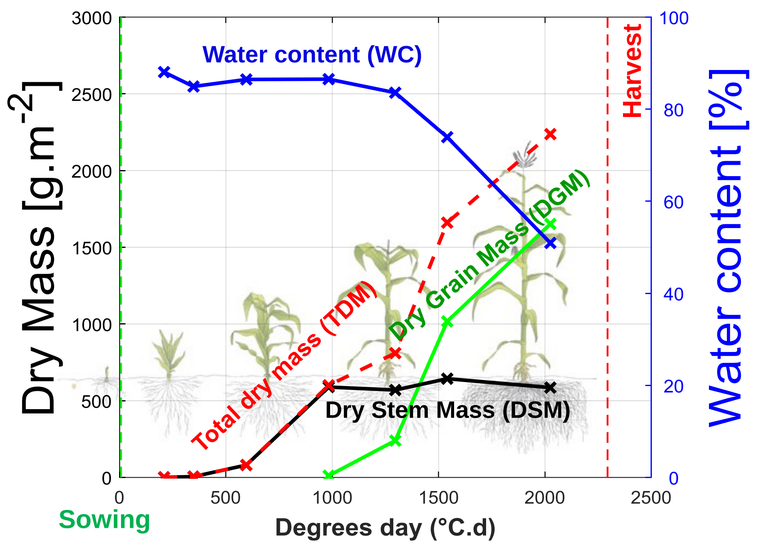
Exponential relation between GAI$_{opt}$ and radar from sowing to average signal saturation (**1200 °C.d**)



Input and validation data

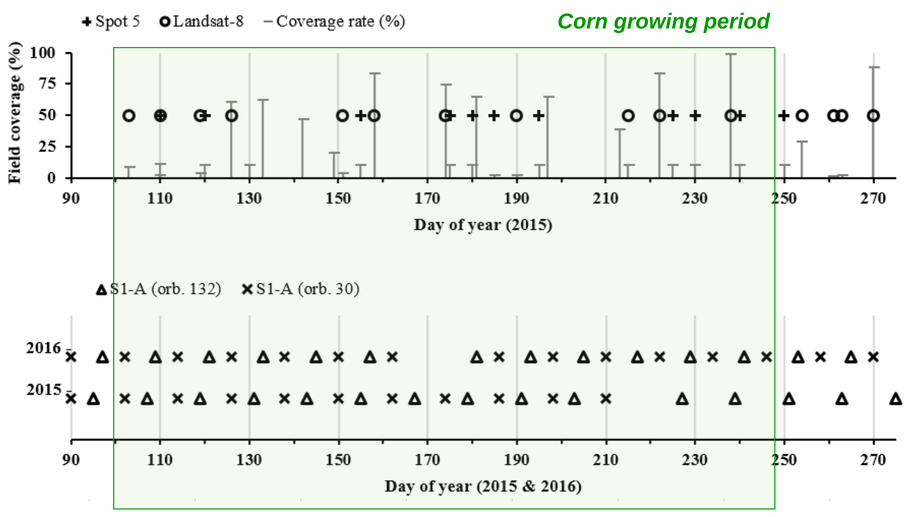
1. Ground data

- **Field measurements** from sowing to harvest (6 fields): Total Dry Mass (Stem, Grain), Water Content
- **Yield:** 65 fields in 2015



2. Satellite data

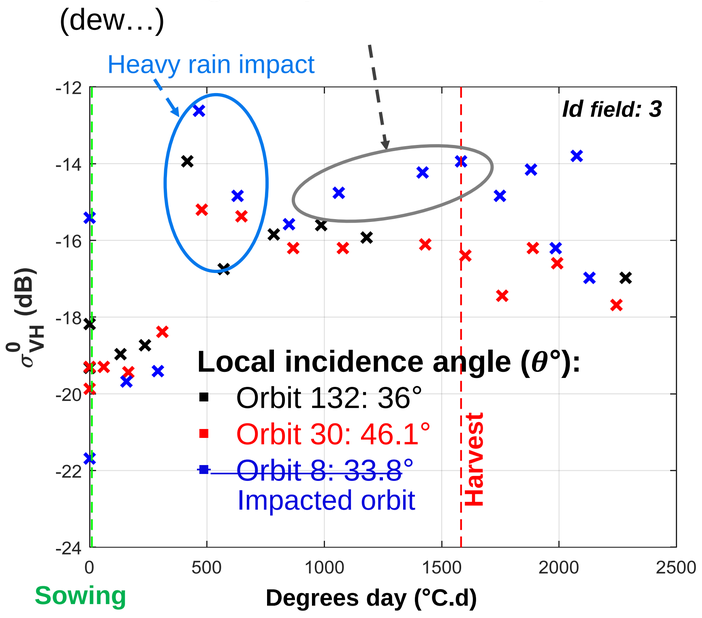
	Radar	Optical	
Mission	Sentinel-1a (Ground)	Landsat-8	Spot 5 Take 5
Swath	250 km (IW)	185 km	60 km
Revisit	12 days	16 days	5 days
Resolution	Range: 5m Azim.: 20m	30 m	10 m
Sensor features	C band: 5.4 GHz Dual polarization (VV/VH) Incidence angle: from 29.1° to 46°	B3: 0.53-0.6 µm B4: 0.63-0.68 µm B5: 0.85-0.89 µm	B1: 0.5-0.59 µm B2: 0.6-0.68µm B3: 0.79-0.89 µm



Radar signal processing

1. Orbit choice

Morning orbit (≈ 6 am GMT) : local **meteorological phenomena impact** (dew…)



2. Angular normalization (2 orbits)

a) Angular sensitivity between close acquisitions:

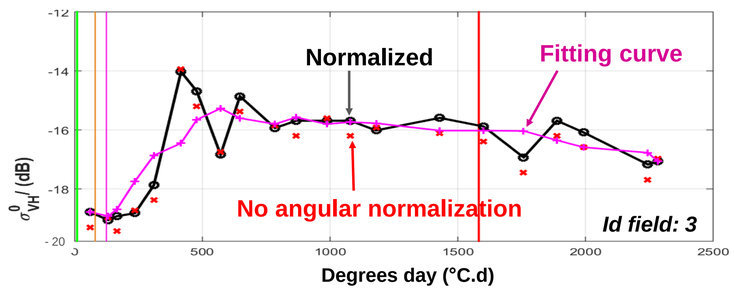
$$\tau = \frac{|\sigma_1^0 - \sigma_2^0|}{|\theta_1 - \theta_2|} \quad With$$

θ_1 *and* θ_2*: local incidence angles (°)*
σ_1^0 *and* σ_2^0*: radar signal (dB)*
θ_{ref}*: reference angle (37.5°)*

b) Normalization application

$$\sigma^0_{norm} = (\theta_{\sigma^0} - \theta_{ref}) \times \tau_{mean} + \sigma^0_i$$

3. Signal fitting: to reduce the rain impact



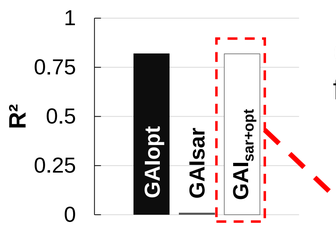
Estimation of biophysical parameters

① Calibration

One field in 2016 (id. 73)

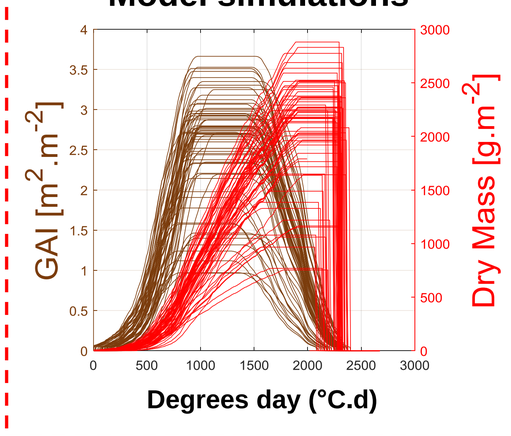
	R²	RRMSE (%)
GAIsar		
GAIsim	0.74	153
DGM	0.94	43
DSM	0.85	60
TDM	0.98	19
GAIopt		
GAIsim	0.99	11
DGM	0.97	25
DSM	0.93	34
TDM	0.98	18
GAIsar+opt		
GAIsim	0.99	10
DGM	0.97	24
DSM	0.94	30
TDM	0.97	18

② Validation : Yield estimation

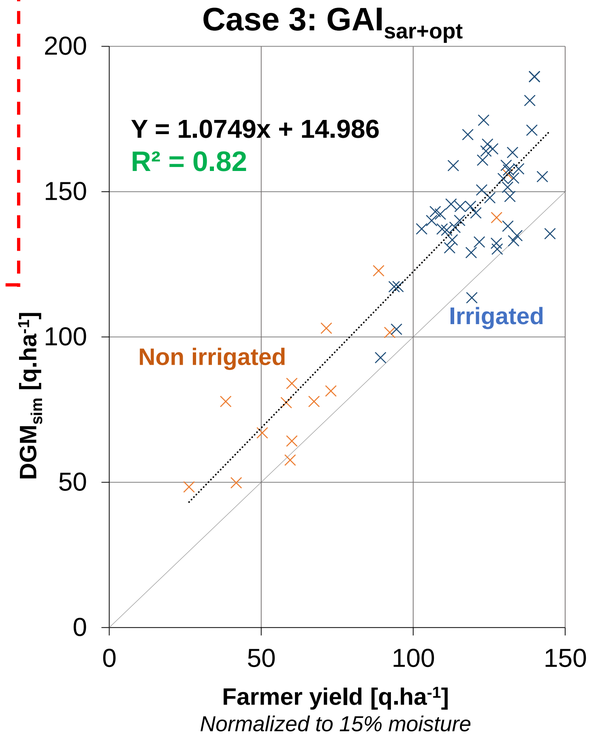


Over 65 fields in 2015

Model simulations



Case 3: GAI$_{sar+opt}$



Conclusion and prospects

- ✓ Using 2 orbits an efficient **angular normalization** allows reducing the time period from 12 to 6 days.
- ✓ High sensitivity of the radar to first phenological stages of corn

Validation parameters retrieval:

- ✓ **D0**: radar signal is able to initialize the model and can replace missing optical data (cloud…)
- ✓ **ELUE**: optical signal contraints the vegetation dynamic

Calibrated parameters are approved over a different cultural year.

The model well reproduces the GAI, dry mass dynamics (and **yield**).

Thanks ESA, ACMG, Région Nouvelle-Aquitaine and farmers for their support