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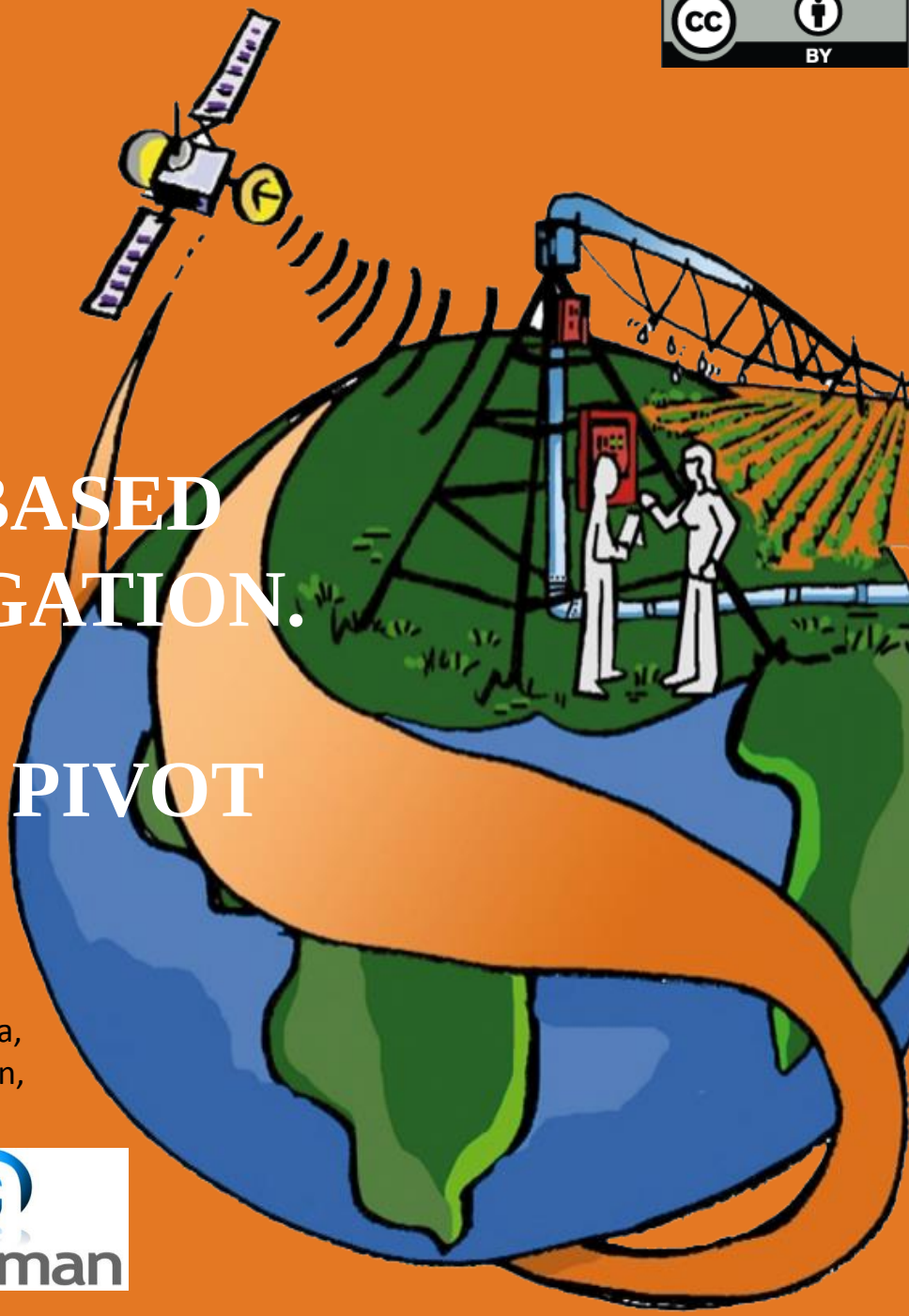
Tu campo desde el cielo



REMOTE SENSING-BASED VARIABLE RATE IRRIGATION. A USE CASE IN A WHEAT CENTER PIVOT

EGU2020

May 4th-8th

María Calera, Carmen Plaza, Andrés Cuesta, Vicente Bodas, Ramón Molina, Anna Osann, Alfonso Calera

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UCLM UNIVERSIDAD DE CASTILLA-LA MANCHA

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Study site

- Study area: La Mancha,
  South-East of Spain

- Climate: Continental-Mediterranean
  - Annual P: 350mm
  - Annual ETo: 1250mm

- Water Source: groundwater from an aquifer threatened by overexploitation

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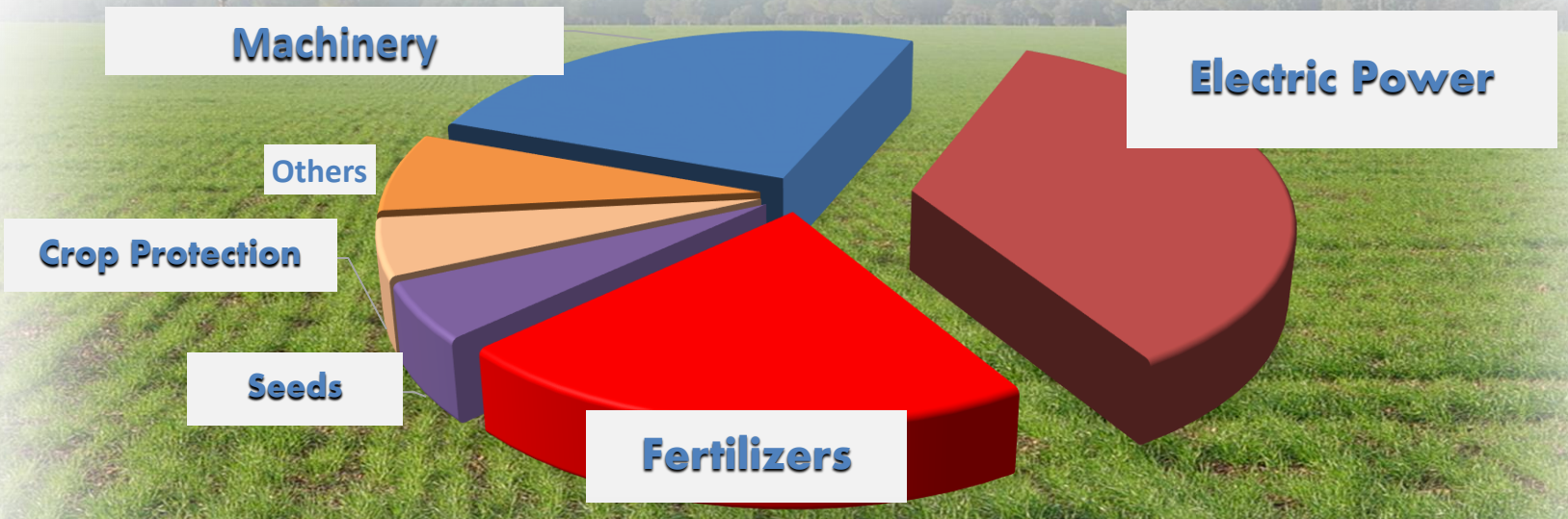
Challenge we face…

Energy for Water Supply (pumping): A third of total production cost



Percentage of costs according to type of farm

	Irrigation Farming	Rainfed Farming
Fertilization	21 %	28 %
Phytosanitary products	8 %	2 %
Seeds	5 %	17 %
Machinery*	25 %	53 %
Maintenances and repair	7 %	
Electric energy	34 %	
Total	**100 %**	**100 %**

* Includes workers, tractors, machinery, repairments, maintenance and fuel

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OBJECTIVE

Improve water irrigation efficiency, by adjusting the supply to the crop water demand, in space and time

MATERIALS

Variable Rate Irrigation

- Center pivot technology able to obtain variable speed through 36 sectors to adjust water supply on each sector

Crop Water Requirements

- Time series of free images from twin Sentinel 2 satellites provides timely images, at high spatial resolution (10mx10m), enough to capture within-field variability
- Meteorological data, providing reference evapotranspiration

METHODOLOGY

Operational coupling of weekly CWR forecasting a week ahead and VRI for water supply at sector scale

RESULTS

Analyisis of the accumulated water savings, análisis of temporal variability.

CONCLUSIONS

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Objectives

Improve water irrigation efficiency, by adjusting it to the crop water demand, in space and time

Demonstrating remote sensing-based crop water requirement as an operational method for driving a low-cost variable Rate Irrigation System

Optimization of the irrigation water in an operational way for Farmers

Put into practice the technology (SicoP system) that allows the pivot to apply variable rate at medium cost for farmers.

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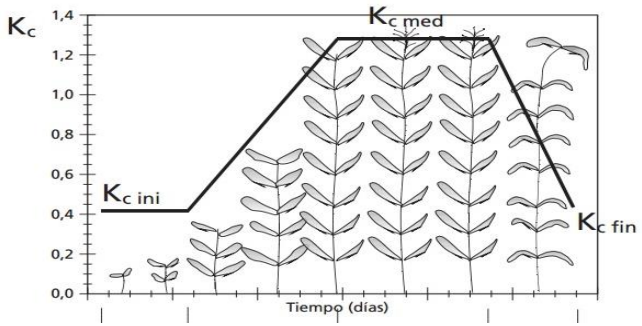
Materials

Water Requirements Estimation

K_c-ET_o *(FAO 56)*

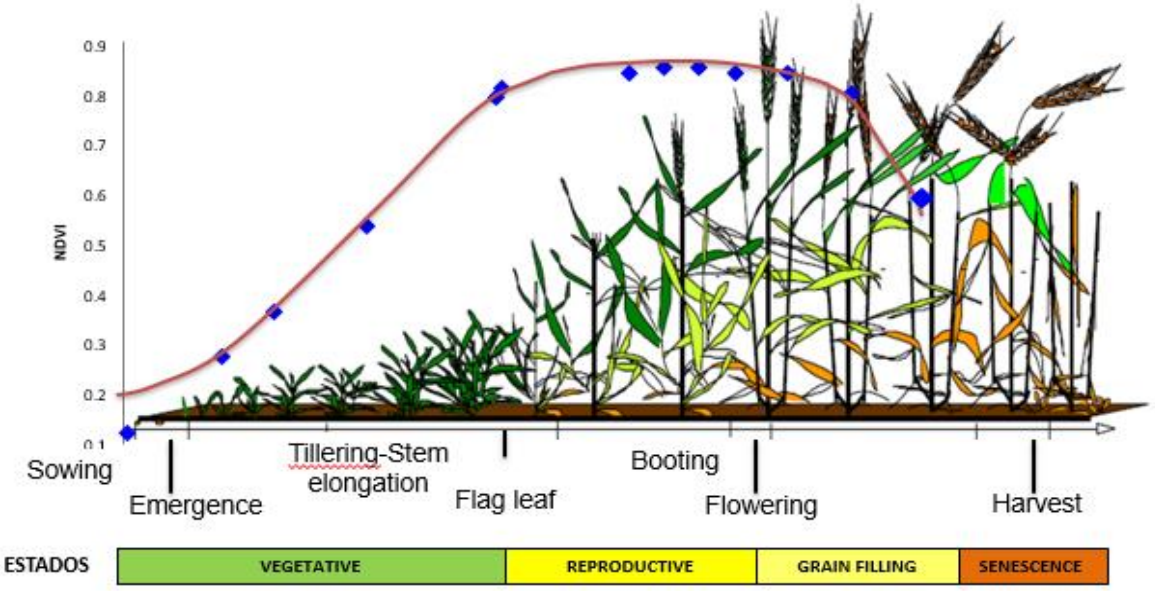
Single Coefficient

$ET_c = K_c\ ET_o$



Kc-NDVI

$K_c = 1.25\ NDVI + 0.1$ *(Calera et al. 2005)*



High frequency NDVI images from L8, S2A and S2B allow us to describe the crop development PIXEL BY PIXEL (10m) providing appropriate

TEMPORAL RESOLUTION AND SPATIAL SCALE FOR AGRICULTURE APPLICATIONS

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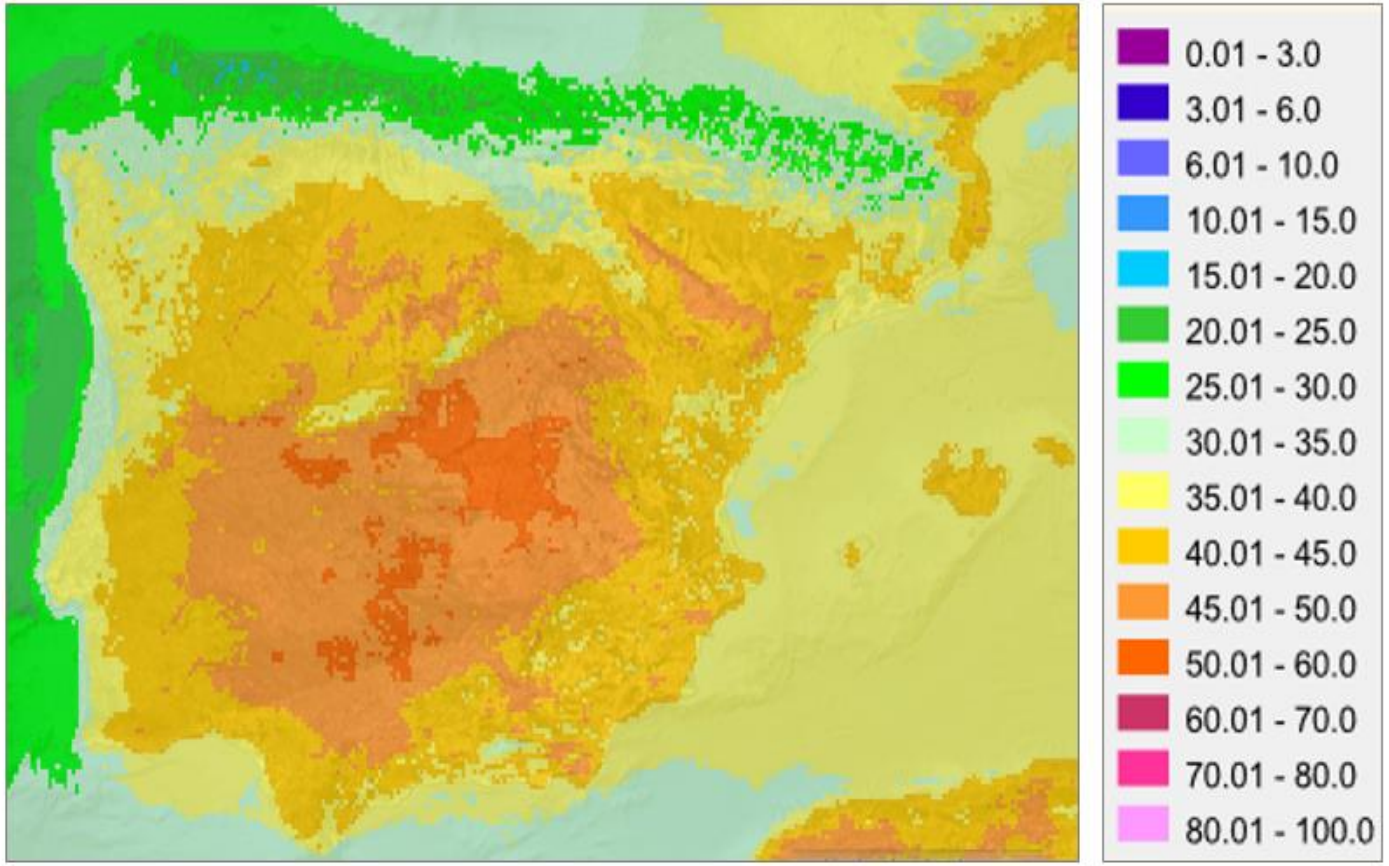
Materials

Weekly Reference Evapotranspiration, ETo, Forecast Map



Provided by **Spanish Meteorological Agency, AEMET,** at Iberian Peninsula Scale with a spatial resolution of 5km x 5km

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The Case Study

Bread Wheat

Center Pivot: 60 ha

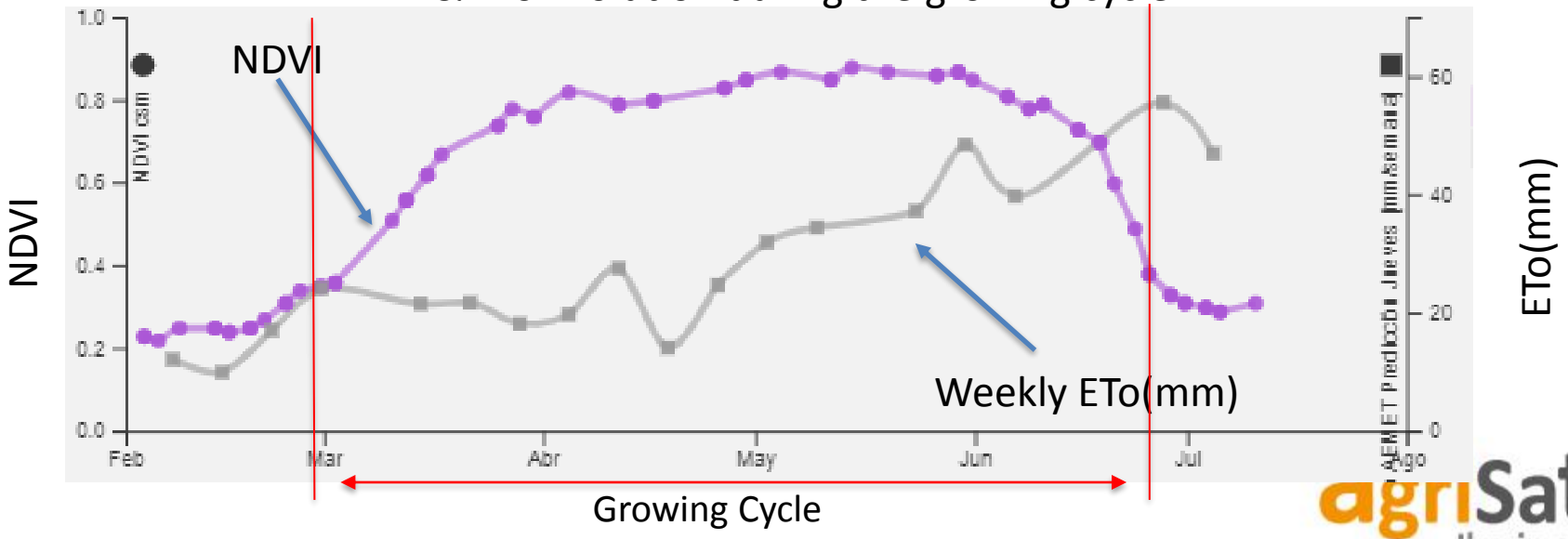
Water table: 125 m depth

Growing Season from 28 February – 27 June

Total ETo: 511 mm

Total Precipitation : 200 mm

NDVI & ETo Evolution during the growing cycle



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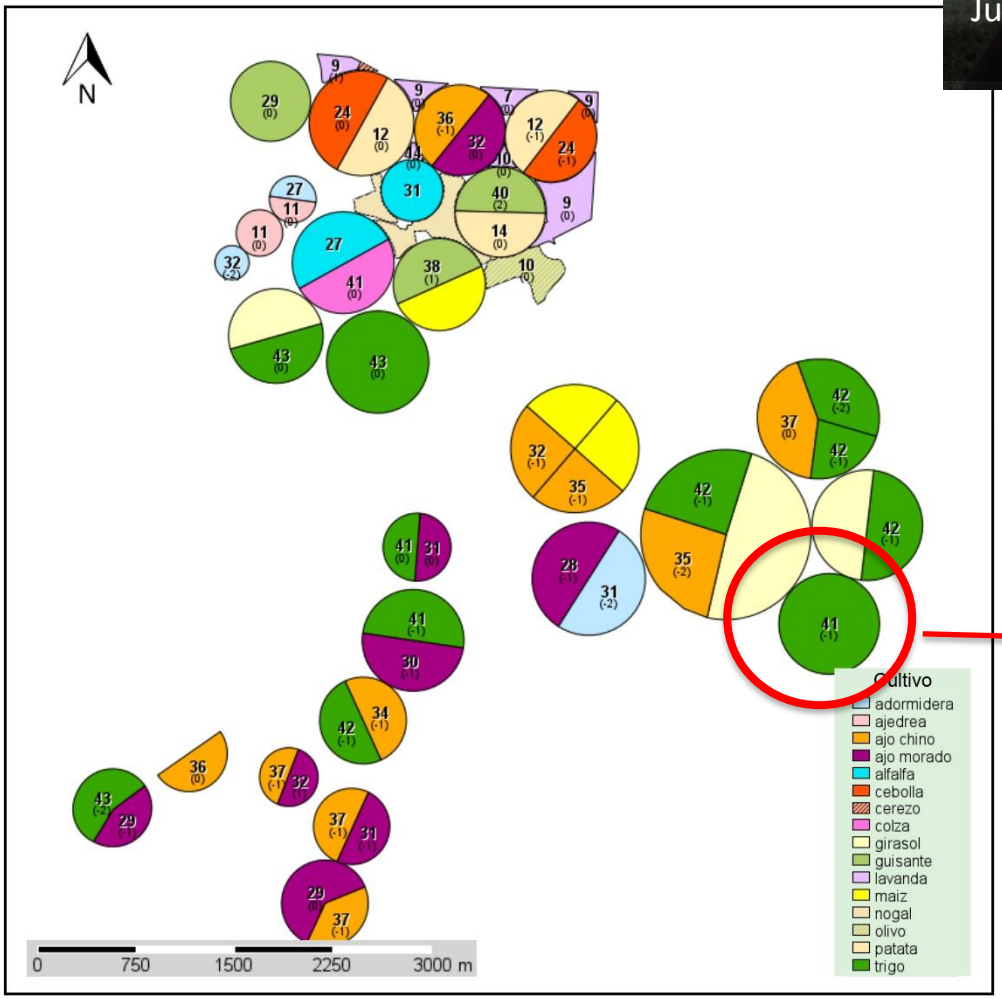
The Case Study

Predicción de Necesidades Hídricas Netas (mm)
09 mayo - 15 mayo
Dehesa de los Llanos

irrimaps Riego eficiente agriSat



Report example of the service provided to the farm by AgriSat weekly Irrimaps® (RS-approach)
For the week 23-29 May 2019
ETc (mm)

1 single rate per plot or irrigation Unit Mangement

Our case Study

Irrigation Variable Rate

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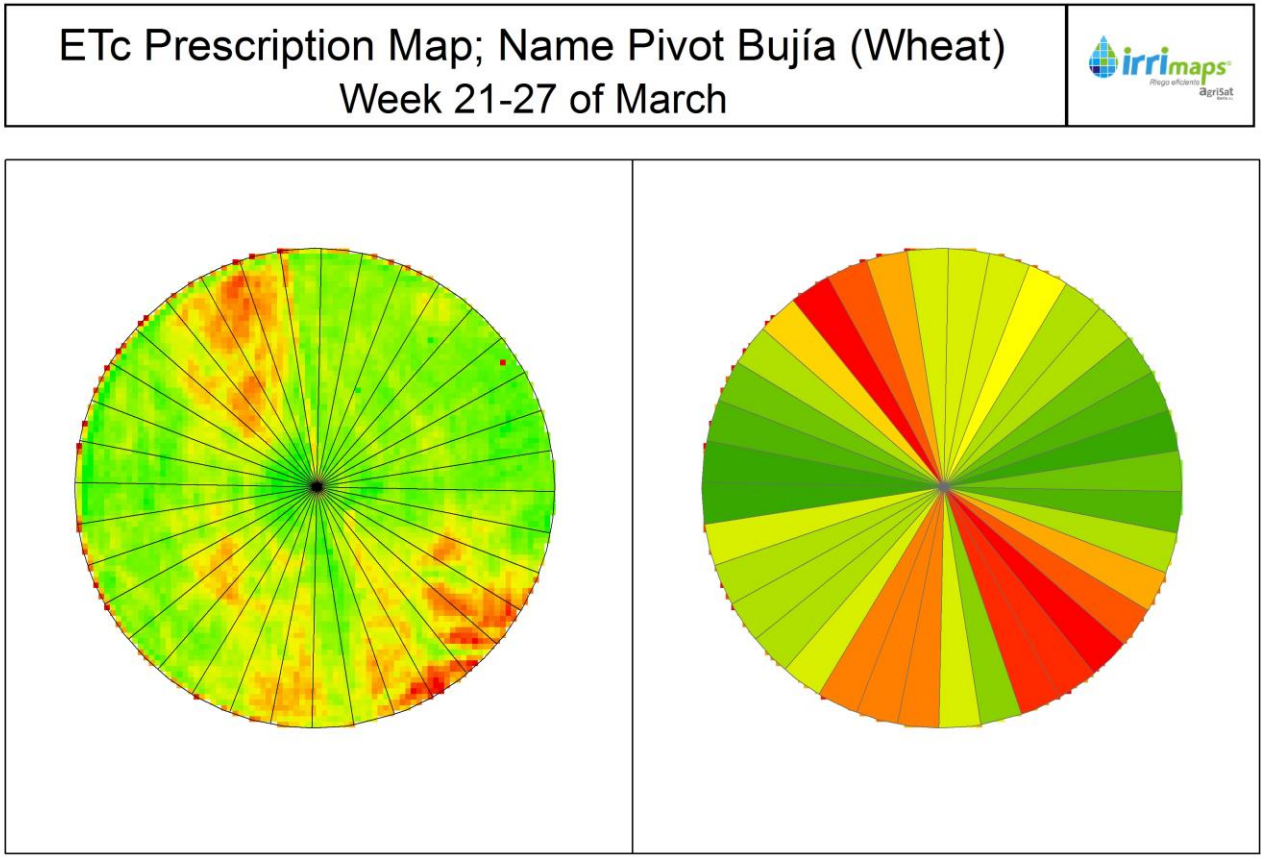
The Case Study

Variable Rate Irrigation and ETc recommendation

Variable Rate Irrigation Technology implemented by modifying the angular speed in each sector (**36 Sectors of 10 Degrees each)**



ETc sector value Kc*ETo;

Kc: 85percentile of the pixel values

Each ETc map prescription has been released every Thursday since March 21st to June 20th

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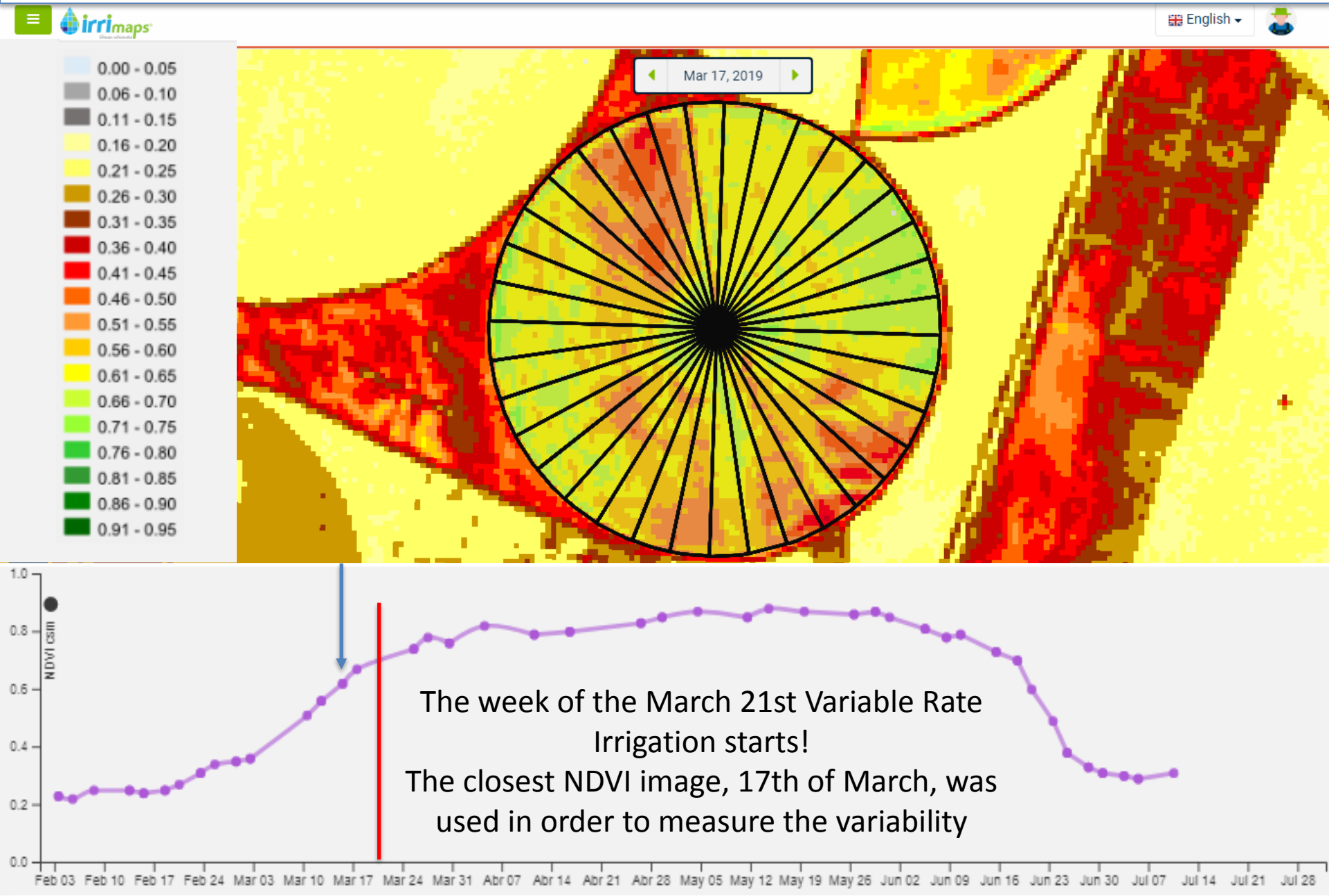
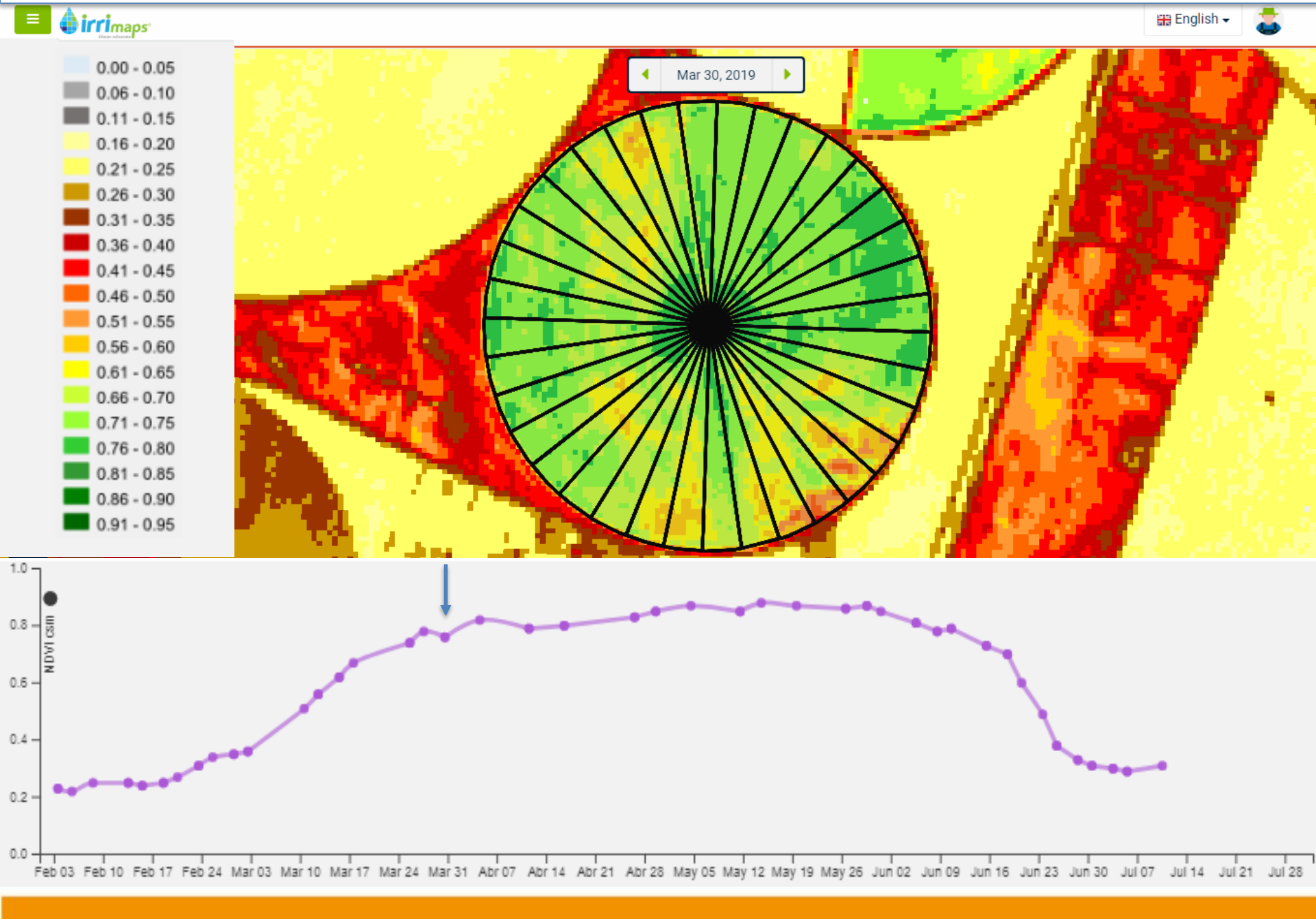
IMAGES USED DURING THE GROWING CYCLE



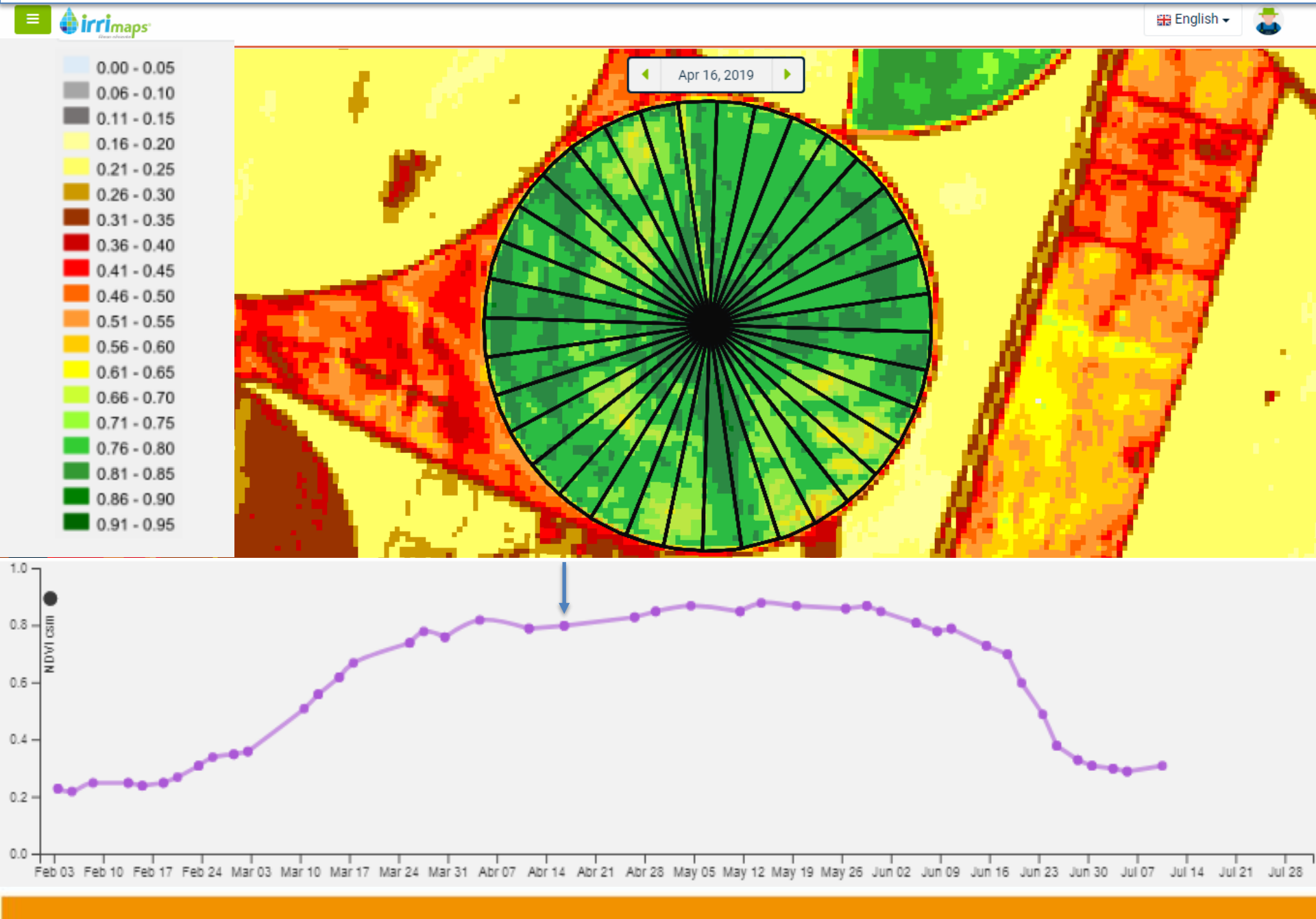
The week of the March 21st Variable Rate Irrigation starts!

The closest NDVI image, 17th of March, was used in order to measure the variability

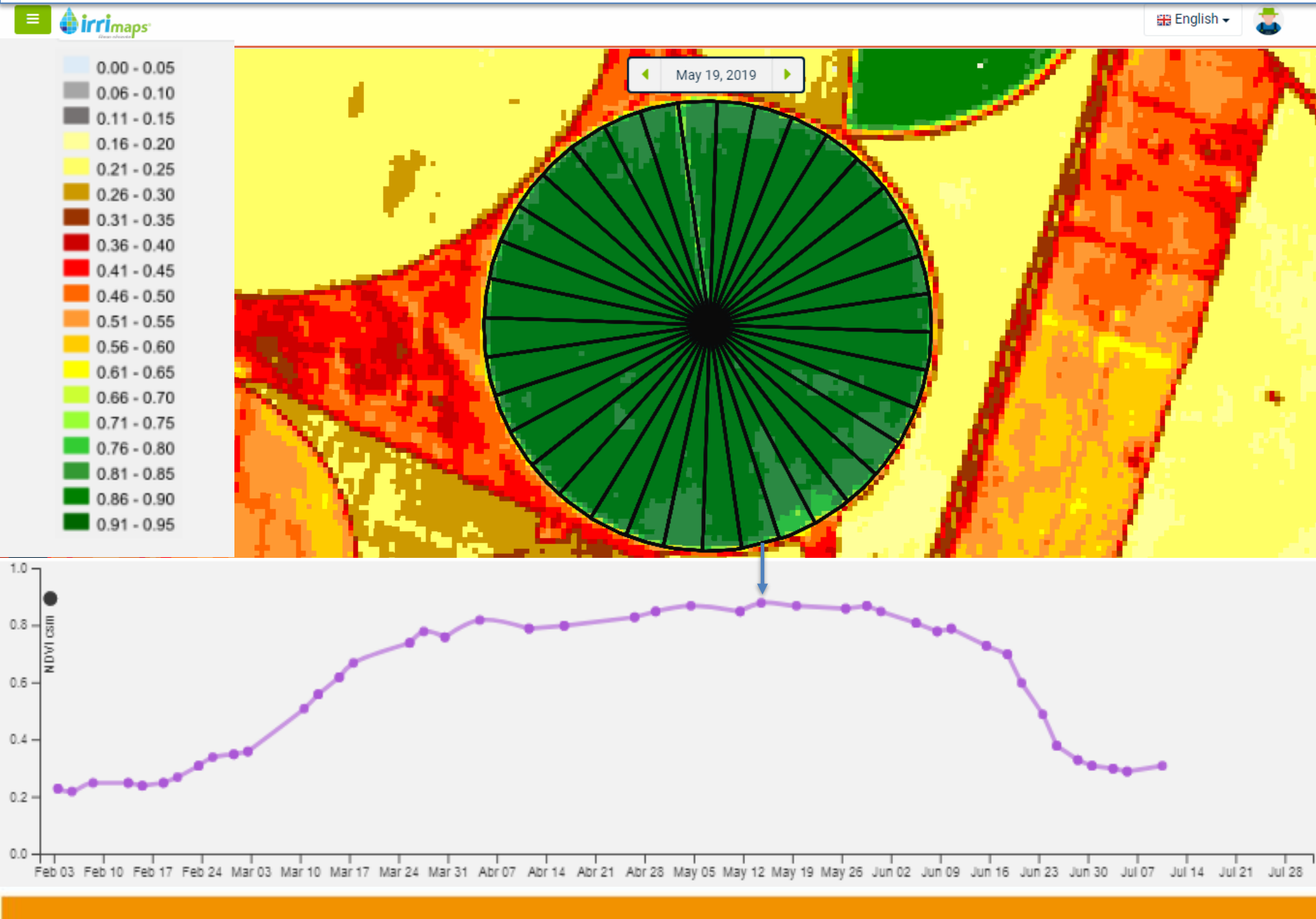
IMAGES USED DURING THE GROWING CYCLE



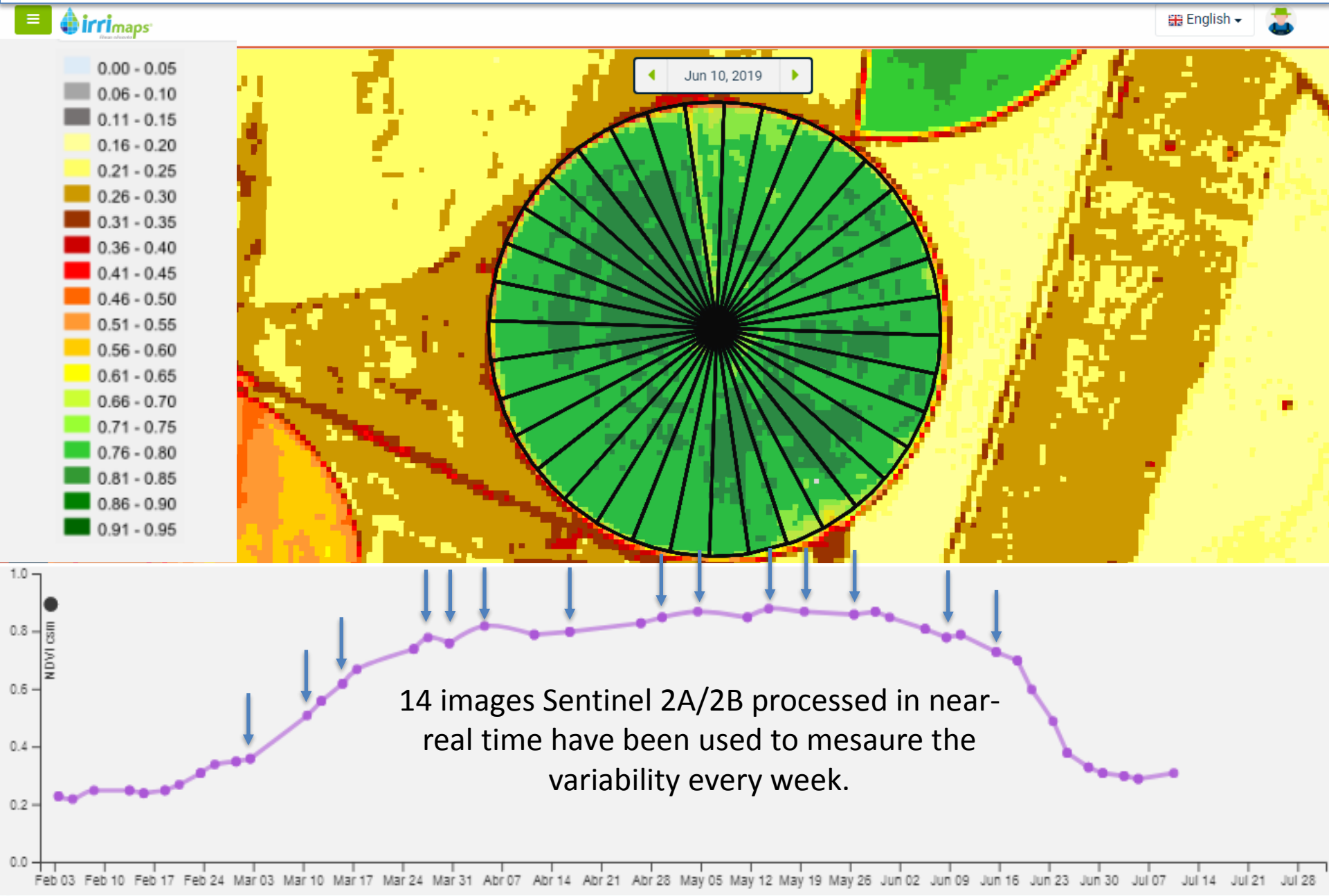
IMAGES USED DURING THE GROWING CYCLE



IMAGES USED DURING THE GROWING CYCLE



IMAGES USED DURING THE GROWING CYCLE

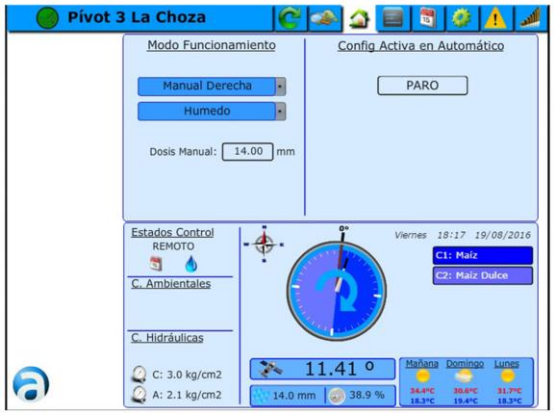


14 images Sentinel 2A/2B processed in near-real time have been used to mesaure the variability every week.

The Case Study

Center Pivot equipped with SICO-P technology:

- Able to variate angular speed every 10 degrees
- Remote activation from a cell phone
- Monitoring irrigation parameters as Irrigation Precipitation
- Alarm system for detecting incidences



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We took advantage of the SICO-P technology even if it wasn´t designed for VR applications.

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Workflow

Forecast ETc per sector

Generation weekly ETc Maps and Operational tables per sector (RS)
Every Thurday
21 March to 27 June

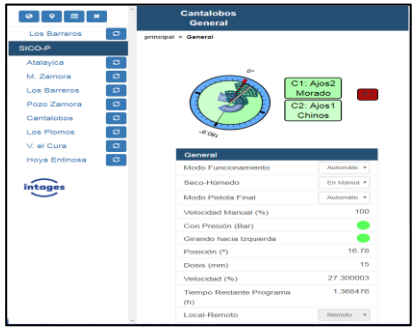
Example week of 28March 2019

Id_Sector	Coefficient	Id_Sector	Coefficient
1	1.01	19	1.02
2	1.00	20	1.00
3	1.00	21	0.98
4	1.01	22	0.96
5	1.01	23	1.00
6	1.01	24	1.00
7	1.02	25	1.00
8	1.02	26	1.02
9	1.02	27	1.01
10	1.02	28	1.02
11	1.03	29	1.02
12	1.02	30	1.01
13	0.99	31	1.00
14	0.97	32	1.01
15	0.95	33	1.00
16	0.97	34	0.97
17	0.95	35	0.99
18	1.00	36	0.99

ETc average (mm)	22.9

Irrigation Decision

Farm decision makers evaluate different aspects as PP, electricity tariffs, in order to decide the Irrigation Rates and timing



Irrigation Application

Data entry to the VRI system

Irrigation Monitoring

Irrigation Rates Control
Incidence Report

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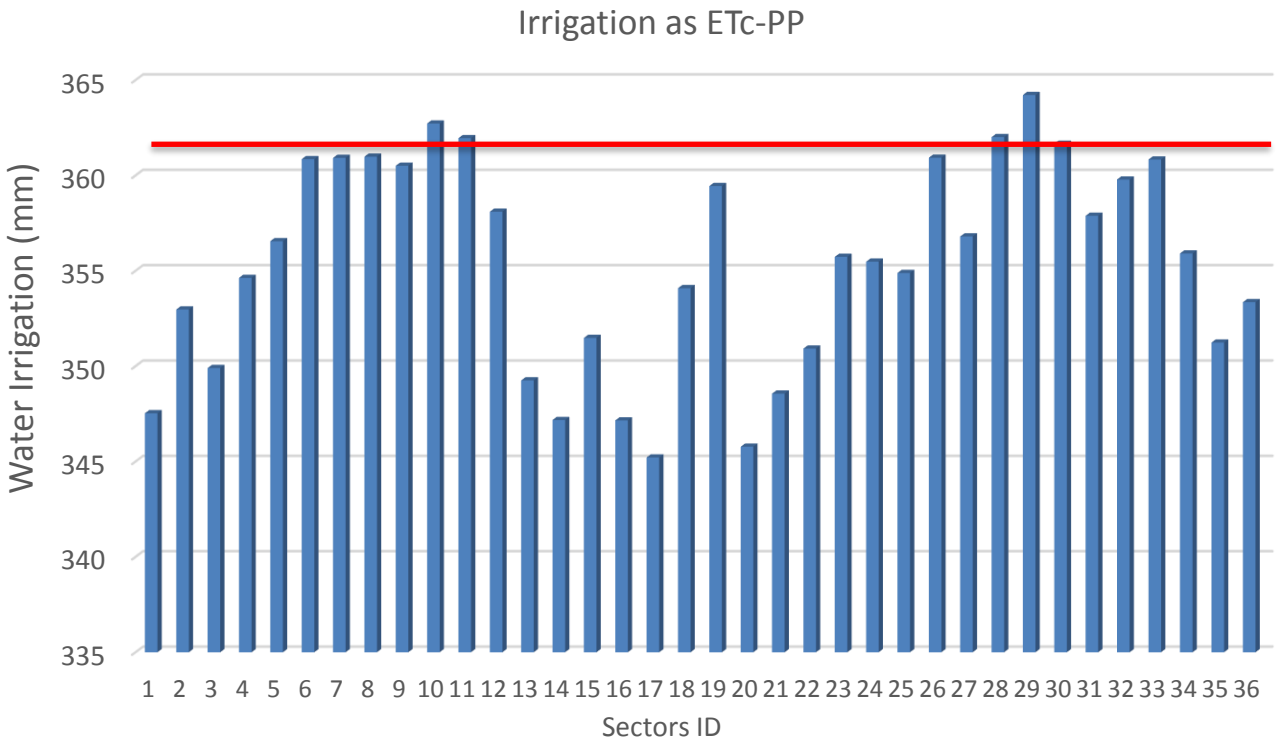
Results

Accumulated Irrigation Water Sectors vs Homogeneous Rate



361mm
Irrigation Water
Homogeneous Rate

HOMOGENEOUS RATE	
Acc. ETc (mm)	Acc. PP(mm)
561.61	200.6

Total savings: 3,181 m3 (more than 300 euros), enough water to irrigate one hectare.

The ETc (homogeneous rate and per sector) has been calculated using 85th Percentile in order to cover the crop water demand of, at least, the 85% of Crop Water Requirement pixels values.

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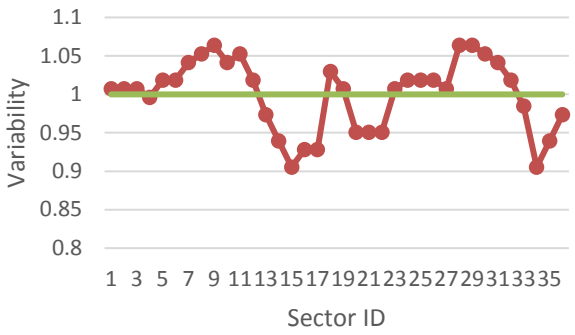
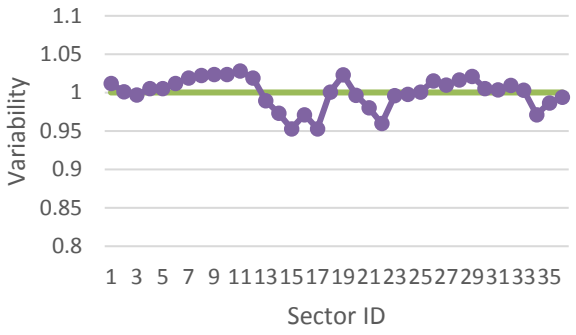
Results

Weekly Variability Analysis

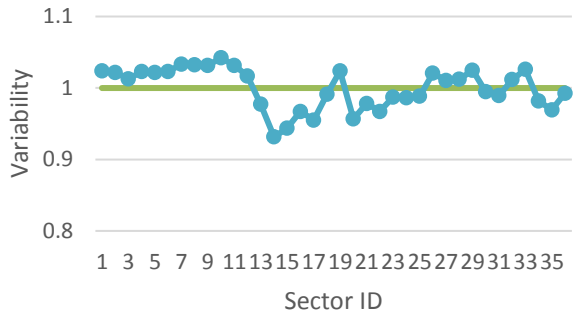
21-27 March



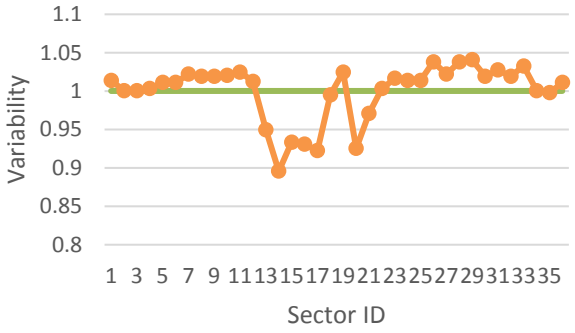
28March - 3April



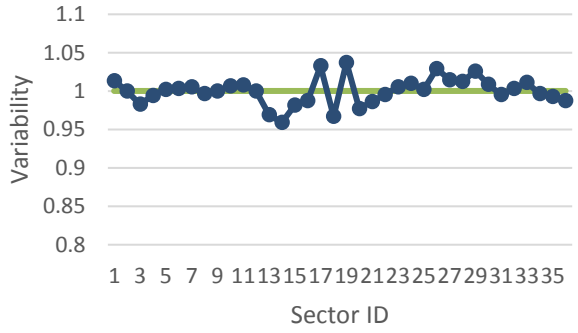
4 - 10 April



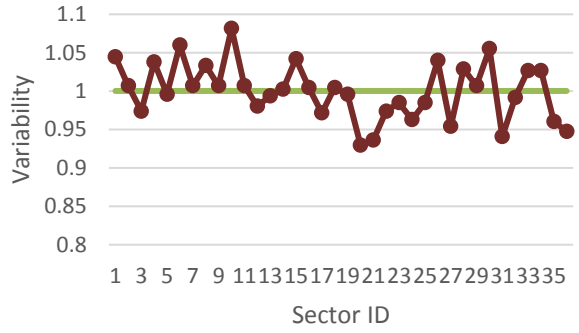
11 - 17 April



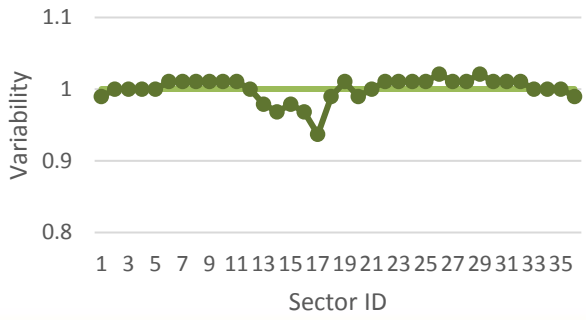
18 - 24 April



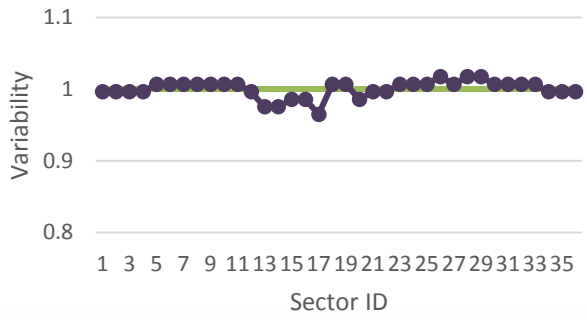
25Apr - 1 May



2 - 8 May



9 - 15 May



Variability Calculated :

ETc (Sector) / ETc (36 Sectors Average)

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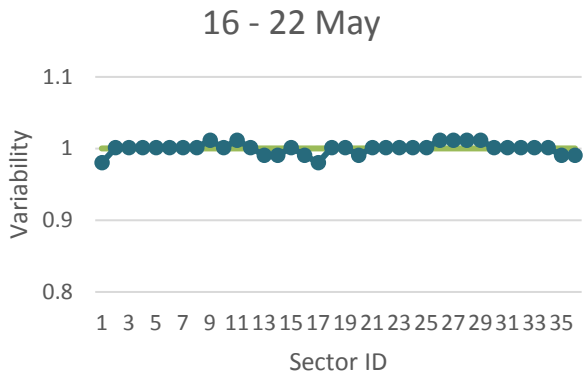
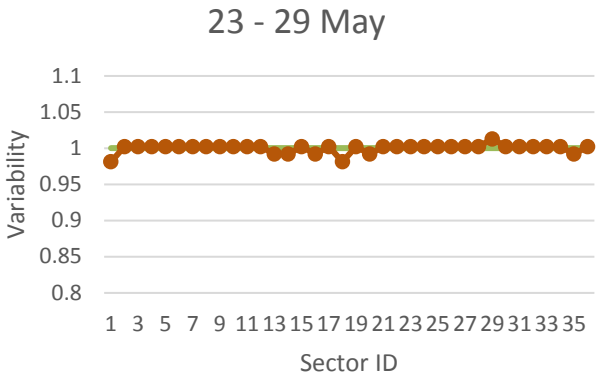
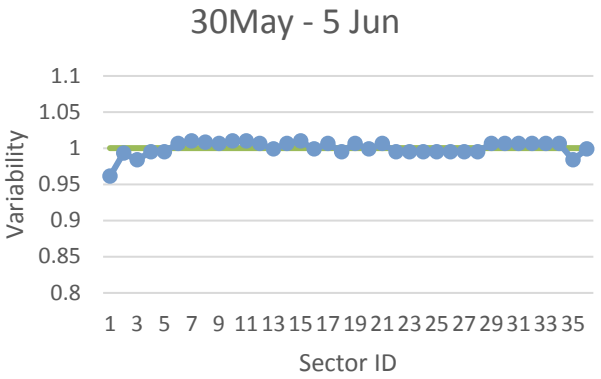
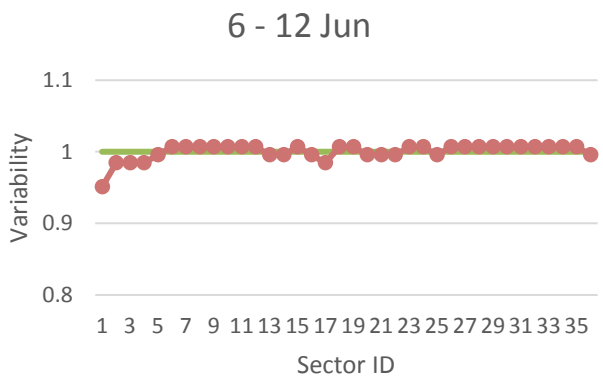
Results

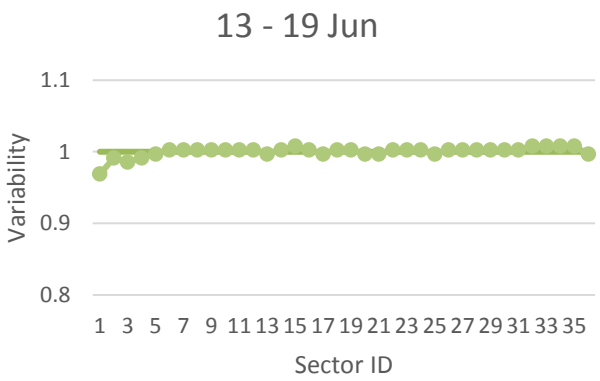
Weekly Variability Analysis

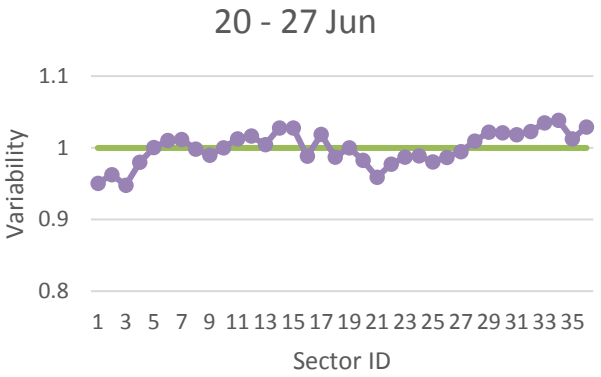












If we look at this preliminary analysis of the variability evolving with time, we observe different phenomena:

- The variability is higher at the begining and at the end of the crop development
- There are sectors which start above the average and finish under the average and vice-versa

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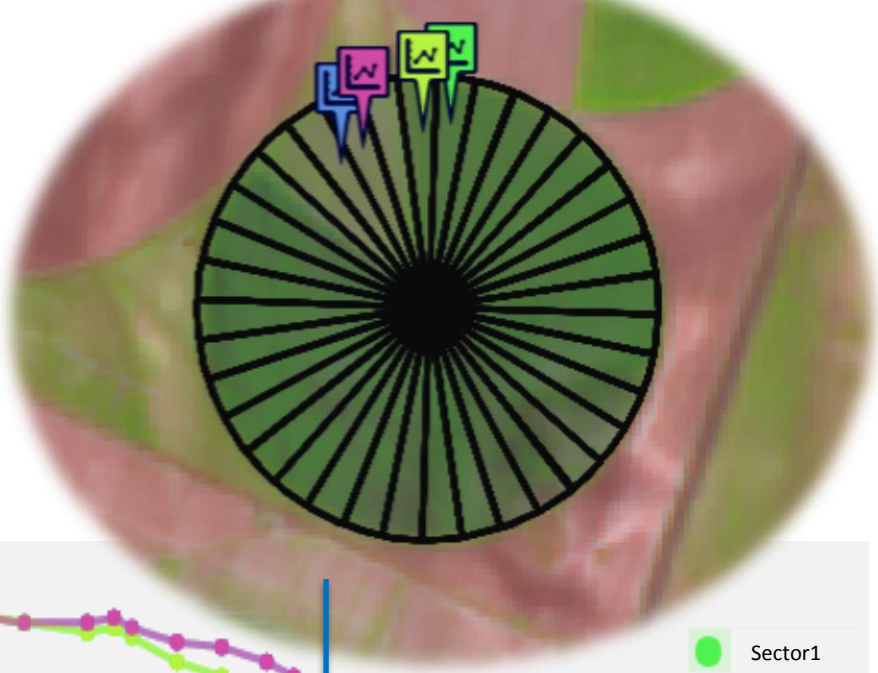
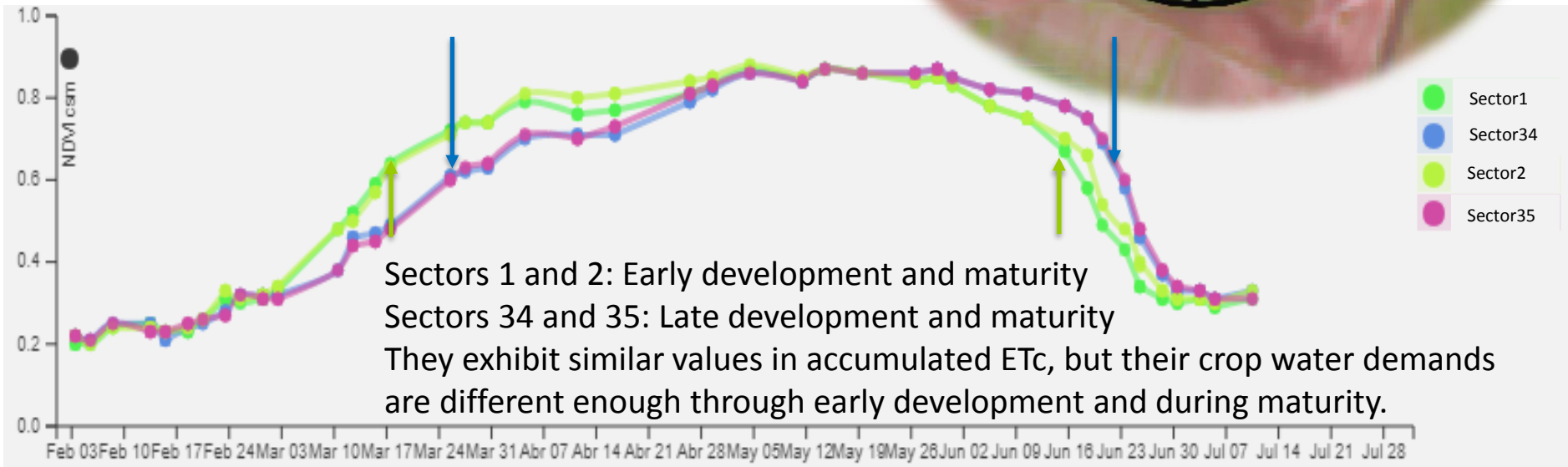
Results

SECTOR	Accumulated ETc
1	532mm
2	538mm
34	540mm
35	535mm





Sectors 1 and 2: Early development and maturity
Sectors 34 and 35: Late development and maturity
They exhibit similar values in accumulated ETc, but their crop water demands are different enough through early development and during maturity.

The capacity of **adjusting the water supply to the crop water demands in the right moment** through Variable Rate Irrigation is crucial in order to optimize the water use and obtain maximum yields

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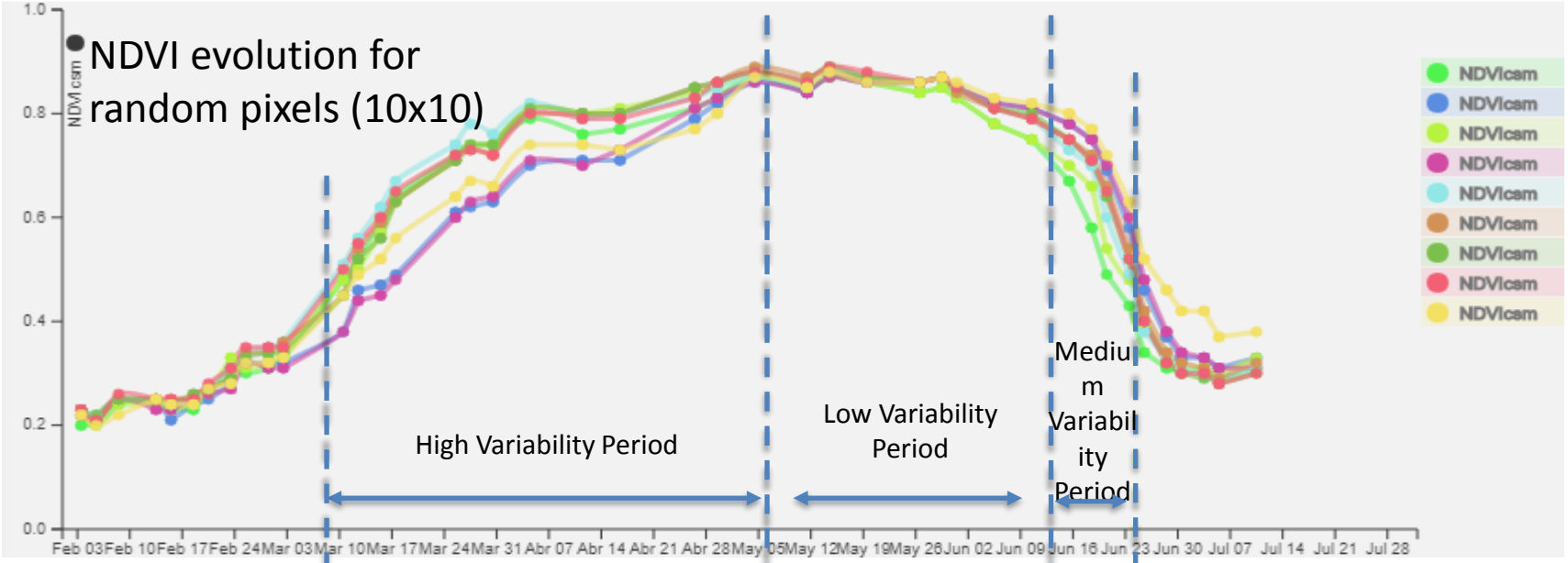
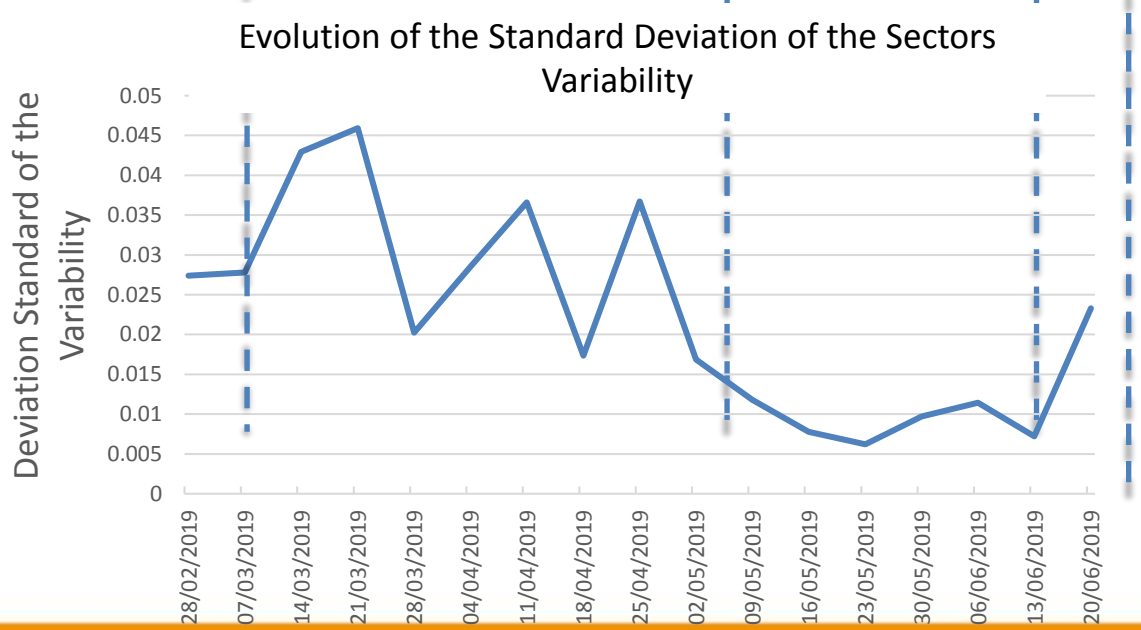
Results

The weeks between May 9th – June 13th are the most uniform of the growing cycle





The Standard Deviation of the Variability shows how higher values at the beginning of the crop development (0.045) start decreasing until 10times at medium-end of the crop development (0.007)

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Conclusions

- Remote sensing-based crop water requirement a week ahead is able to drive a low-cost variable rate irrigation technology.

- The yield obtained, 8200kg/ha, was one of the best in the previous 12 wheat campaigns in this plot during the last 17 years. This promising result encourages to keep the Variable Rate RS-approach in the upcoming campaigns.

- The variable rate sectors design is adapting well to the crop variability over time adjusting the rate to the different evolution behaviors.

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Conclusions

- Variable rate not only improves water use efficiency, demonstrated by the historical high yield average, but also generates savings with respect to the homogeneous dose (the usual practice of the farmer).

- High within-field variability has been observed in the early stages, lower variability around flowering and an increase at the end of the crop development.

- The sectorization in 10 degrees worked well avoiding big investment by the farm

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Tu campo desde el cielo

Thanks!

maria.calera@agrisat.es