Multi-frequency SAR time series for the detection of sowing events and early-season crop classification

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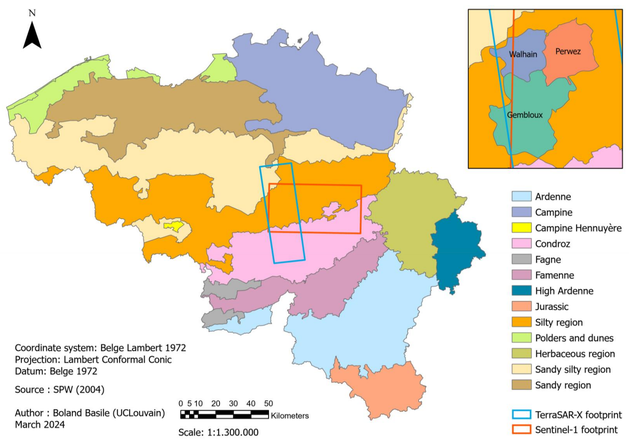
Context



- ROI = Intersection of both footprints (~1500 fields)
- Field campaign : **166 fields** (2021-03 → 2021-05)
  11 days revisit time
- Focus on three main spring crops :

Beet **Potato** **Maize**

Comparative and combined analysis C & X-Band

➔ Different sensitivity to soil roughness and moisture

TerraSAR-X
X-band (λ ≈ 2.5 cm)
Surface monitoring
11 days revisit

Sentinel-1
C-band (λ ≈ 5 cm)
Soil penetration
6 days revisit (1A+1B)

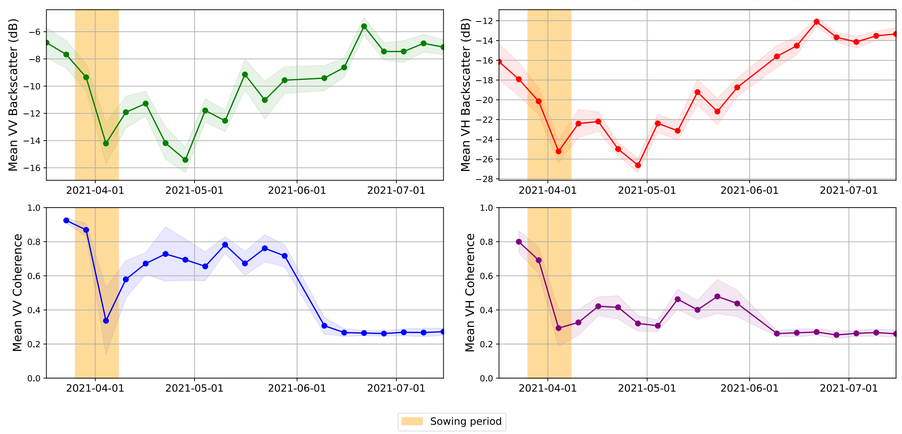
Early and consistent monitoring enhance crisis management

Improve agriculture modelling in early season (yield, disease spread,...)

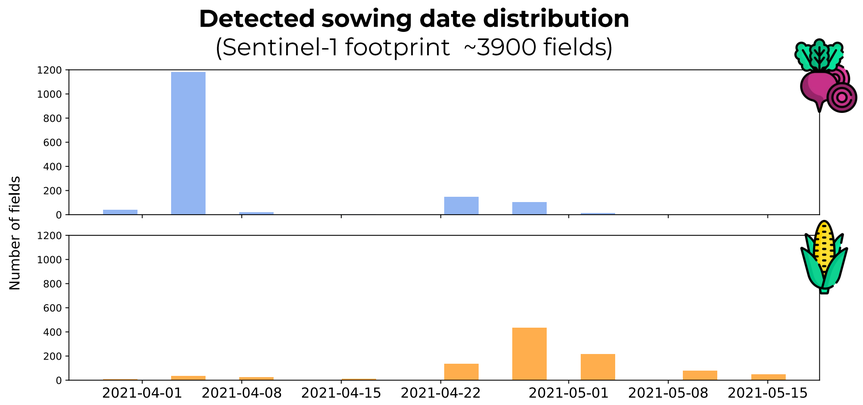
Insurance validation and support of CAP-related policies

Detection of sowing events using Sentinel-1 coherence

Time series for beet fields using Sentinel-1 (Field campaign)



Detected sowing date distribution
(Sentinel-1 footprint ~3900 fields)



Methods

- **Backscatter** and **coherence** (S1 only) time series for same crop type plots sharing a common sowing period (field campaign)
- Highlights differences in roughness and moisture due to soil management practices and/or vegetation emergence

Key findings

- Sowing period defined by the **minimum in VV coherence** before mid May (average vegetation emergence period)
- Detection accuracy of **81%**
  (±1 day margin with n = 48)
  - 89% for beet
  - 78% for potato
  - 73% for maize
- The predicted sowing date distribution (complete S1 footprint) highlights the **temporal homo- & heterogeneity** of sowing events over time, depending on the crop type

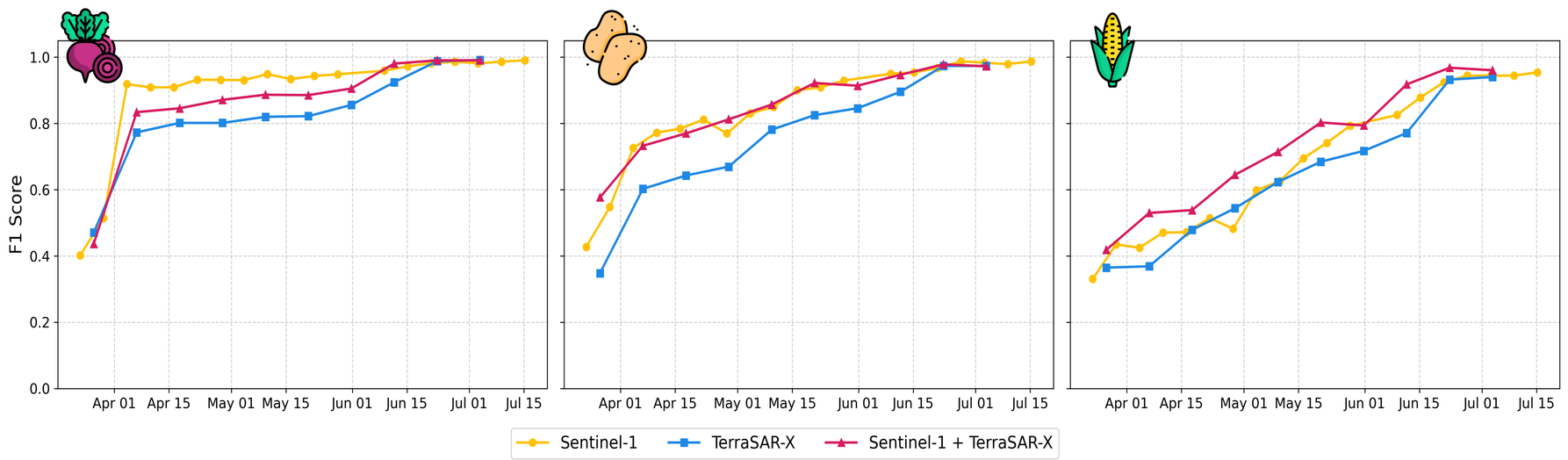
Early-season crop classification – How do different sensors perform ?

Methods

- **Random Forest** algorithm (80/20 split) using SMOTE for class balance
- Parcel based zonal statistics (ROI) :
  - VV, VH **backscatter** (mean, std dev)
  - Radar **indices** (CR, DpRVI)
  - VV, VH **coherence** (mean, std dev)
- **Cumulative addition** of data features by acquisition date, allowing representation of an evolution in the F1 score over time
- Interest on the **individual and combined performance** of C-band and X-band data but also performance **by crop type**

Key findings

- When comparing sensors individually : **S1 performs better than TSX** for all crop types
- **Multi-frequency** can help discriminating maize compared to individual sensors
- Beet fields show better early-season classification than maize and potato



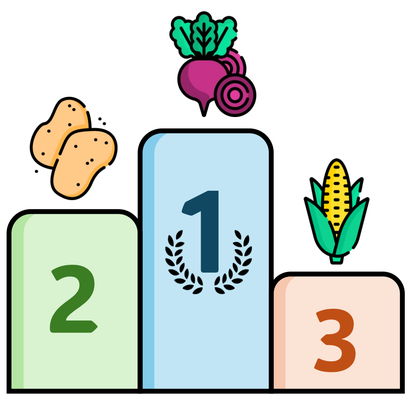
When are different crop types reaching an **F1 score of 0.8** for each sensor?

	Beet	Potato	Maize
Sentinel-1	April 4th	April 22nd	June 9th
TerraSAR-X	April 17th	May 20th	June 20th
Combined	April 6th	April 28th	May 20th

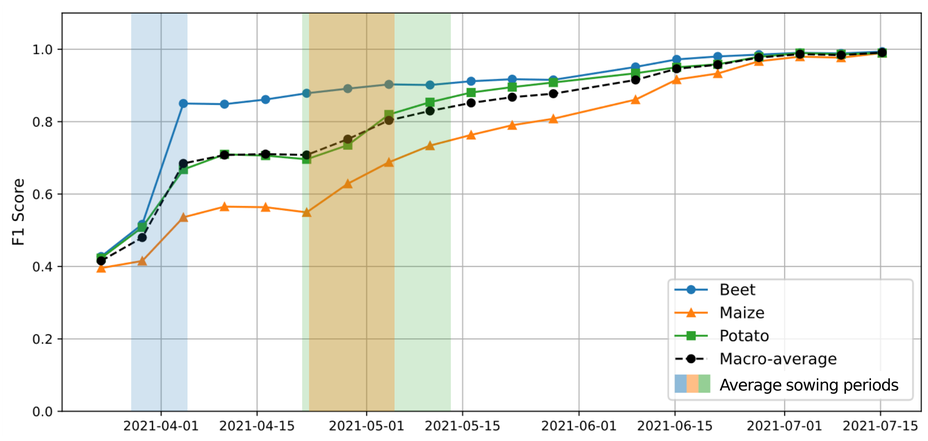
➔ Besides the difference in moisture and rugosity sensitivity, the high temporal resolution of S1 offers more precise detection and classification

Conclusions and perspectives

At first sight we could conclude that beet fields are more easily classified in the early season compared to other main crops



However, classification results are strongly influenced by the average sowing period of each crop
➔ F1 score increases during that event
(here with the complete S1 footprint)



- In intensive crop systems, SAR sowing detection is reliable and supports **very early crop type mapping (F1 score >0.8), before any vegetation development**
- Overall, the use or addition of **X-band data does not improve** early classification significantly (except for maize fields), highlighting the importance of **C-band soil penetration** in the monitoring of agricultural landscapes
- Future perspectives for the study include the addition of other crop types and the assessment over multiple years to evaluate the impact of changes in the agricultural calendar and/or weather conditions

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