

USE OF SENTINEL-2 IMAGES FOR PLANT GROWTH AND WATER-NEED MONITORING: APPLICATION ON AN INDUSTRIAL TOMATO CROP IN CENTRAL ITALY

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Operational challenges

- Monitoring plant WUE;
- Improving local irrigation practices;
- Supporting crop variability management.

Main aims of this work

- Set-up of an integrated system for remote control of tomato growth and plant water requirements;
- Evaluation of Sentinel-2 images for systematic crop coverage (%) and crop coefficient (K_c) updating;
- Determination of automatic procedures for a second level irrigation control.

SECOND LEVEL IRRIGATION CONTROL

MEANS

THAT AN INTEGRATED SYSTEM CONTROLS THE NORMAL IRRIGATION PRACTICES OF LOCAL FARMERS, REDUCING THE QUANTITY OF WATER WHEN SOME THRESHOLDS ARE EXCEEDED (e.g. Soil Water Content or Cumulative ET_a).

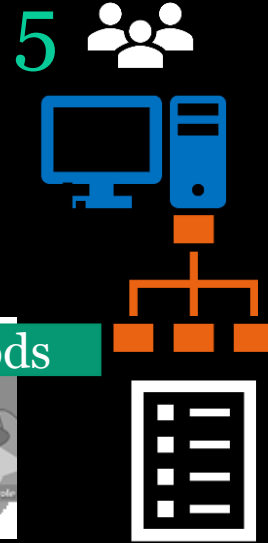
Integrated Support System for on Field Tomato Irrigation Management

Hardware components

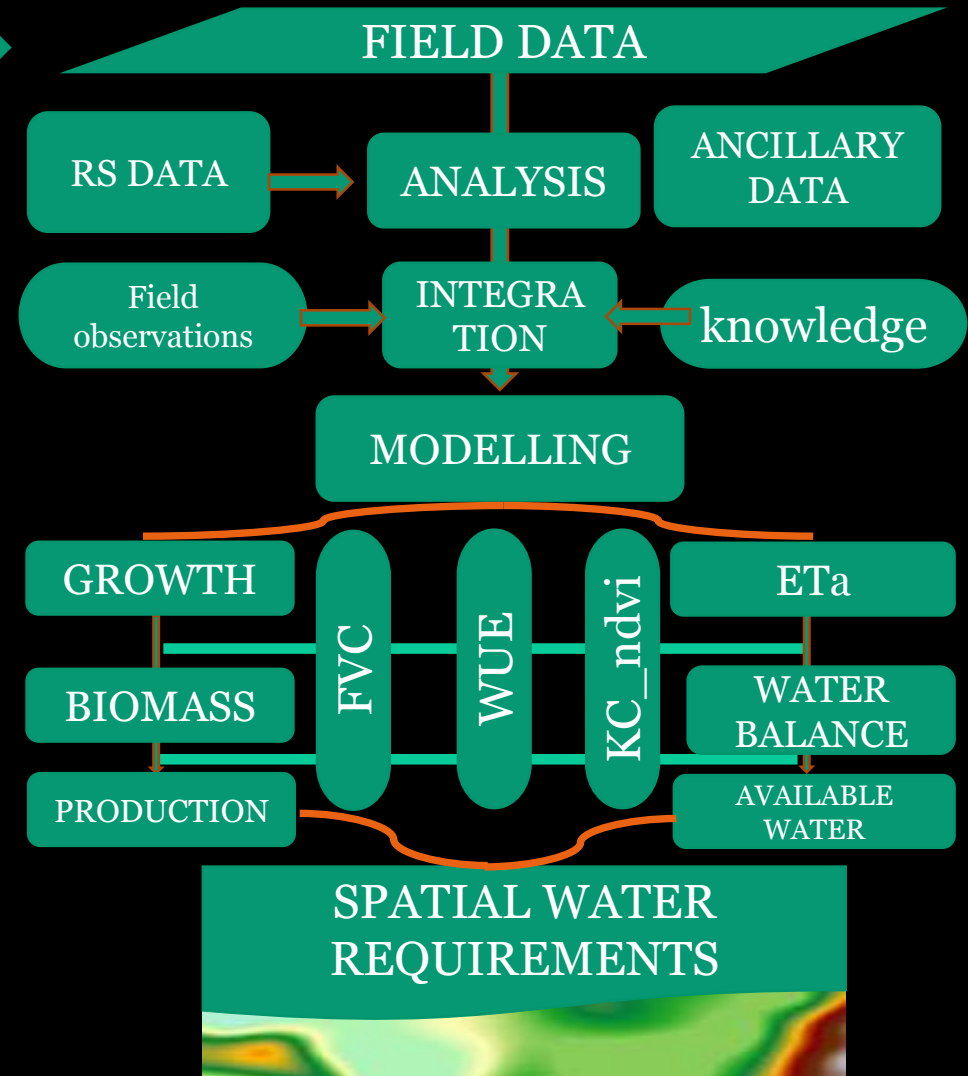


FARMER

Research Unit

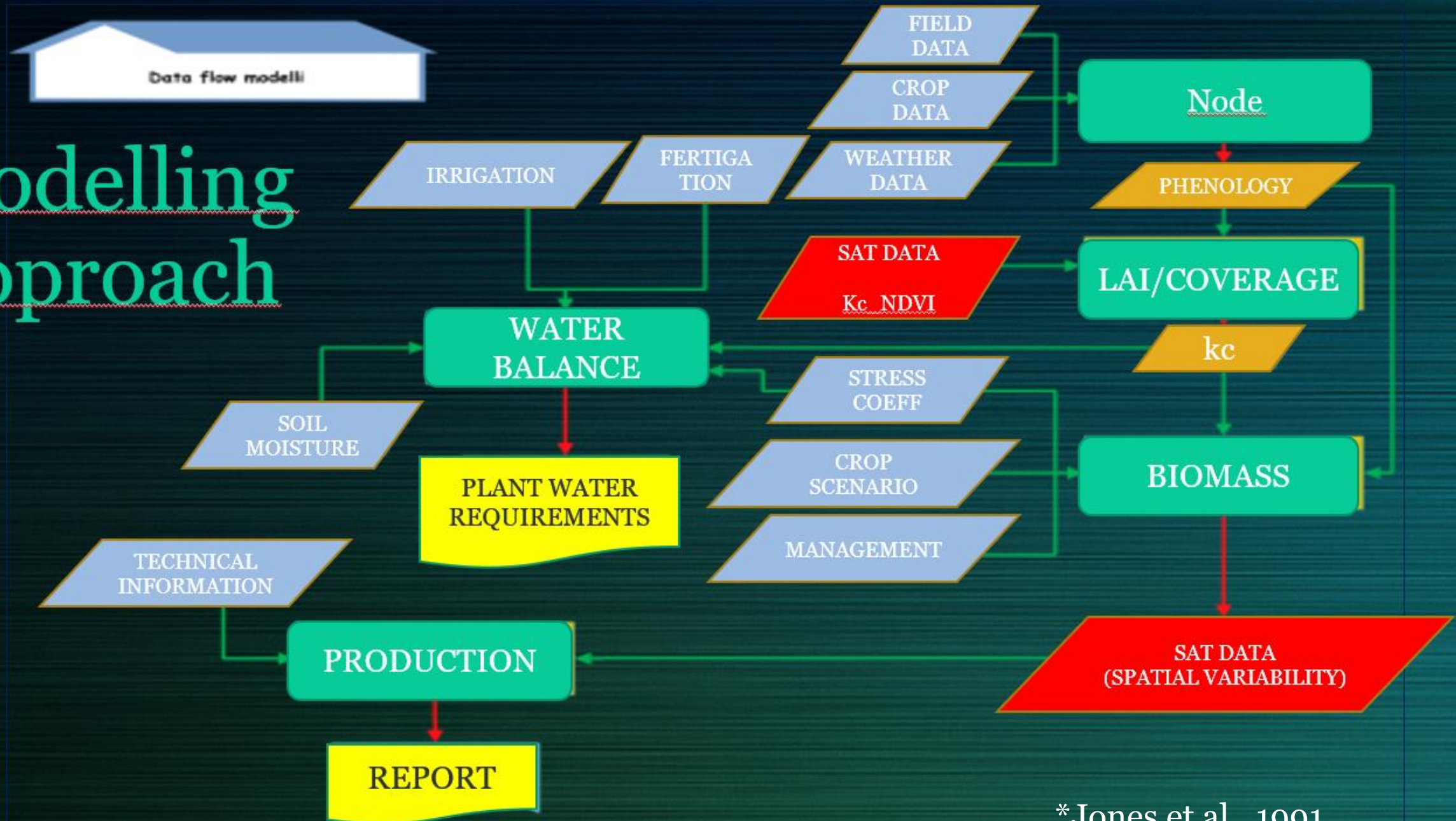


SOFTWARE PROCEDURES

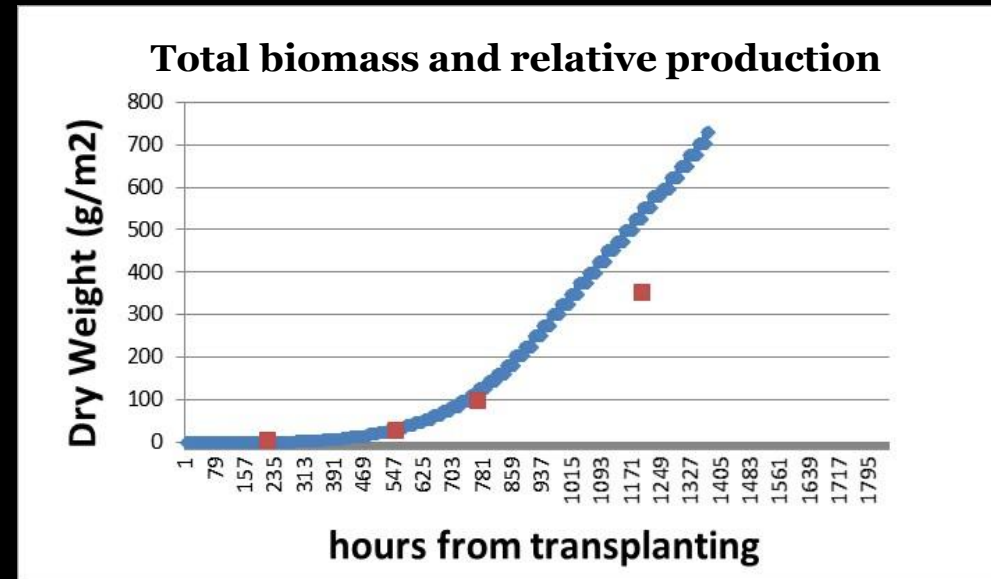
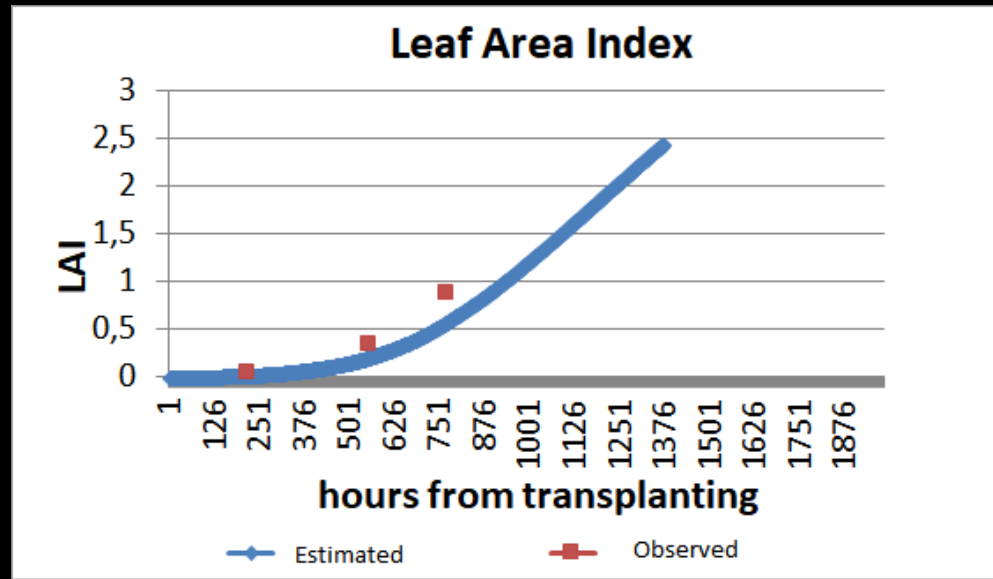
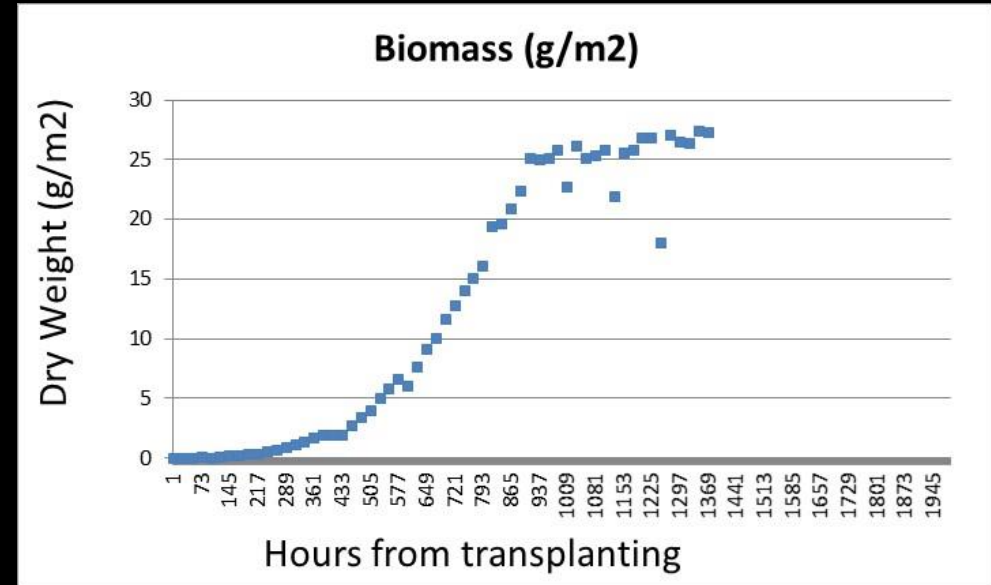
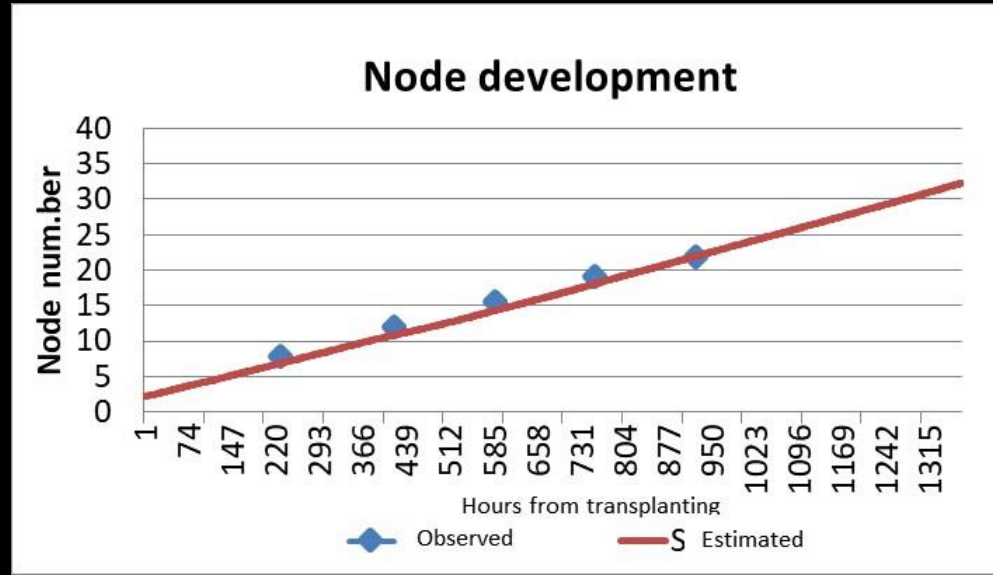


1. Complete agrometeorological station (real time data updating)
2. Soil moisture sensors (at 15-20 cm and 35-40 cm of depth; 15 min updating)
3. Local control unit + actuators (Hourly updating)
4. Satellite images (Sentinel-2 passage updating)
5. Remote Server

Modelling approach

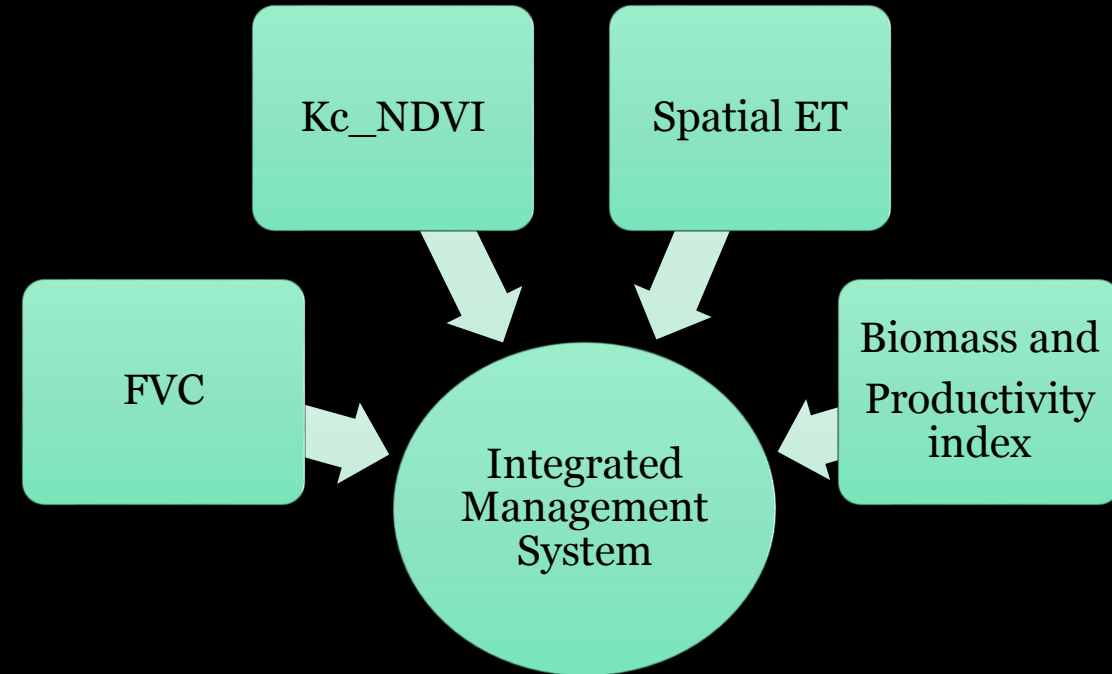


TOMGRO Model output



Satellite Contribution

- Sentinel-2 images can provide basic spatial and temporal information to extensive agricultural water management systems;
- Plant growth and water requirements can be frequently evaluated and updated, allowing the weighting of the differences between field sectors;
- Integrated systems (satellite + local monitoring networks + modelling), can be used to evaluate crop water uptaking at different scale (until regional one).



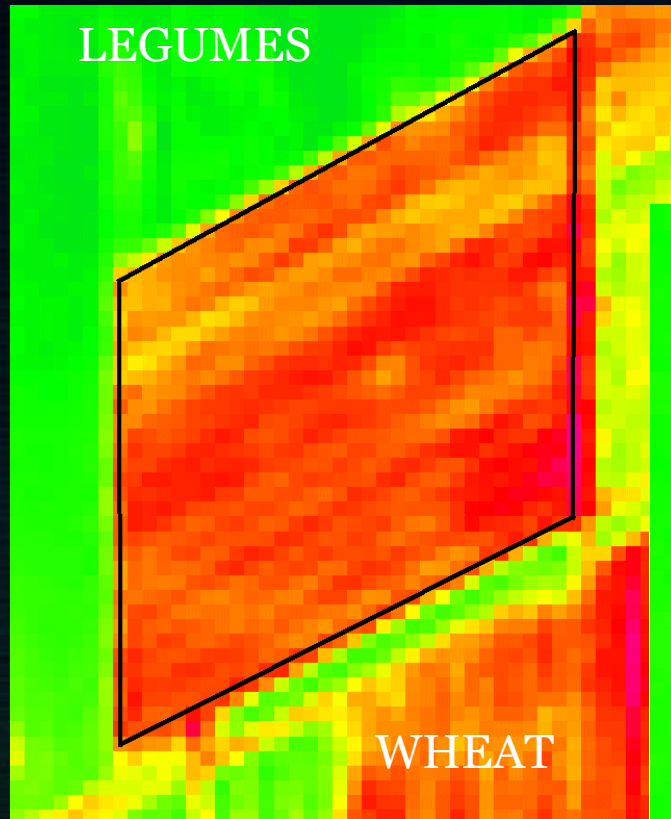
IN THIS STUDY

Sentinel II data support model simulation and irrigation management providing:

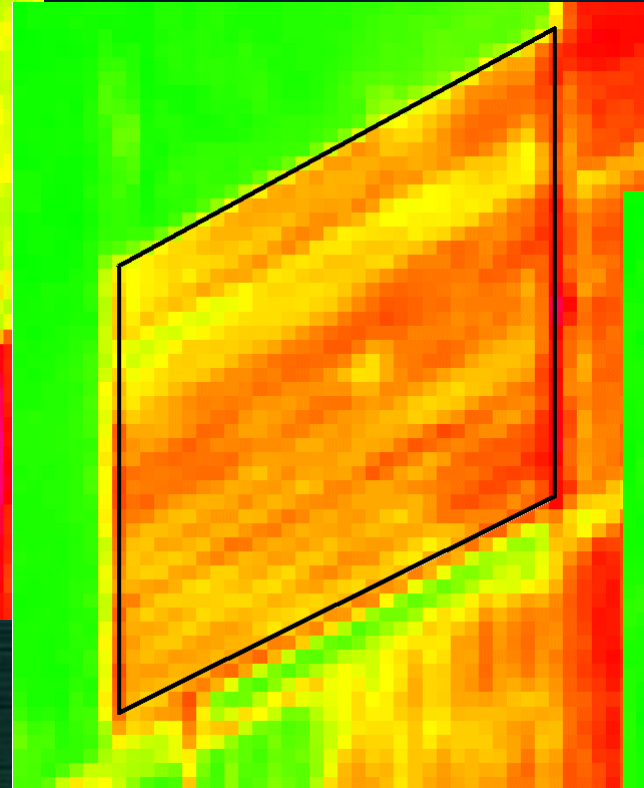
- frequently updated Crop Coefficients for each field sectors, taking into account real plant development;
- Reliable and objective Fractional Vegetation Coverage;
- Independent system of ETa computation for different model comparison;
- Spatial indication on biomass distribution over the field.

An index of productivity for further analysis on soil tillage and water management techniques will be also tested.

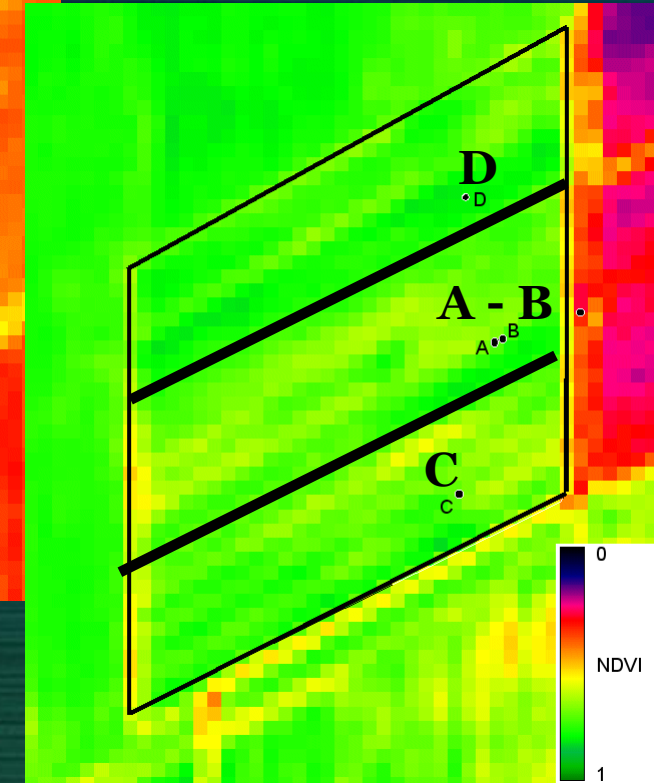
NDVI evolution



29.05.2018



03.06.2018



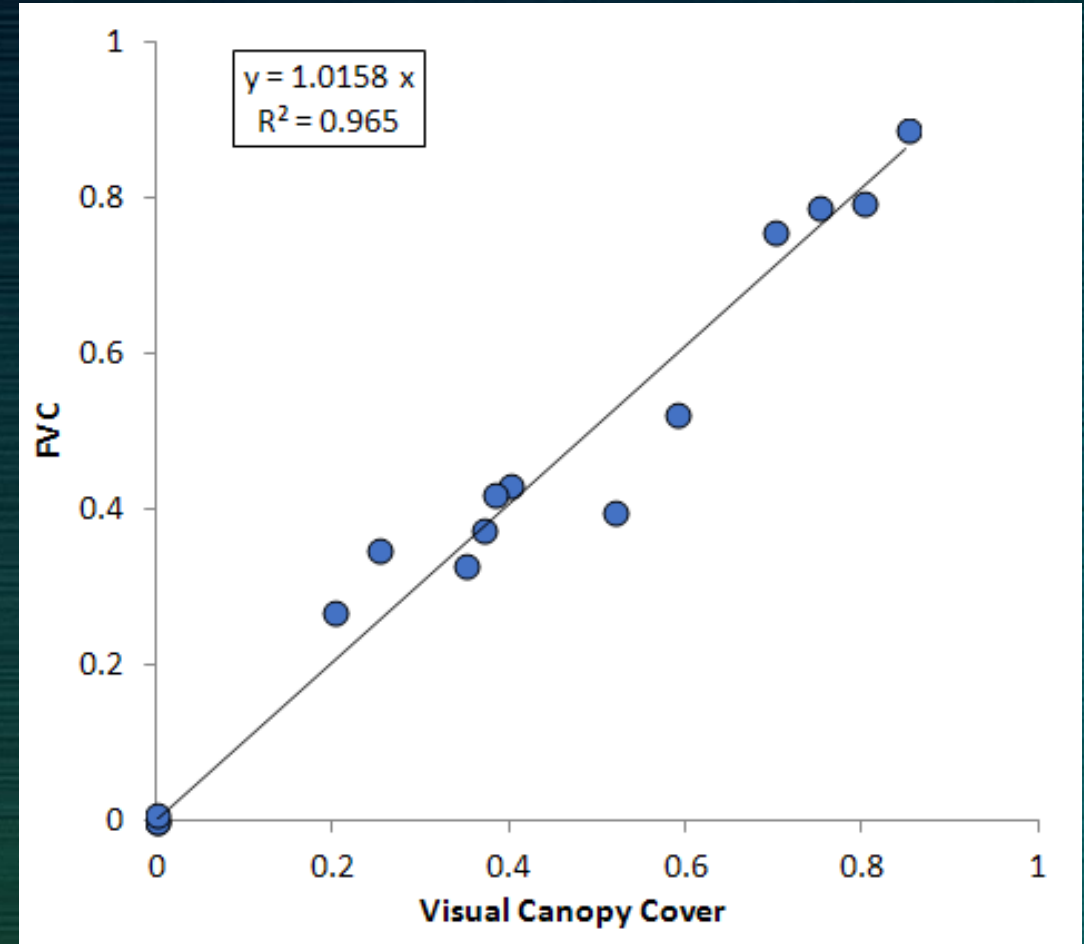
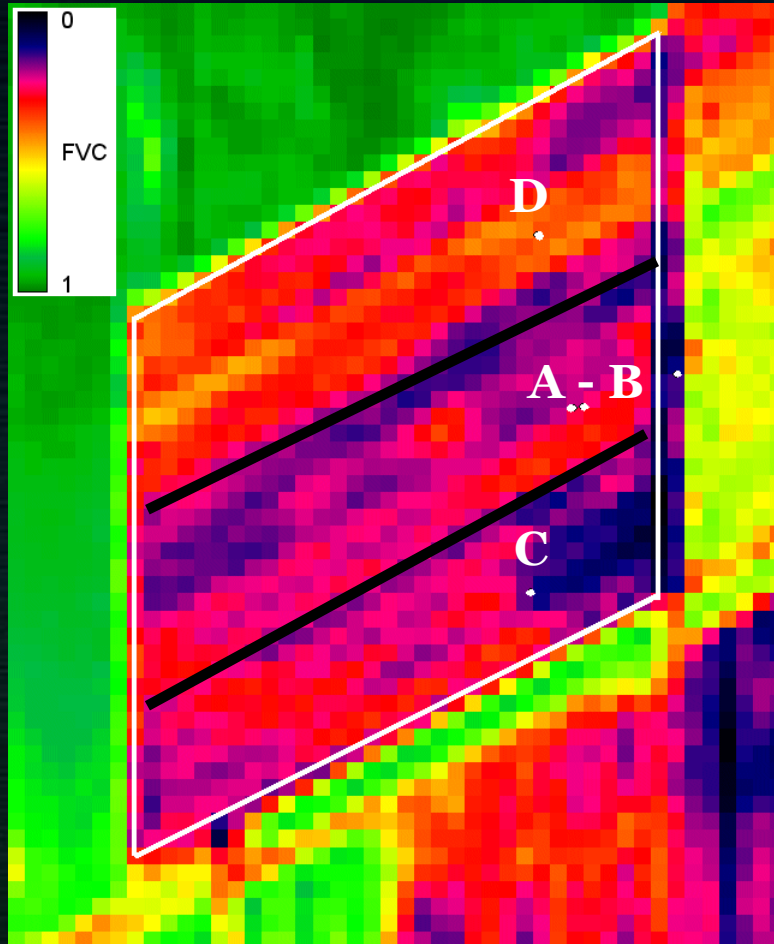
18.06.2018

Field dimensions: 360 x 280 meters
Plants are in two lines at 20 cm from the tube
Irrig. tubes are at a distance of 170 cm

We observe differences inside the field that remain from the beginning of the season, mainly due to soil characteristics and water availability.



Fractional Vegetation Cover



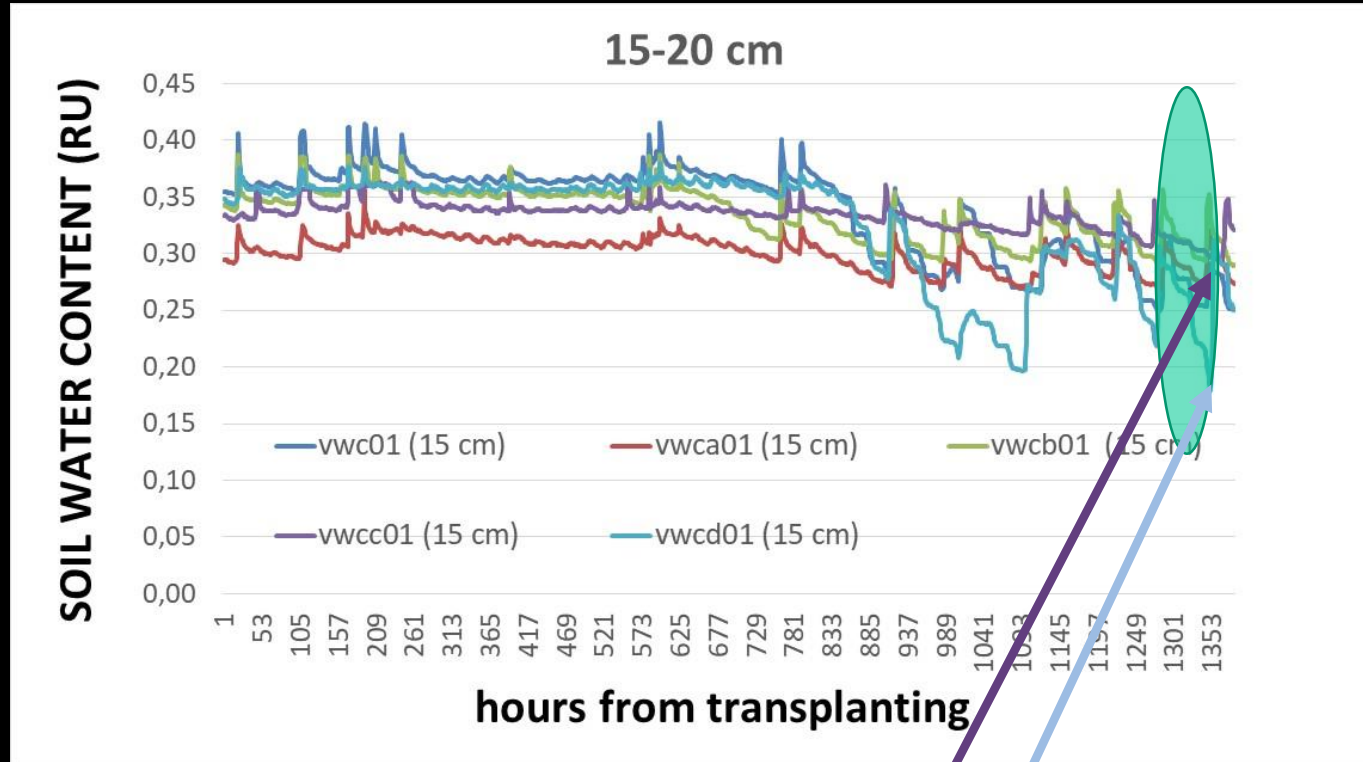
3/06/2018

$$FVC = (NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})$$

Visual Vs Sentinel II Images

TRANSPIRATION

SOIL wetness sensors



SWC variation between two irrigations

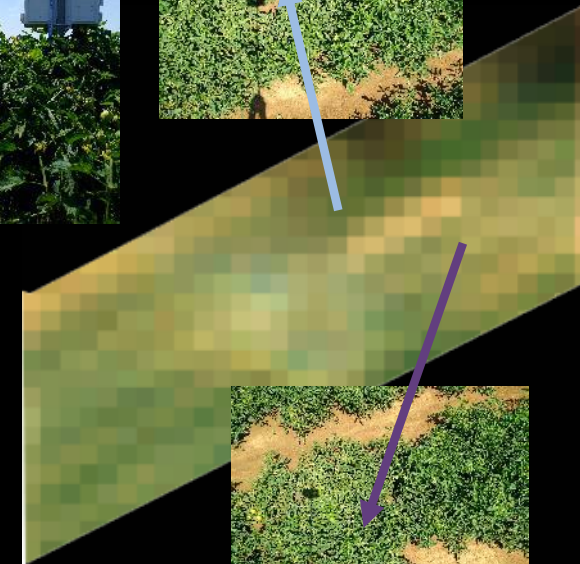
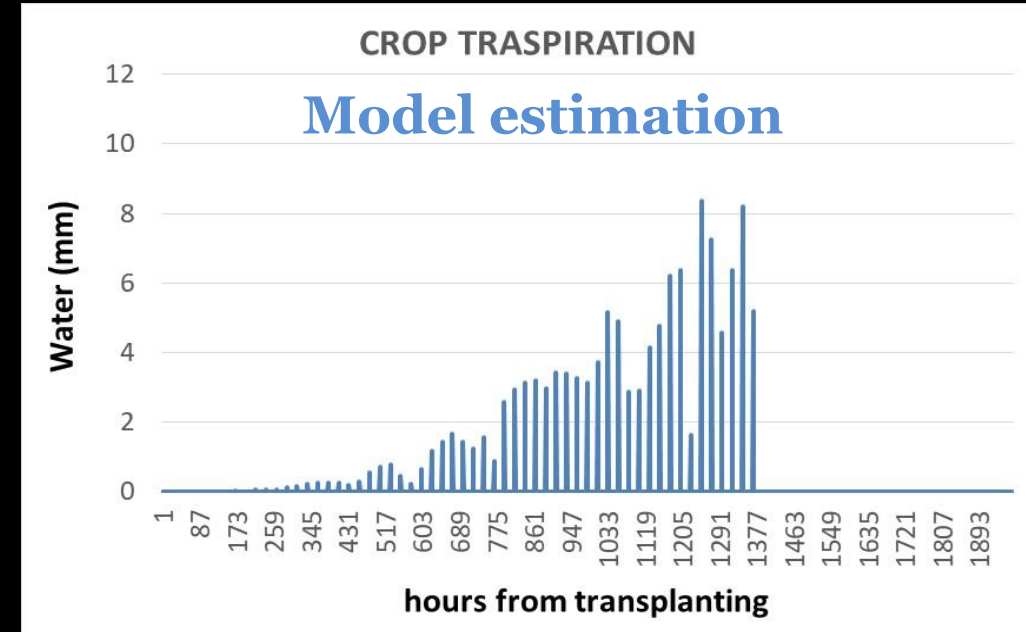
Min Variation = 0,05

Max Variation. = 0,12

Var. 0,05 = 5%

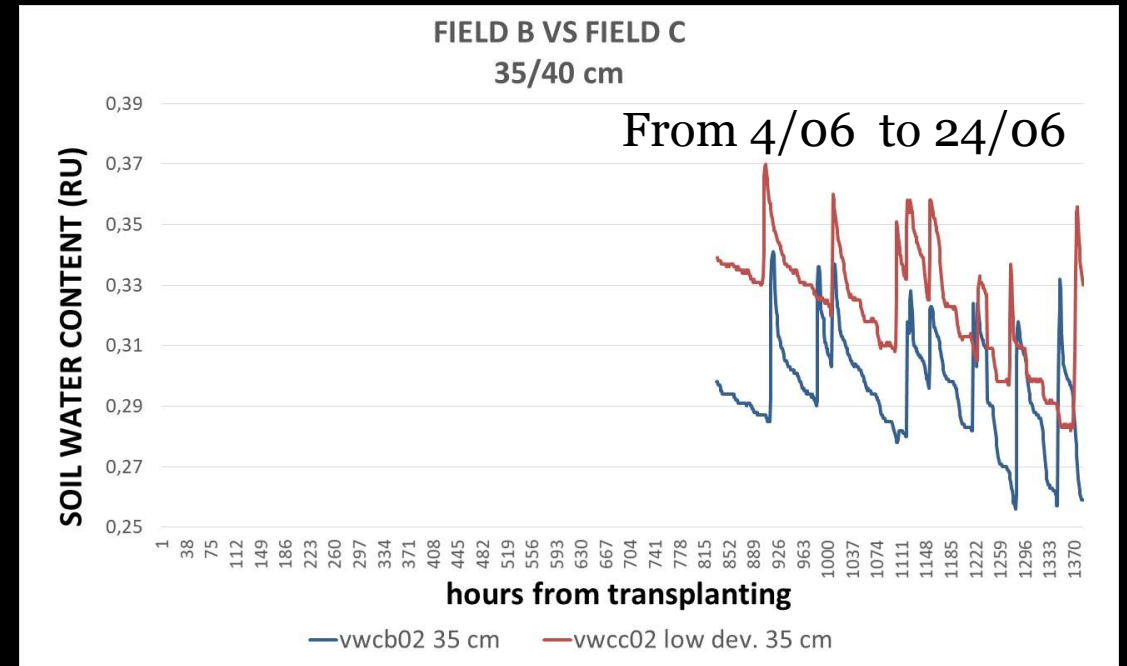
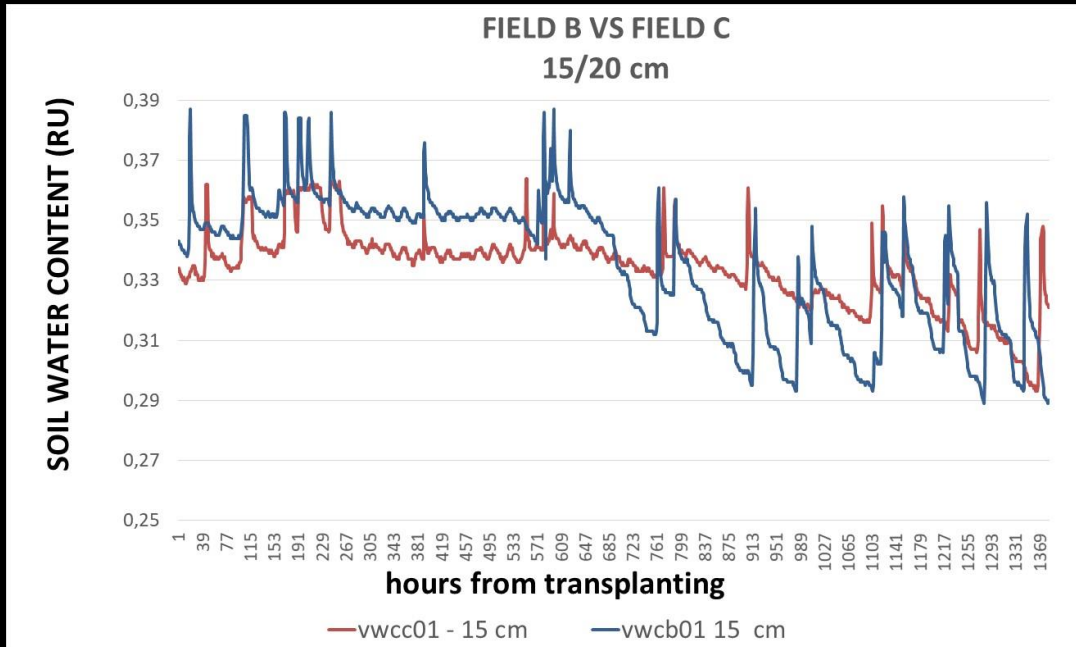
Unlucky or not representative?

(54 hours)



Field condition and spatial variability at 18/06/2018

Soil water content behavior B vs C At two layers of depth (20 and 40 cm)



B – System Managed



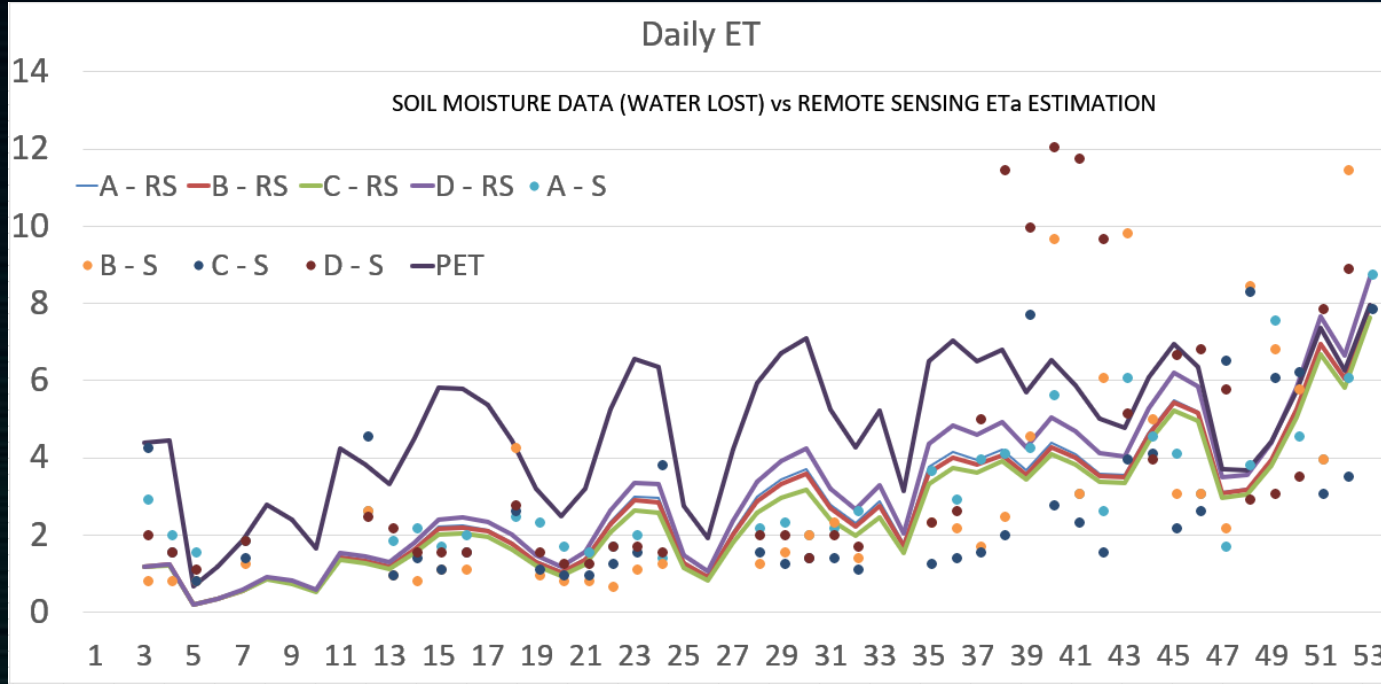
Note that the slope of the two paths, corresponding to different water uptaking efficiency, is linked to the root development.

Crop coverage: $B > C$ (about 10%)
Water uptaking: $B > C$ (about 20%)

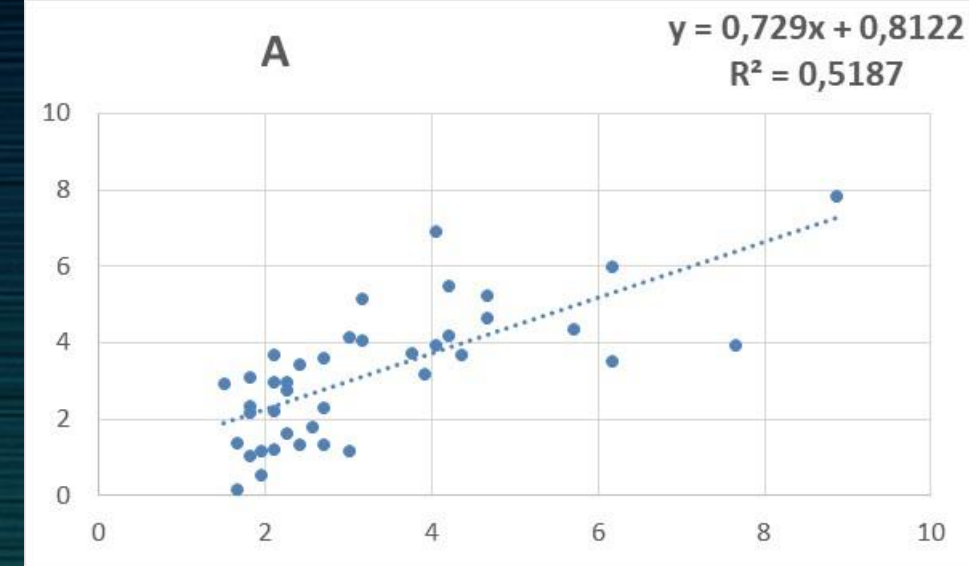
C – Lower development



ESTIMATES OF ET_A

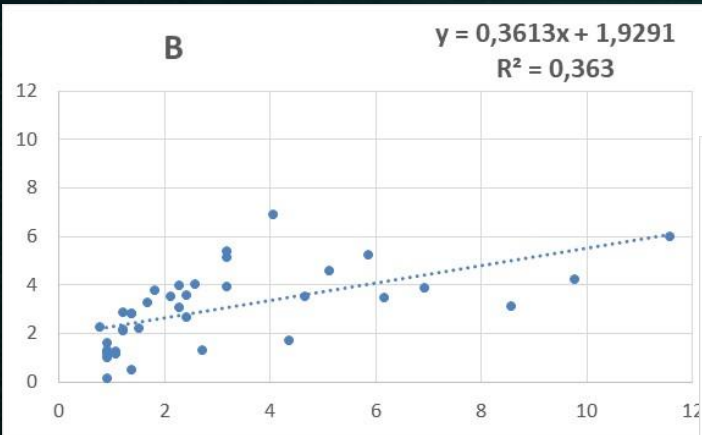


ETa from SAT (mm)

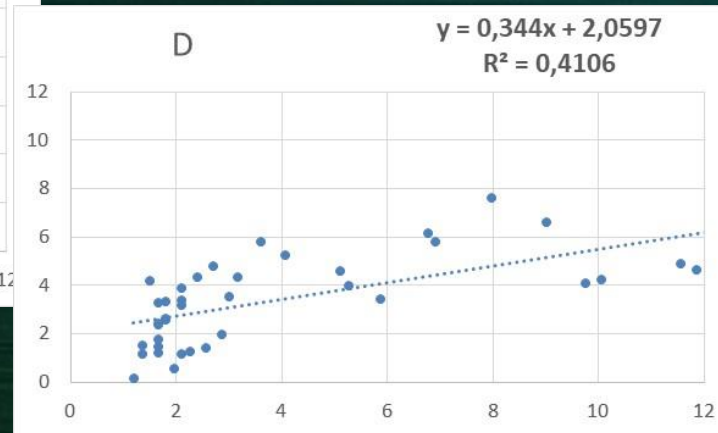


ETa from Sensors (mm)

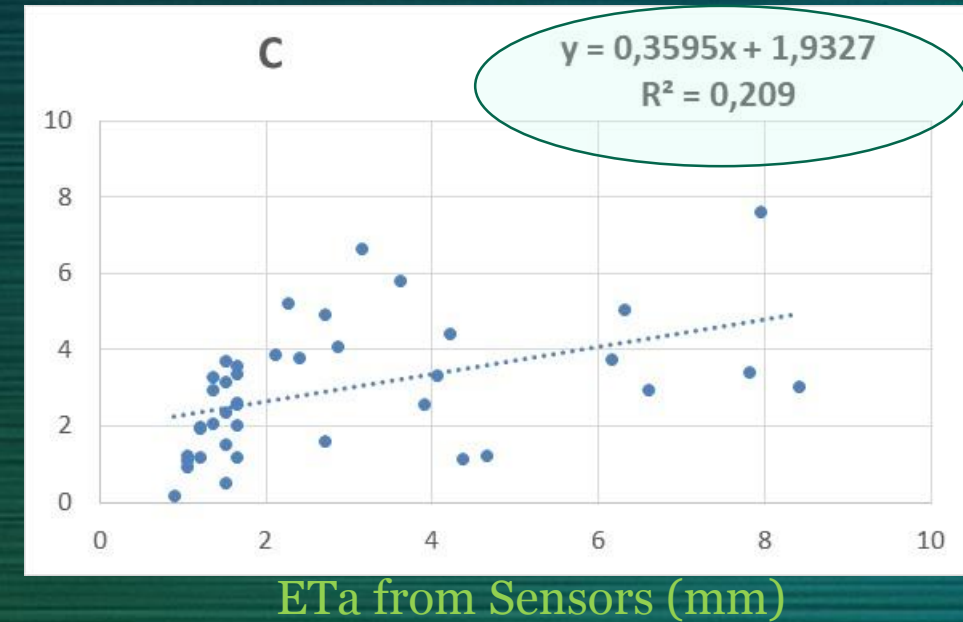
ETa from SAT (mm)



ETa from Sensors (mm)



ETa from SAT (mm)



ETa from Sensors (mm)

Plant growth and water consumption

Information provided by the integrated system

23/06/2018	DATA SOURCE			
Information	Field Detection A / B / C	Model simulation A / B / C	Satellite + Model A / B / C	EVALUATION
Node number	28/24/28	32	28/24/28	Good and reliable
Branch Stage	5/4/5	5	5/4/5	Good
Fractional Vegetation Cover	0,85/0,80/0,70	0,8	0,89/0,80/0,76	Quite good
Biomass (ss g m-2)	600	705	----	Under study
Fruit weight (ss g m-2)	300	351	----	Under study
Effective rainfall / Chaptal (mm)	184,8	122,1	----	Under study
Water Uptaking (mm)	79/79/63	265/155	----	Under study
WUE (Biomass/Water consumption)	2,3/2,4	2,6/4,5	----	Under study
Irrigation (l*m-2) provided/required	52,2 / 56,5 / 64,6	60,0	65,4 / 60,0 / 57,6	Under study
IRRIGATION advices (24/06)			13,2 / 3,5 / -7,0	

IN THIS CASE, THE MAIN PROBLEM IS THE MOMENT OF SOMMINISTRATION

PRELIMINARY CONSIDERATIONS

Controversial aspects

- For different reasons (critical phenological periods, weather condition, etc.), from an operational point of view, the secondary level control of irrigation can be quite hard to carry out;
- Until now, only a limited number of satellite passages has provided useful information (cloudy sky);
- A full validation of procedures and methodologies requires an intensification of field measurements and higher level of final user involvement.
- At the moment, there are many factors affecting plant growth and efficiency that are not taken into account by the system (e.g. tillage and nutrition), limiting analytical capability and field variability management.

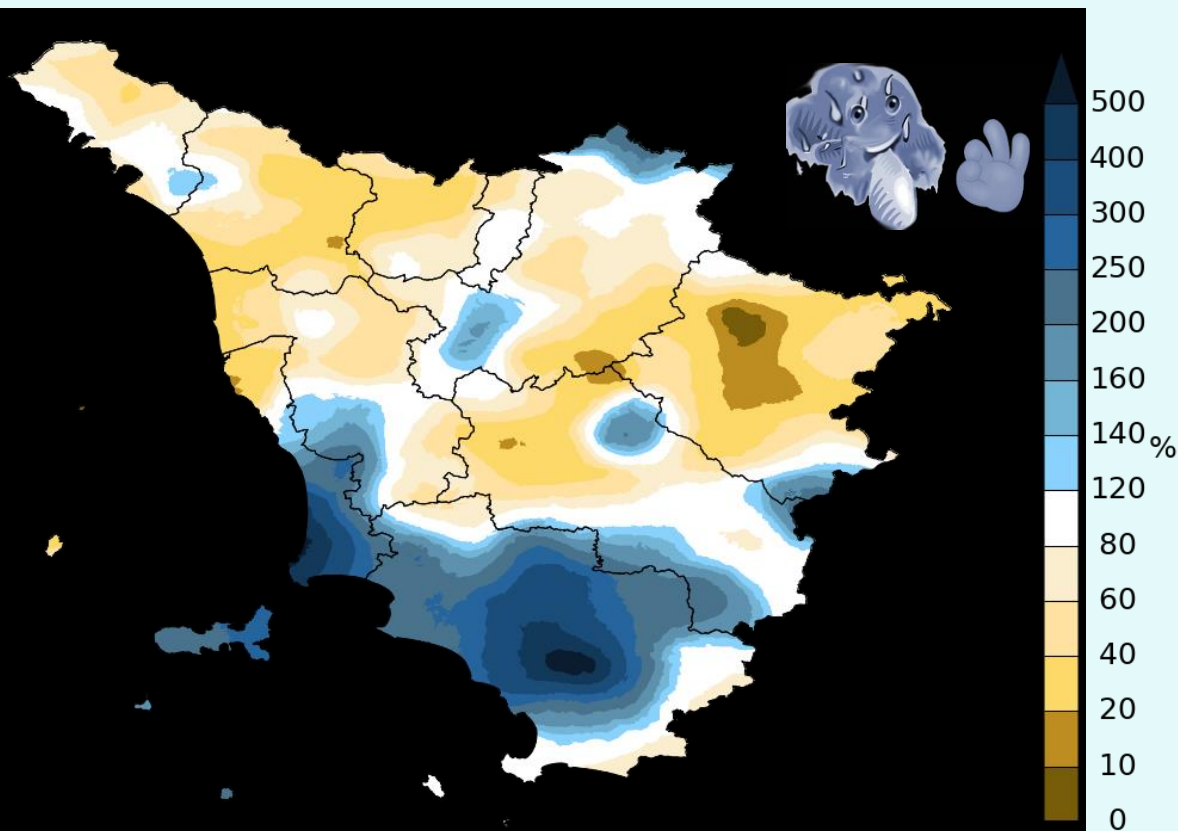
Positive elements

- Spatial and temporal resolution of Sentinel-2 appear appropriate for pilot site sector management;
- Data collected from different sources are in agreement with models and literature;
- Under the limits of the experimental conditions, the integrated system has reduced irrigation of about 20%, assuring good plant growth (biomass > of field average);

The index of productivity will be tested during the last phase of the experiment.

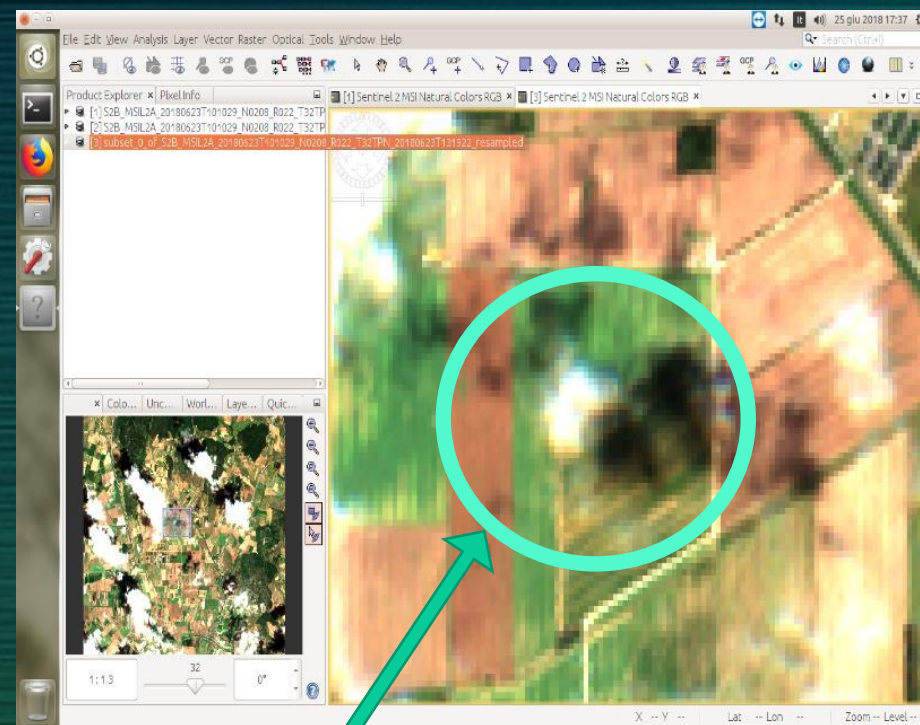
WORK IN PROGRESS – WEATHER PERMITTING

Percentuale di Precipitazione rispetto alla media climatica
dal 11/06/2018 al 20/06/2018



THANK YOU!

For further information
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**We can't avoid
the classic cloud on the pilot site**