UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE E AMBIENTALI - PRODUZIONE, TERRITORIO, AGROENERGIA

DiSAA INGEGNERIA AGRARIA



# Can an agro-hydrological model improve the irrigation management of maize under a center pivot?

A. Facchi[1], A. Mayer[1], B. Ortuani[1], A. Crema[2]

[1] Department of Agricultural and Environmental Sciences (DiSAA), University of Milan, Milan, Italy (arianna.facchi@unimi.it)

[2] Institute for Electromagnetic Sensing of the Environment (IREA), Italian National Research Council, Milan, Italy(crema.a@irea.cnr.it)

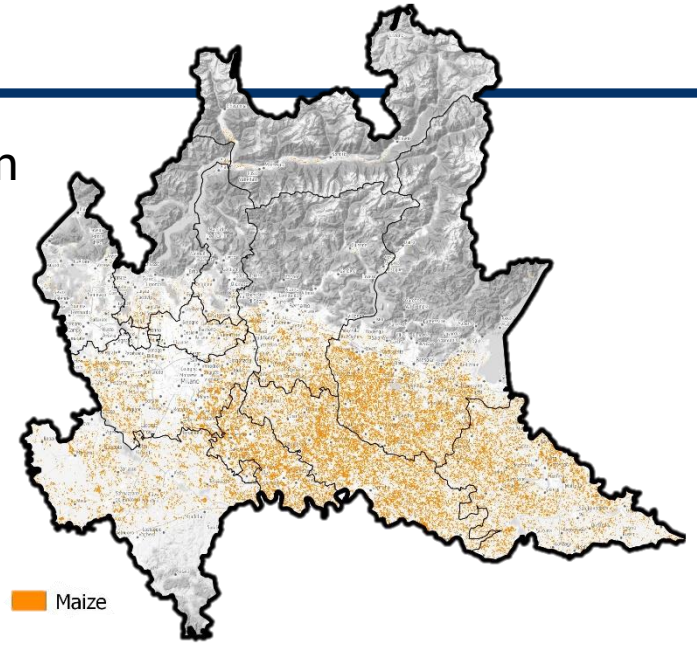
Consiglio Nazionale delle Ricerche

PSR 2014 2020 LOMBARDIA L'INNOVAZIONE METTE RADICI

Regione Lombardia

# Context

- Plain areas of Lombardy are characterised by a strong zootechnical vocation
- The main crop is maize, which in some provinces covers the totality of the Utilised Agricultural Area (UAA)



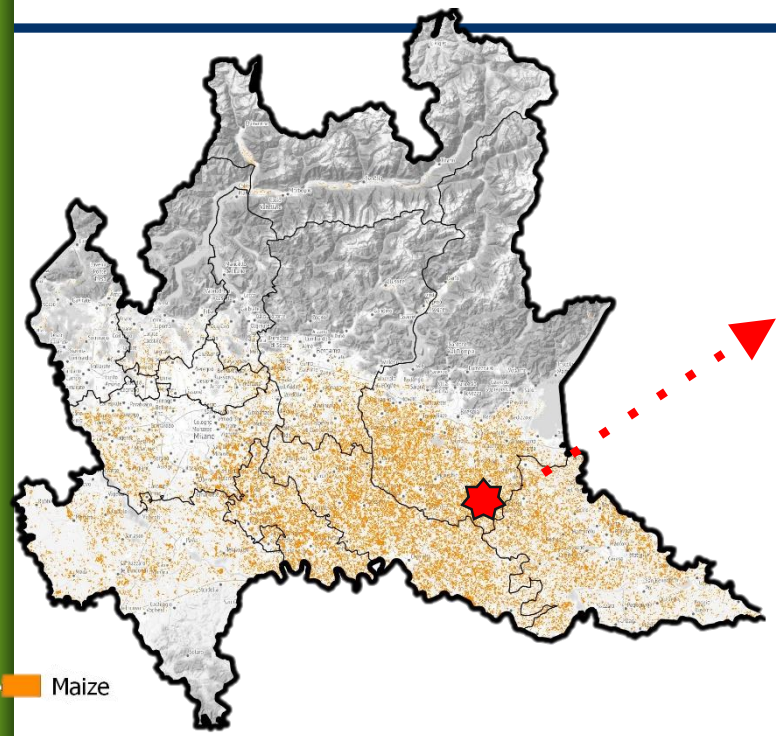

- Maize is generally irrigated by border irrigation, a low-efficiency method that leads to the use of huge water volumes
- In recent years, water scarcity periods increased their frequency in many areas. As a consequence, more efficient irrigation methods are being introduced by farmers.
- Nevertheless, the change towards efficient methods must be accompanied by tools to support the irrigation management, in order to provide the optimal irrigation amount with the optimal timing.

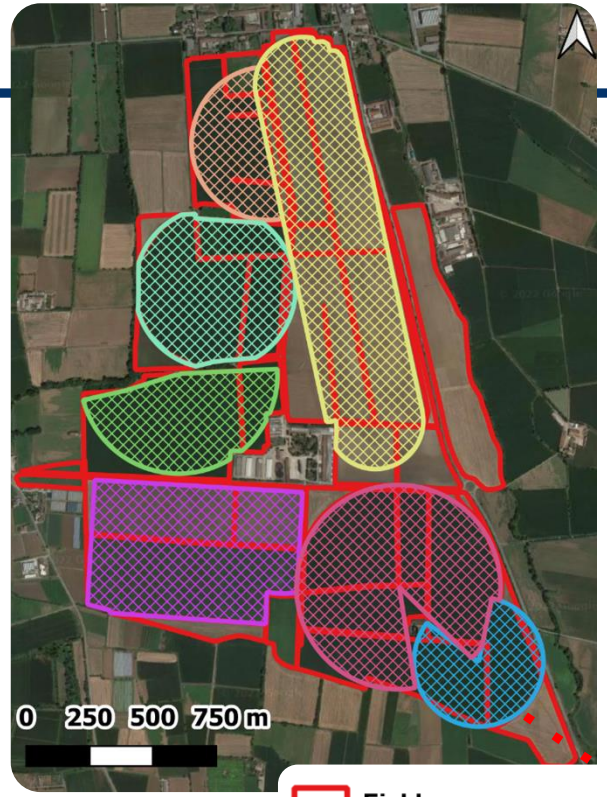
**Aim of the study**

To develop a **precision irrigation approach** and apply it in the Lombardy agricultural context, based on: (1) **characterization** of the **within field soil variability** through an **EMI sensor**, (2) **decision** about **when and how much irrigation to apply** taken with the support of **soil moisture probes** and an **agro-hydrological model**, (3) **distribution** of **variable rate irrigation** through a **VR center pivot**.

DiSAA INGEGNERIA AGRARIA
UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE E AMBIENTALI - PRODUZIONE, TERRITORIO, AGROENERGIA

# Pilot site

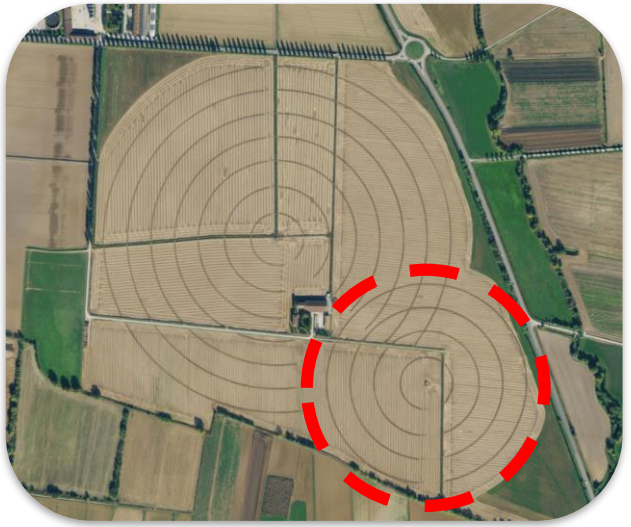



## La Canova farm (Gambara, Brescia)

- Typical large-scale (~300 ha) farm in the core of Lombardy maize basin
- Crops: maize and other forage crops
- Irrigation provided by 7 irrigation systems (linears and center pivots)
- Uniform rate irrigation with fixed time intervals

## Pilot field



- Surface of 15 ha
- Irrigation is provided with 4-5 days shifts and fixed depths (25-30 mm depending on the crop growth stage)
- Irrigation must be managed taking into account of the overlapping of two center pivots tracks
- In 2021 a new panel was mounted on the pivot, allowing VR irrigation by regulating the pivot speed

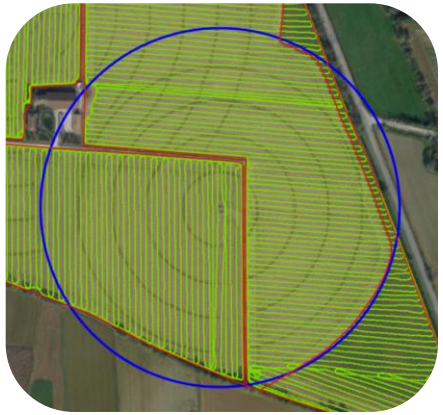
UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE E AMBIENTALI - PRODUZIONE, TERRITORIO, AGROENERGIA

# Soil characterization

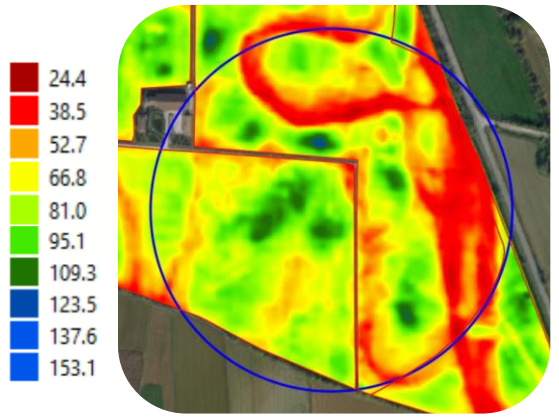
## Soil variability survey

Soil mapping with EMI sensor (3 depths)

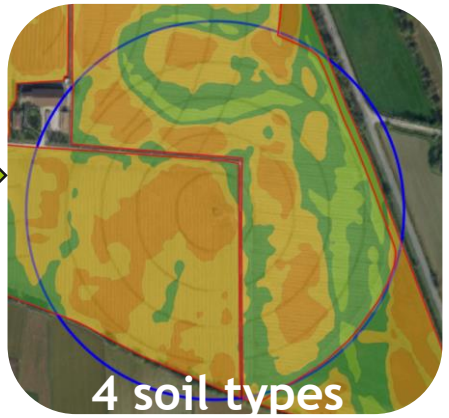
Acquisition lines



Electical resistivity maps [Ωm]

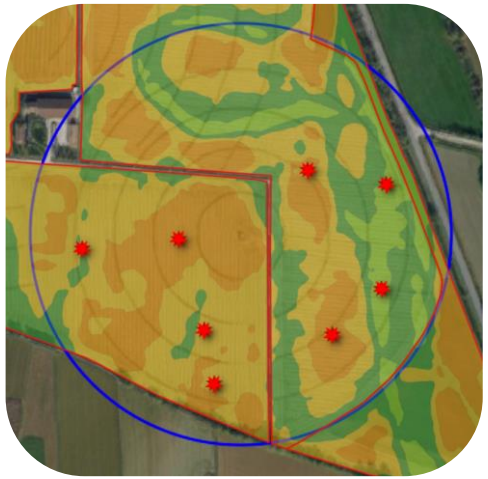



Cluster analysis (MZA,USDA)




## Soil types characterization

Soil sampling & lab analysis



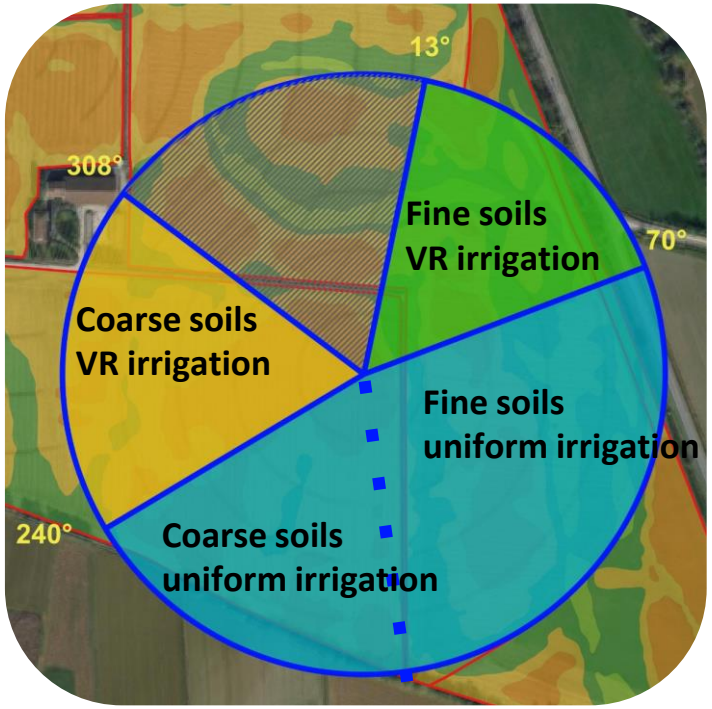
Loam with high content of rock fragments

Sandy loam

Clay loam

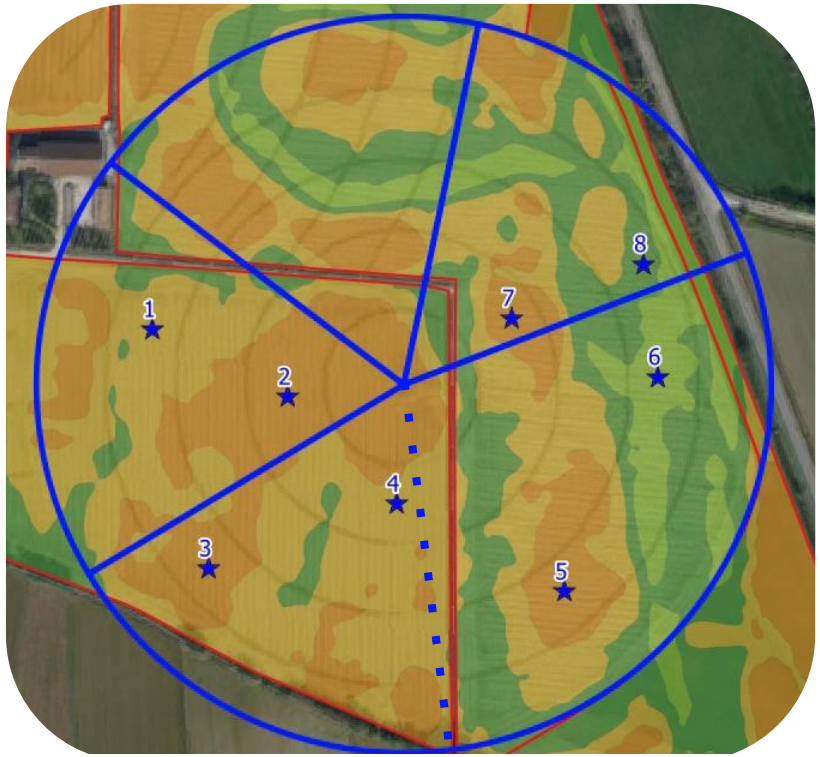
Clay loam, coarse in deep horizons

## Irrigation sectors definition



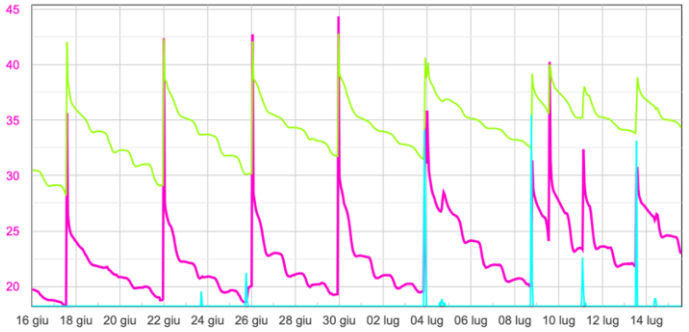
# Soil water content monitoring

**Installation of soil water content probes (two points for each irrigation sector)**





- Probes installed at two depths: 20 and 40 cm (depth reached by maize roots under sprinkler irrigation)

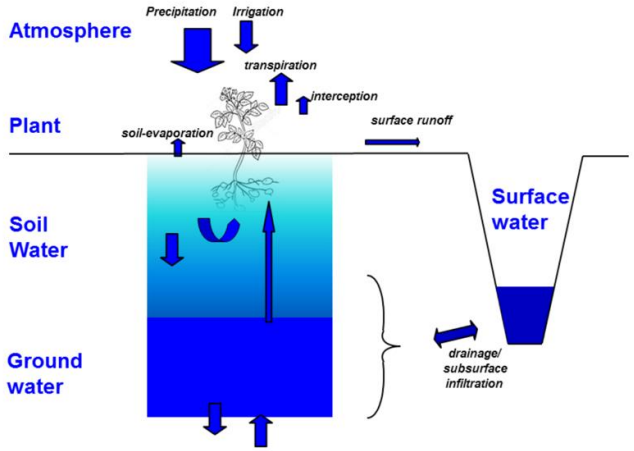



- Data sent to a server to be accessed remotely

| Evidenzia | Postazione | Unità | Misura |
|---|---|---|---|
| ● | UniMi 5 | Unità 1 | WVC A |
| ○ | UniMi 5 | Unità 1 | WVC B |
| ○ | UniMi 5 | Sensori meteo | Pioggia |

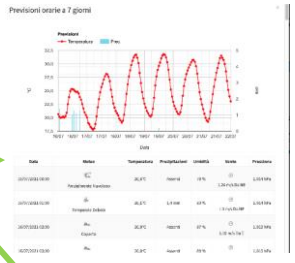
# Agro-hydrological model implementation

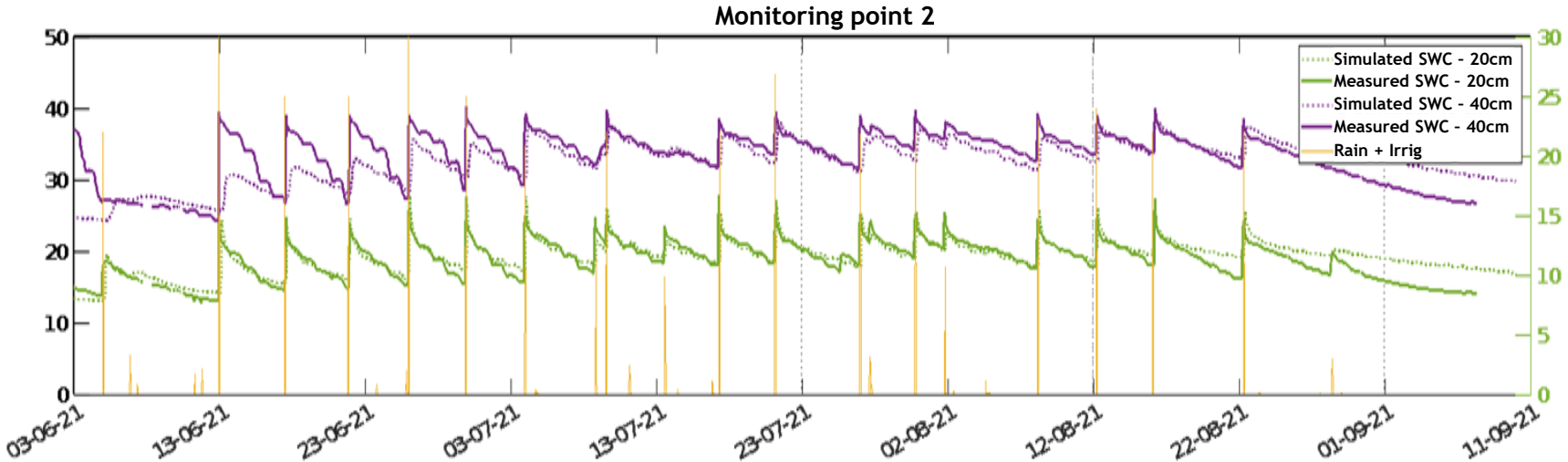
## Implementation of SWAP (Soil Water Atmosphere Plant)* model for each monitoring point




## Required data

- Agro-meteorological data → Weather station installed in the farm + 7-days weather forecasts
- Soil parameters → Lab analysis + pedotransfer functions (PTFs) for soil hydraulic parameters
- Crop parameters → Crop phenology monitored in the field + literature data
- Irrigation management → Dates and irrigation depths
- Groundwater table depth → Piezometers installed in the farm





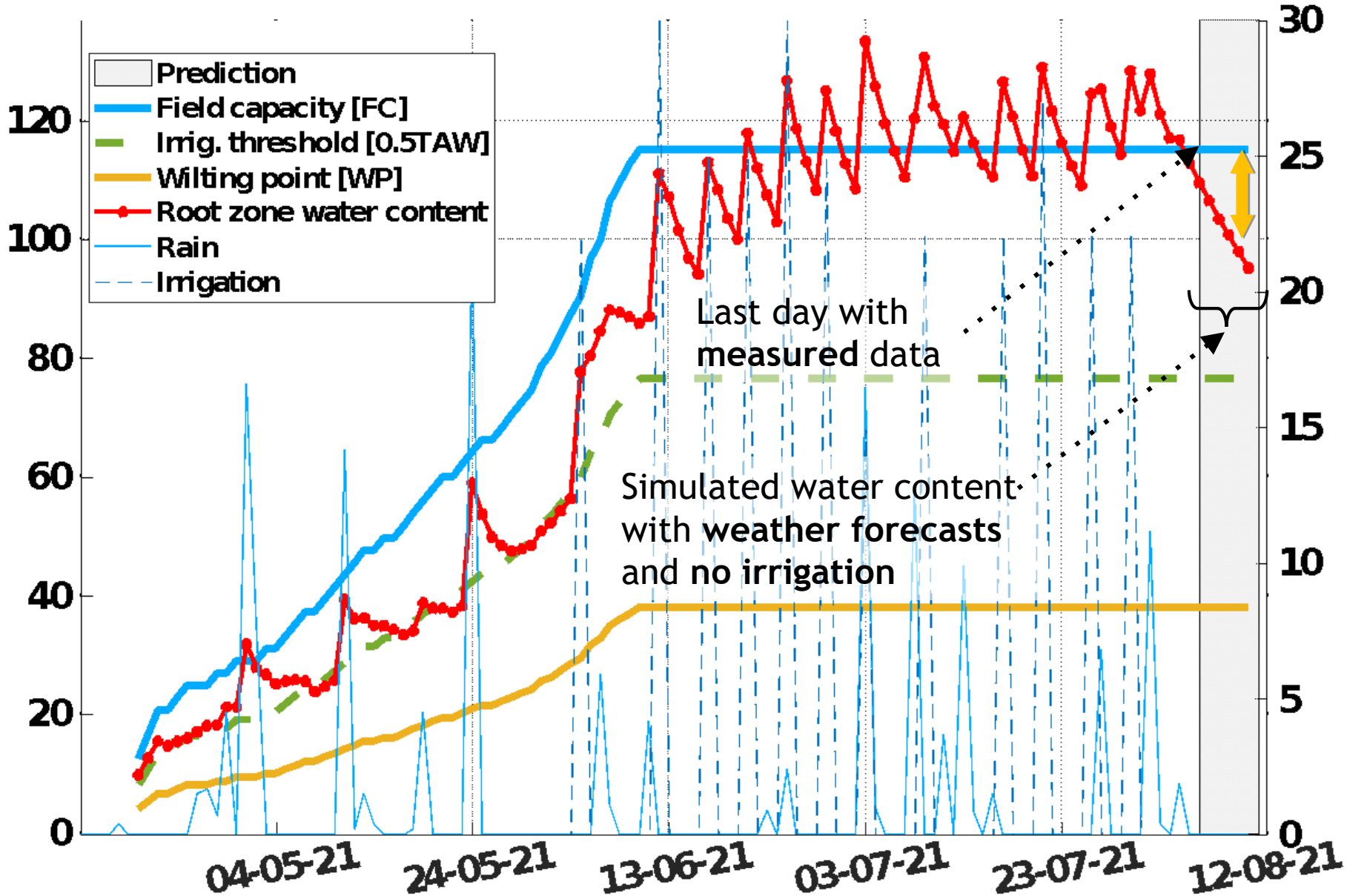

## RESULTS:

**Model calibration through soil water content values measured by the probes**

* Kroes et al., 2017

# RESULTS: irrigation management in VR sectors

Farm scheduled irrigation turns were mantained. Model was run before each turn in **previsional mode**.




Irrigation provided to "replenish" soil water content up to **FC**

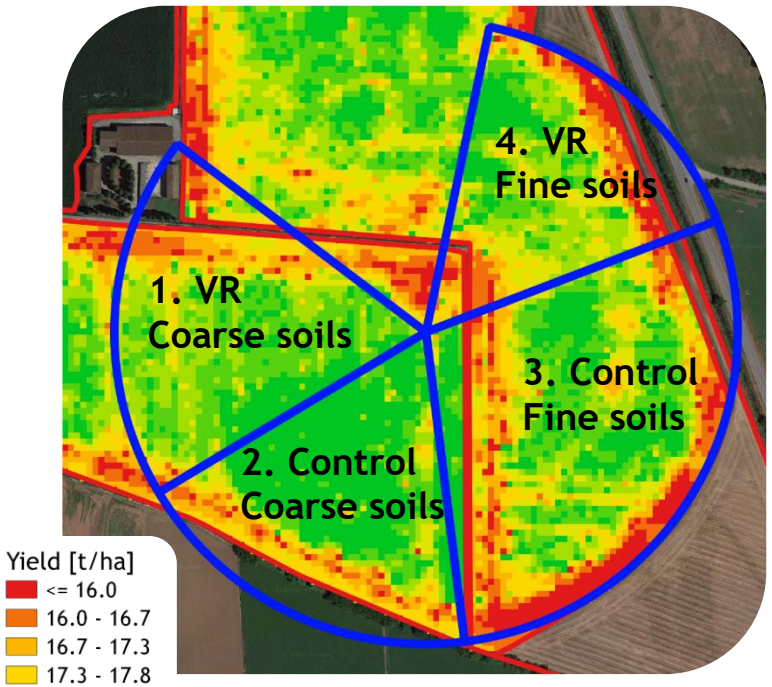
# RESULTS: irrigation applied, yield and grain moisture

## Total irrigation provided

| Date | Irrigation depth mm | | |
|---|---|---|---|
| | Control sector | "Coarse" sector | "Fine" sector |
| 04/06/2021 | 25 | 20 | 28 |
| 12/06/2021 | 30 | 30 | 30 |
| 17/06/2021 | 30 | 25 | 25 |
| 21/06/2021 | 30 | 30 | 30 |
| 25/06/2021 | 30 | 30 | 30 |
| 29/06/2021 | 30 | 25 | 22 |
| 04/07/2021 | 30 | 25 | 25 |
| 09/07/2021 | 30 | 22 | 18 |
| 17/07/2021 | 30 | 22 | 18 |
| 21/07/2021 | 30 | 27 | 23 |
| 26/07/2021 | 26 | 22 | 18 |
| 30/07/2021 | 26 | 22 | 18 |
| 08/08/2021 | 26 | 23 | 19 |
| 12/08/2021 | 26 | 24 | 20 |
| 16/08/2021 | 26 | 22 | 18 |
| 22/08/2021 | 22 | 22 | 18 |
| 26/08/2021 | 22 | | |
| | **469** | **391** | **360** |

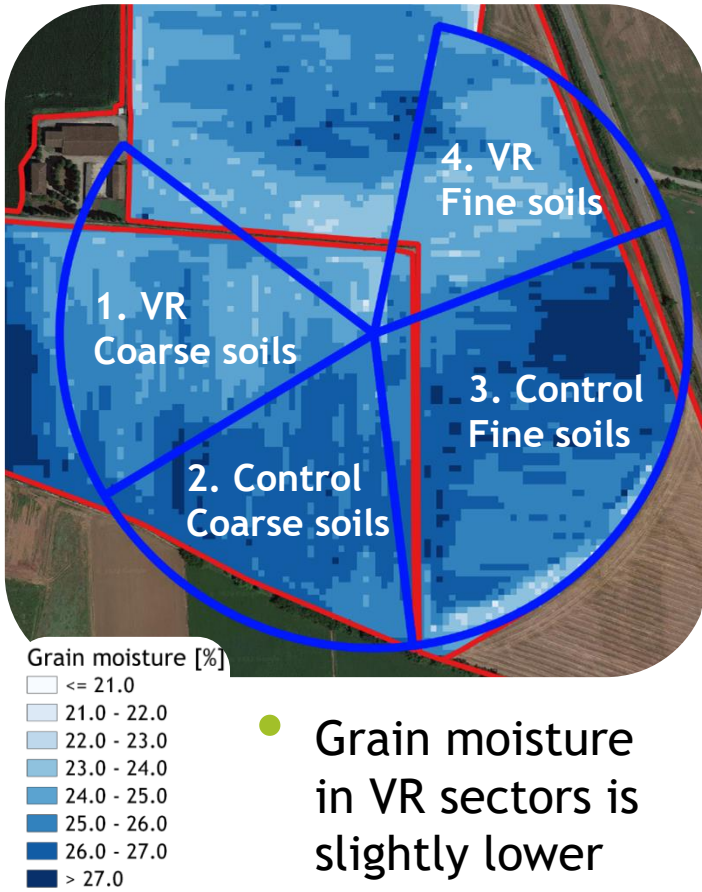
- -78 mm (-16%) coarse sector
- -109 mm (-24%) fine sector

## Yield and grain moisture




| Sector | Management | Average yield [t/ha] |
|---|---|---|
| 1 | VR | 18.34 |
| 2 | VR | 18.43 |
| 3 | Uniform | 18.78 |
| 4 | Uniform | 18.24 |

- Average yield on VR sectors is comparable with yield of control sectors




- Grain moisture in VR sectors is slightly lower than in control sectors

# Conclusions

- During the agricultural season 2021, a center pivot in La Canova farm was managed trough a **Variable Rate** approach.
- The pivot area was divided into **four sectors** based on **soil variability**:
  - two sectors were managed with the support of **soil moisture probes** and a **hydrological model** fed with **weather forecasts**;
  - two control sectors were managed **uniformly**.
- In the VR sectors, results showed an **irrigation saving of about 20%** (80 mm in the coarse soil sector and 110 mm in the fine soil sector) compared to control sectors. **Energy saving was also 20%.**
- Average **yield** values of VR sectors were **comparable** with those of control sectors; grain **moisture** was **lower** in VR sectors (advantage in the grain drying process).
- Future developments of the project are focussing on the assessment of **water and energy saving** that can be achieved at the farm scale using a VR approach, through the application of the agro-hydrological model in a spatially-distributed mode.

DiSAA INGEGNERIA AGRARIA
UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE E AMBIENTALI - PRODUZIONE, TERRITORIO, AGROENERGIA

# Thanks for your attention

DiSAA INGEGNERIA AGRARIA

UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE E AMBIENTALI - PRODUZIONE, TERRITORIO, AGROENERGIA