EGU General Assembly 2020

EGU2020-6935

SIM: smart irrigation from soil moisture forecast using satellite and hydro –meteorological modelling

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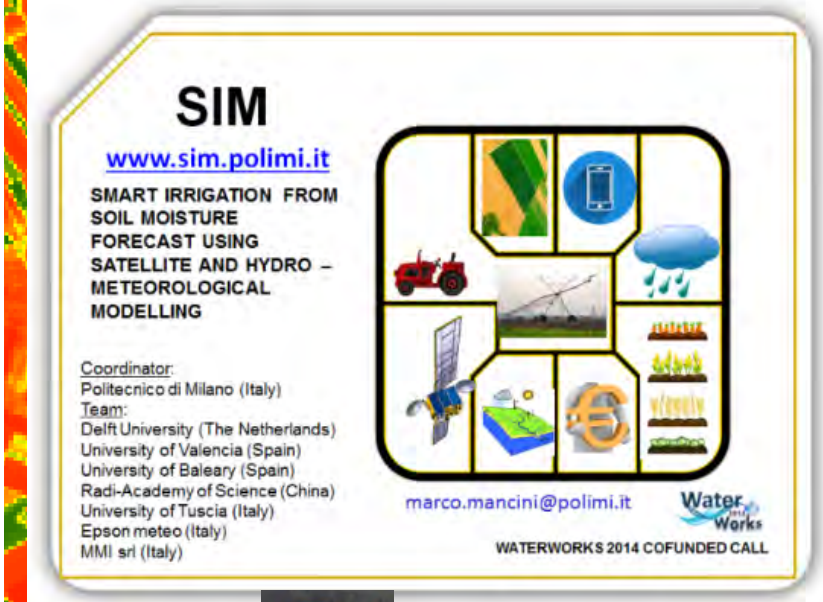
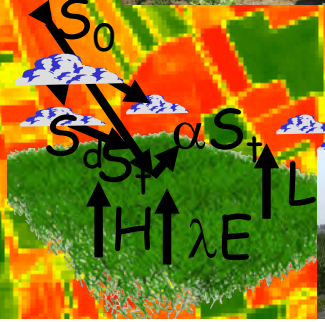
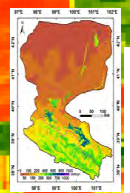
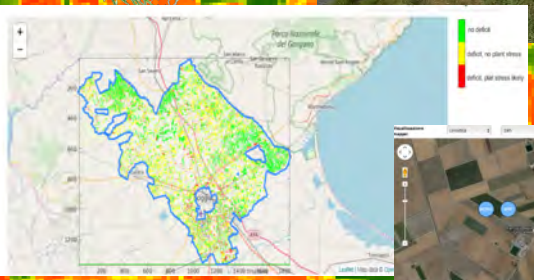








mipaaft
ministero delle politiche agricole alimentari, forestali e del turismo

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

esa

NASA

NASCC

RANET ED

copernicus
obseruing the earth

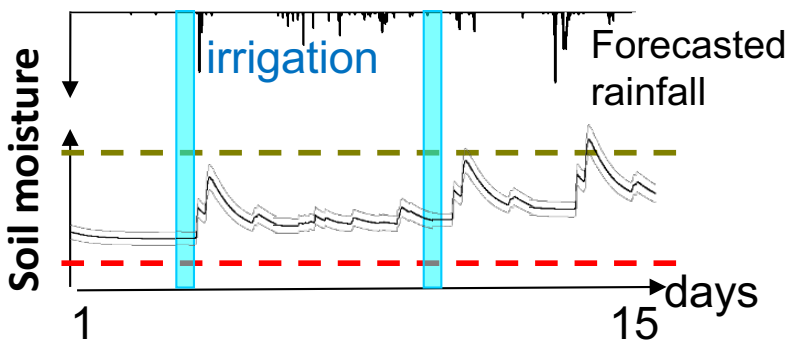
BAR
Digital Belt and Road

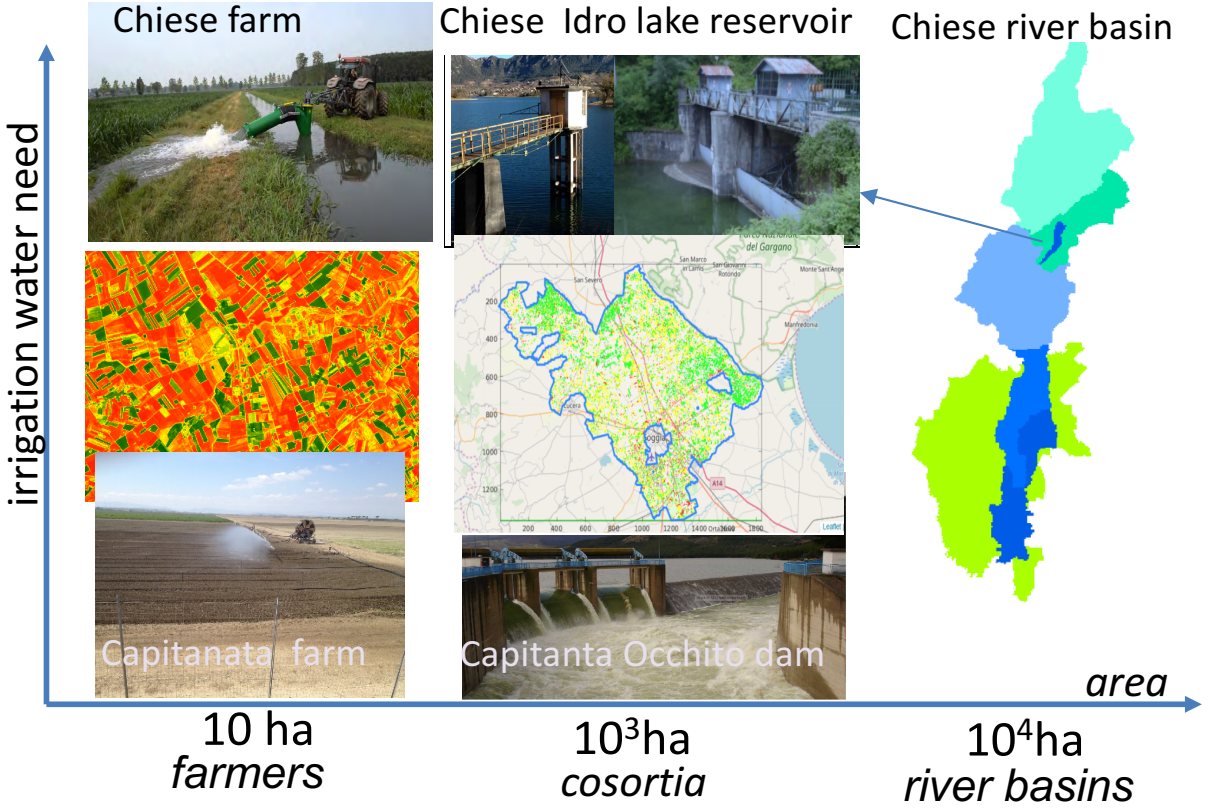
Water JPI

SIM: objectives and stakeholders

1 **Monitor and forecast crop water need for: parsimonious & precise irrigation**

2 **Setting a irrigation strategy for: Increasing irrigation efficiency (ton/m³) and economic water productivity (€/m³)**





but also: …….

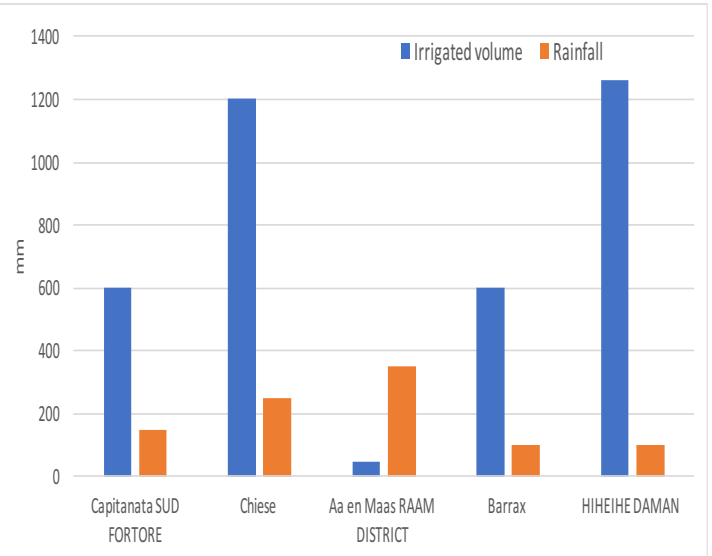
- **irrigation strategy at field scale: water amount and timing;**
- **economic analysis of parsimonious irrigation;**
- **satellite land surface temperature data for soil moisture hydro model update;**
- **dynamic actual evapotranspiration;**
- **satellite Fraction Cover and Leaf Area Index for cultivated area identification and parametrization;**
- **Impacts of meteorological forecast ;**
- **impacts on existing irrigation disribution network.**

SIM: WHERE AND WHY ?

SIM CASE STUDIES

DIFFERENT CLIMATATES DIFFERENT PRACTICES

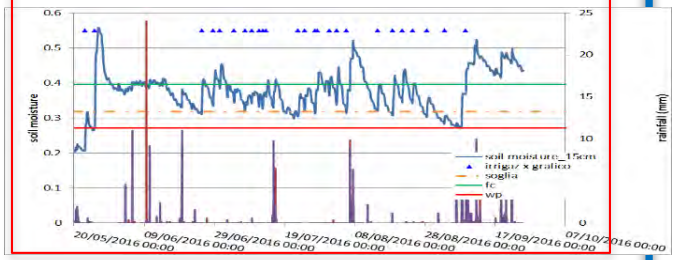
Irrigation supply and **rainfall** in the crop season (mm)



Irrigatium Consortia	Irrigated surface	Irrigation technique	irrigation timing
Chiese	20000 ha	flooding irrigation	fix scheduled 7,5 days
Capitanata SUD Fortore district	50000 ha	drip (70%) & spring (30%)	on demand
AA en Maas RAAM distritct	12600 ha	sprinkler	on demand
Barrax ITAP	1500ha	central pivot sprinkler	on demand
Hehie Daman district	20000 ha	flooding	fix schedule

The SIM methodology: from field to consortium area
SIM.polimi.it

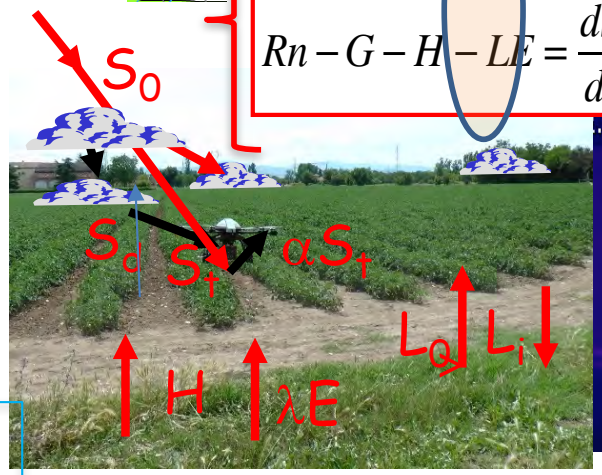
GROUND MONITORING

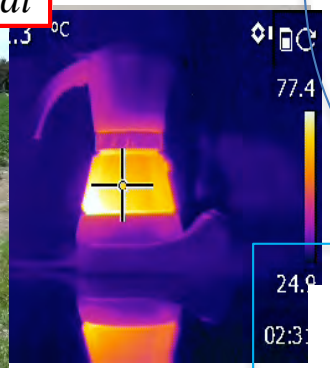


HYDROLOGICAL MODELING: MASS & ENERGY BALANCE

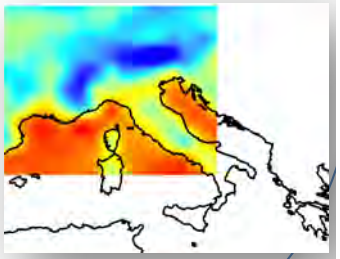
$$P_{tot}=R+ET_{eff}+D+(\theta_{t+1}-\theta_t)*Z$$

$$Rn-G-H-LE=\frac{dS}{dt}$$

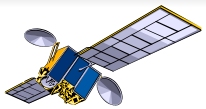




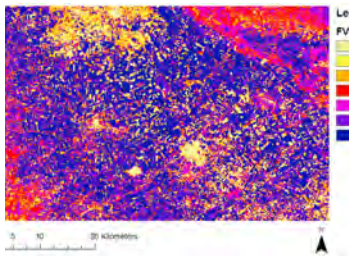
Meteorological forecast UNIBAL + EPSON

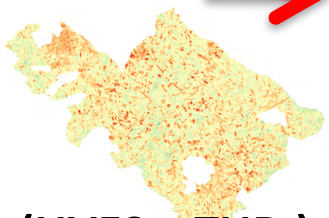


SATELLITE MONITORING



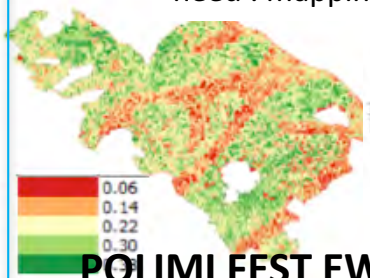
(LANDSAT – SENTINEL) Vegetation and LST





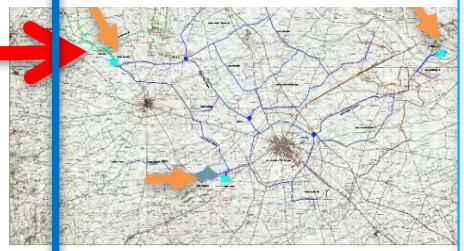
(UVES + TUD)

soil moisture and irrigation water need : mapping and pixel wise

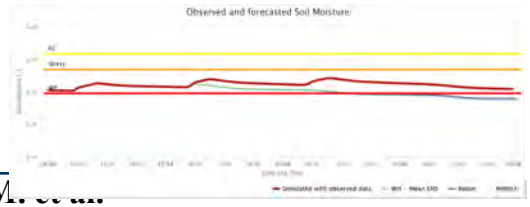


POLIMI FEST EWB, ETP RADI CAS

irrigation aqueduct model MMI



POLIMI Irrigation water needs forecast and operative tool

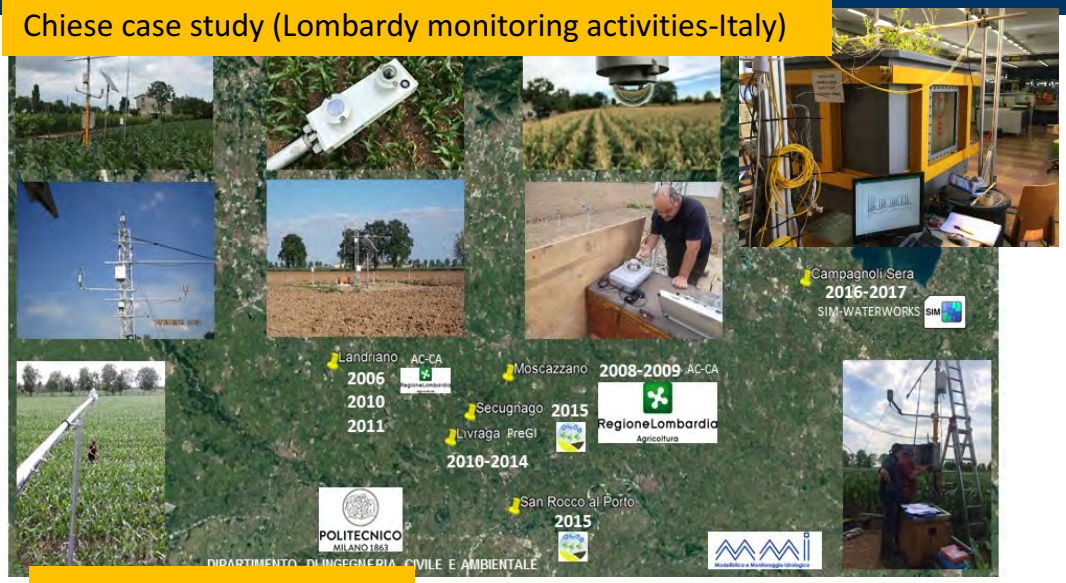


Economic profitability (UNITUS)

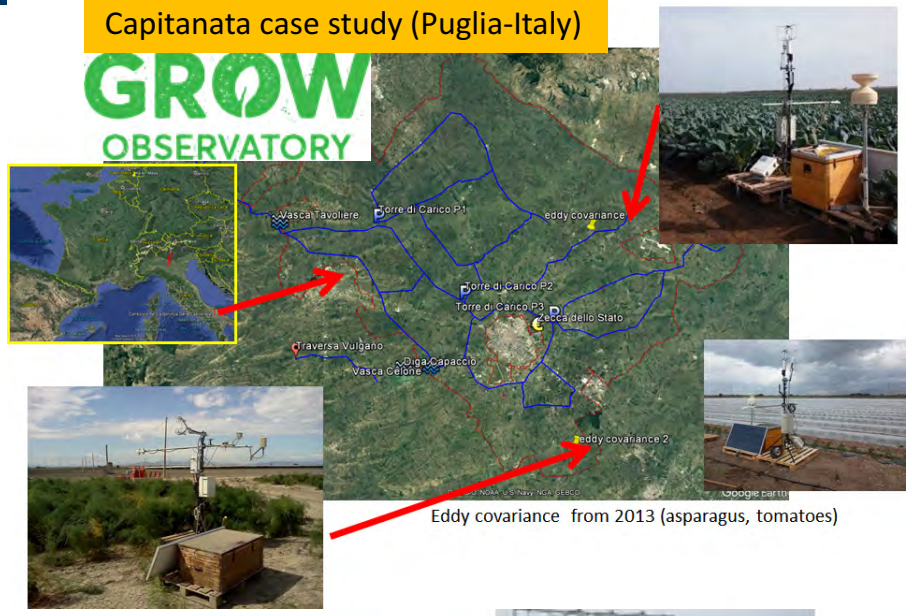
	Scenario	
1 = Water savings	3%	(% of 2015 Effective AWU)
2 = CY increased	2%	(% of 2015 CY at Average 2015 CP)
3 = Depreciation savings	2%	(% of technical duration of irrigation system)
4 = Energy cost savings	4%	(% of lifting and pressure costs)
5 = Labor cost savings	5%	(% of labor for maintenance irrigation sytem
CAP	0,15	(average consortium price for m^3/ha)

How data support the modelling: ground measurements:
Soil Moisture, Irrigation Evaporation, discharge

Chiese case study (Lombardy monitoring activities-Italy)

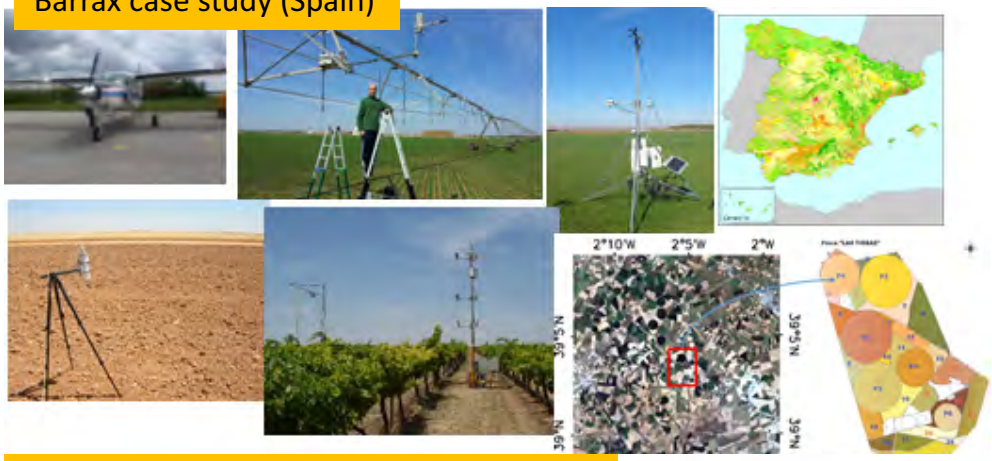


Capitanata case study (Puglia-Italy)

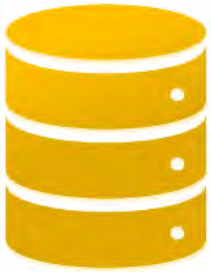


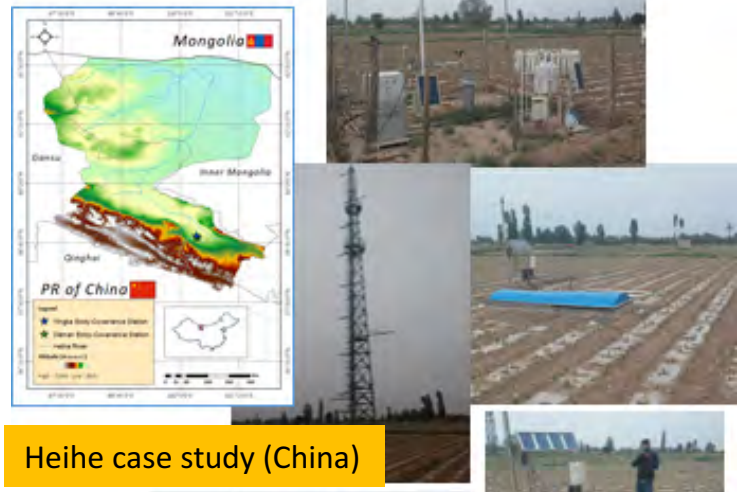
Eddy covariance from 2013 (asparagus, tomatoes)

Barrax case study (Spain)



On-line Database





Aa en Maas case study (The Netherlands)

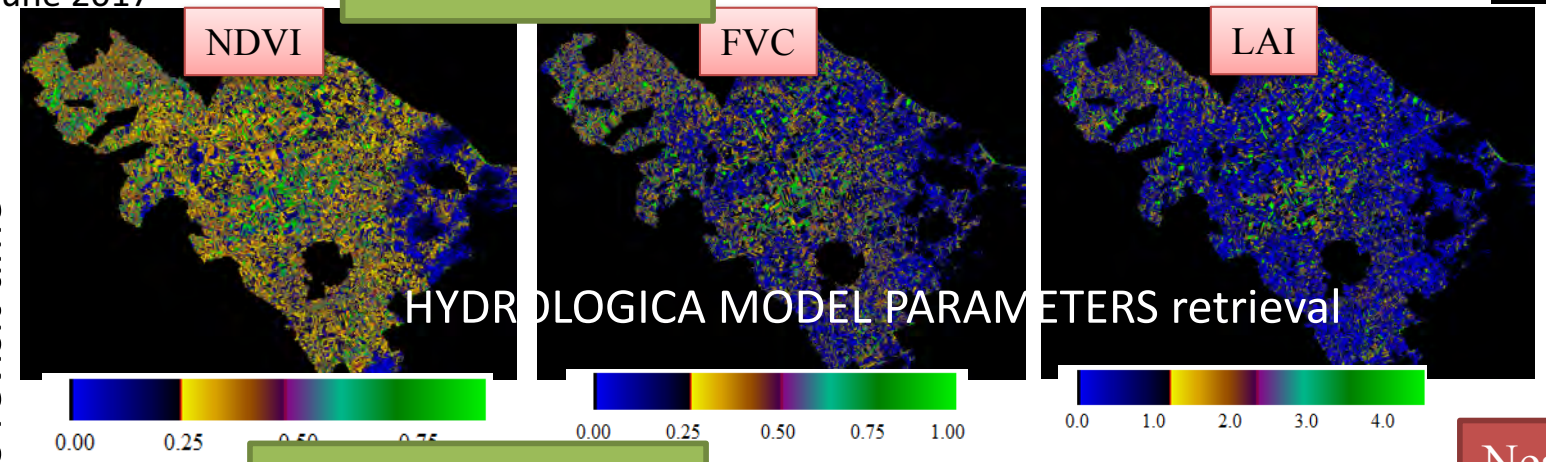
Heihe case study (China)

How Satellite data supporting Hydrological model

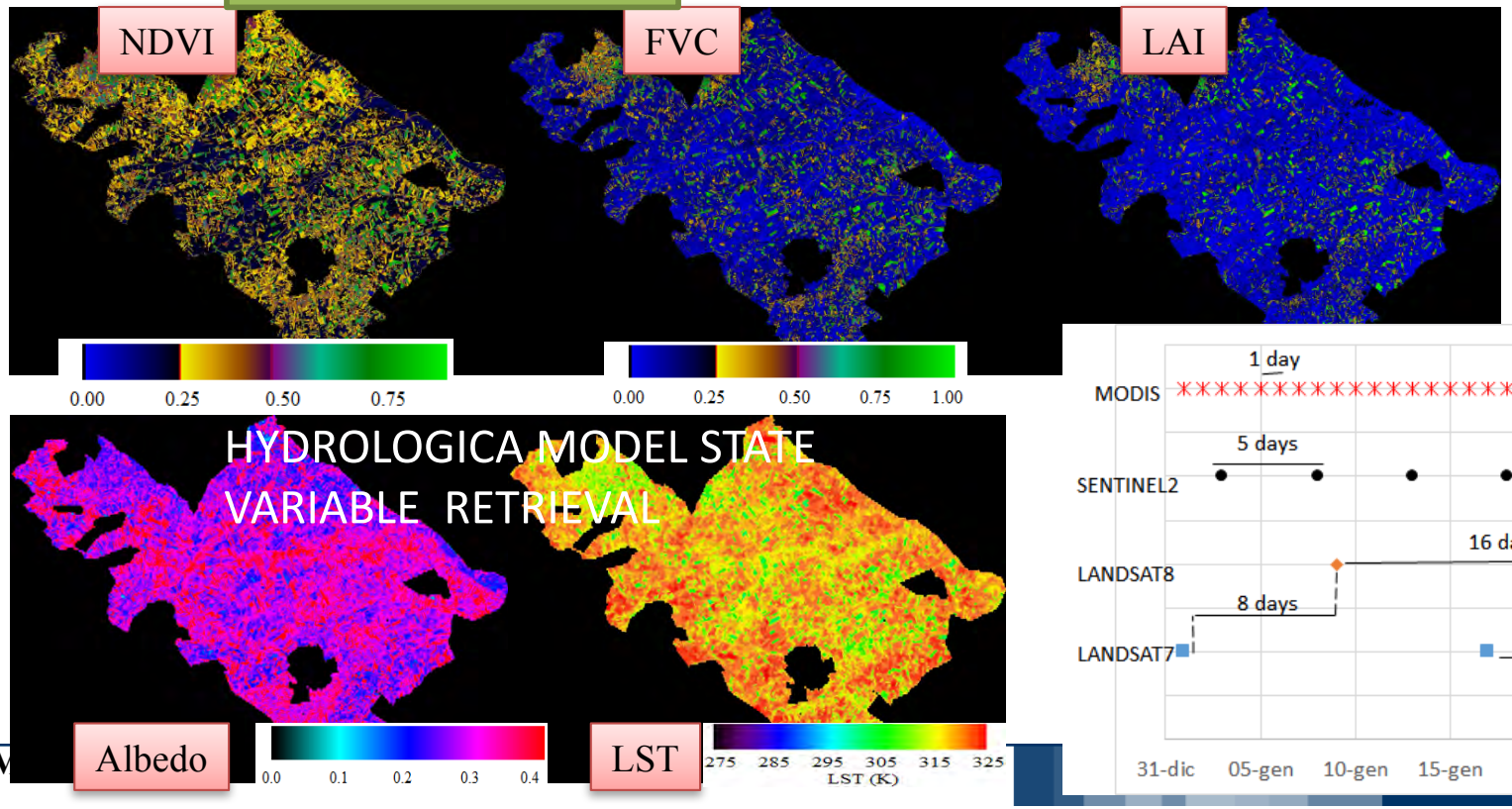
5 june 2017

DATA integration IMPROVES revisit time

SENTINEL-2 MSI



LANDSAT-8 OLI/TIRS



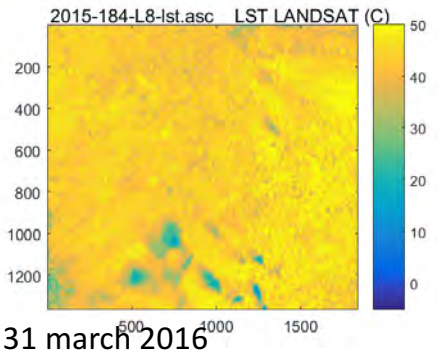
Sobrino and all 2017

Near real time images

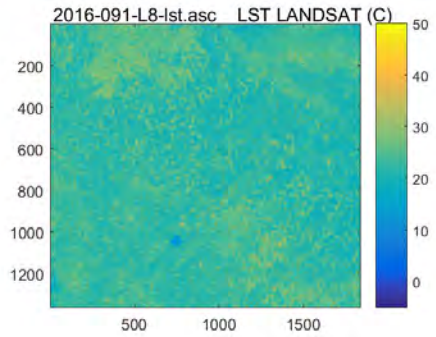
Calibration of FEST-EWB model: soil surface parameters calibration pixel by pixel through minimising LST differences

LANDSAT 8

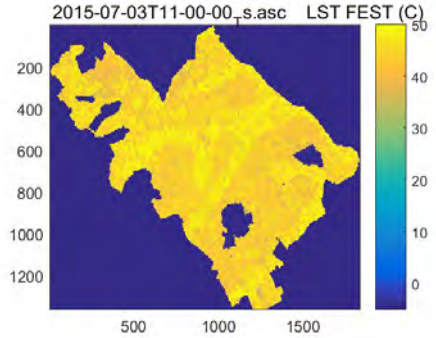
3 July 2015

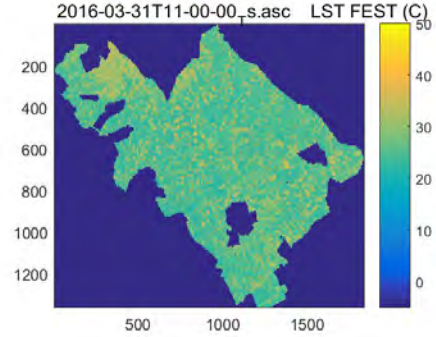


31 march 2016

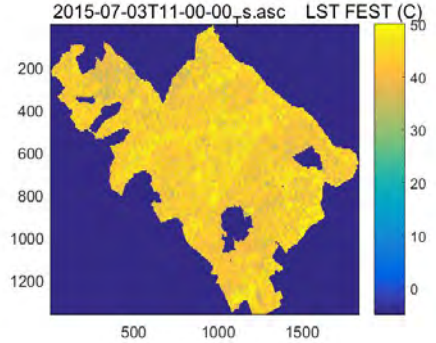


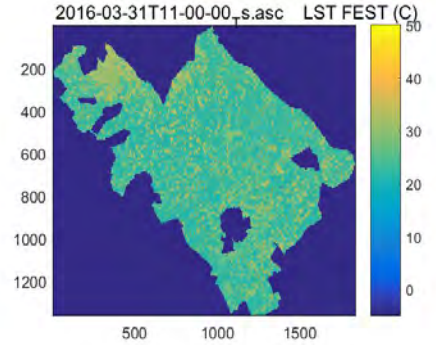
FEST-EWB not calibrated

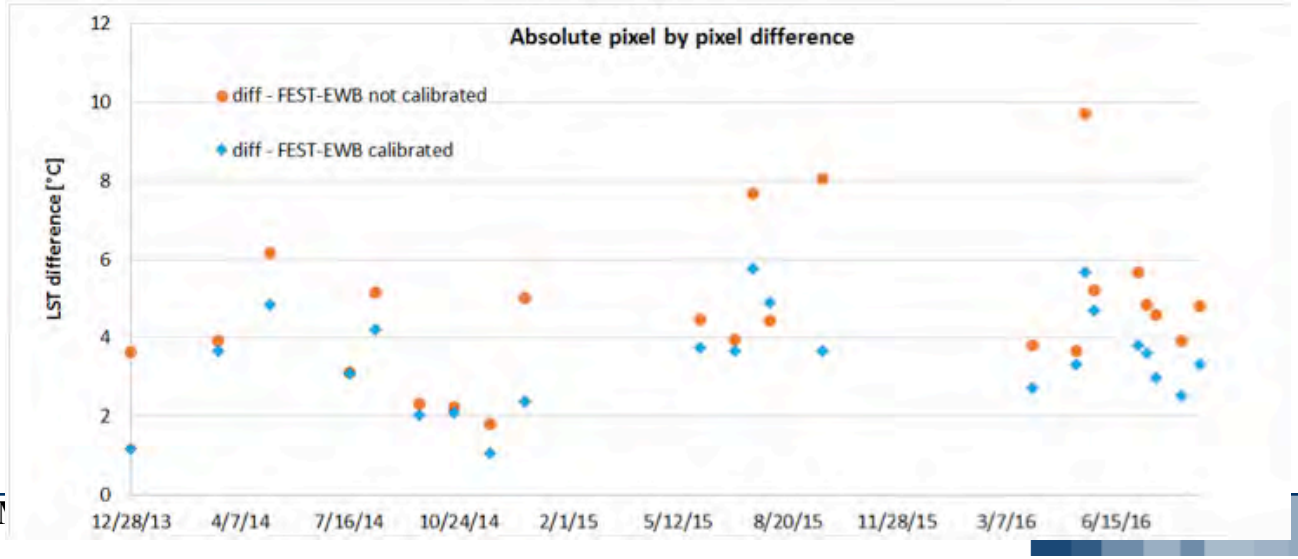




FEST-EWB calibrated







Statistics are computed for the same number of pixels (e.g. if MODIS is covered with clouds also FEST-EWB is clouded)

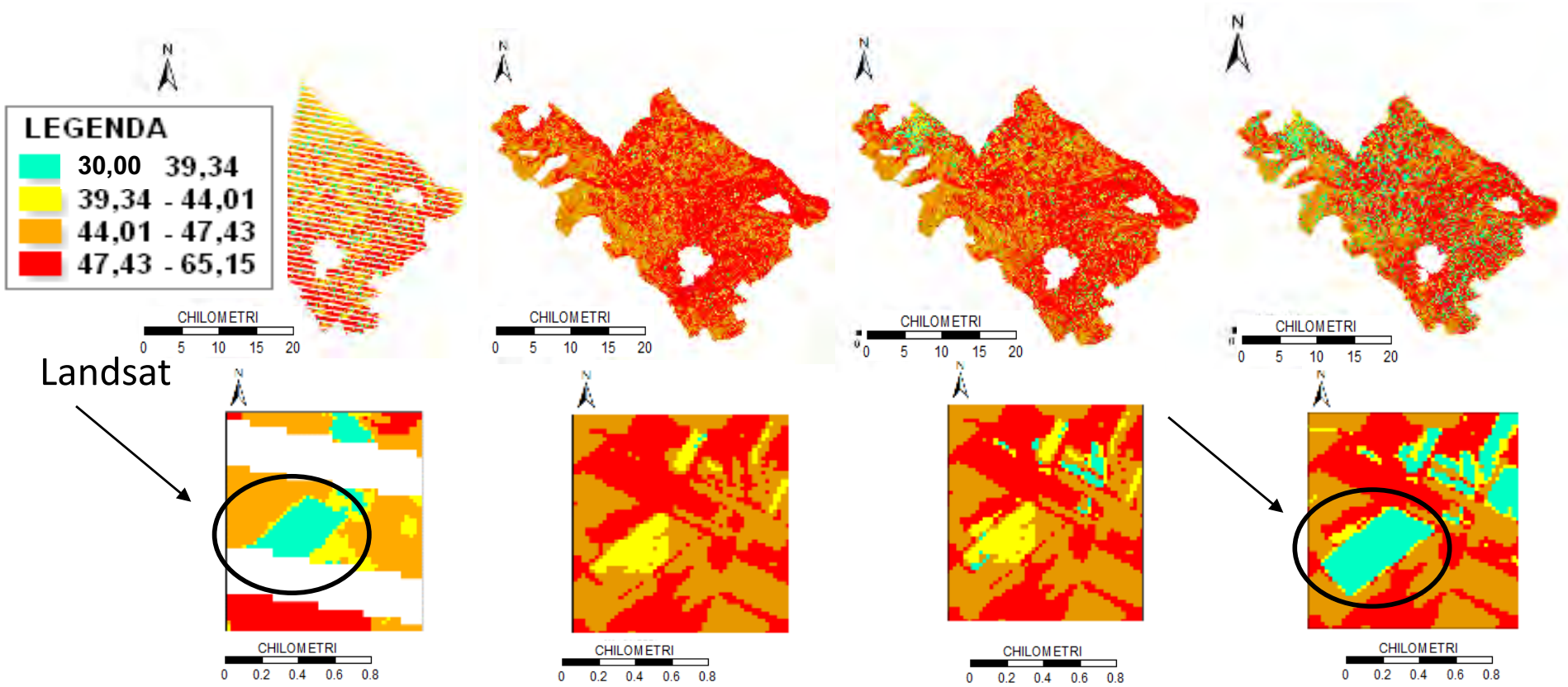
FEST-EWB model can help in creating complete long time series of LST data

Mean error 5 °C

Mean error 2.5 °C

FEST-EWB hydrological model LST estimates with irrigation distribution

Irrigation is applied, according to local practice only in SATELLITE vegetated area with **ndvi>0.3, LST from FEST-EWB reproduces the satellite observed LST**



SATELLITE

(a) Uniform distribution of irrigation

(b) irrigation in all vegetated area

(c) Irrigation in all vegetated areas with NDVI >0.3

for 53 images 2017-2018

Mean error 4.7 °C

Mean error 4 °C

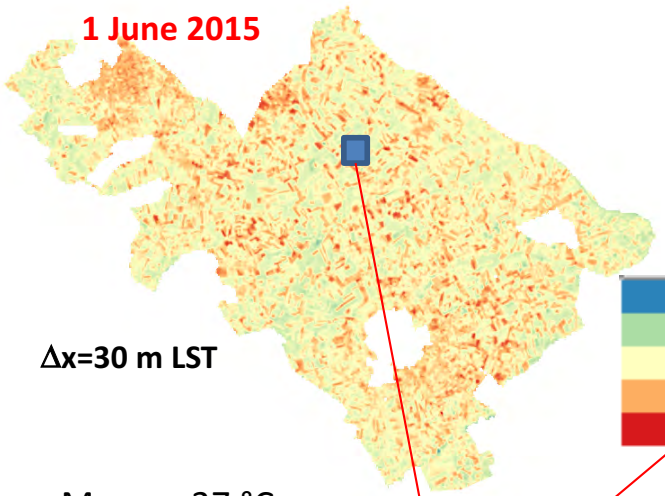
Mean error 3.5 °C

Satellite temperature data and Hydrological FEST-EWB model from consortium to field scale

SATELLITE Data ⟷ **HYDROLOGICAL MASS ENERGY MODEL FEST-EWB OUTPUTS**

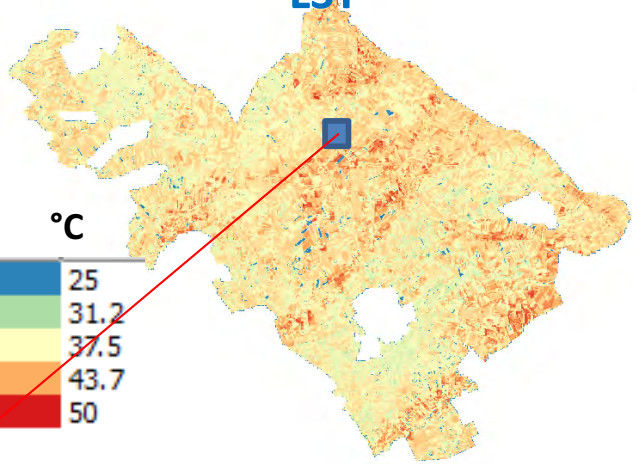
LANDSAT_8 Surface Temperature

1 June 2015

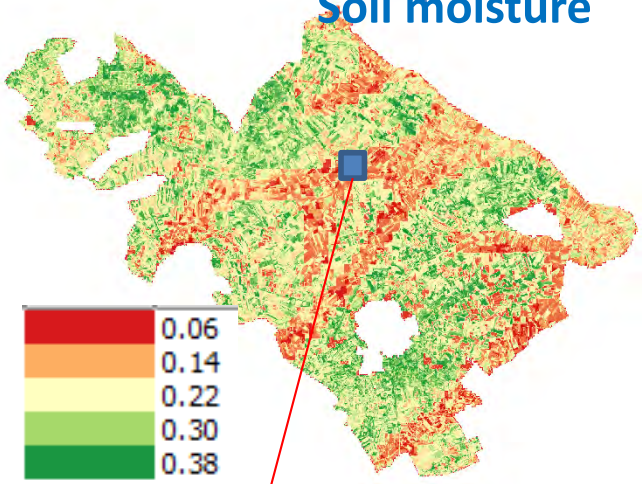


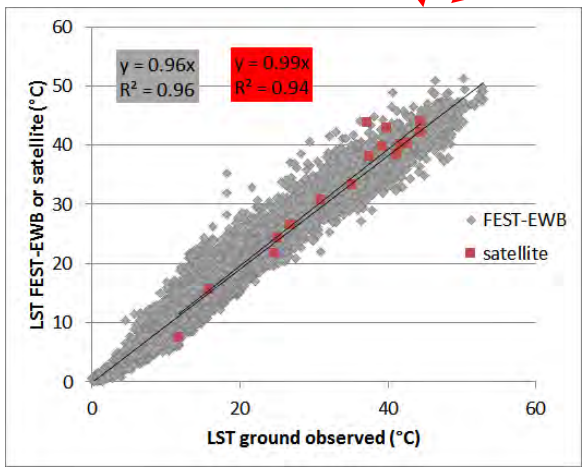
Δx=30 m LST

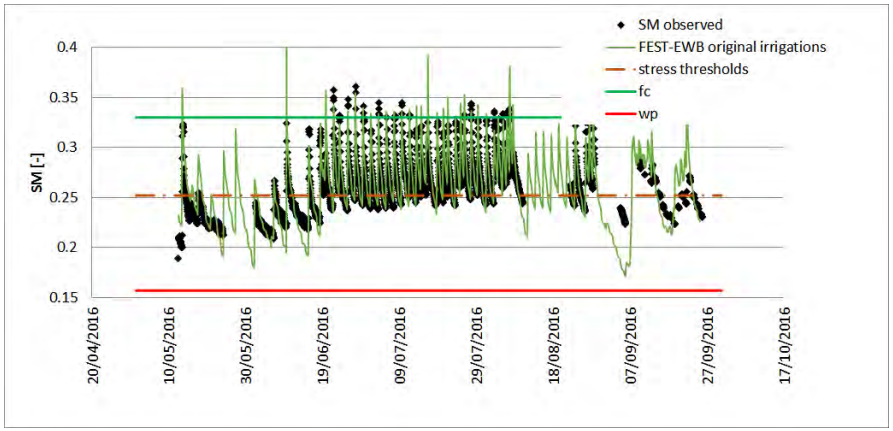
Mean = 37 °C



Mean= 36.5 °C







SIM IRRIGATION STRATEGY: effect on soil moisture

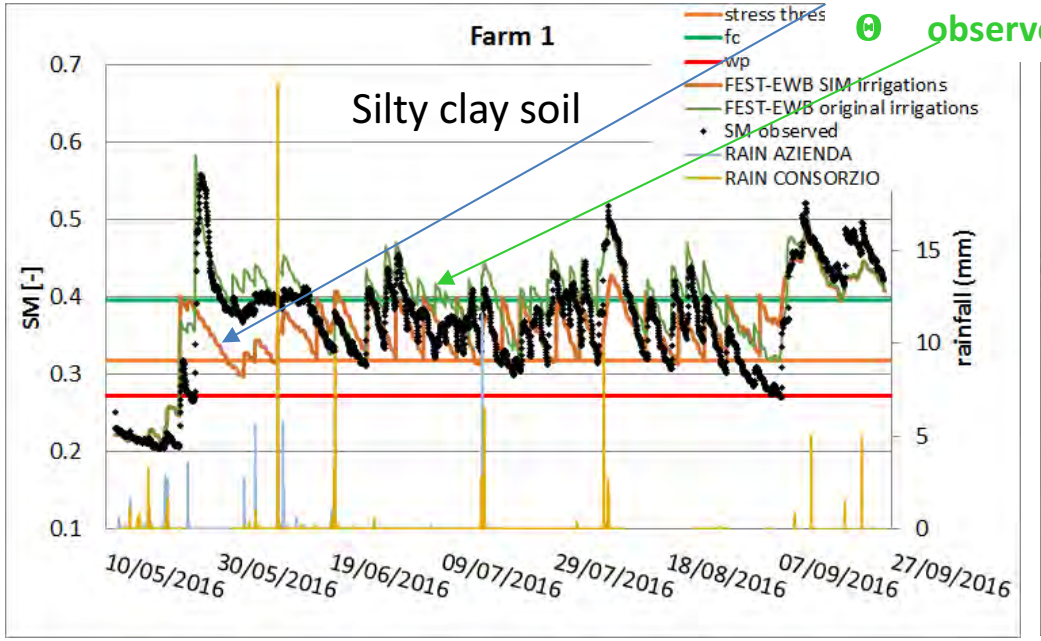
Capitanata irrigation consortium

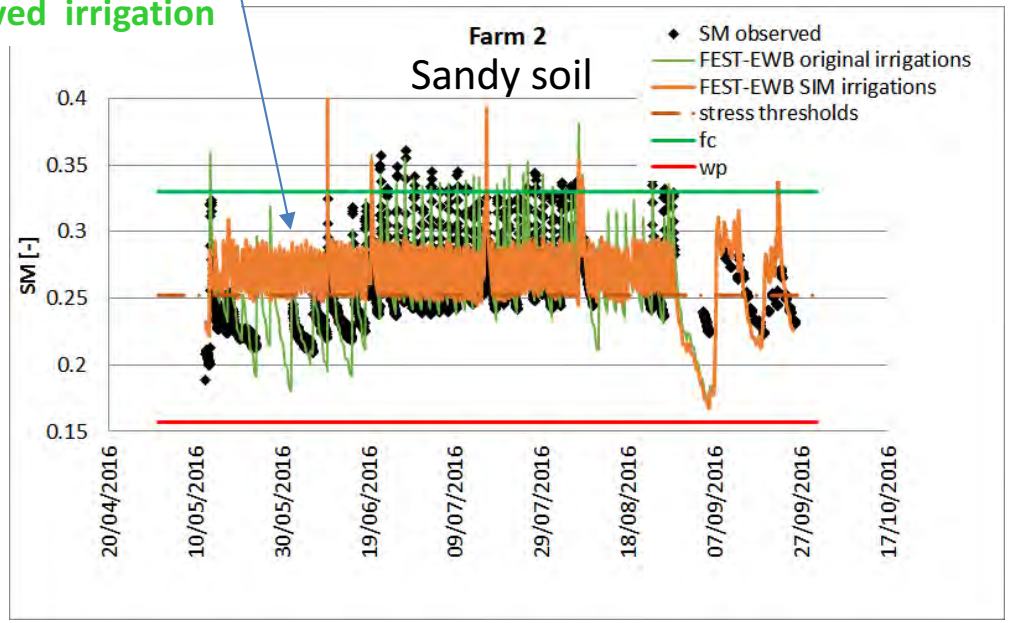
Capitanata Consortium fields: tomatoes

on demand pressurized Irrigation

θ SIM IRRIGATIONS

θ observed irrigation





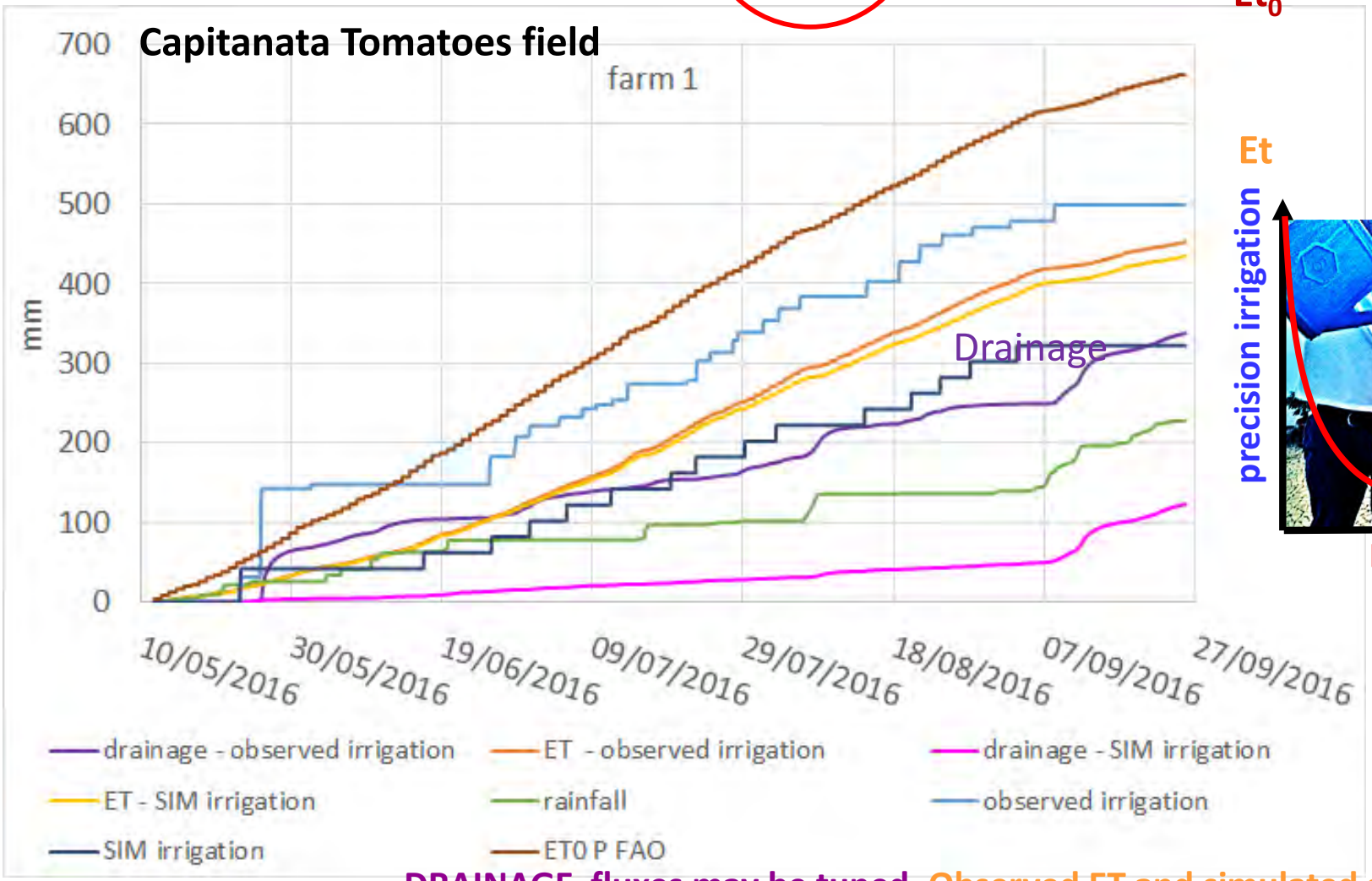
		Irrigation (mm)	Number of irrigations	Rainfall cum (mm)
Farm 1 (2016)	**Observed**	**547.9**	**27**	**145**
	SIM	**322.3**	**15**	
Farm 2 (2016)	**Observed**	**646.6**	**43**	**150**
	SIM	**590**	**90**	
Farm 3 (2017)	**Observed**	**1000**	**43**	**28**
	SIM	**850**	**25**	

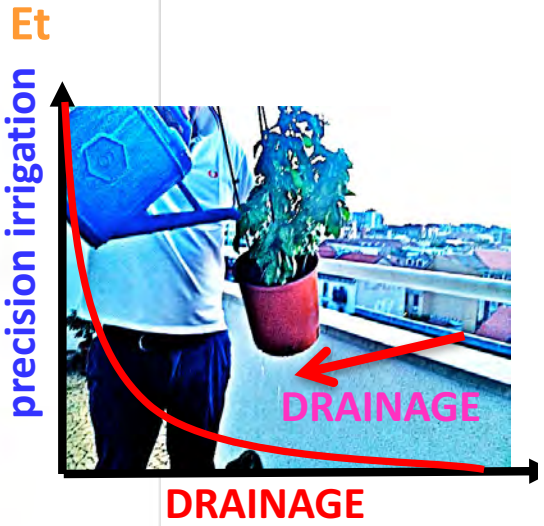
the SIM strategy allows to reduce the passage over the FC threshold reducing the percolation flux with a saving of irrigation volume

SIM IRRIGATION STRATEGY: where saving water and improve Irrigation Water Efficiency

Rainfall	+ Irrigation =	ETP	+ Drainage	+ DW
145	+ 547	= 450	+ 320	– 70. (mm)
145.	+ 322	= 440	+ 110	- 80 (mm)

SIM IRRIGAZIONE Et_0





DRAINAGE fluxes may be tuned. Observed ET and simulated are similar

SIM IRRIGATION STRATEGY: water indicators at field scale

South Italy Capitanata consortium Tomatoes field

INDICATORS:

water use efficiency (WUE = yield/ET) [kg/m^3]

irrigation water use efficiency (IWUE = yield/irrigation [kg/m^3]

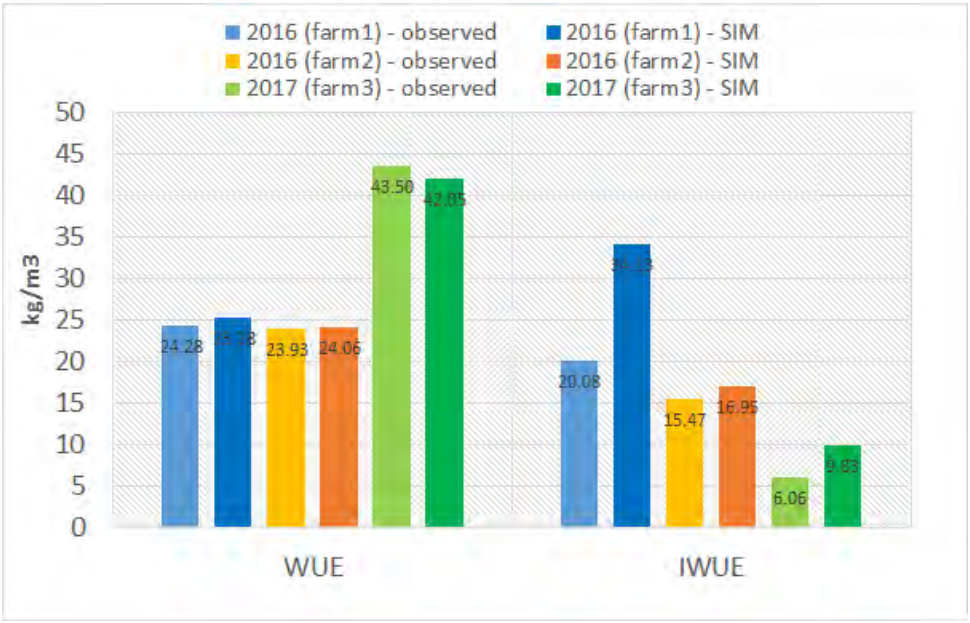
evaporation deficit =ETP – ET [mm]

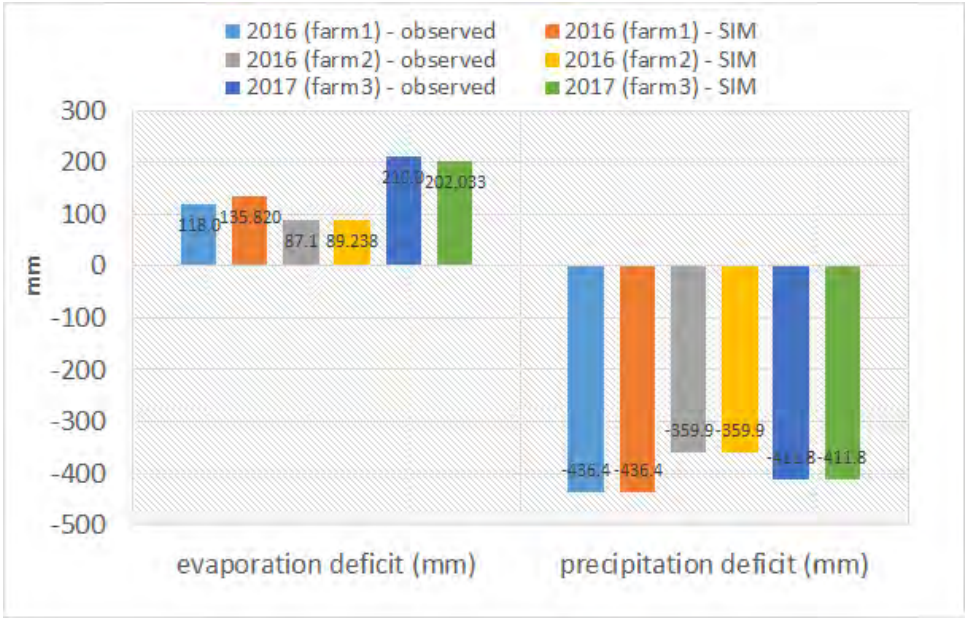
precipitation deficit = P − ETP [mm]

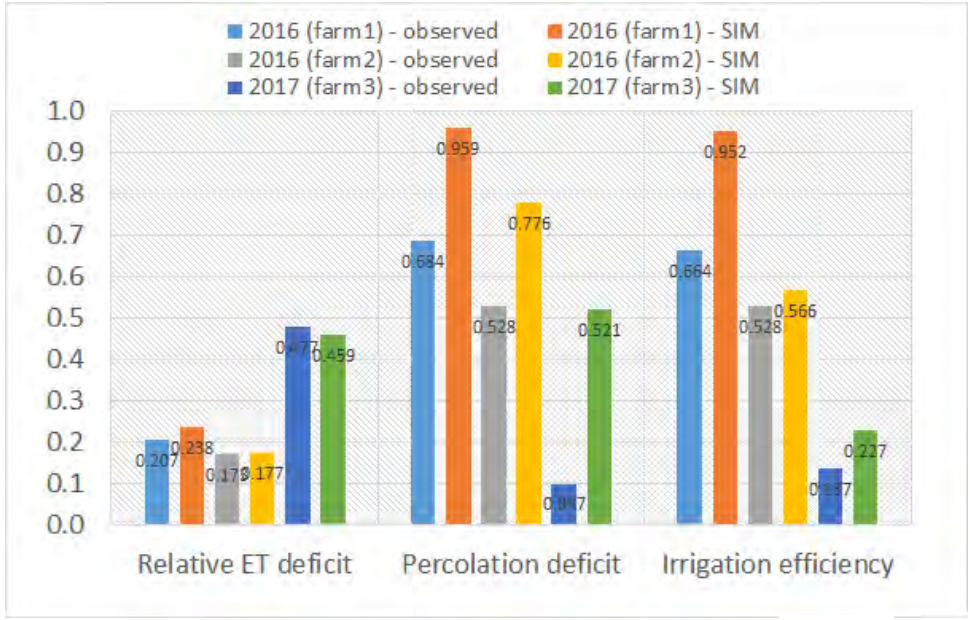
Relative ET deficit = 1-ET/ETP [-]

Percolation deficit =((rainfall+irrigation) - percolation) / (rainfall+irrigation) [-]

Irrigation efficiency = ET /(rainfall+irrigation) [-]

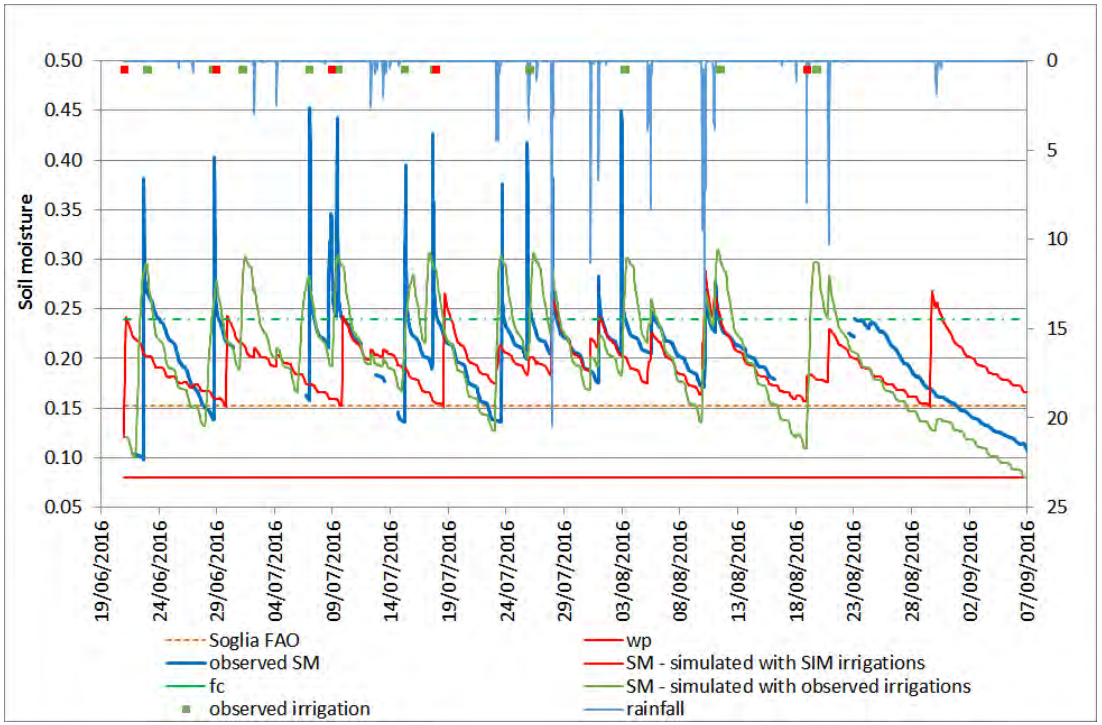




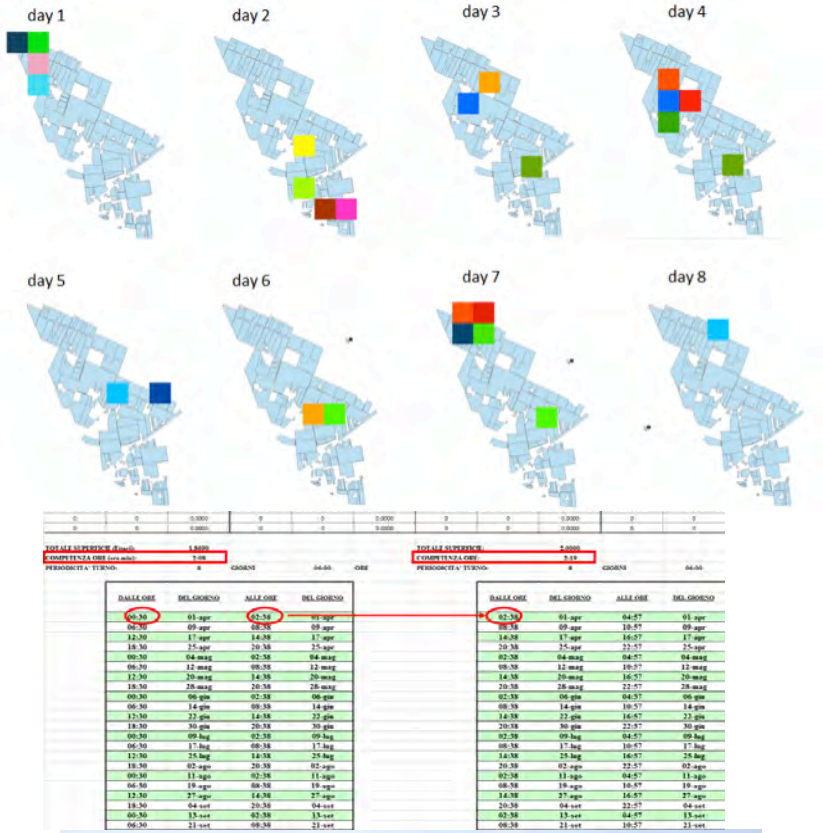


SIM IRRIGATION STRATEGY: effect on soil moisture

Northern Italy: Chiese consortium Fields ,Maize fields



Scheduled flooding irrigation



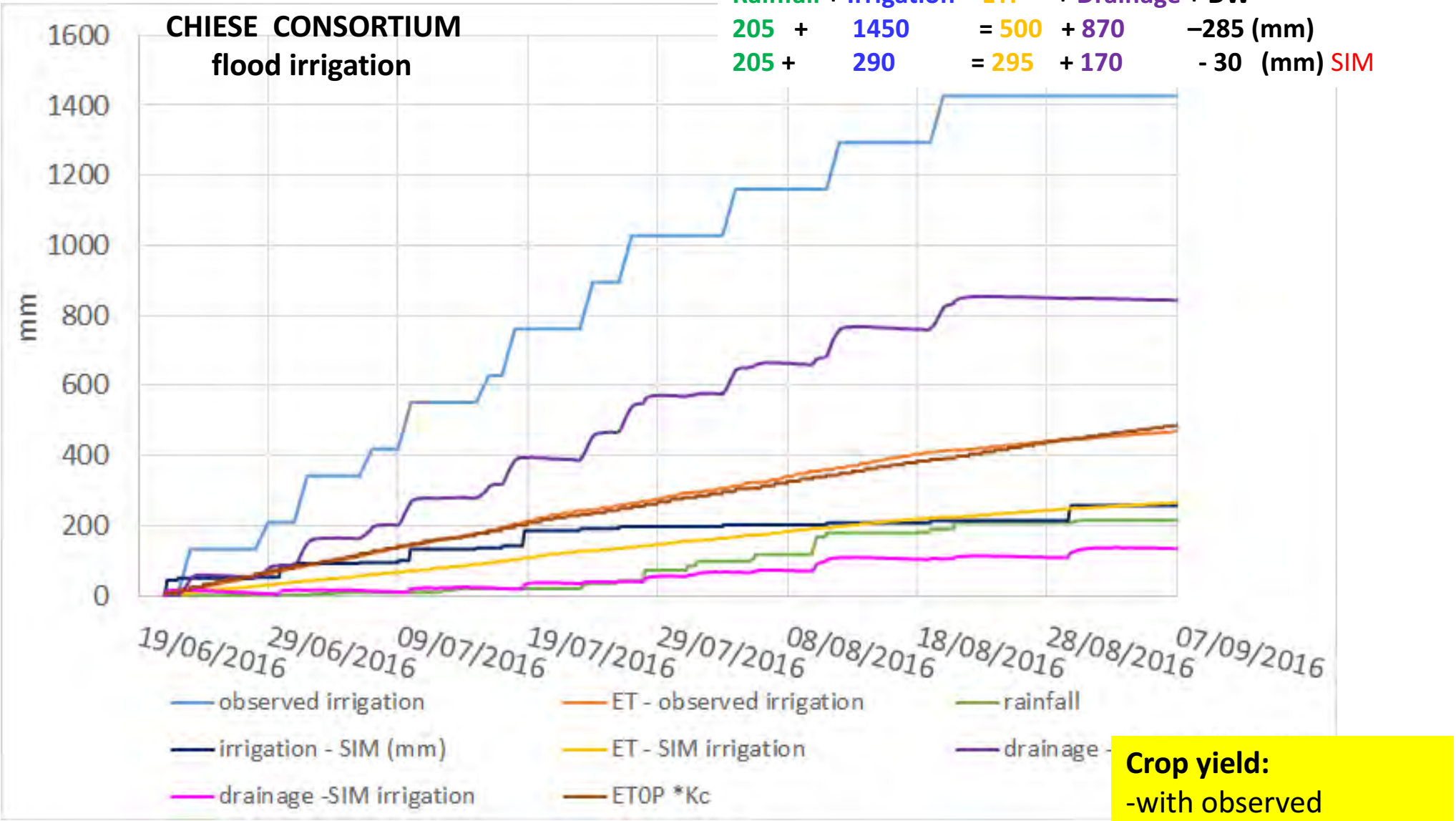
		Irrigation (mm)	Number of irrigations	Rainfall cum (mm)
2016	**Observed**	**1426**	**11**	**269**
	SIM	**301**	**5**	
2017	**Observed**	**1480**	**17**	**223**
	SIM	**488**	**10**	
2018	**Observed**	**1750**	**13**	**515**
	SIM	**200**	**5**	

SIM IRRIGATION STRATEGY : where saving water?

Rainfall + Irrigation = ETP + Drainage + DW

205 + 1450 = 500 + 870 –285 (mm)

205 + 290 = 295 + 170 - 30 (mm) SIM



DRAINAGE fluxes may be reduced

Crop yield:
-with observed irrigation 9,1 ton/ha
-with SIM strategies 8,9 ton/ha

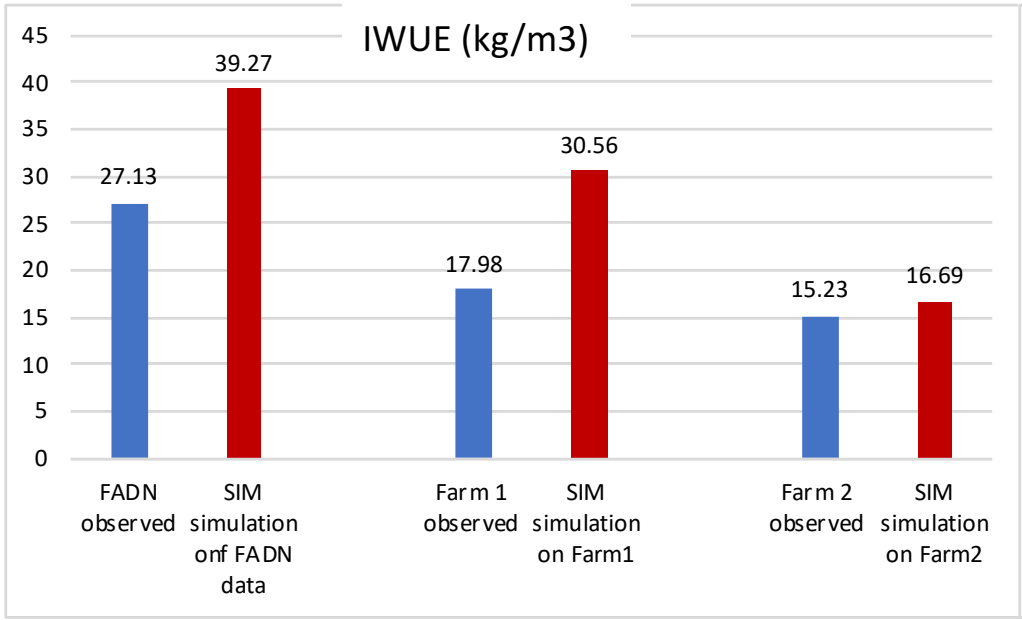
Capitanata Tomatoes field drip irrigation

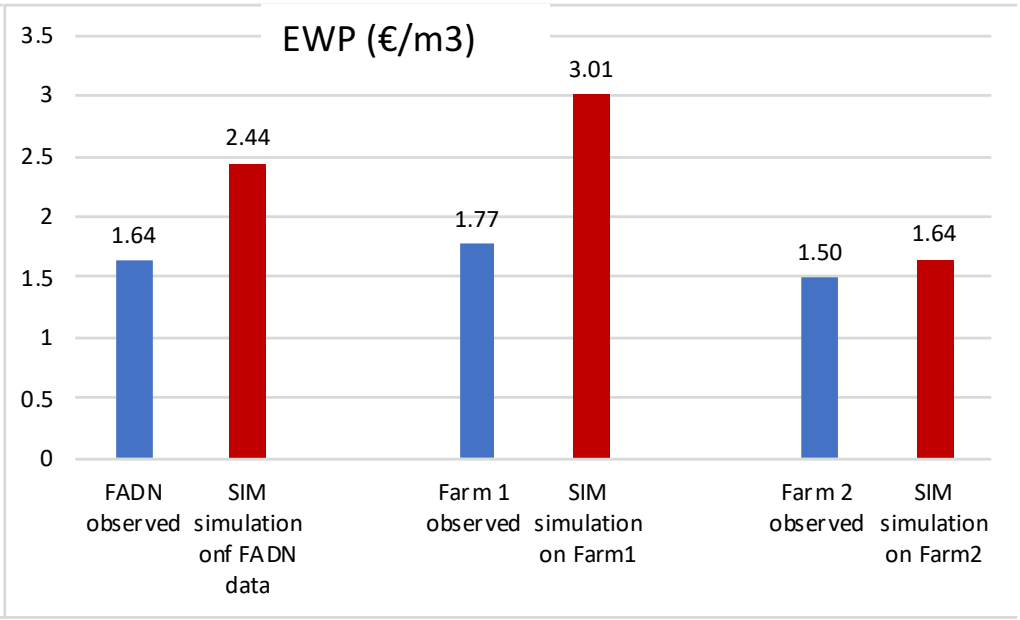
Irrigation water use efficiency or physical water productivity

$$IWUE = PWP = \frac{Ya}{AWU} = \frac{k\,g/h\,a}{m^3/h\,a}$$

Economic Water Productivity

$$EWP = \frac{Gross\ margin}{AWU} = \frac{€/ha}{m^3/ha}$$





EU Farm Accountancy Data Network (FADN)

SIM IRRIGATION STRATEGY: economic indicators

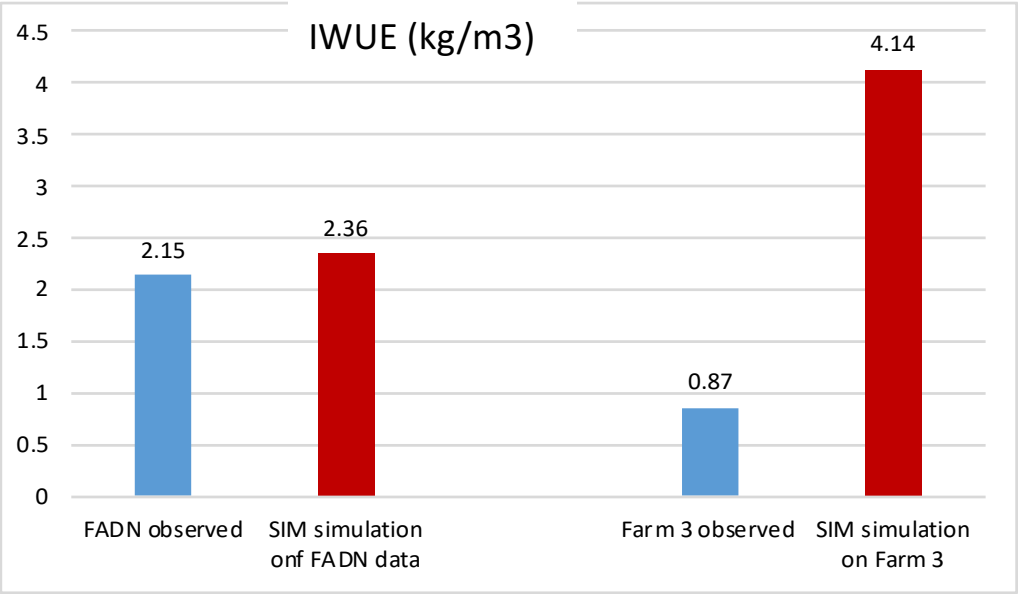
CHIESE IRRIGATION CONSORTIUM
flood irrigation Maize

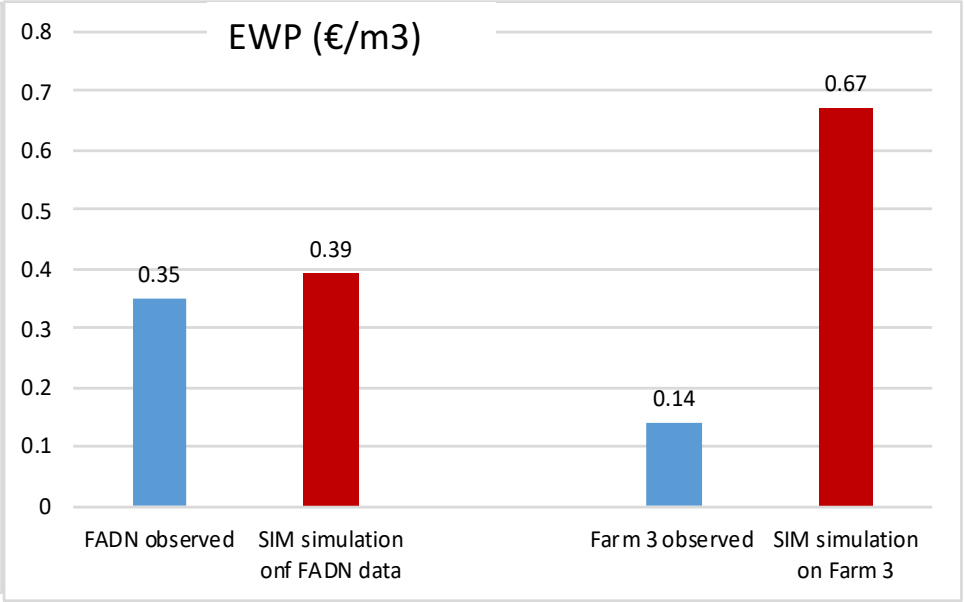
Irrigation Water Use Efficiency
or physical water productivity

$$IWUE = PWP = \frac{Ya}{AWU} = \frac{kg/ha}{m^3/ha}$$

Economic Water Productivity

$$EWP = \frac{Gross\ margin}{AWU} = \frac{€/ha}{m^3/ha}$$

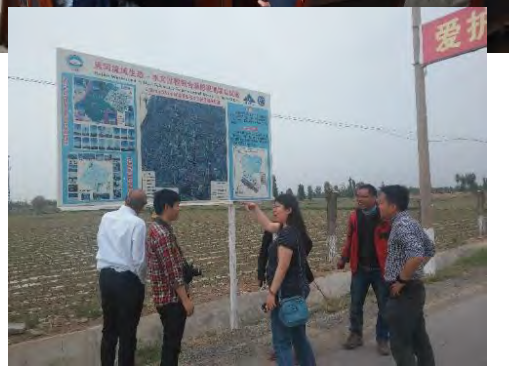




EU Farm Accountancy Data Network (FADN)

PROJECT STAKEHOLDER INTERACTIONS

Zhangye (China) during a meeting between the **Heihe water basin authority**, and the chinese partner RADI-CAS and the italian partner POLIMI. (19-23 may 2016)



The SIM at the «The consortium and its territory» meeting organized by **Capitanata Irrigation Consortium** (Foggia – Italy), many other meetings (2015-2017)

Aa en Maas water authority (Ne)

INTERNATIONAL ORGANIZATION INTERACTIONS

esa

copernicus observing the earth

NASA

NASCC

AARSE

MARSE

RANETIIED

PROJECT CITIZEN SCIENCE INTERACTIONS

GROW OBSERVATORY

https://growobservatory.org

Concluding remarks

Satellite data may provide a significant help in distributed hydrology, in particular for field and basin surface hydrology. This is assessed especially if hydrologic models equations make explicit those variables retrievable directly from Satellite remote sensing.

The synergism with remote sensing data helps in achieving these results in: a) soil surface model calibration; b) state variable retrieval c) irrigation management

Precise irrigation controlling soil moisture between percolation thresholds and stress thresholds save consistent amount of water and improve economic gain

Monitoring and forecast soil moisture using the above concepts may be transferred in a operative dashboard

From the SIM website **www.sim.polimi.it**
You can access the operative dashboards