CHARACTERIZATION OF INTERCROPPING PERIODS USING MULTI-TEMPORAL OPTICAL SATELLITE IMAGES

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Context & Objectives

• In a rotation of cash crops, the period between the harvest and the subsequent sowing is referred to as the intercropping period. In France, it is mandatory to establish cover crop during these periods, especially in the vulnerable nitrates zones which represent almost 75% of the agricultural area allocated to the cultivation of seasonal crops (Justes et al., 2012).

• The quantification of the advantages associated with the establishment of the cover crop is then a major stake for a sustainable and reasoned management of agricultural surfaces. The establishment of cover crop obviously entails additional cost and workload, offset by a set of 'ecosystem services'. In this context, carrying out a balance requires the monitoring of key vegetation descriptors, which are used as a control indicator of advantages of the cover crop.

• In the present study, the objective is first to characterize the satellite-observed vegetation development during the intercropping period and then to estimate the biomass of cover crop using optical images acquired by Sentinel-2.

Materials

• The **study area** is located in southwestern France, near Toulouse (Figure 1). The territory is characterized by a great diversity of landscapes and types of soil, and controlled by a temperate climate.

• Experimental devices were conducted throughout four successive intercropping periods on a network of plots to collect a dataset making it possible to characterize the variability of cover crop.

• Time series of images were regularly acquired from 2017 to 2021 throughout the growth of the cover crop, together with biomass measurements collected just before the destruction by burial of the vegetation.

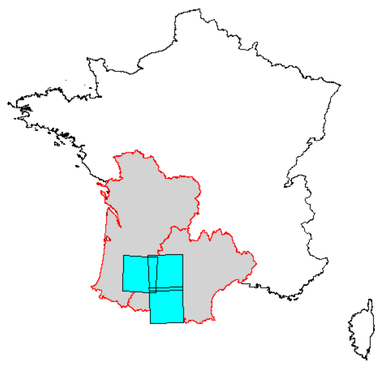

Figure 1 Location of the study site.

• On the considered plots, two cover crop species were mainly sown after the cultivation of wheat (i.e., faba bean and phacelia), and up to five different species were observed on some plots.

Methodology

• All the Sentinel-2 images were ortho-rectified and corrected from atmospheric disturbances (products freely available at https://theia.cnes.fr).

• **Classifications of surface conditions**: Conducted at the plot spatial scale, the analyses aimed to distinguish behaviors (using an unsupervised approach: K-means) interpreted via field observations, and reflecting the implemented agricultural practices (such as the establishment of an intermediate cover crop or, on the contrary, a bare soil following tillage events).

• **Intra-plot heterogeneity**: The number of days with active vegetation during the intercropping period was determined using a threshold applied on the daily-interpolated NDVI time series.

• **Cover crop biomass estimation**: Linear and non-linear empirical relationships were established between vegetation indices and in-situ cover crop biomass measurements. Numerous different vegetation indices were derived from the last acquisition before vegetation destruction and tested (including the SAVI (Soil Adjusted Vegetation Index), NDVI (Normalized Difference Vegetation Index), NDRE (Normalized Difference RedEdge Index), and others widely used indices).

Results

• Classifications of the surface conditions observed at the plot spatial scale

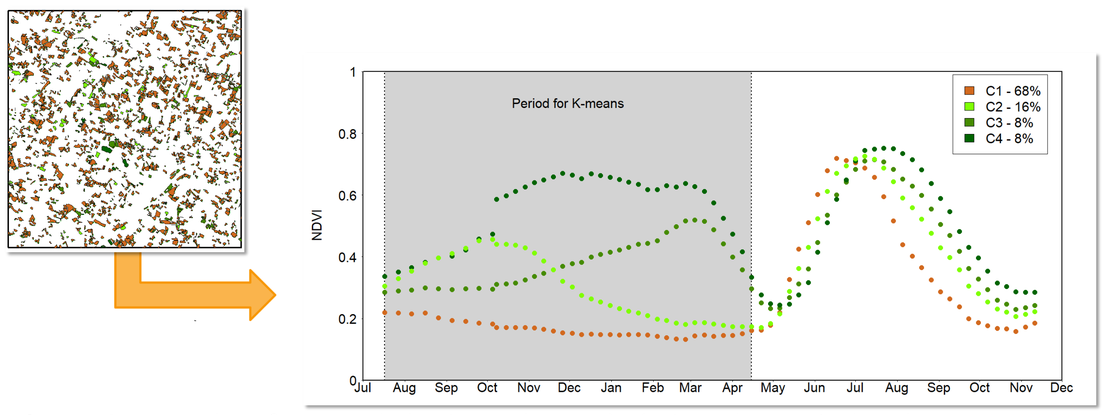

Figure 2 Example of mean behaviors observed during the agricultural season 2017/2018, for the intercropping period between a rotation of winter (e.g., wheat or rapeseed) and summer (e.g., corn or sunflower) crops.

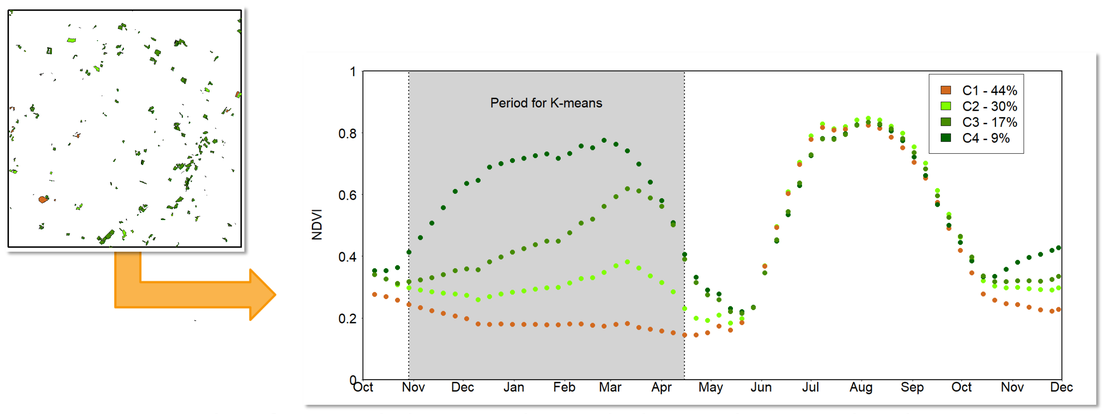

Figure 3 Example of mean behaviors observed during the agricultural season 2017/2018, for the intercropping period between a succession of two summer crops (e.g., corn, sorghum, soybean or sunflower).

• Characterization of the intra-plot heterogeneity

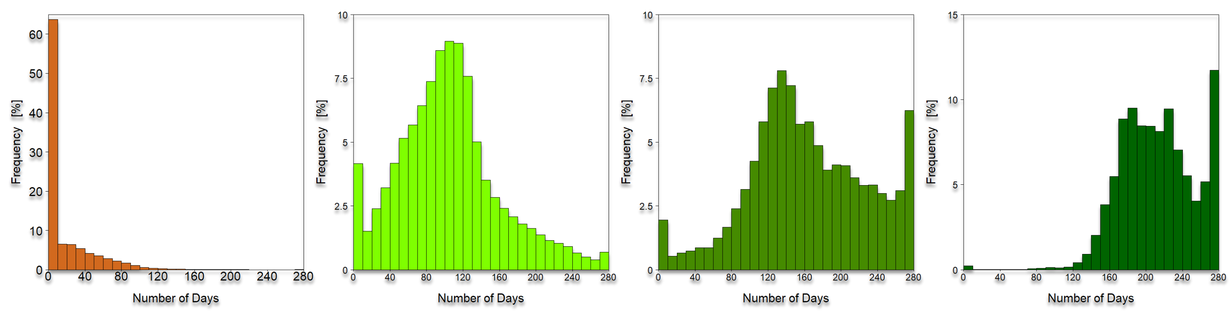

Figure 4 Number of days with active vegetation for the four classes observed during the intercropping between a rotation of winter and summer crops.

• Estimation of cover crop dry biomass

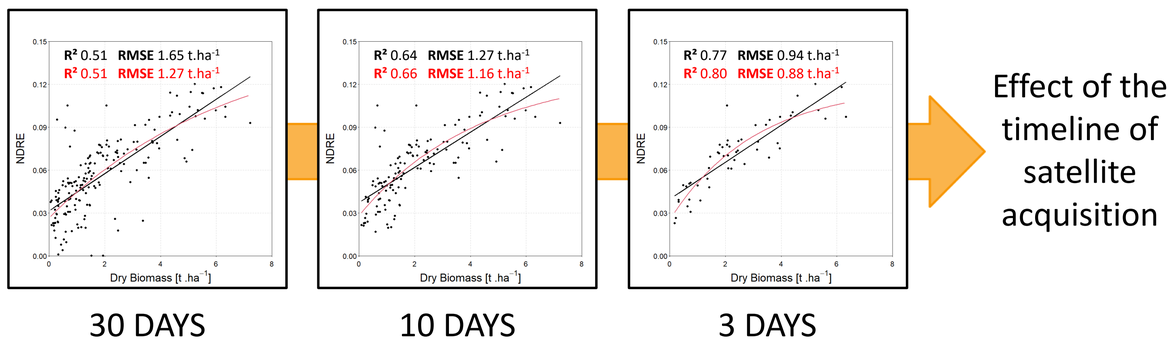

Figure 5 Empirical relationships established between the NDRE derived from Sentinel-2 images and cover crop dry biomass measurements considering different time lag between satellite acquisitions and ground measurements.

Conclusion & Prospects

• The time series of images acquired during intercropping periods allow the identification of different surface conditions, related to specific cultivation practices and highlighting different levels of vegetation development.

• The decametric resolution of satellite images makes it possible to understand the heterogeneity of vegetation development within plots, a necessary characteristic for monitoring intermediate cover crops.

• On the basis of images acquired before the destruction of cover crops, it is possible to estimate the dry biomass, with levels of precision depending on the availability of satellite images.

• Further work will focus on the detection by remote sensing of the date of vegetation destruction by farmers, in order to be able to apply the empirical relationship of biomass estimation as close as possible to the actual farmer's practice.

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