EARLY DETECTION OF SUMMER CROP USING HIGH SPATIAL RESOLUTION IMAGE TIME SERIES

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OBJECTIVE

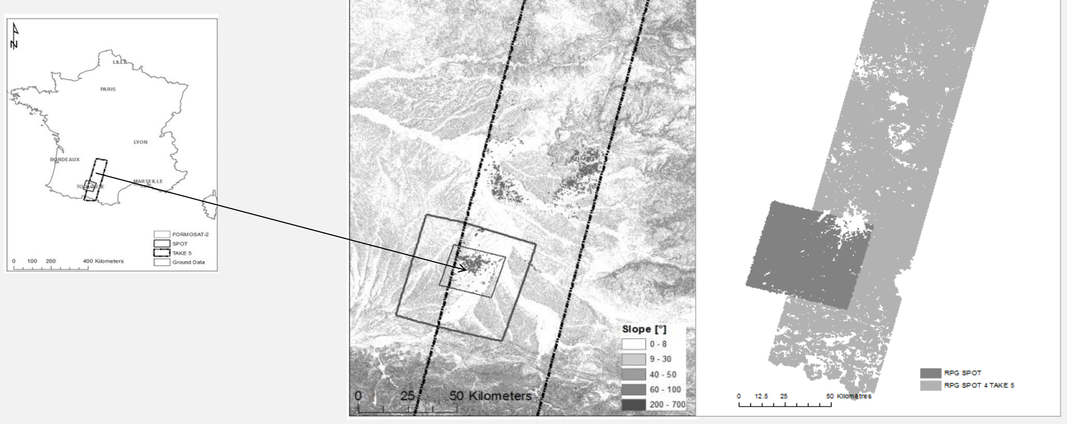
The objective of this study is to detect the fields dedicated to the cultivation of summer crops (Corn, Sunflower, Sorghum, Soybean and Hemp) on a wide geographical area. The constraint is to perform this land classification before the start of the irrigation period (i.e. before the end of June), in order to anticipate the water requirement.

MATERIALS

Site description

The studied site was located in the **South West of France**, near Toulouse. From **2006 to 2013**, satellite time series were acquired by FORMOSAT-2, SPOT-4/5, and Take-5 program, over an area of respectively 500 km2, 4000 km2, and 13000 km2.

The site includes **different eco-climatic zones.**



The studied period ranges from **2006 to 2013**.

Satellite data

Only three images acquired between February and June were used, depending on their availability. For the period from 2006 to 2013, during the first semester: 24 FORMOSAT-2, 12 SPOT-4, 4 SPOT-5 and 6 SPOT-4 Take5 images were available.

FORMOSAT-2

- 0.45 – 0.90 µm
- 8 m resolution
- 500 km²
- Constant viewing angles

SPOT 4 /SPOT 5

- 0.45 – 0.89 µm
- 1.58 – 1.75 µm (MIR)
- 10 m/20 m resolution
- 4 000 km² (SPOT) & 13 000 km² (Spot 4 Take 5)
- Viewing angles : + 31.06° to – 31.06° (SPOT) & Constant (Spot 4 Take 5)

Ground data

Synchronous to satellite acquisitions, **land use was collected over 500 agricultural fields** from 2006 to 2013. Those surface states were used, depending on their availability, as prior knowledge about the behavior of the crops in the period before their emergence.

Exogeneous data

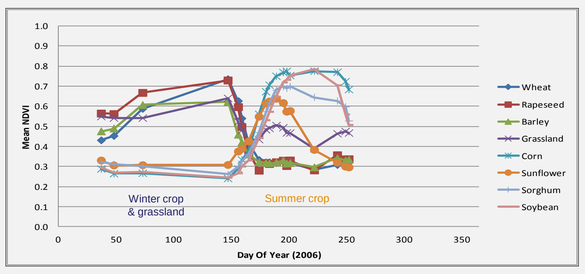
The "Registre Parcellaire Graphique" (R.P.G) is a reference data base that describes the field occupation on the cultivated areas. It was used as a mask layer, in order to restrict the analysis only to identified areas.

METHODOLOGY

Optical remote sensing data were used to calculate the Normalized Difference Vegetation Index, NDVI. The methodology is based on thresholds on NDVI, in order to discriminate summer's crops from winter's crops or grassland.

Study of phenology

Independently of the year, the weather, and soil type,…, between April and June (days 90 to 150):

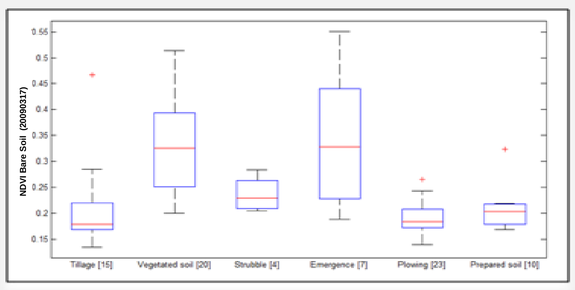


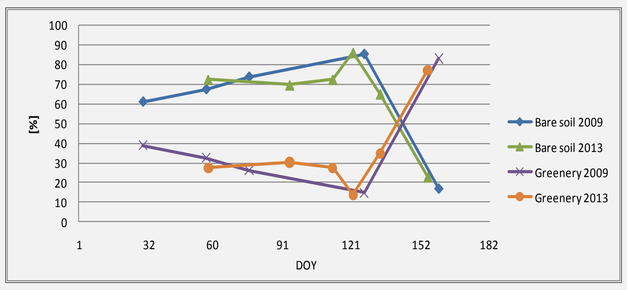
- **Summer crop** ➔ Mean NDVI <0.4 (0.10<std <0.11)
- Winter crop and grassland ➔ Mean NDVI > 0.5 (0.08<std <0.17)

Several possible **stages of development** of Summer crops in early Spring : vegetated (a), bare soil (b), emergence (c), growing crop (d).

4 different stages ➔ 3 dates required

Maximum amount of **bare soil** plots => days 90 to 135



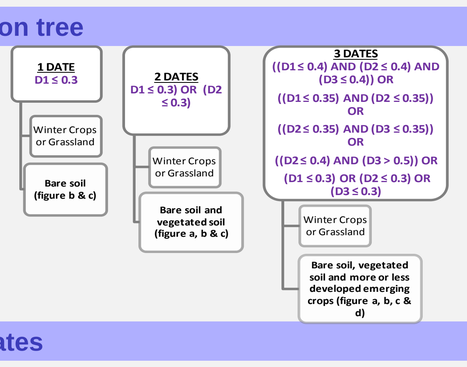


Mean NDVI of **different types** of monitored **bare soil** **0.13< NDVI <0.3**

Mean NDVI of **vegetated soil** or **emerging** **crops** **0.2<NDVI<0.5**

Thresholding with decision tree

- Thresholds are used on 1, 2 or 3 images dates (D1,D2 & D3) to account for the different stages of development of summer crops
- Identical thresholds for all satellites, all resolutions, all years, all soil types...



Choice of images dates

- When available, 3 dates between days 90 and 150 are chosen (darken) - maximum amount of bare soil
- With one month gap if possible

Years	2006 (FORMOSAT-2)	2007 (FORMOSAT-2)	2009 (FORMOSAT-2)	2010 (FORMOSAT-2)	2010 (SPOT 4 & 5)	2011 (SPOT 4 & 5)	2012 (SPOT 5)	2013 (SPOT 4 TAKE 5)
Resolution	8 m	8 m	8 m	8 m	20 m	20 m	10 m	20 m
Dates of available images	06-Feb-06	23-Feb-07	15-Feb-09	02-Mar-10	18-Feb-10	09-Feb-11	21-Feb-12	17-Feb-13
	17-Feb-06	20-Apr-07	17-Mar-09	10-Apr-10	26-Mar-10	07-Mar-11	24-Mar-12	22-Feb-13
	14-Mar-06	30-May-07	21-Mar-09	18-Apr-10	10-Apr-10	08-Apr-11	03-May-12	04-Mar-13
	14-Apr-06	30-Jun-07	30-Mar-09	27-Apr-10	23-May-10	18-Apr-11	14-Jun-12	13-Apr-13
	02-May-06		03-May-09	21-May-10	30-Apr-11			07-Jun-13
	27-May-06		03-Jun-09		26-Jun-10	21-May-11		12-Jun-13
	23-Jun-06		23-Jun-09					
	29-Jun-06							

RESULTS AND DISCUSSION

- The methodology is applied to the SPOT and FORMOSAT-2 times series, from 2006 to 2013
- 2 different analyses: chronological addition (1 to 3 dates images) and test on all years.
- Validation is performed using a confusion matrix between the masks of summer crops obtained and the data from the RPG (2007 and 2009) or collected in situ (2013).

Chronological addition

- Using **one image** in the first quarter of year can isolate at least **65%** of summer crops
- Using **two images** before May allows to obtain **80%** of summer crops.

	1 Date		2 Dates		3 Dates	
	Prod. Accuracy	User Accuracy	Prod. Accuracy	User Accuracy	Prod. Accuracy	User Accuracy
2007	**64.38**	94.13	**82.04**	93.31	**95.17**	92.19
2009	**88.75**	92.21	**92.83**	92.45	**98.32**	92.55
2013	**69.8**	69.5	**80.64**	87.79	**90.01**	65.13

Thresholding on 3 dates

- Independently of the climatic year, the date of emergence and growth rate of the crops➔ Thresholding on **3 dates** allows to identify as early as June from **90%** (2013) **to 98%** (2009) of Summer crops.

Years	2006 (Formosat-2)	2007 (Formosat-2)	2009 (Formosat-2)	2010 (Formosat-2)	2010 (Spot 4)	2011 (Spot 4)	2012 (Spot 5)	2013 (Spot 4)
Resolution	8 m	8 m	8 m	8 m	20 m	20 m	10 m	20 m
Producer Accuracy	97.12	95.17	98.32	96.72	92.92	96.6	99.04	90.01
User Accuracy	87.73	92.19	92.55	90.42	97.84	98.18	95.53	65.13

CONCLUSIONS

This simple and robust approach based on thresholding of the NDVI provides good early detection of summer crops in phenological cycle:

-It overcomes the differences in the dates of emergence, growth rates and differences in weather conditions between years

- It overcomes the differences in the sensor, the resolution and the angle of incidence

PERSPECTIVES

- Improve the detection of Summer crops in real time
- Monitor the development of the vegetation and the water needs
- Map the irrigated crops for a better management of water resources
- Improve land use classifications and decrease confusion between cultures and grasslands