MONITORING CROP PHENOLOGY AT FIELD SCALE COMBINING HIGH AND MEDIUM SPATIAL RESOLUTION DATA

Henry Rivas[1], Nicolas Delbart[2], Catherine Ottlé[3], Fabienne Maignan[3], and Emmanuelle Vaudour[4]

[1]Université de Paris, UMR8586 PRODIG
[2]Université Paris Diderot, UMR8586 PRODIG
[3]Laboratoire des Sciences du Climat et l'Environnement
[4]ECOSYS, AgroParisTech

November 22, 2022

Abstract

Crop monitoring requires both high spatial resolution data (HSR) for observing within sub-parcel scale, and high temporal resolution (HTR) to monitor vegetation changes during along the crop cycle. However, these simultaneous requirements are difficult to fulfill by the same satellite. In temperate areas such as the Versailles Plain, near Paris, France, HRS data have at best a dozen images exploitable per year, even with Sentinel-2 because of cloud cover, while those with medium spatial resolution (MRS) provide daily images, but at the generally mixed pixel scale. In France, the Land Parcel Identification System (LPIS) is an information system of the crop types declared by farmers, providing reference information about the annual crops cultivated within each agricultural parcel. In this work, the objective was to monitor the phenology of annual crops recorded in the LPIS of 2016, using satellite image time series from HRS Sentinel-2 (10m) and MRS Proba-V (100m) acquired from early to end of 2016 over the Versailles Plain, a small agricultural region (221 km2) cultivated with annual crops. From the two types of time series, the temporal variations of vegetation indices (NDVI / EVI2) of crops were extracted in order to analyze the crop seasonal variations of winter wheat, winter oilseed rape and maize over 2857 parcels with average size of 6.88 ha. The linear method of spatial disaggregation was applied on the MRS data, using fractions of each crop type in the mixed pixels calculated from the 2016-LPIS. The temporal responses from HRS data were compared with those of the MRS sub-pixels. Comparisons between both time series revealed significant correlations for the three studied crops (winter wheat = 0.94, winter oilseed rape = 0.74 and maize = 0.79). By improving the temporal frequency of the monitoring, from13 images for HRS to 25 images for MRS, the disaggregated MRS time series enabled to distinguish the phenological stages of the three studied crops better than the HRS time series. In conclusion, our method of spatial disaggregation can be used to improve the exploitation of satellite data at MRS in seasonal crop monitoring, especially during the transition periods when the spectral indices of crops are likely to change quickly.

Geophysical Research Abstracts
Vol. 21, EGU2019-11103, 2019
EGU General Assembly 2019

Monitoring phenology of crops at the parcel scale : combining high and medium spatial resolution data

Henry Rivas (1), Nicolas Delbart (1), Catherine Ottlé (2), Fabienne Maignan (2), and Emmanuelle Vaudour (3)
(1) PRODIG (UMR8586), Université Paris Diderot, Paris, France, (2) LSCE (UMR8212), Orme des Merisiers, Gif-sur-Yvette, France , (3) UMR ECOSYS, AgroParisTech, INRA, Université Paris-Saclay, 78850, Thiverval-Grignon, France

Remotely-sensed vegetation phenology is used here to identify key stages of annual crop development and, in this basis, as an indicator of annual crop type.

Crop monitoring requires both high spatial resolution data (HSR) for observing within sub-parcel scale, and high temporal resolution (HTR) to monitor vegetation changes during along the crop cycle. However, these simultaneous requirements are difficult to fulfill by the same satellite. In temperate areas such as the Versailles Plain, near Paris, France, HRS data have at best a dozen images exploitable per year, even with Sentinel-2 because of cloud cover, while those with medium spatial resolution (MRS) provide daily images, but at the generally mixed pixel scale.

In France, the Land Parcel Identification System (LPIS) is an information system of the crop types declared by farmers, providing reference information about the annual crops cultivated within each agricultural parcel. In this work, the objective was to monitor the phenology of annual crops recorded in the LPIS of 2016, using satellite image time series from HRS Sentinel-2 (10m) and MRS Proba-V (100m) acquired from early to end of 2016 over the Versailles Plain, a small agricultural region (221 km^2) cultivated with annual crops.

From the two types of time series, the temporal variations of vegetation indices (NDVI / EVI2) of crops were extracted in order to analyze the crop seasonal variations of winter wheat, winter oilseed rape and maize over 2857 parcels with average size of 6.88 ha. The linear method of spatial disaggregation was applied on the MRS data, using fractions of each crop type in the mixed pixels calculated from the 2016-LPIS.

The temporal responses from HRS data were compared with those of the MRS sub-pixels. Comparisons between both time series revealed significant correlations for the three studied crops (winter wheat = 0.94, winter oilseed rape = 0.74 and maize = 0.79). By improving the temporal frequency of the monitoring, from13 images for HRS to 25 images for MRS, the disaggregated MRS time series enabled to distinguish the phenological stages of the three studied crops better than the HRS time series.

In conclusion, our method of spatial disaggregation can be used to improve the exploitation of satellite data at MRS in seasonal crop monitoring, especially during the transition periods when the spectral indices of crops are likely to change quickly.

MONITORING CROP PHENOLOGY AT FIELD SCALE COMBINING HIGH AND MEDIUM SPATIAL RESOLUTION DATA

Henry **RIVAS**[1], Nicolas **DELBART**[1], Catherine **OTTLE**[2], Fabienne **MAIGNAN**[2], Emmanuelle **VAUDOUR**[3]

[1] **PRODIG**, Université Paris Diderot, Paris, France, [2] **LSCE**, Orme des Merisiers, Gif-sur-Yvette, France, [3] **ECOSYS**, AgroParisTech, INRA, Université Paris-Saclay, 78850, Thiverval-Grignon, France.
Contact: **henry_ullon@hotmail.com**

1. Introduction

Monitoring agricultural vegetation changes along the crop cycles at **field scale** requires both **high spatial resolution** data (HSR) and **high temporal resolution** (HTR) to follow changes even during transition periods. However, it is quite difficult for a same satellite to comply with these simultaneous requirements. In temperate areas such as the Versailles Plain, near Paris, France, HSR data have at best twelve exploitable images per year, even with Sentinel-2 (10m) because of cloud cover, while medium spatial resolution (MSR) data provide daily images, which allow to synthetize cloud-free images every 5 to 10 days, but generally at the cost of mixing several crop types within each pixel.

Objective : Merge the spatial information of Sentinel-2 (10m) data with the higher frequency of Proba-V (100m) data to monitor the phenology of annual crops at field scale.

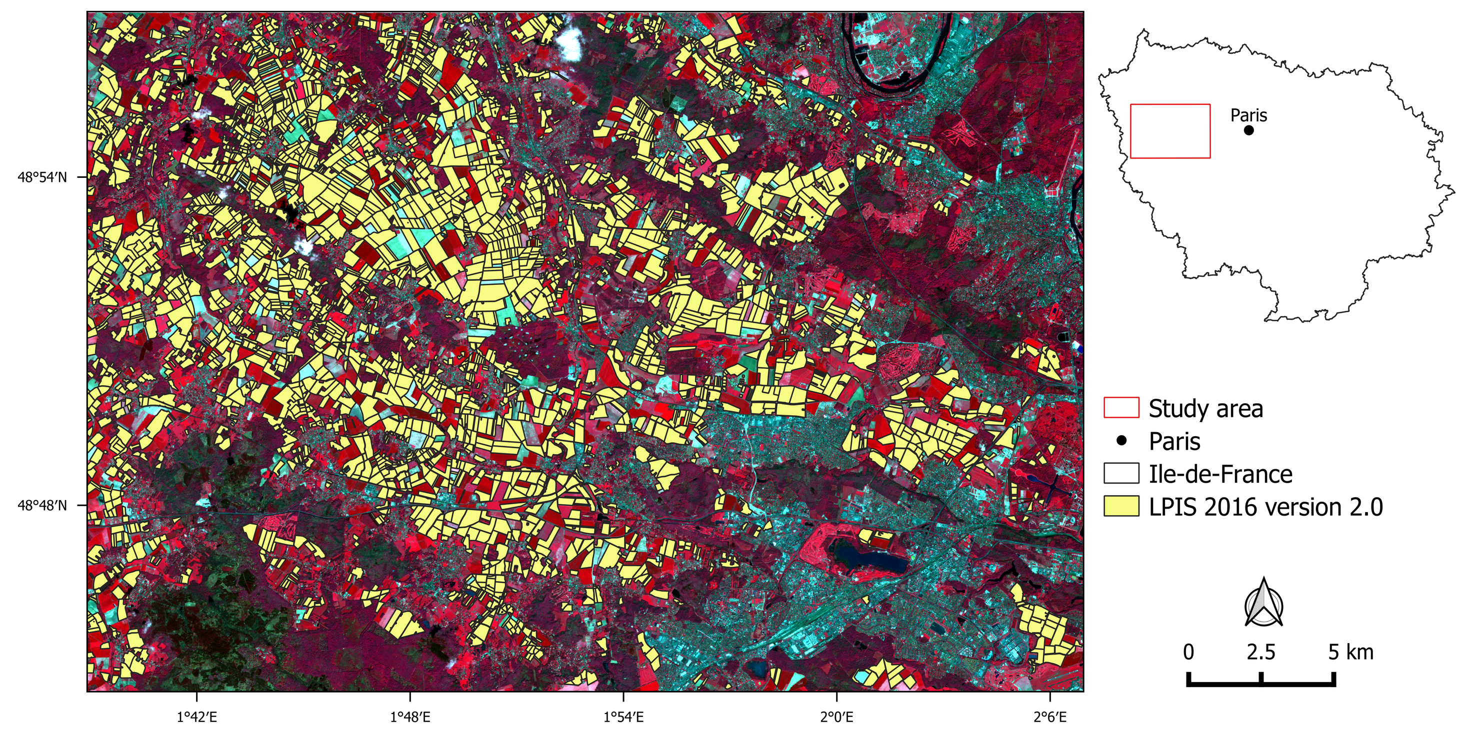

Figure1. False color composite Sentinel-2 (10m) image of May 04, 2016 over study area superimposed by fields of winter wheat, winter oilseed rape and maize from the LPIS of 2016 version 2.0 (geographic information system of the crops types declared by farmers). The study area is a 221 km² agricultural region in the Yvelines department, West of the Ile-de-France region, 30 km away from Paris (48°45'-48°57'N; 1°40'-2°10'E).

2. Methods

The linear method of spatial disaggregation was applied on the MSR data, using fractions of each crop type in the mixed pixels calculated from the LPIS of 2016 version 2.0. The principle of this method is that the energy reaching the sensor is a simple linear sum of each component of the vegetation cover, as shown by the following equation [1]:

$$R_b = \sum_{i=1}^{n} r_{i,b} x_i + e_b$$

Where ***Rb*** is the reflectance of pixel in the band ***b***, ***ri,b*** is the reflectance of crop ***i*** in the band ***b***, ***xi*** is the fraction of crop ***i*** in the pixel and ***eb*** is the additive noise in the band ***b***.

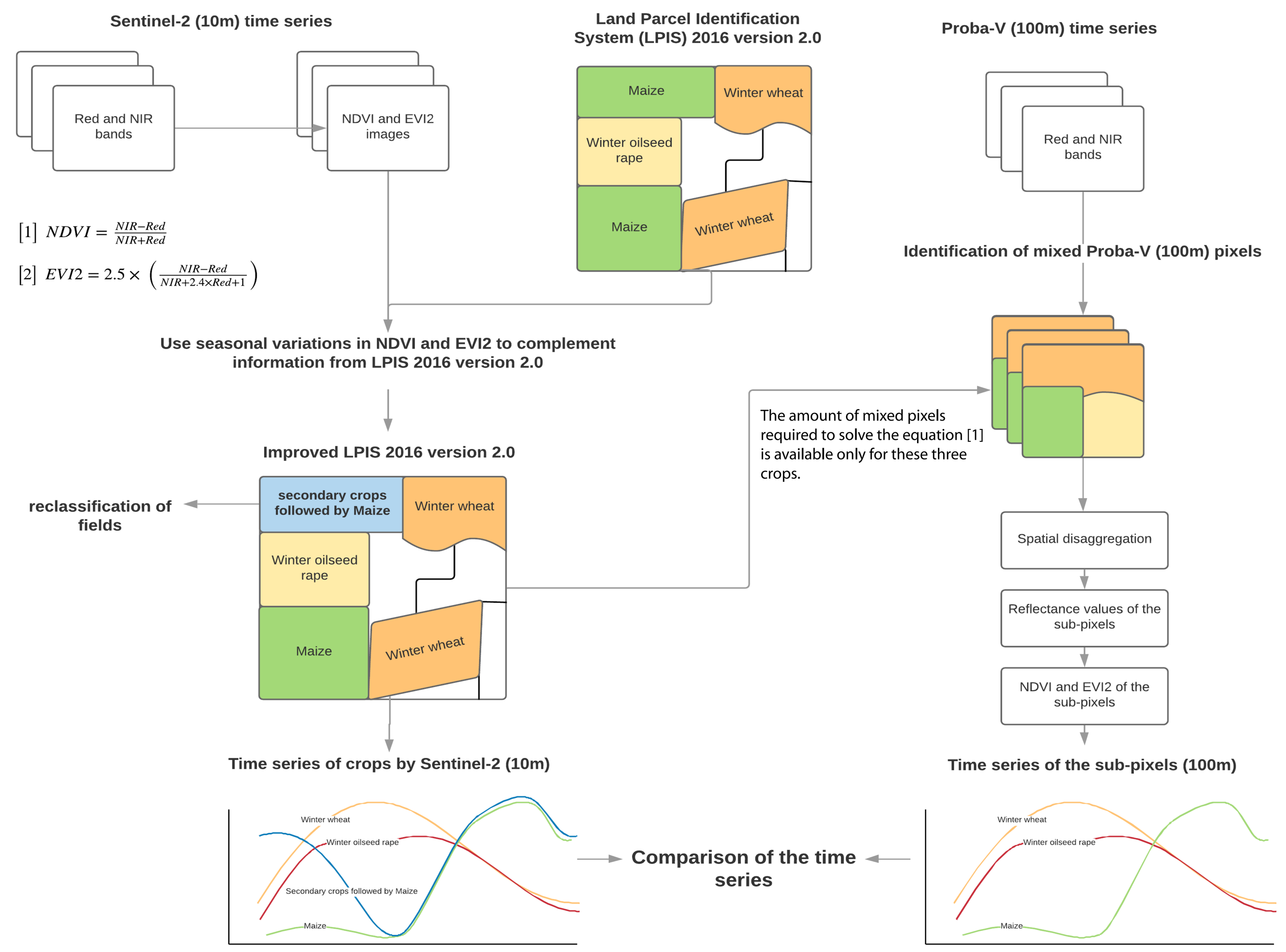

Figure 2. Workflow of extraction of temporal variation of crops vegetation index (NDVI and EVI2).

3. Results

The HSR data illustrate the different phenological stages of crops (Figure 3) but with a low temporality (5 images between March and June, flowering period and senescence for winter crops).

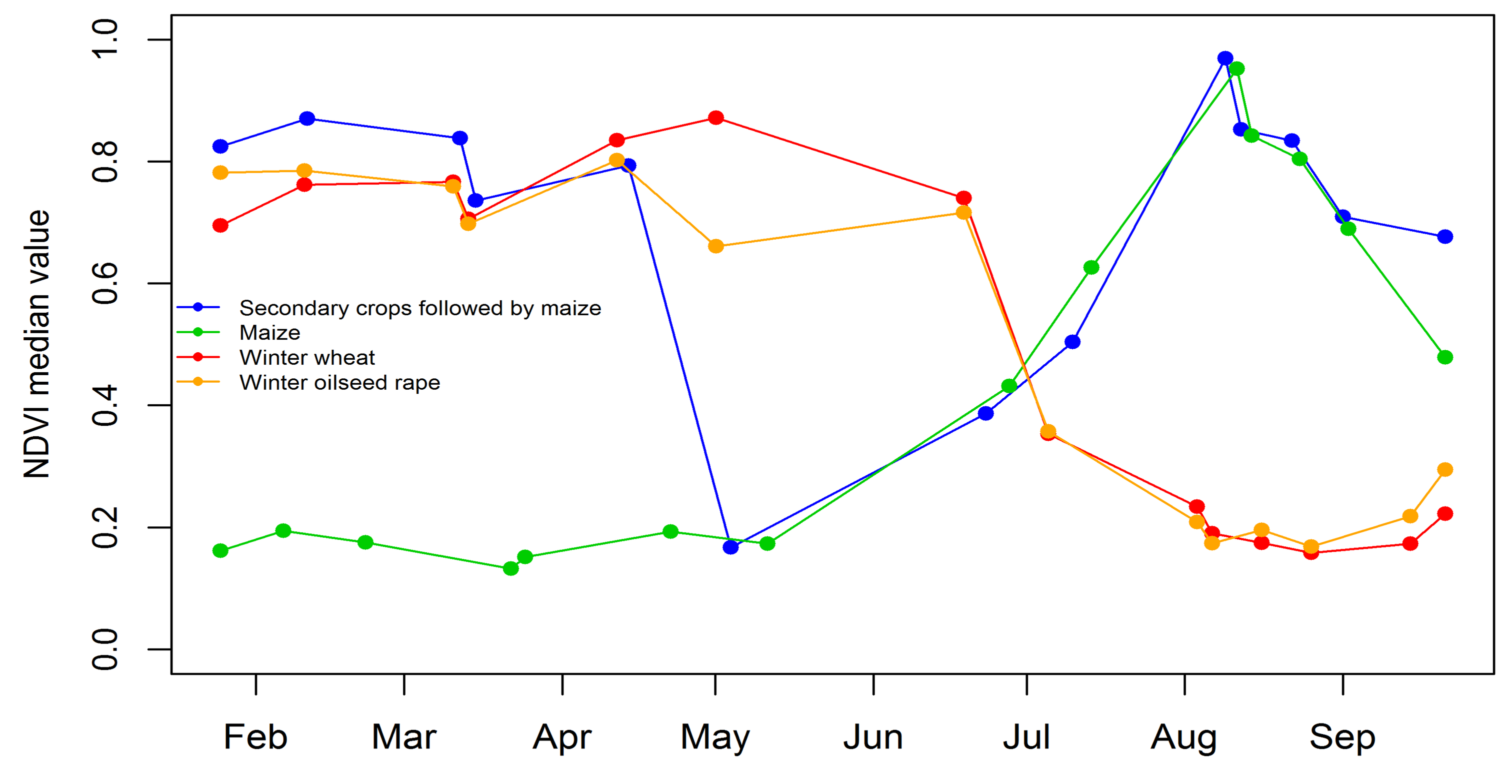

Figure 3. Time series of NDVI from Sentinel-2 (10m).

Disaggregated Proba-V (100m) time series is correlated with Sentinel-2 (10m) time series for the three studied crops (Table 1). The temporal frequency of the monitoring is improved from 13 images for HSR to 25 images for MSR. Thus the disaggregated MSR time series enabled to distinguish the phenological stages of the three studied crops at least as well than the HSR time series (Figure 4).

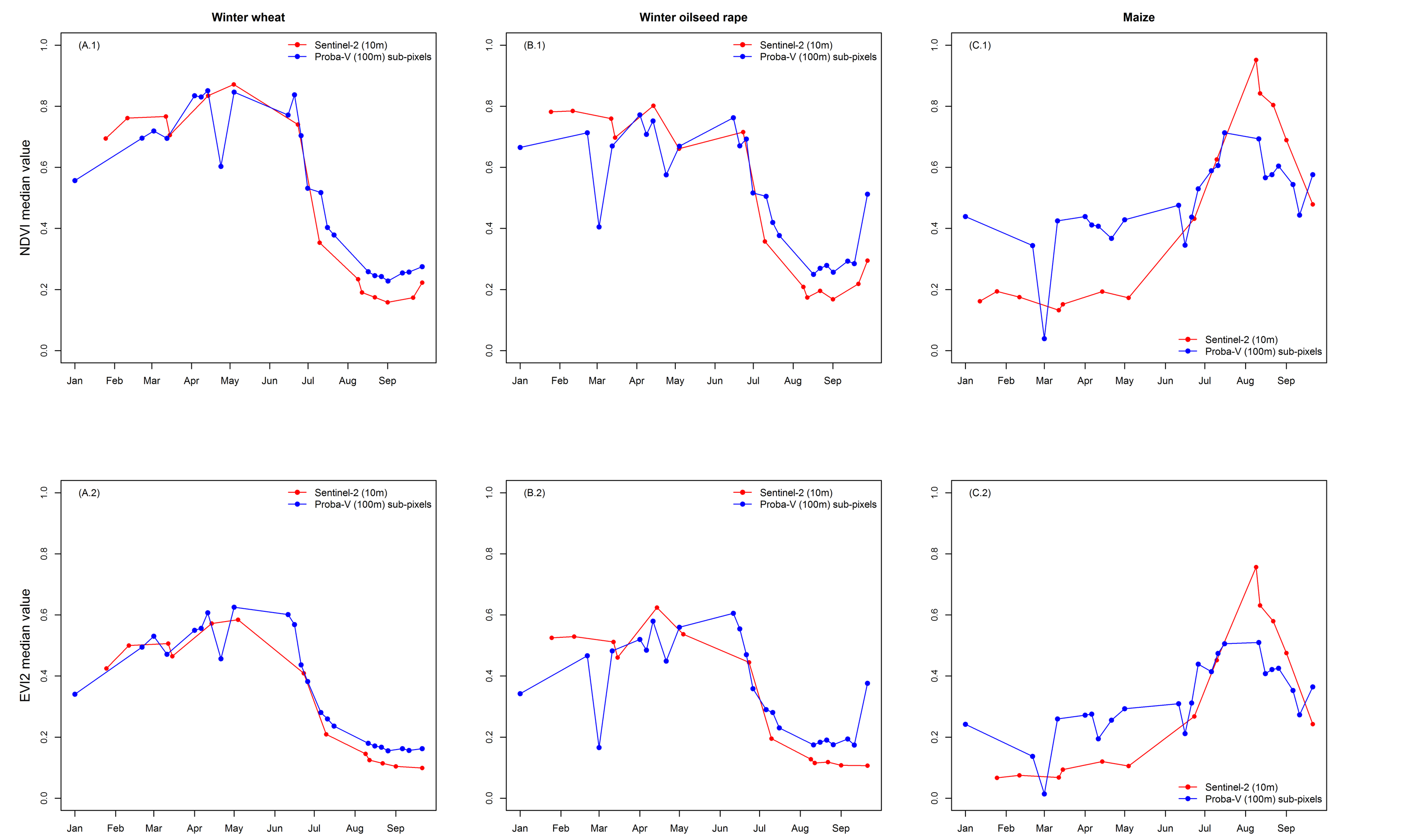

Figure 4. Comparison of the times series from HSR data with those of the MSR sub-pixels. Note : from 5 HSR images to ~ 9 MSR images between March and June (flowering period and senescence for winter crops).

Table1.
Correlation values of both time series for each crop on the common dates (± 5 days).

	Winter wheat		Winter oilseed rape		Maize	
	NDVI	EVI2	NDVI	EVI2	NDVI	EVI2
Sentinel-2 (10m) and Sub-pixels (100m)	0.98	0.99	0.93	0.92	0.89	0.90
Sub-pixels and pure pixels (100m)	0.99	0.94	0.94	0.90	0.82	0.85

4. Conclusion and perspectives

In conclusion, our method of spatial disaggregation can be used to improve the exploitation of satellite data at MSR in seasonal crop monitoring, especially during the transition periods when the spectral indices of crops are likely to change quickly.

Perspectives: To test the spatial disaggregation method for Proba-V (300m and 1km) and SPOT-VGT (1km) data for monitoring crop phenology and seasonality since 1998. This will allow following the **crop phenology at field scale even before the Sentinel-2 era.**

5. Reference

[1] Keshava, N., Mustard, J.F., 2002. Spectral unmixing. IEEE Signal Processing Magazine, 19, 44–57. https://doi.org/10.1109/79.974727

UNIVERSITÉ PARIS DIDEROT PARIS 7 · PRODIG UMR 8586 · LSCE LABORATOIRE DES SCIENCES DU CLIMAT & DE L'ENVIRONNEMENT · EcoSys · INRA SCIENCE & IMPACT · AgroParisTech

Acknowledgements:
Project **SURFAC_EGC_SENTINEL_PLEIADES_CO,** financed by **CNES** (French National Space Agency).
BECAL Program, financed by the Government of Paraguay.