



# Monitoring of the evolution of agro-hydrosystems in a mediterranean region

*Dominique Courault<sup>1</sup> et al*



UMR TETIS  
UMR Innovation  
CEEP réserve Crau  
Fondation Tour du Valat

Montpellier



<sup>1</sup>AVIGNON





# SPOT4 on the mediterranean region

*A wide variety of landscapes,  
natural ecosystems,  
crops*



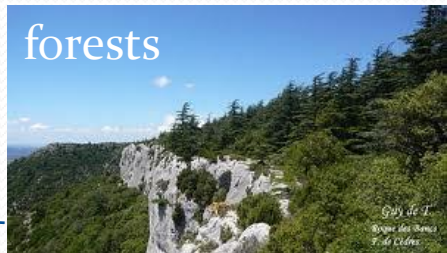
biodiversity



orchard



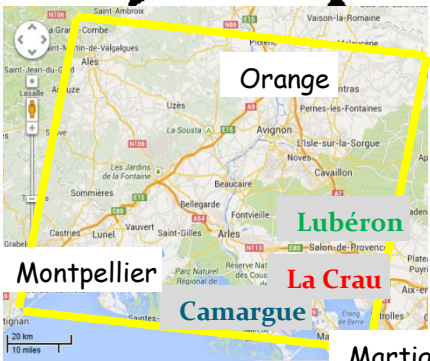
Urban areas



forests



Irrigated grasslands



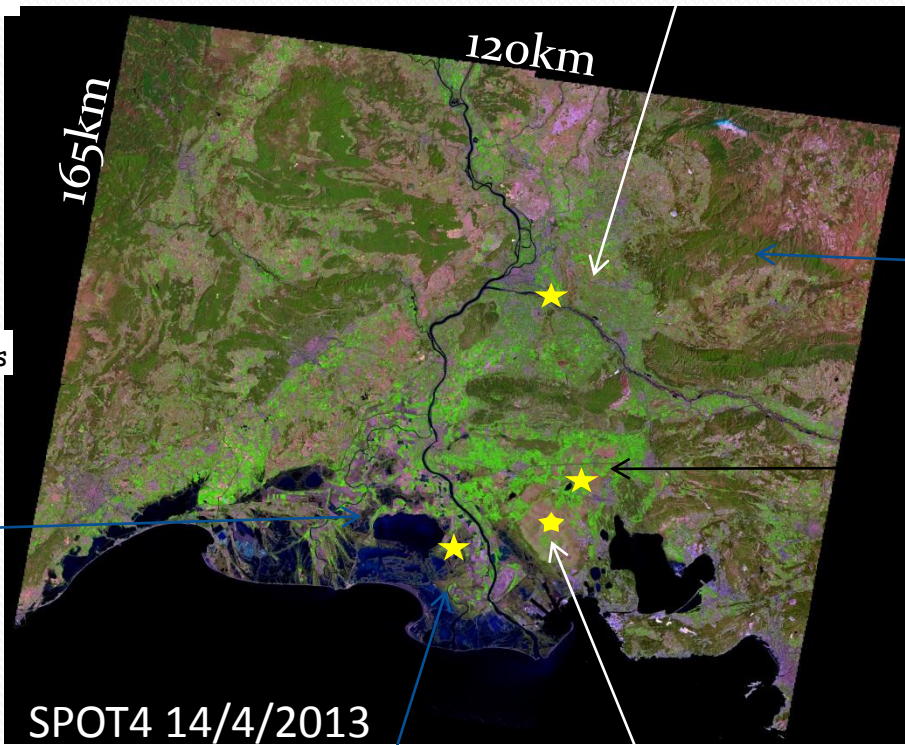
Orange

Lubéron

La Crau

Camargue

Martigues



SPOT4 14/4/2013



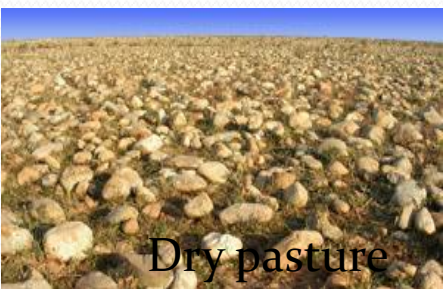
rice



Wet areas



swamps



Dry pasture



LAI  
fCover




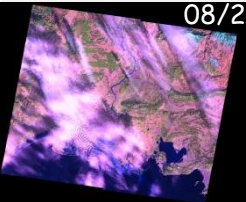
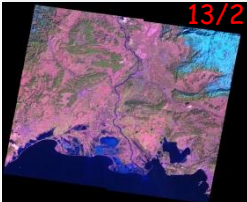
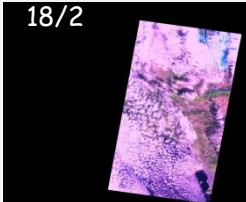
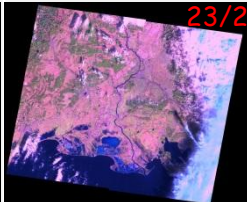
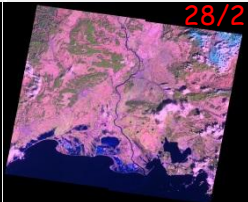
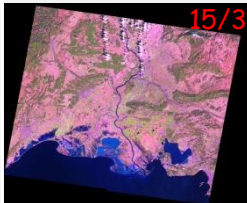

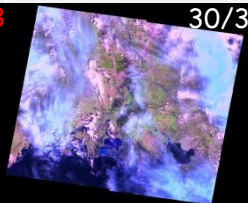
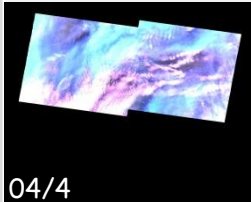
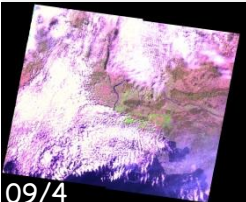
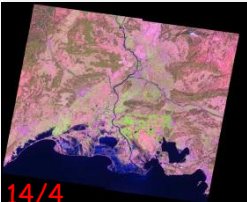



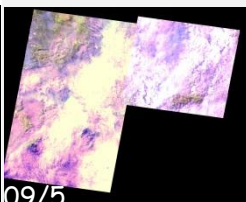
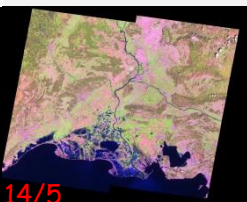
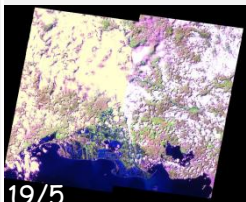
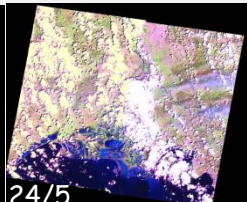
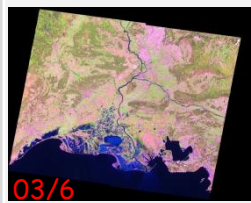

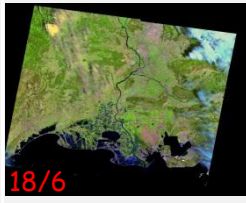
CNR1



flux  
measur<sup>ts</sup>

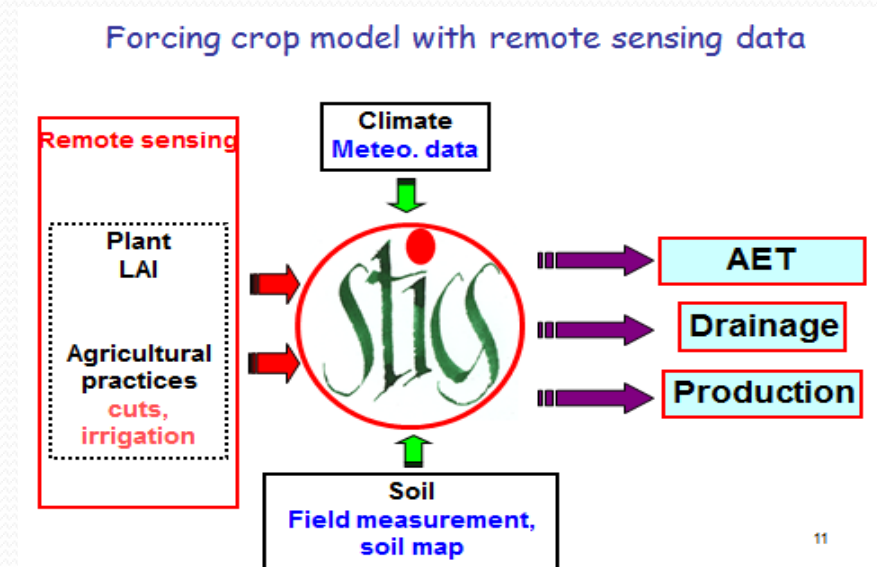
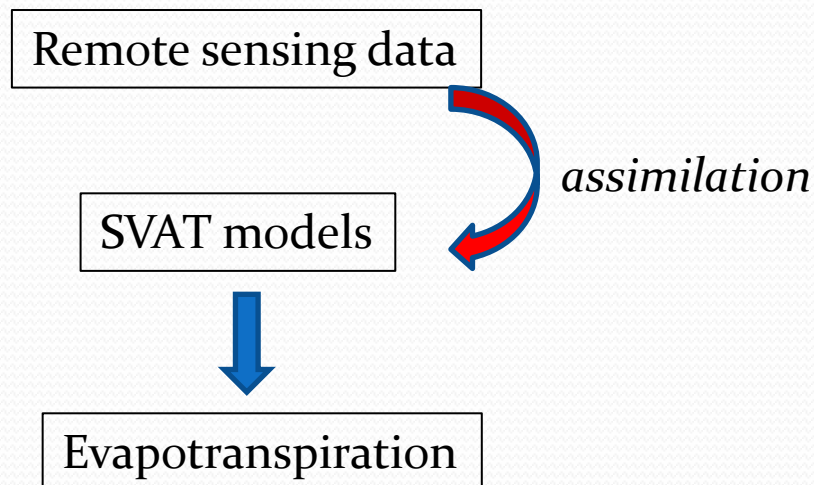


# SPOT4 acquisitions over the SE site from 3/02 to 18/06/2013

Feb	 03/2	 08/2	 13/2	 18/2	 23/2	 28/2
Mar			 15/3		 25/3	 30/3
Apr	 04/4	 09/4	 14/4	 19/4	 24/4	
May	 04/5	 09/5	 14/5	 19/5	 24/5	
Jun	 03/6		 13/6	 18/6	22 images <b>12 without clouds!</b> 😊	

## EMMAH research questions

- 1- What interactions between agricultural surfaces and practices and ground water recharge?
  - irrigation of grasslands in Crau
  - impact of flooding with fresh water in rice fields on the saline transfers to the superficial groundtable in Camargue
- 2- How production is impacted by the global changes (water restriction, ITK modifications) ?



## detection of agricultural practices (cut, irrigation, rice flooding, ...)

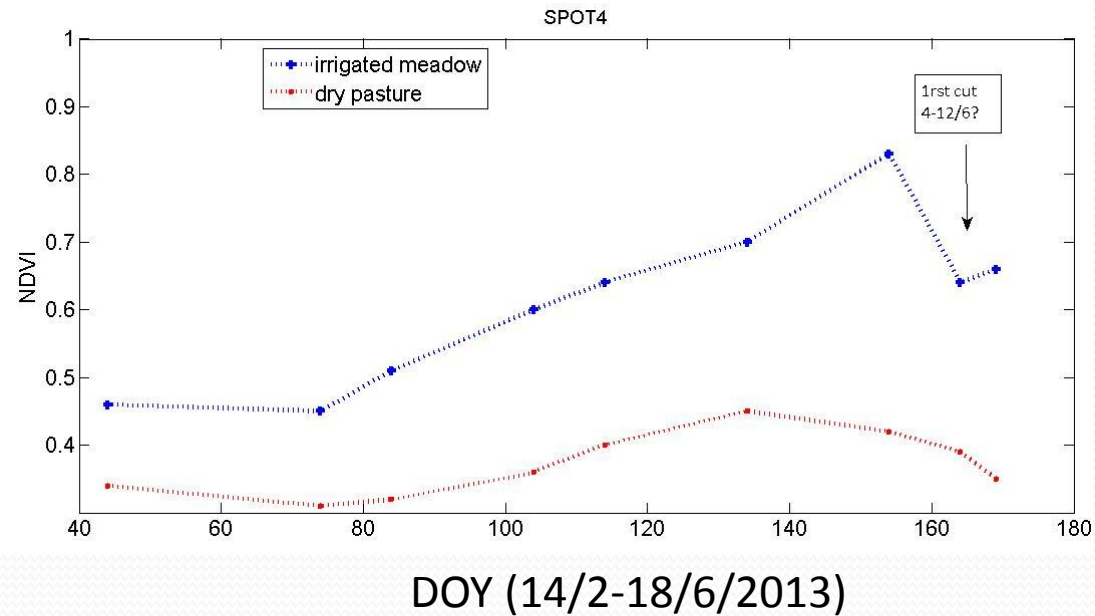
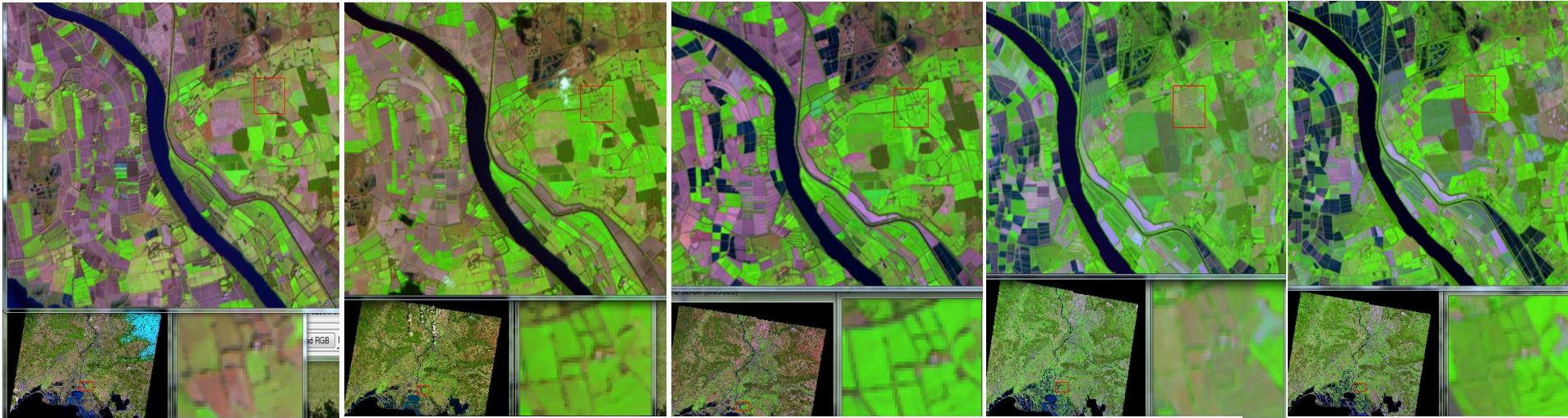
13/2

15/3

14/4

3/6

14/6





# Estimation of biophysical variables (BV-net tool developed by EMMAH (*Baret, Weiss et al*))

Input image

Open image  Spectral bands

Input values

☐ Digital Number ☐ TOA Reflectance  
☐ TOA Radiance ☒ TOC Reflectance

Year [1980-2012]:  Lat (Dec. degrees):   
Month [01-12]:  Long (Dec. degrees):   
Day [01-31]:  Height (m):   
Hour (U.T.) [0-23]:  View Zenith Angle (Degrees):   
Minutes [0-59]:  View Azimuth Angle (Degrees):

Atmospheric correction

Canopy model

☒ SAIL ☐ GeoSAIL

Output biophysical variables

☒ LAI ☒ fCOVER ☒ fAPAR ☒ Albedo

Soils spectra

Reflectance

☒ Specify soil spectra

Load soil file

Image characteristics

Filename: D:\Home\coursault\Documents\Crau\_C\BV\_net\SPOT0414  
Bands: 4  
Interleave: bgr  
Datatype: uint8  
Rows: 6750  
Columns: 8250  
Pixel Size: 20 000000

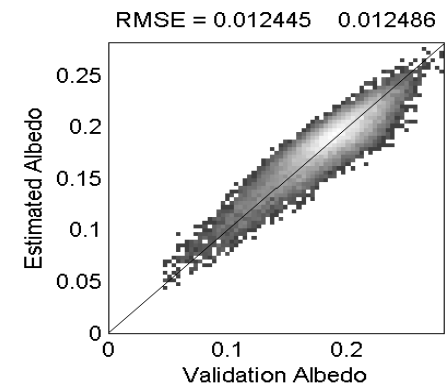
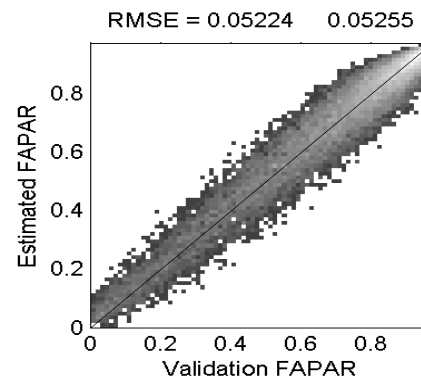
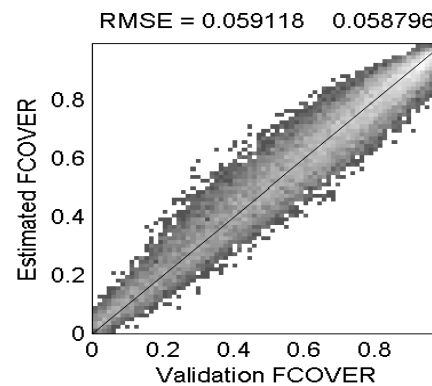
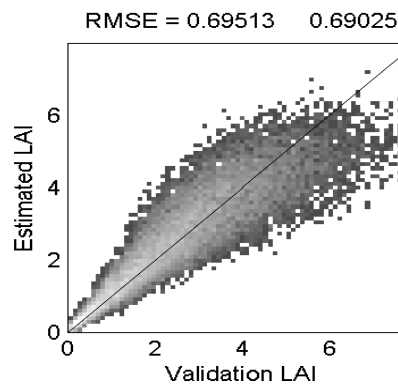
Spectral sensitivity

Color composite

Red: XS3  
Green: XS2  
Blue: XS1

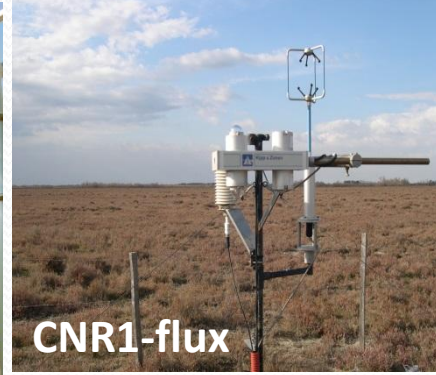
Configuration name: s0414test2

Launch processing



# Validation: ground measurements during SPOT4 acquisitions

- Continuous measurements on various surfaces: albedo (CNR<sub>1</sub>), LAI, surface fluxes



- Punctual measurements: vegetation height, hemispheric photos (LAI,fcover), ITK obs



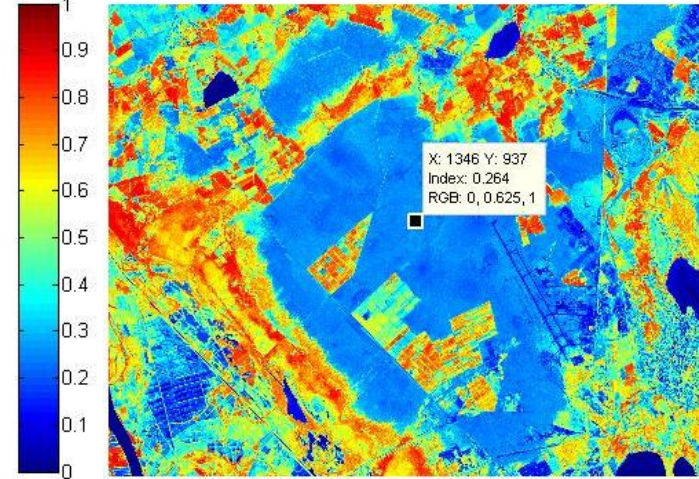
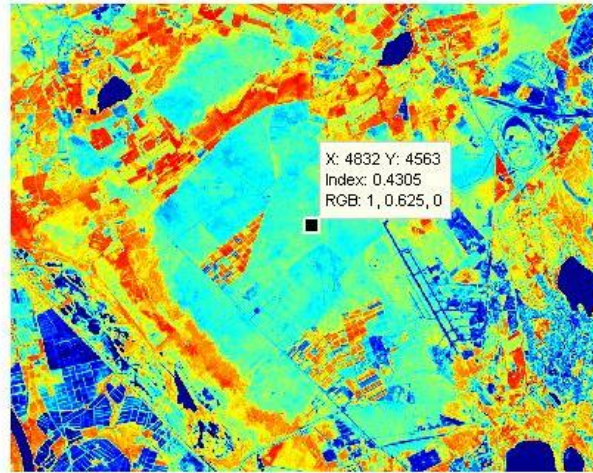


# Questions for CEN PACA - Pôle Crau (réserve naturelle pôle Crau St Martin de Crau)

SPOT4 3/6/2013

NDVI

FORMOSAT2 2/6/2006



*jun2006*  
 $\Sigma \text{rain} = 160 \text{mm}$

*jun2013*  
 $\Sigma \text{rain} = 300 \text{mm}$



**Evolution of the steppe area?**

→ **biotope protection (biomass estimation)**

→ **sheep path & pasture production**

→ **maps of ecological habitats**

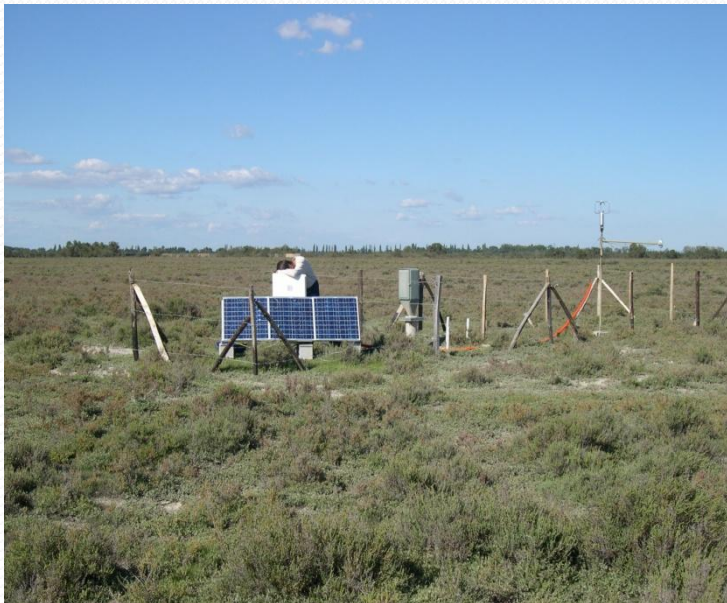




- saline transfers between lakes, ponds and sea ?
- regulation of water levels for the biodiversity ?



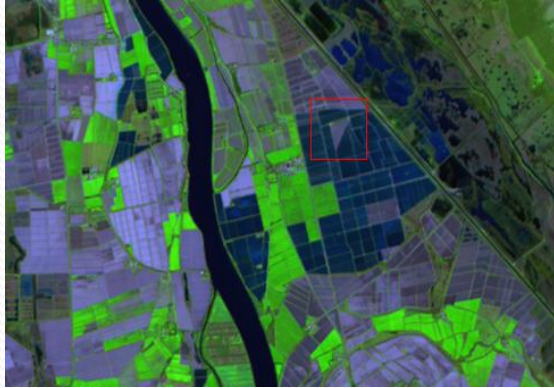
## Regulation of natural ecosystems



- use of hydrological models

# Questions UMR innovation Montpellier

14/4



13/6



18/6



- detection of dates of water flooding for rice
- Identify an optimum land use (combination of agricultural activities)
- Typology of farm (f(ITK))

Bio-economic modeling

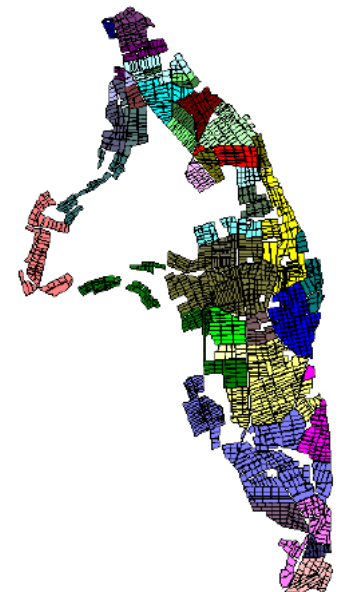
Toward a spatial models for water quantity and quality?

MsC Thesis Feng Zhu

Irrigation bassin



Farms



$$\text{Water volume (m3/ha)} = A * \text{Area under rice} + B$$

Sylvestre Delmotte

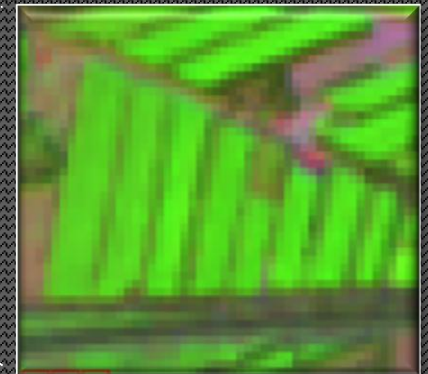


## Subject of thesis

### Monitoring of soil water balance and vegetation for management of irrigation systems



SPOT4 14/4



Presented by: Mohamad El Hajj

Director: Nicolas Baghdadi (UMR TETIS)

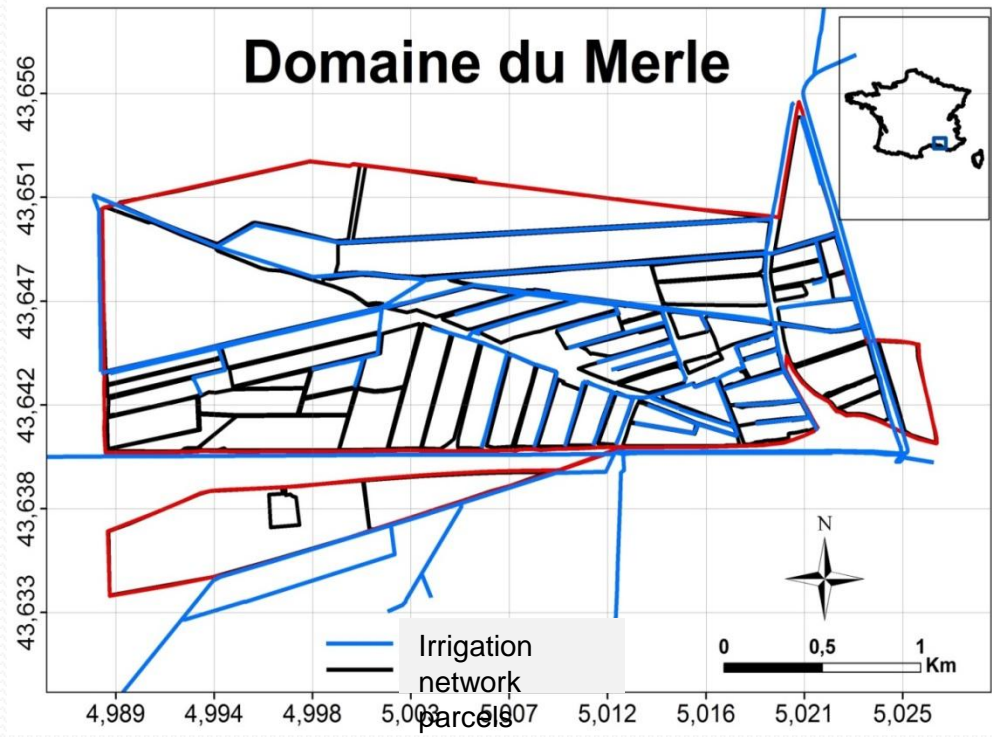
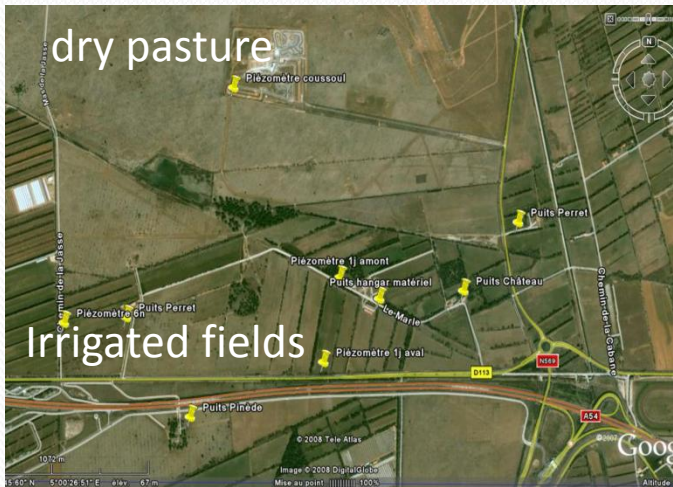
Co-director : Gilles Belaud (UMR G-EAU)

# Objectives

- Remote sensing:
  - ❖ Characterize the physical parameters of the soil and vegetation
  - ❖ Improve the hydro-agricultural models with information derived from remote sensing data (soil moisture, Biomass, LAI, ...)
- Hydraulic modeling:
  - ❖ Assimilate the spatial data in the hydro-agricultural models
  - ❖ monitoring the water balance at different spatial scales



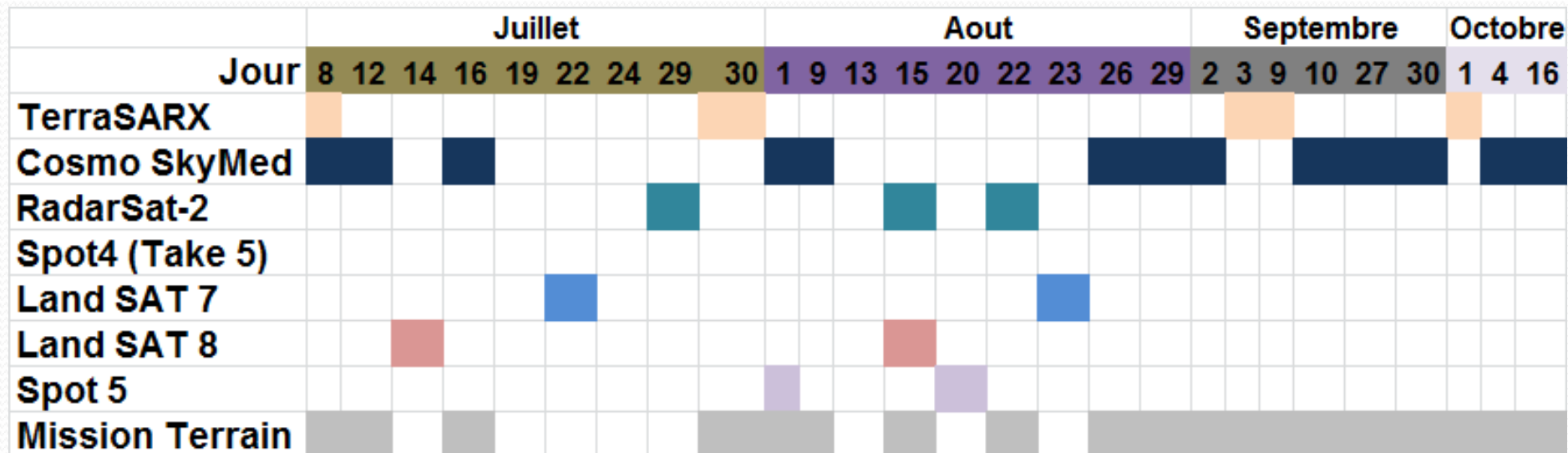
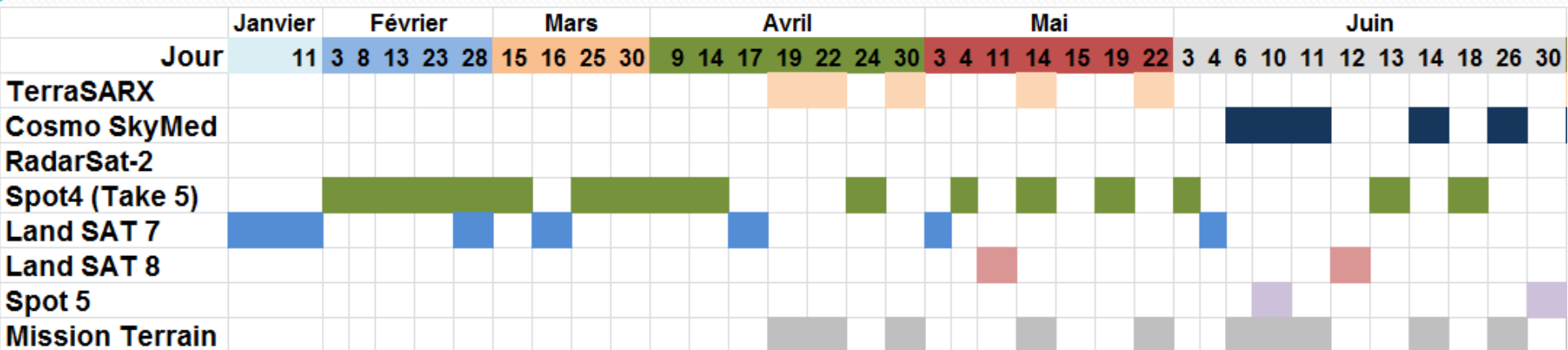
## An aerial photograph showing a rural landscape with a mix of green fields, brownish soil, and some structures. A red rectangular box is drawn over a central area, highlighting a specific region of interest. The box contains a cluster of green fields and some structures. The surrounding area includes more fields, a road, and some distant structures.



- Monoculture system (Plaine de la Crau)
- Experimental field of SupAgro (Support: F. Charron)
- Known rules of irrigation (IRD-GEAU Study, Thesis A. Mérot 2007)
- Irrigation system already studied in several works
- Further work by Emmah Unit



# Dates of acquisition of spatial data and field works

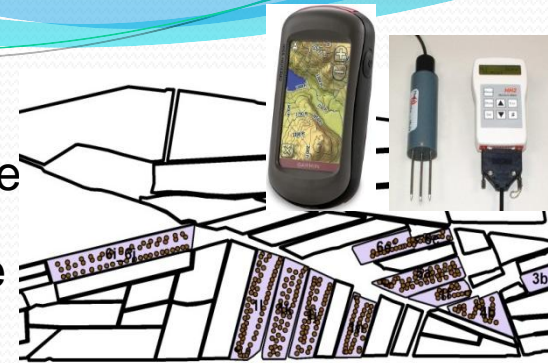




# Field measurements of the physical parameters of the soil and vegetation

## ➤ Soil moisture

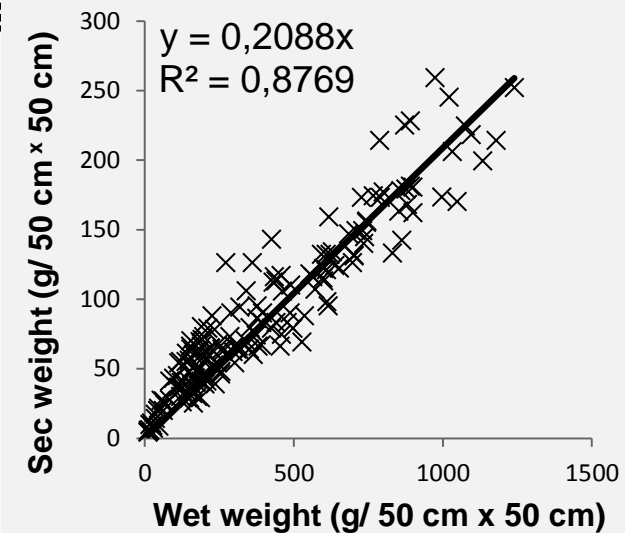
- ❖ Is the total amount of water present in the unsaturated zone
- Top-layer(1-5 cm) soil moisture : radar sensitive



## ➤ Soil roughness: Standard deviation of heights

$$rms^2 = (z(x) - \langle z_{mean} \rangle)^2$$

## ➤ Vegetation Water Content (VWC) →



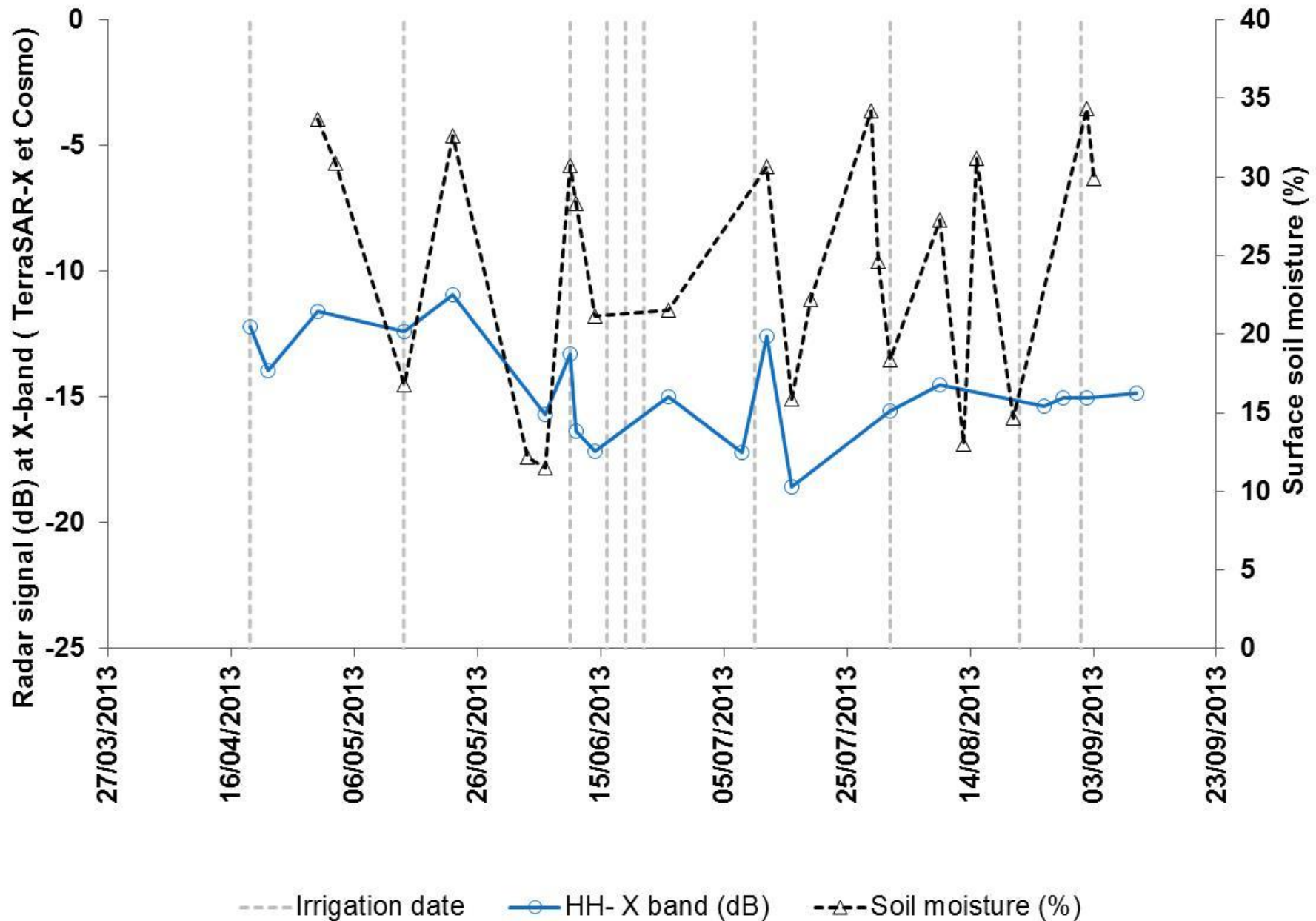
## ➤ Vegetation height

## ➤ Leaf area index ( LAI) →



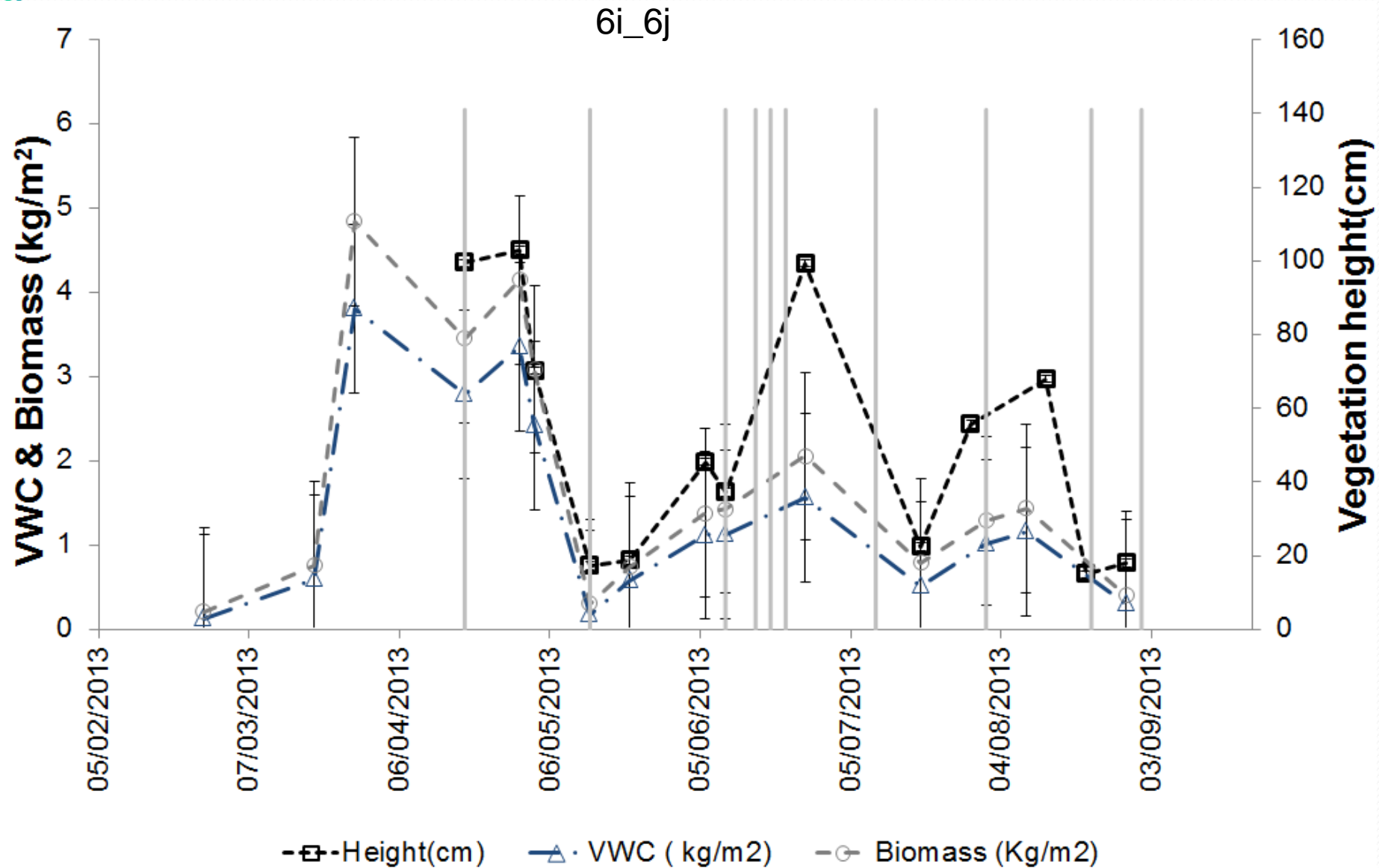
## ➤ Biomass

# Radar signal as a function of the surface soil moisture





# Temporal variation of the physical parameters of the vegetation



# Future Work

## **Remote Sensing section :**

- ❖ Analyze the potential of radar data to estimate the physical parameters of the soil and vegetation.
- ❖ Synergy between optical and radar data for:
  - 1- Calibrate radar scattering models using physical parameters of the vegetation, estimated from optical data.
  - 2- Inversion of models to estimate surface soil moisture and physical parameters of the vegetation at plot and intra-plot scale

## **Hydrological section :**

- ❖ Integration of spatial information in the management of an irrigation system at different spatial scale (field scale, large-network scale)



An aerial photograph showing a coastal region. On the left, a large, dark blue body of water (likely a bay or harbor) is visible. To the right, the land is densely developed with various structures, including buildings, roads, and what appears to be a large industrial or commercial area. The land is colored in shades of brown, tan, and green, indicating different types of terrain and vegetation. The text "Thanks to the CNES team Olivier et al...!" is overlaid in white on the dark water area.

Thanks to the CNES team  
Olivier et al...!

**UMR EMMAH Avignon:** impact of ITK modifications on water and productions, interaction groundtable recharge- surface-atmosphere  
(tool development: BV-net-EVASPA)  
(Projects: Hymex, SIRRIMED, TOSCA, PNTS...)  
*[//www4.paca.inra.fr/emmah/](http://www4.paca.inra.fr/emmah/)*

**UMR TETIS Montpellier:** Monitoring of irrigation combining radar + SPOT4  
(PhD M El Hajj)  
*<http://tetis.teledetection.fr/index.php/fr/>*

**UMR Geau and Innovation Montpellier:** crop and water management  
(ScenaRice project)  
*<http://www.iamm.fr/recherche/umr/g-eau>*

**UR ECODEV INRA Avignon:** urban development- impact of landuse modifications on ecosystemic services  
*<https://www4.paca.inra.fr/ecodeveloppement>*

**La fondation de la Tour du Valat :** natural ecosystem monitoring (water, biodiversity)  
*[www.tourduvalat.org](http://www.tourduvalat.org)*