

SIM PROJECT OVERVIEW

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SIM

www.sim.polimi.it

SMART IRRIGATION FROM
SOIL MOISTURE
FORECAST USING
SATELLITE AND HYDRO –
METEOROLOGICAL
MODELLING



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Water
Works

WATERWORKS 2014 COFUNDED CALL

Coordinator:

Politecnico di Milano (Italy)

Team:

Delft University (The Netherlands)

University of Valencia (Spain)

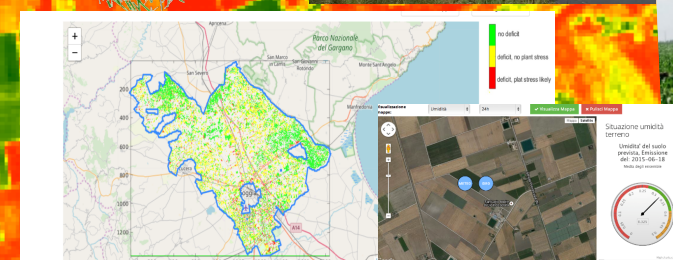
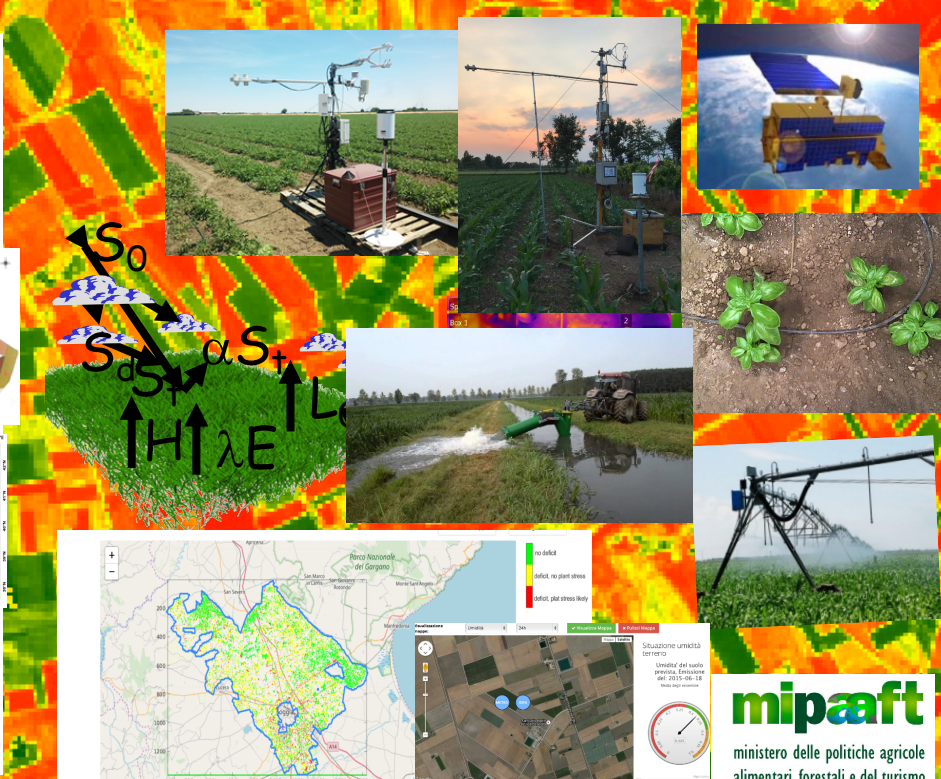
University of Balears (Spain)

Radi-Academy of Science (China)

University of Tuscia (Italy)

Epson meteo (Italy)

MMI srl (Italy)



mipaft
ministero delle politiche agricole
alimentari, forestali e del turismo

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

ANP

esa

NASA

NASCC

RANET ED

copernicus
observing the earth

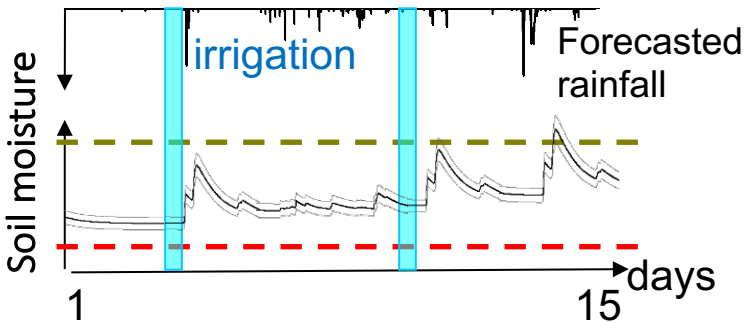
BAR
Dipartimento di Biologia e Biologia

Water JPI

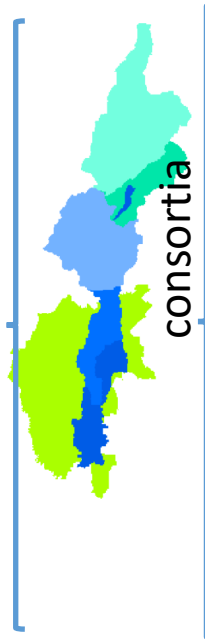
Roma, June 12 2019



- 1 monitor and forecast crop water need** for parsimonious precise irrigation
- 2 setting a irrigation strategy:** Increasing irrigation efficiency (ton/mc) and water productivity (€/mc)



river basin



consortia



Idro lake reservoir

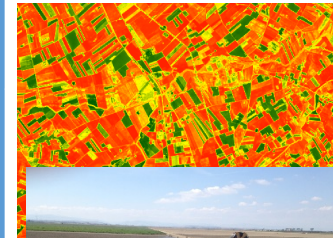


Occhito DAM

farmers



Chiese farm



Capitanata farm

but also:

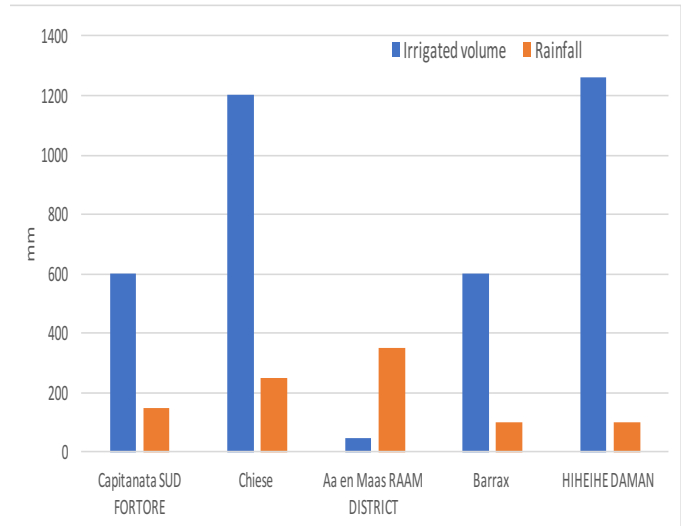
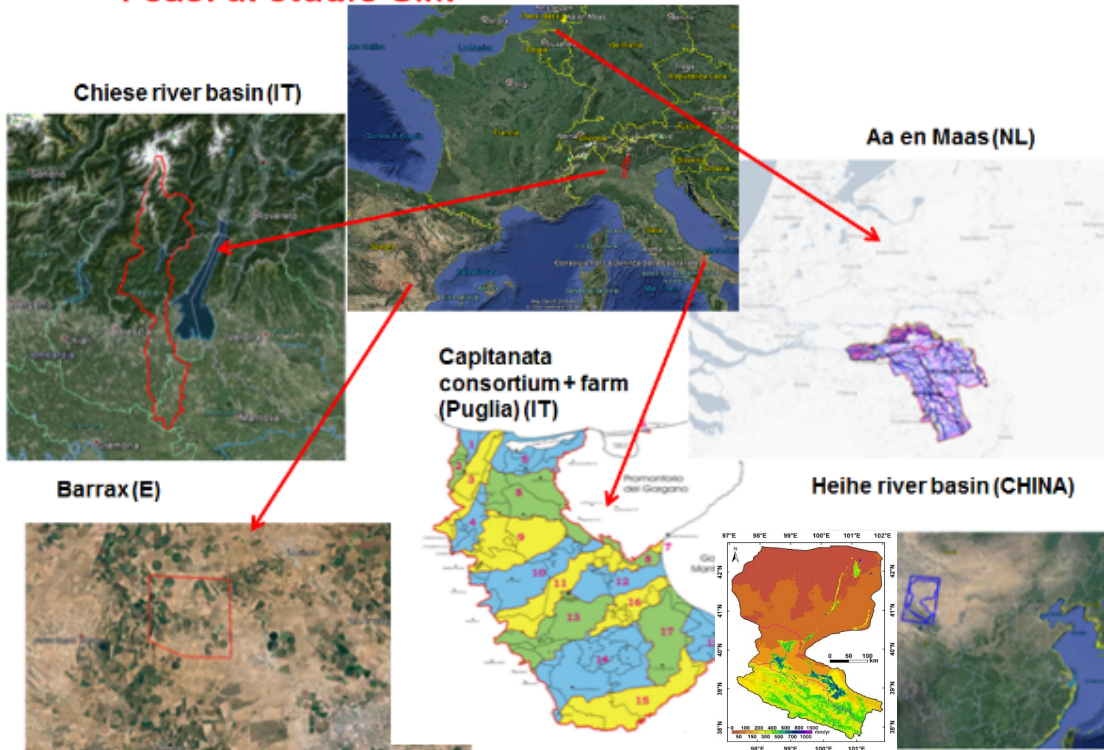
- irrigation strategy at field scale: water amount and timing;
- economic analysis of parsimonious irrigation;
- satellite land surface temperature data for soil moisture hydro model update;
- dynamic actual evapotranspiration;
- satellite Fraction Cover and Leaf Area Index for cultivated area identification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



I casi di studio SIM

DIFFERENT CLIMATATE 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 schiese



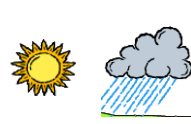
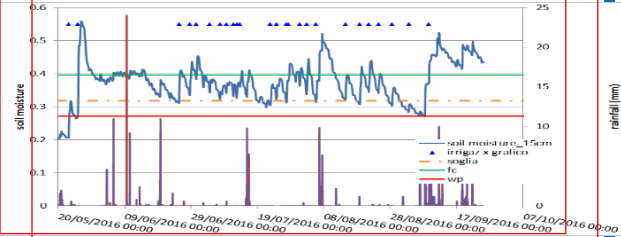
SIM AND OTHER IRRIGATION MONITORING & MANAGEMENT SYSTEMS



Dashboards	Satellite data Drones	Weather forecasts	ET estimation	Real time data	Soil moisture monitoring	Saving assesement
Figaro: www.figaro-irrigation.net	–	X	Kc	X	X	fresh water + energy savings
SWAMP: swamp-project.org	Drones	X	–	X	X	Water saving
Apollo: http://apollo-h2020.eu/	Satellite + Drones	X	–	X	X	Environmental + water+economic benefits
IrriSAT: www.irrisat.com	Satellite	X	Kc	X	–	water + energy saving
Moses: http://moses-project.eu/moses_website/	Satellite	X	Kc	X	–	Water + energy + cost + drought reduction
Irrinet/irriframe www.irriframe.it	–	–	Kc	X	–	Water saving
Blue leaf: www.bluleaf.it	X	X	Kc	X	X	Water + energy + Environmental impact reduction
FATIMA http://fatima-h2020.eu/	X	X	Kc	X	X	Water+ energy + economic saving
NetBeat™ - NETAFIM www.netafim.com/en/digital-farming/netbeat	X	X	Kc	X	X	Commercial purpose
SIM – www.sim.polimi.it	X	X	Water energy budget	X	X	Water, economic savings

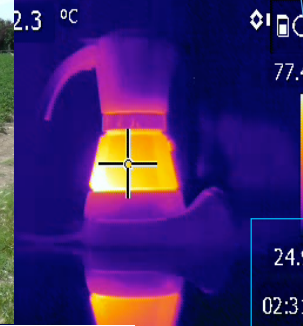
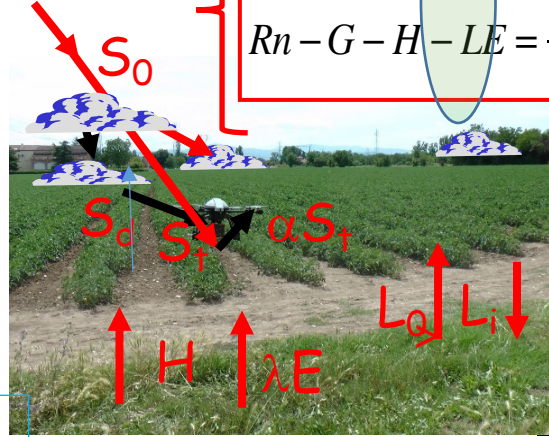
HYDROLOGICAL MODELING: MASS & ENERGY BALANCE

GROUND MONITORING

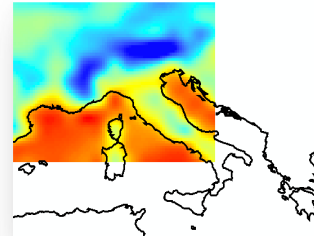


$$P_{tot} = R + ET_{eff} + D + (\theta_{t+1} - \theta_t) * Z$$

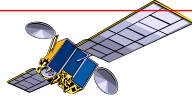
$$Rn - G - H - LE = \frac{dS}{dt}$$



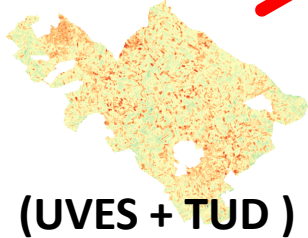
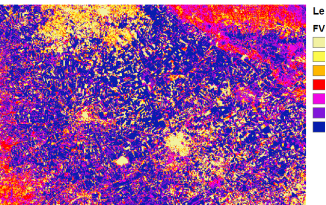
Meteorological forecast
UNIBAL + EPSON



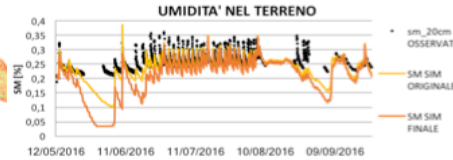
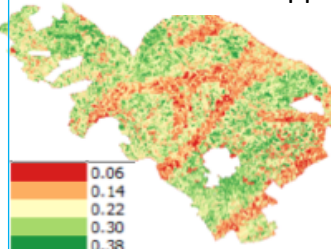
SATELLITE MONITORING



(LANDSAT – SENTINEL) Vegetation and LST

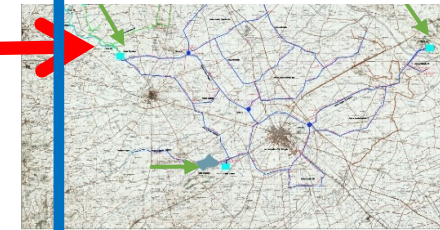


soil moisture and irrigation water need : mapping and pixel wise

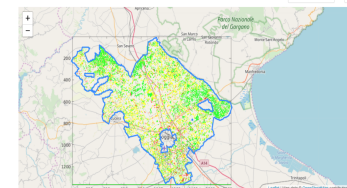
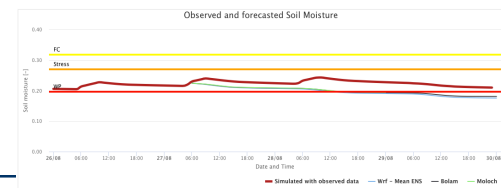


POLIMI FEST EWB, ETP RADI CAS

irrigation aqueduct model
MMI



POLIMI Irrigation water needs forecast and operative tool



Economic profitability (UNITUS)

Scenario	Value	Description
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 system)
CAP	0,15	(average consortium price for m³/ha)



LANDSAT_8 Surface Temperature

LST

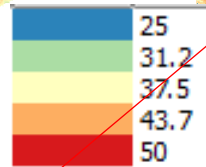
Soil moisture

1 June 2015

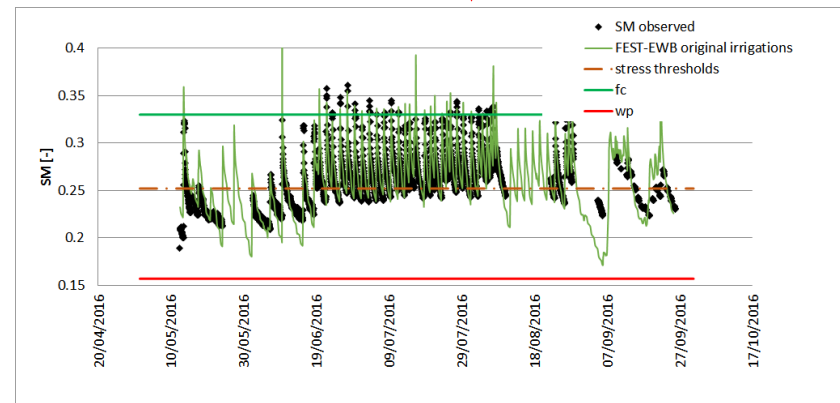
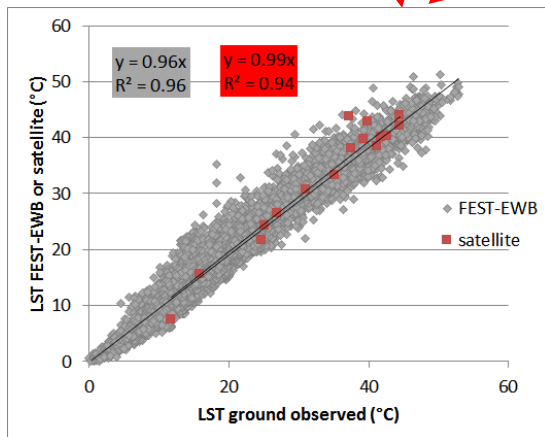
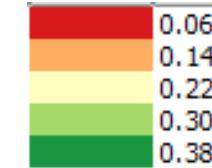
$\Delta x = 30$ m LST

Mean = 37 °C

°C



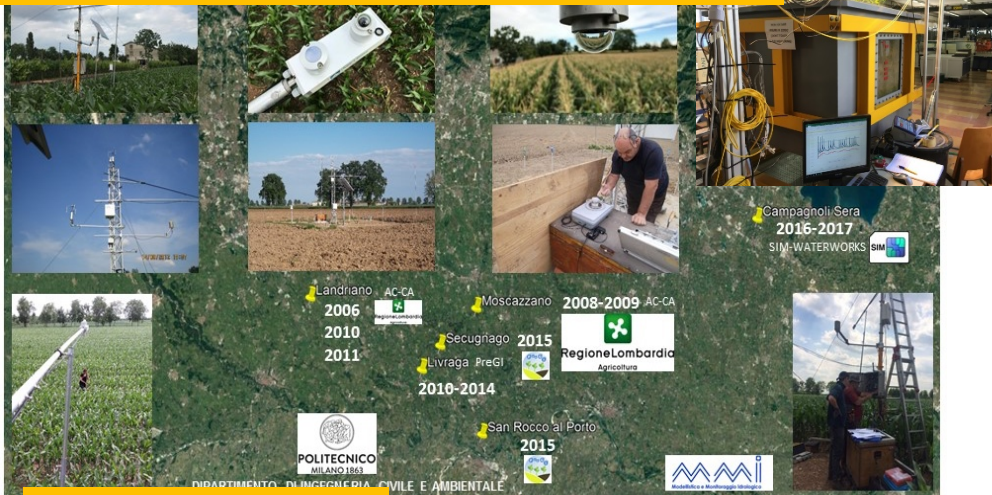
Mean = 36.5 °C



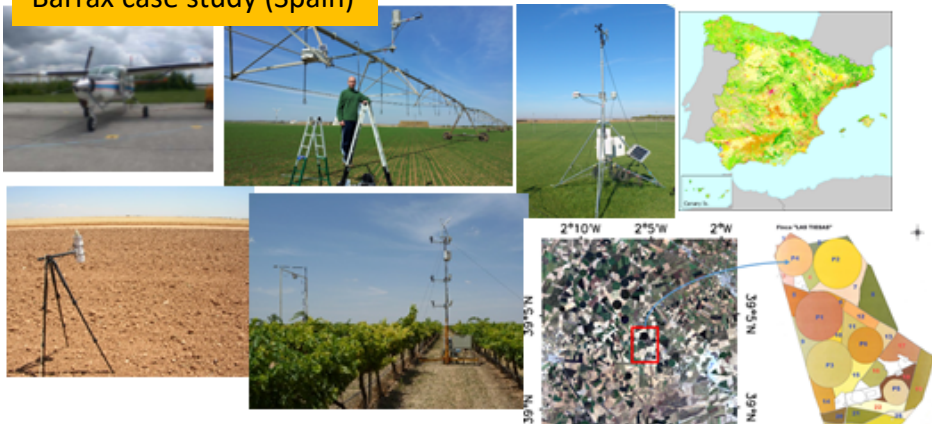


Ground measurements: Soil Moisture, Evaporation, discharge measures

Chiese case study (Lombardy monitoring activities-Italy)



Barrax case study (Spain)



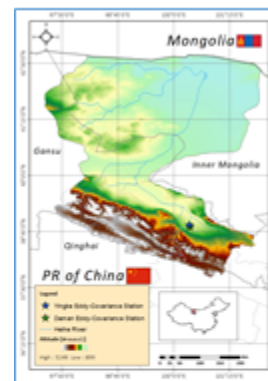
Aa en Maas case study (The Netherlands)



Capitanata case study (Puglia-Italy)



On-line Database



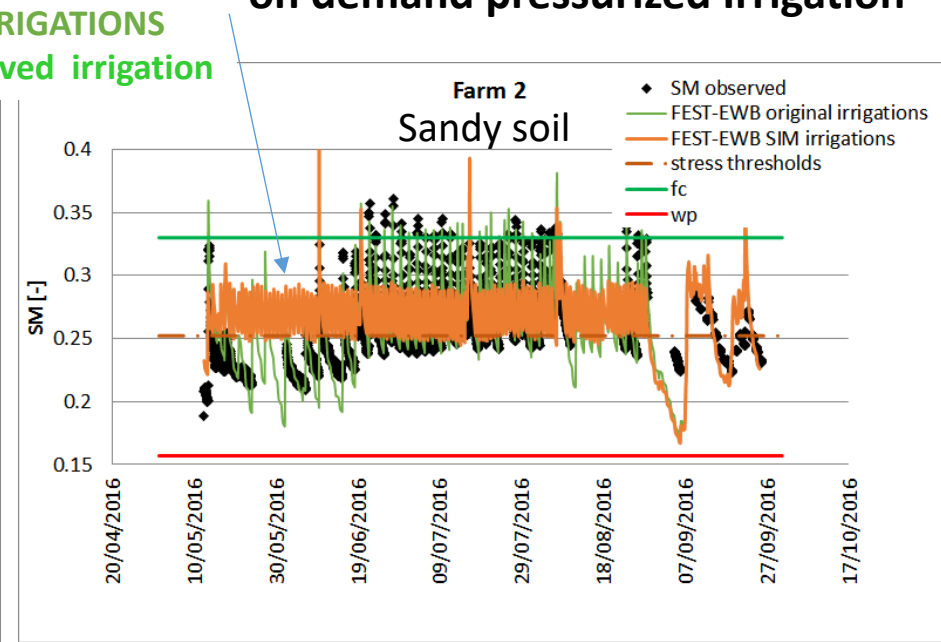
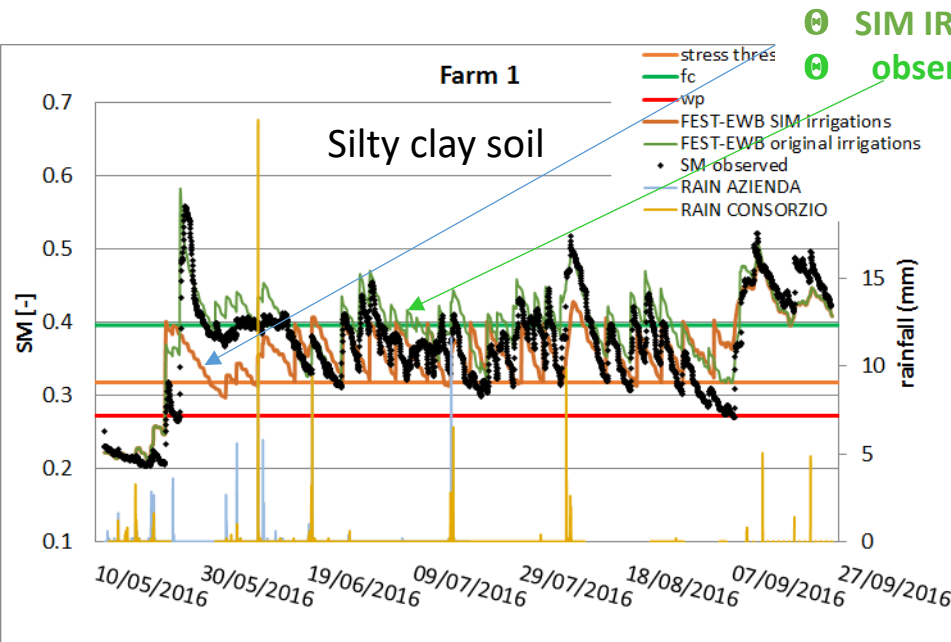
Heihe case study (China)





Capitanata Consortium fields: tomatoes

on demand pressurized 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	



Capitanata irrigation consortium

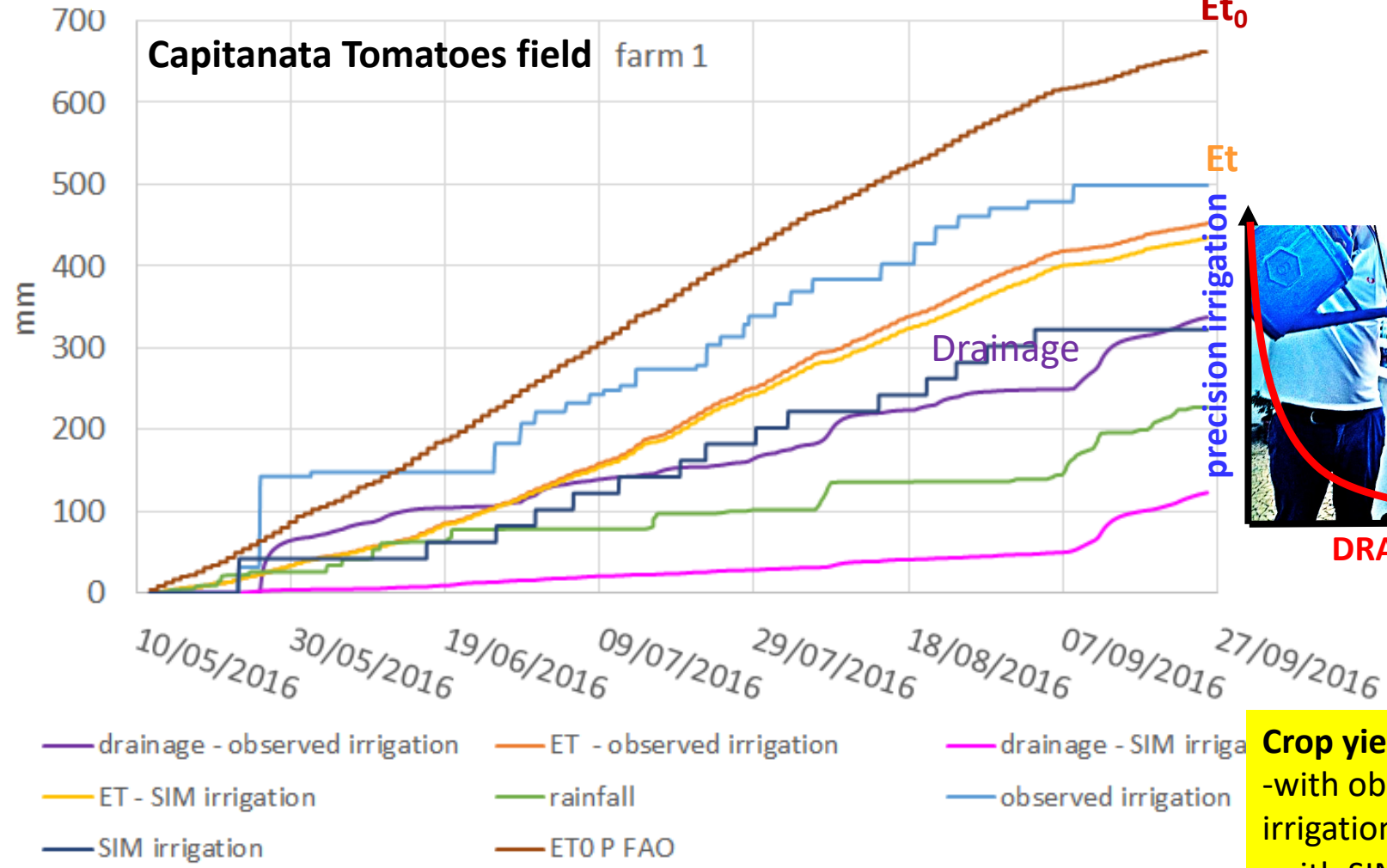
the SIM strategy allows to reduce the passage over the FC threshold reducing the percolation flux with a saving of irrigation volume



SIM IRRIGATION STRATEGY: where saving water AND IMPROVE WATER EFFICIENCY ?

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

SIM IRRIGAZIONE
Et₀

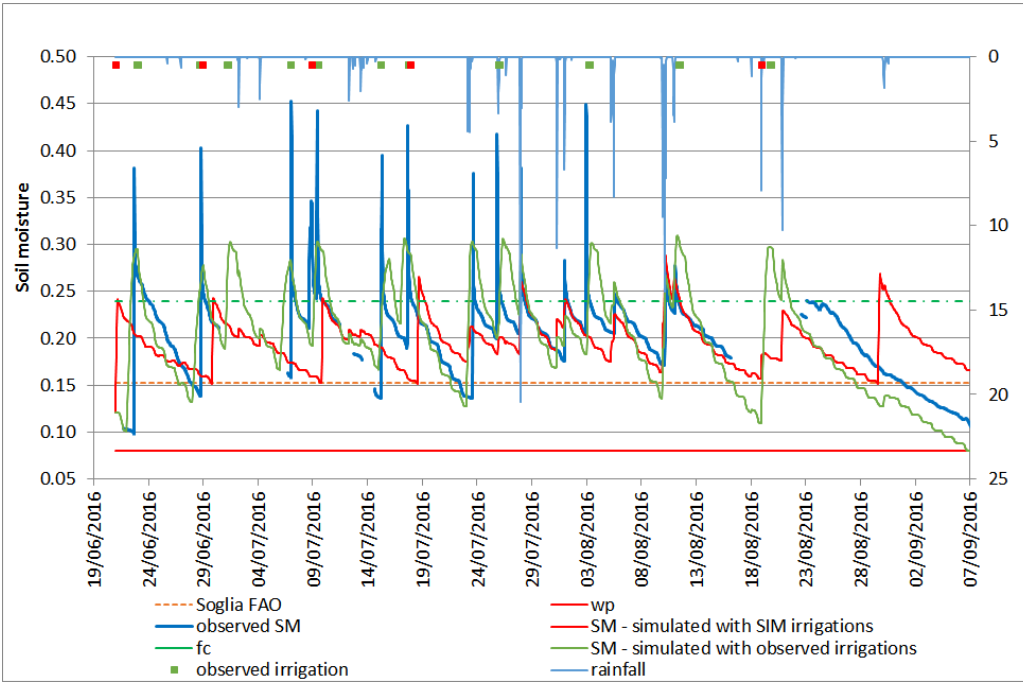


DRAINAGE

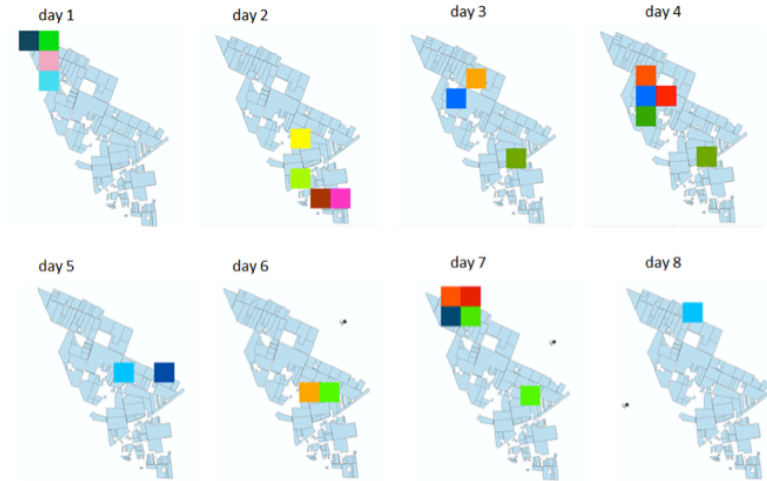
Crop yield:
 -with observed irrigation 120 ton/ha
 -with SIM strategies 116,3 ton/ha



Chiese irrigation consortium Fields ,Maize fields



Scheduled flooding irrigation



PERIODO A TAVOLINO				PERIODO A TAVOLINO			
DALLE ORE	DEL GIORNO	ALLE ORE	DEL GIORNO	DALLE ORE	DEL GIORNO	ALLE ORE	DEL GIORNO
00:30	01 ago	02:38	01 ago	00:30	01 ago	04:57	01 ago
02:30	09 ago	08:58	09 ago	08:58	09 ago	10:57	09 ago
12:30	17 ago	14:58	17 ago	14:58	17 ago	16:57	17 ago
18:30	25 ago	20:58	25 ago	20:58	25 ago	22:57	25 ago
00:30	04 mag	02:58	04 mag	02:58	04 mag	04:57	04 mag
06:30	12 mag	08:58	12 mag	08:58	12 mag	10:57	12 mag
12:30	20 mag	14:58	20 mag	14:58	20 mag	16:57	20 mag
18:30	28 mag	20:58	28 mag	20:58	28 mag	22:57	28 mag
00:30	06 gen	02:58	06 gen	02:58	06 gen	04:57	06 gen
06:30	14 gen	08:58	14 gen	08:58	14 gen	10:57	14 gen
12:30	22 gen	14:58	22 gen	14:58	22 gen	16:57	22 gen
18:30	30 gen	20:58	30 gen	20:58	30 gen	22:57	30 gen
00:30	09 feb	02:58	09 feb	02:58	09 feb	04:57	09 feb
06:30	17 feb	08:58	17 feb	08:58	17 feb	10:57	17 feb
12:30	25 feb	14:58	25 feb	14:58	25 feb	16:57	25 feb
18:30	02 ago	20:58	02 ago	20:58	02 ago	22:57	02 ago
00:30	11 ago	02:58	11 ago	02:58	11 ago	04:57	11 ago
06:30	19 ago	08:58	19 ago	08:58	19 ago	10:57	19 ago
12:30	27 ago	14:58	27 ago	14:58	27 ago	16:57	27 ago
18:30	04 set	20:58	04 set	20:58	04 set	22:57	04 set
00:30	13 set	02:58	13 set	02:58	13 set	04:57	13 set
06:30	21 set	08:58	21 set	08:58	21 set	10:57	21 set

		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	

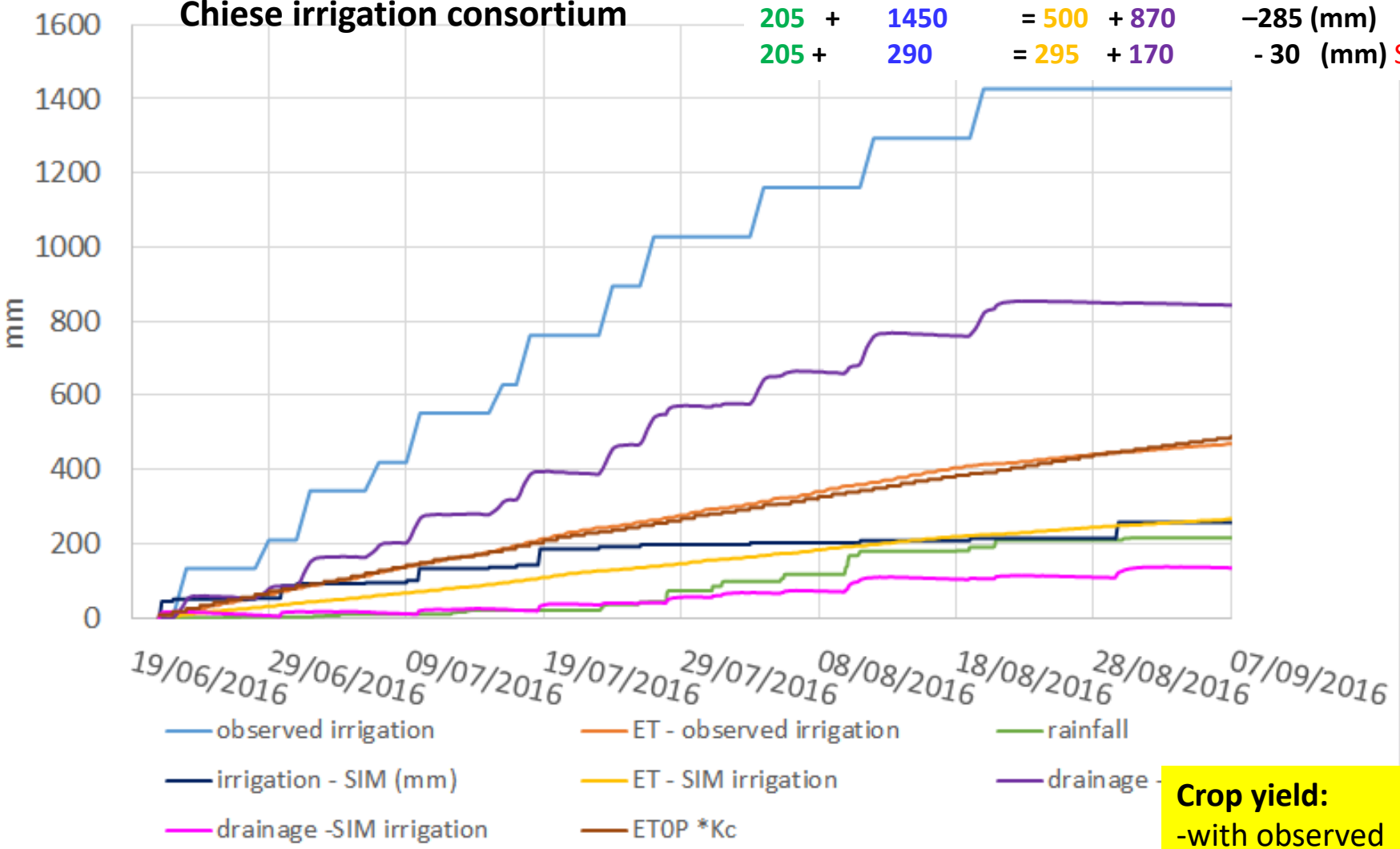




SIM IRRIGATION STRATEGY : where saving water?

Chiese irrigation consortium

Rainfall	+	Irrigation	=	ETP	+	Drainage	+ DW	
205	+	1450	=	500	+	870		-285 (mm)
205	+	290	=	295	+	170		- 30 (mm) SIM



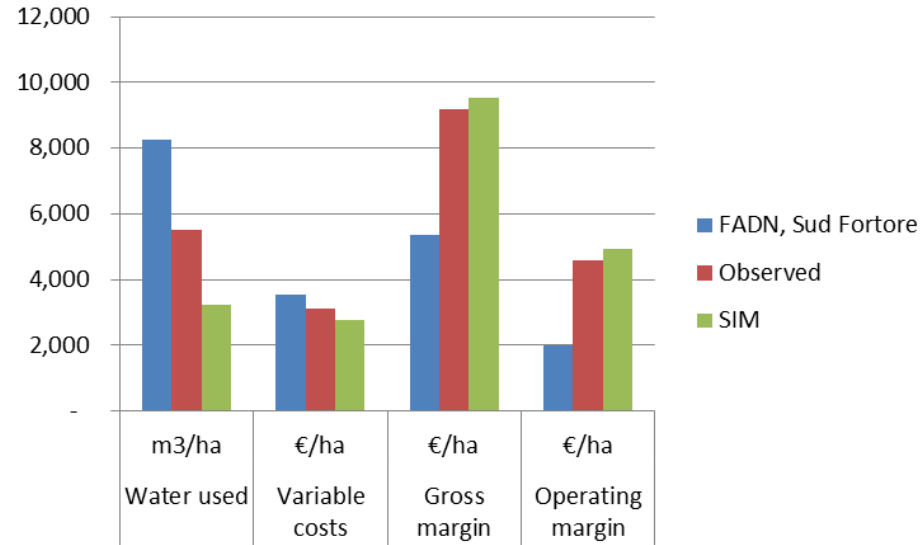
Crop yield:
 -with observed irrigation 9,1 ton/ha
 -with SIM strategies 8,9 ton/ha



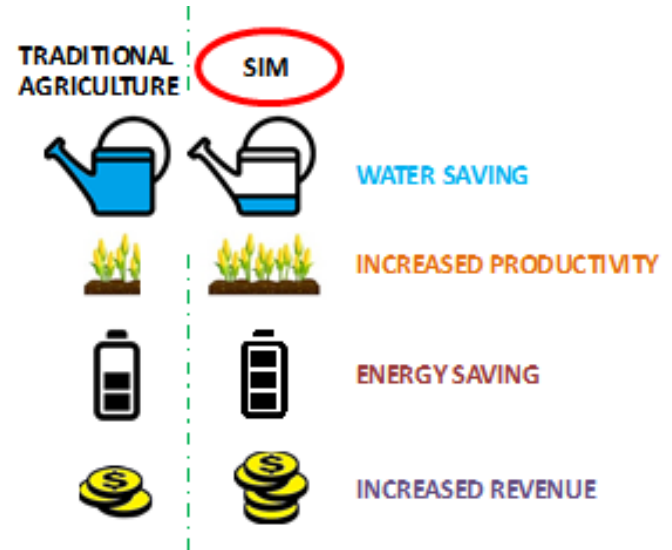
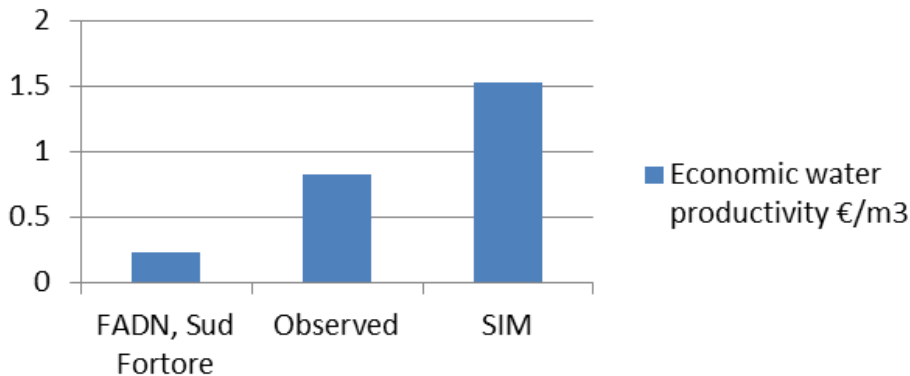
irrigation water use efficiency (Kg / mc)



Economic water productivity = Operating margins costs/Water used



Economic water productivity

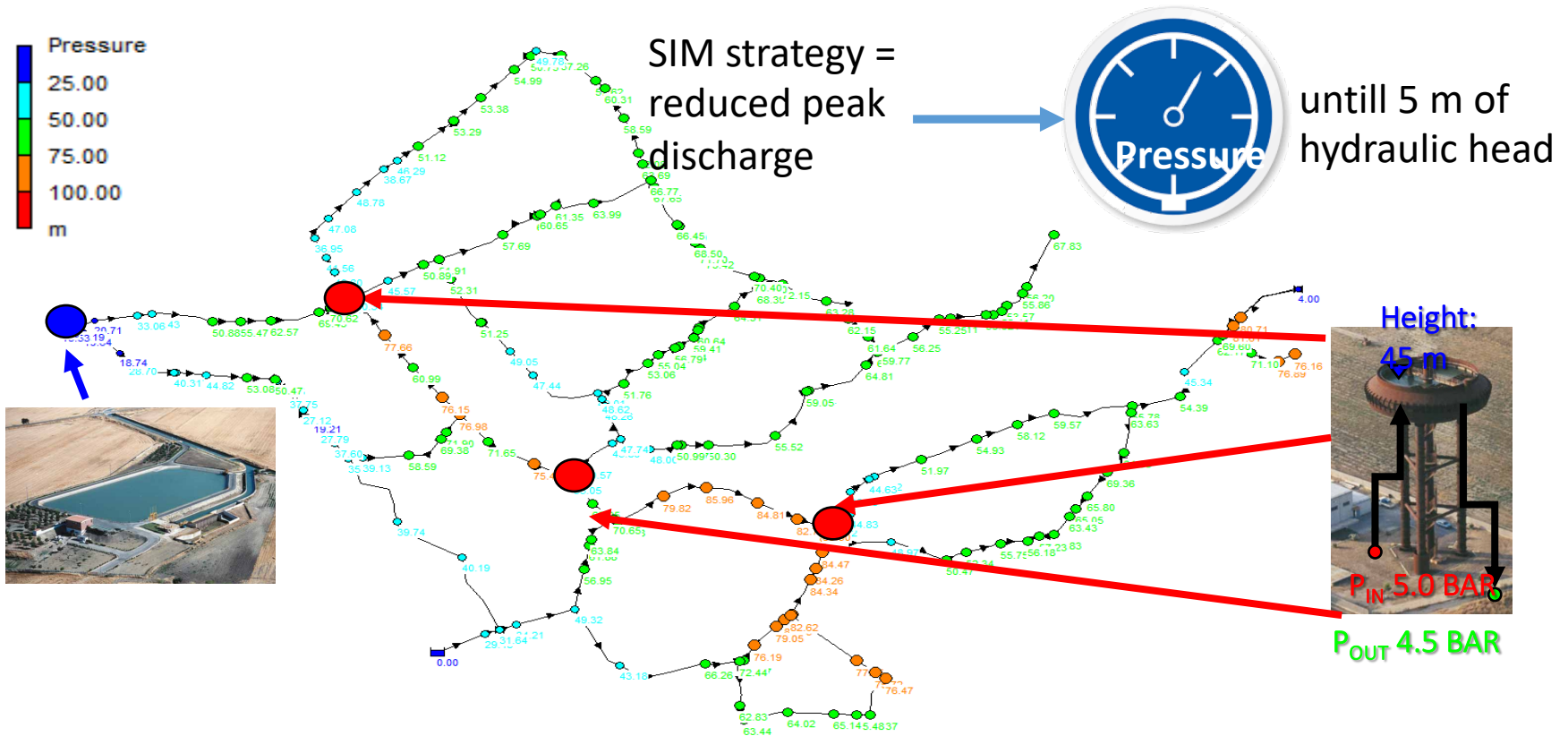




SIM IMPACT ON PRESSURIZED DISTRIBUTION NETWORK: THE CAPITANATA SUD FORTORE EXAMPLE



- USERS DEMAND $10 \div 500$ L/S IN 124 NODES
- NODES ARE LINKED TO A SECOND MORE COMPLEX NETWORK MANAGED BY THE CONSORTIUM



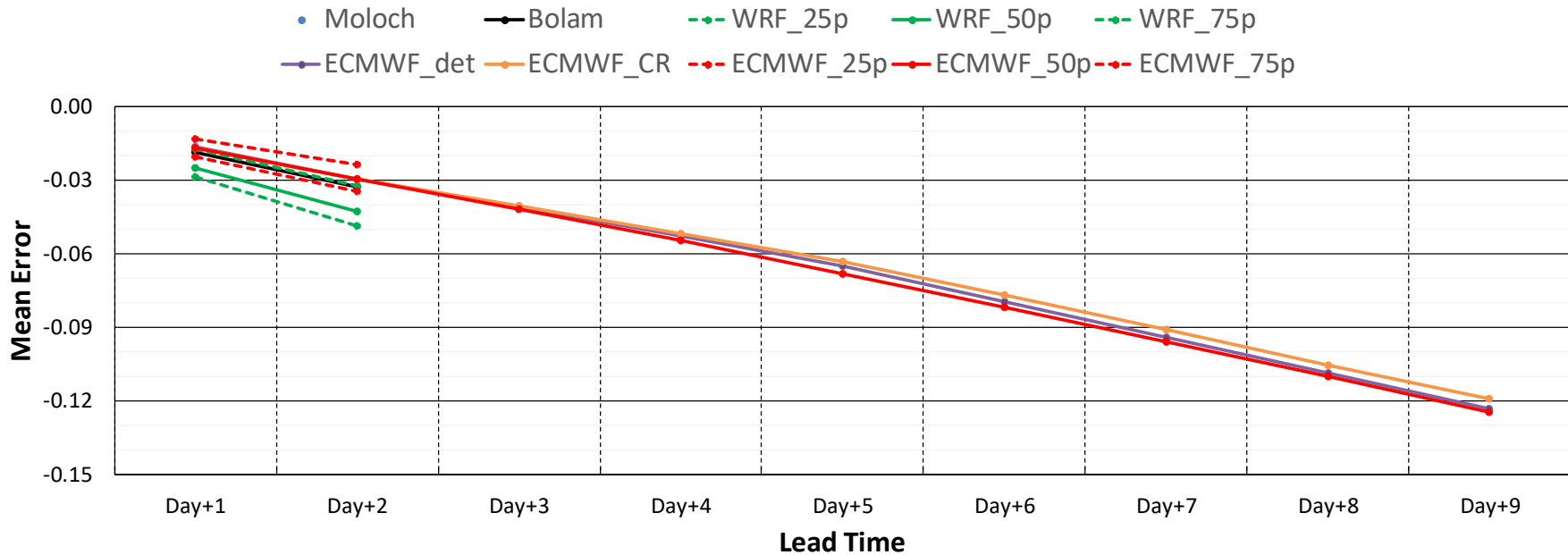


THE METEOROLOGIC DATA CHAIN AND IMPACT OF METEOROLOGIC FORECAST

At 10 am: get the

At 1 pm: observed and

Soil Moisture [-]



model



At 5 pm: WRF-MOPI forecasted data are uploaded on the SIM dashboard

CPU information:

1 Processor Intel Xeon (6 Cores, 12 threads)
32 GB ECC RAM
Hard Disk: Primary 256 GB SDD
Secondary: 9.1 TB Array of 5 Hard Disk in Raid-5 Configuration
NAS: 14 TB Array of 5 Hard Disk in Raid-5 Configuration



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 project has been invited for presentation 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





SIM Project diffusion

www.sim.polimi.it



dashboard selection



TERZA GIORNATA NAZIONALE DELL'INNOVAZIONE PER L'IRRIGAZIONE ACQUA CAMPUS

GIOVEDÌ 9 MAGGIO ORE 10.00 - 12.30 ANFITRATTO - INGRESSO SUD

Meeting aperto

PROGRAMMA
Moderatore: PAOLO MANNINI (Dir. CER - Carlo Emanuele Romagnolo)
Intervengono: DR. ALDO MORONE (Pres. Regione Emilia Romagna) STEFANO BONACCINI (Dir. Servizio Agricoltura) VALLARI (Ass. Agricoltura Emilia Romagna) SIMONA CASELLI (Pres. Consorzio MACFRUT RIMINI)
Dove: Palazzo VINCI (Fiera ANBI)



GROW OBSERVATORY

Science & Technology

SPECIAL FEATURE: WATER INNOVATION

SMART IRRIGATION MONITORING AND FORECAST (SIM)

Professor Marco Mancini of the Politecnico di Milano, Italy, introduces the SIM Project, a system based on satellite data and hydro-meteorological models funded by the European Union's Horizon 2020 Programme.

The conflicting use of water is becoming more and more acute... The SIM Project... The SIM Project... The SIM Project...

The SIM Project... The SIM Project... The SIM Project... The SIM Project... The SIM Project...



A NASA Landsat Program piace il tuo Tweet - 12 h
Chiara @chiaraco81
SIM - real time SMART IRRIGATION from soil moisture forecast usin...

Water JPI @WaterJPI - 5 min
SIM - real time SMART IRRIGATION from soil moisture forecast using satellite @CopernicusEU @NASA_Landsat and hydro-meteorological modelling sim.polimi.it
@WaterJPI funded project
Chiara @chiaraco81
SIM - real time SMART IRRIGATION from soil moisture forecast using satellite @CopernicusEU @NASA_Landsat and hydro-meteorological modelling sim.polimi.it @WaterJPI funded project

- A number of scientific conferences
- European Geoscience Union (Austria)
- Digital Earth Summit – Africa
- DBAR (Digital Belt and Road)- China
- ESA Living planet symposium (Italy)
- convegno di Idraulica/Idrologia (Italy)
- Recent Advances in Quantitative Remote Sensing (Spain)

Papers on scientific journals
PhD and master thesis

marco.mancini@polimi.it

research&innovation
Smart irrigation and floods
Satellite data and meteorological modelling
When and how to irrigate
The SIM system, developed in the European Smart Irrigation Modelling project (www.sim.polimi.it), is an operative web-based system which monitors and forecast water needs in real time, allowing to use less water, fertilizers and energy than in traditional systems, keeping a constant crop yield. The main targets of the system are farmers, irrigation consortia and water authorities. The system quantifies the right amount of water at the right time needed for optimal crop production, based on the weather conditions, type of soil and farming practices. It combines the state of the art of satellite monitoring, weather forecasting and hydrological modelling with ground monitoring. Specific indicators, calculated for different user levels, quantify the economic and environmental benefits to the system is capable of generating. It is currently being tested in Italy, in collaboration with ANBI and CREA, the Netherlands, China and Spain, all of which have different climates, water availability, crop types and irrigation systems.



Operative tool for real time irrigation water needs forecast

The SIM dashboard WATER INFORMATION SYSTEM



CASE STUDIES WORK PACKAGES DASHBOARDS

Dashboards

SIM tool will enable you to real-time monitor and forecast the irrigation water requirements

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

Fully operative in real time

- Capitanata Irrigation Consortium (Southern Italy)
Read More
- Chiese Irrigation Consortium (Northern Italy)
Read More
- Las Tiesas Farm - Barrax - Spain
Read More
- Heihe (China)
Read More
- Aa-en-maas (Holland)
Read More

Area irrigua della Capitanata Sud Fortore: Deficit Irrigo

La seguente mappa mostra le aree in deficit irriguo medio giornaliero ottenuto accoppiando un modello idrologico (FEST-EWB o ETMonitor) con diversi output di modelli meteorologici (WRF, ECMWF, BOLAM, MCL, OCH). In verde sono le aree dove l'umidità del suolo è al di sopra della capacità di campo, in giallo dove l'umidità del suolo è inferiore alla capacità di campo e superiore alla soglia di stress della coltura, in rosso dove l'umidità del suolo si trova al di sotto della soglia di stress.

Modello idrologico: FEST EWB | Data Emissione: 2018-06-19 | Presente | Applica

Data Inizializzazione FEST EWB: | |

Basin: water deficit | Control: Field | Meteorological: Maps | Economic: indicators | manager

Chiese river agricultural basin: Water deficit

The following map displays the daily mean water deficit obtained coupling a hydrological model (FEST-EWB or ETMonitor) with several meteorological models outputs (WRF, BOLAM, MCL, OCH). In green the areas where soil moisture is higher than the field capacity, in yellow the areas where soil moisture is in between the field capacity and the crop stress threshold, in red the areas where soil moisture is below the crop stress threshold.

Hydrological Model: | Emission Date: 2018-11-15 | Forecast time: | Present | Apply

Basin: water deficit | Control: Field | Meteorological: Maps | Economic: indicators | manager

Barrax - Las Tiesas

The following map displays the daily mean water deficit obtained coupling a hydrological model (FEST_EWB and GFS). In green the areas where soil moisture is higher than the field capacity, in yellow the areas where soil moisture is in between the field capacity and the crop stress threshold, in red the areas where soil moisture is below the crop stress threshold.

Hydrological Model: FEST EWB | Emission Date: 2018-11-15 | Forecast time: | Present | Apply

Basin: water deficit | Control: Field | Meteorological: Maps | Economic: indicators | manager

Raam Irrigation District: Land Surface Temperature

The following map displays the land surface LST at 12 DE obtained from the FEST-EWB model and MODIS satellite data.

MODIS | Emission Date: 2011-05-01 | Reset Map

Basin: LST | Control: Field | Meteorological: Maps | Economic: indicators | manager

Heihe river basin: evapotranspiration

The following map displays the daily evapotranspiration obtained coupling a hydrological model (FEST EWB or ETMonitor) with satellite data.

Hydrological Model: ETMonitor | Emission Date: 2012-06-06 | Reset Map | Histogram

Basin: Evapotranspiration | Control: Field | Meteorological: Maps | Economic: indicators | manager

Available for reanalysis



The SIM Group!



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*Thanks!
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