

# SIM

## Smart Irrigation from Soil moisture Forecast Using Satellite And Hydro –Meteorological Modelling



**SIM**

[www.sim.polimi.it](http://www.sim.polimi.it)

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



Coordinator:  
Politecnico di Milano (Italy)  
Team:  
Delft University (The Netherlands)  
University of Valencia (Spain)  
University of Baleary (Spain)  
Radi-Academy of Science (China)  
University of Tuscany (Italy)  
Epson meteo (Italy)  
MMI srl (Italy)

**Marco Mancini**  
[marco.mancini@polimi.it](mailto:marco.mancini@polimi.it)  
DICA, Politecnico di Milano

C. Corbari<sup>1</sup>, G. Ravazzani<sup>1</sup>, A. Ceppi<sup>1</sup>  
M. Menenti<sup>2</sup>, M. Herrero-Huerta<sup>2</sup>, L. Jia<sup>3</sup>, C. Zhang<sup>3</sup>  
R. Romero<sup>4</sup>, A. Amengual<sup>4</sup>, J. A. Sobrino<sup>5</sup>, D. Skoković<sup>5</sup>  
S. Meucci<sup>6</sup>, C. Maiorano<sup>6</sup>, R. Salerno<sup>7</sup>, G. Branca<sup>8</sup>, R. Zucaro<sup>9</sup>



**copernicus**  
observing the earth



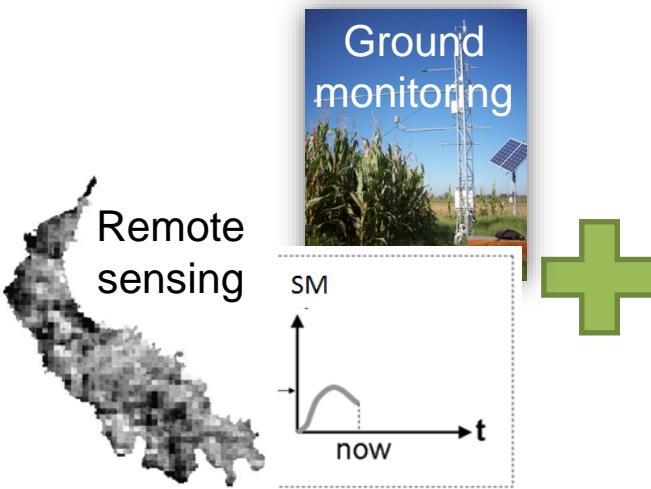
**esa - most china dragon cooperation**



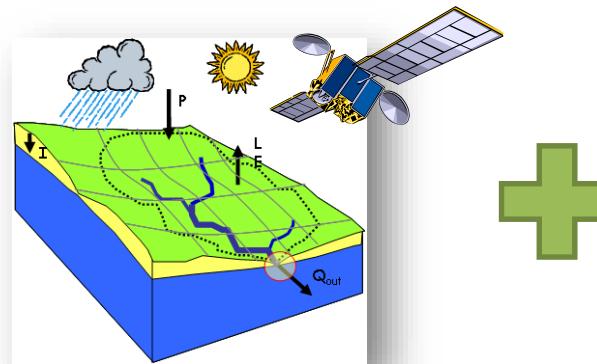


# The SIM methodology

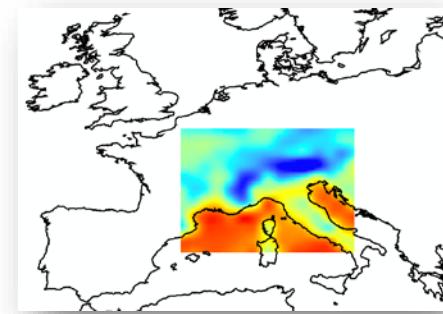
## Initial State



## Hydrological Modeling and Satellite data

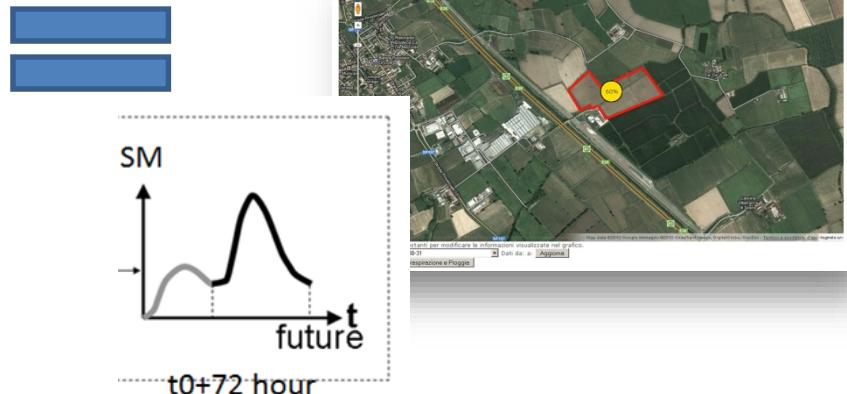


## Meteorological Forecast

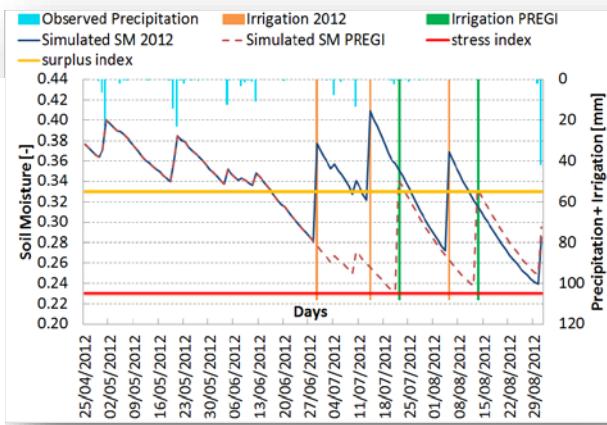


## MONITORING AND FORECAST SOIL MOISTURE DYNAMIC

### Management at farm scale



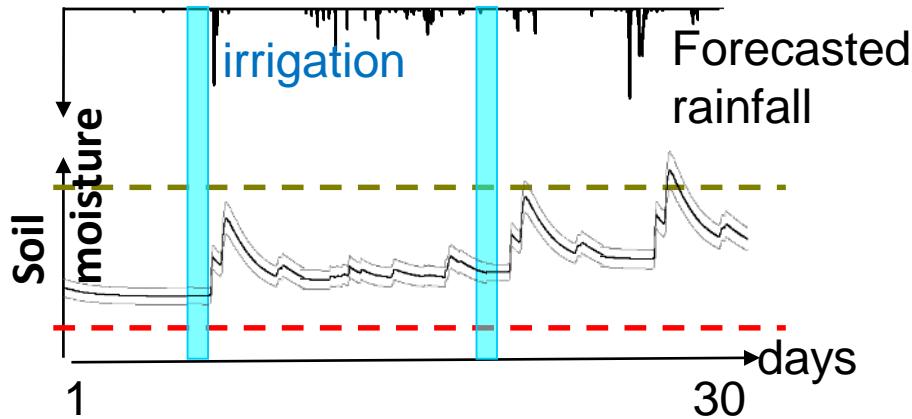
### Management at irrigation consortium scale



# SIM objectives and end users

## Objects:

real time monitor and forecast crop water need for precise irrigation supply parsimonious use of water, energy and fertilizer increasing productivity (economic saving.)



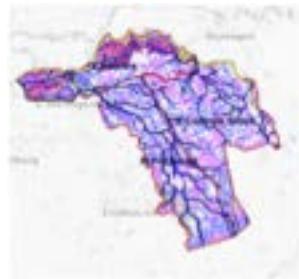
## End-users scales and needs:



river basin authority



Irrigation consortia



farmers

## More crop per drop

TRADITIONAL AGRICULTURE



SIM



WATER SAVING



INCREASED PRODUCTIVITY



ENERGY SAVING



INCREASED REVENUE



# SIM Project case studies

## I casi di studio SIM

Chiese river basin (IT)



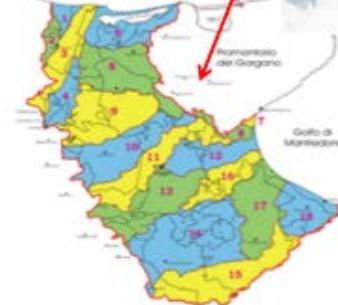
Aa en Maas (NL)



Barrax (E)



Capitanata consortium + farm (Puglia) (IT)



Heihe river basin (CHINA)



### Consortium

Chiese ( IT )

Capitanata SUD Fortore district ( IT )

AA en Maas RAAM district ( Ne )

Barrax ITAP ( SP )

Heihe Daman district ( CN )

### Irrigated surface

20000 ha

50000 ha

12600 ha

1500ha

20000 ha

### Irrigation technique

flooding irrigation

drip (70%) & spring (30%)

sprinkler

central pivot sprinkler

flooding

### irrigation timing

fix scheduled 7,5 days

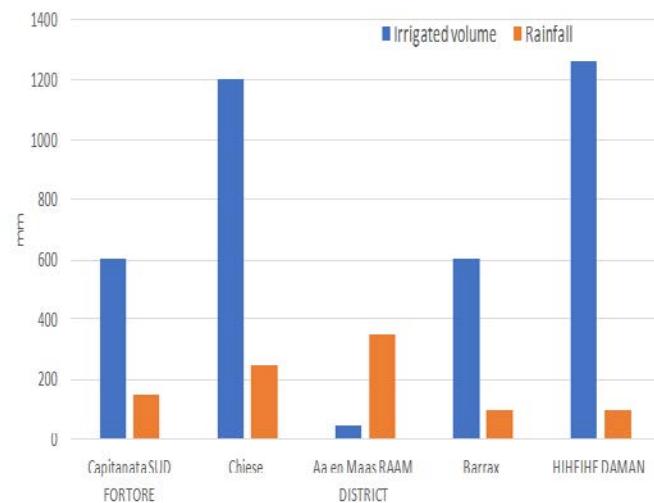
on demand

on demand

on demand

fix schedule

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



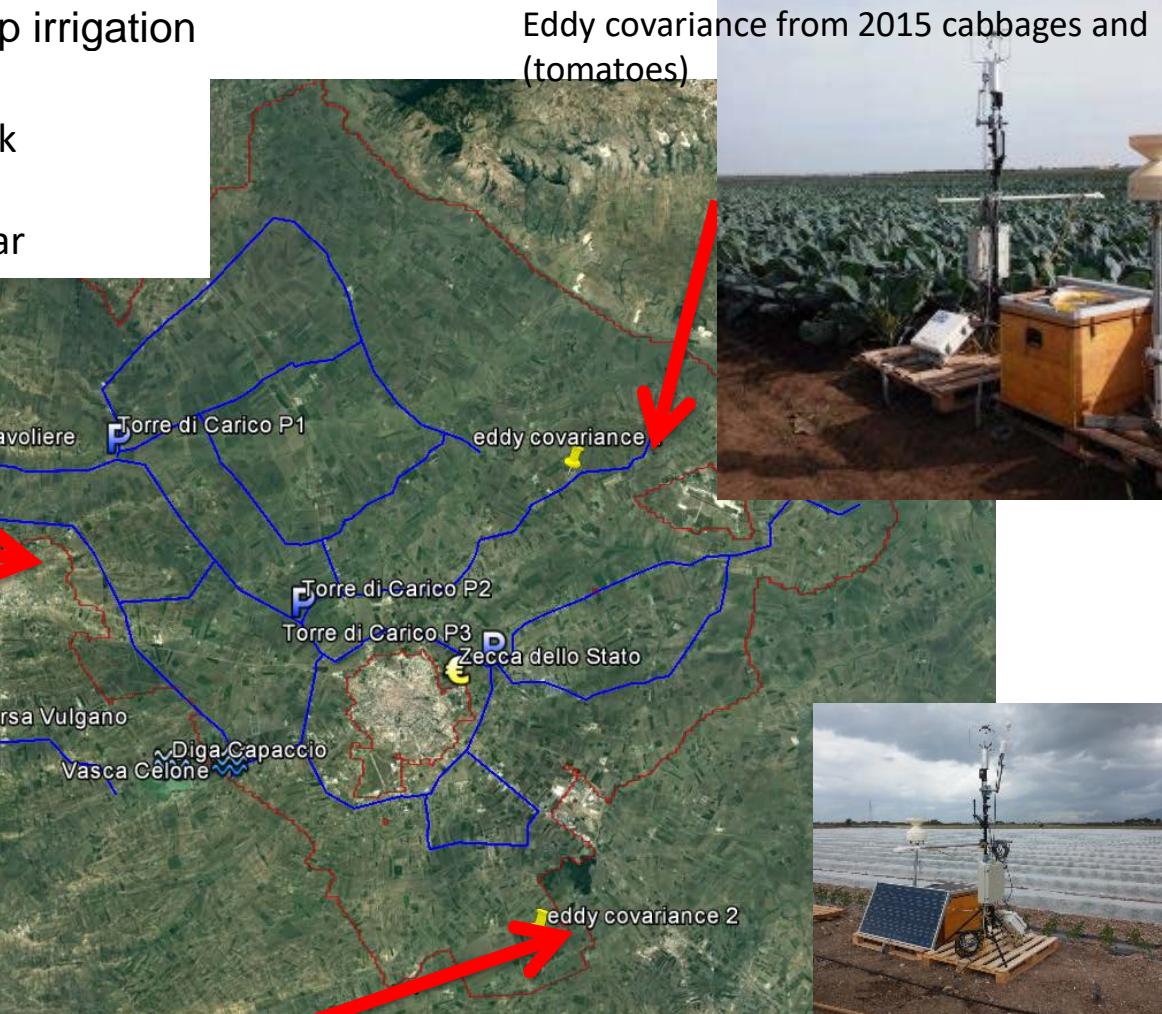
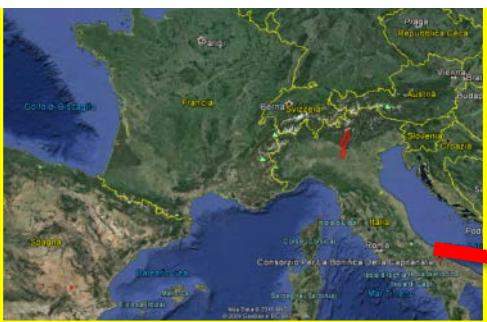
# Sud Fortore irrigation district (Southern Italy): experimental sites and pressurized water distribution network

70% of crops are irrigated by drip irrigation

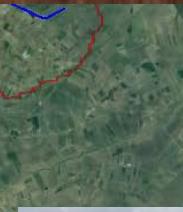
**Sud Fortore 65.000 ha):**

5900 km pressurized irrigation network  
aqueduct (Occhito and Celone dam)

96 million m<sup>3</sup> water for irrigation a year



Eddy covariance from 2015 cabbages and (tomatoes)



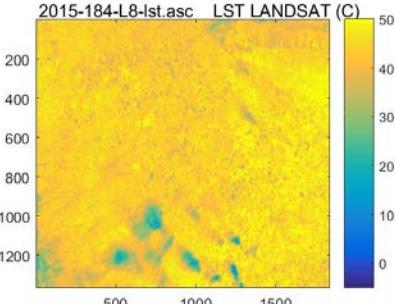
Eddy covariance from 2013 (asparagus, tomatoes)



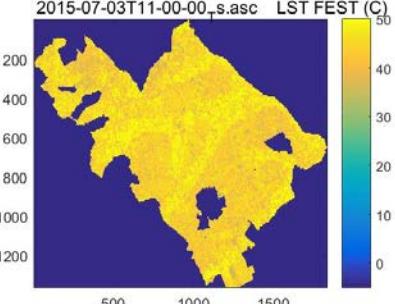
# Calibration of FEST-EWB model soil surface parameters pixel by pixel minimising satellite LST and Hydrological model LST differences

3 luglio 2015

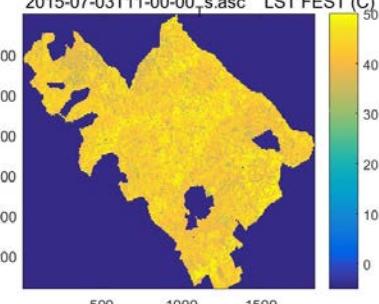
LANDSAT 8



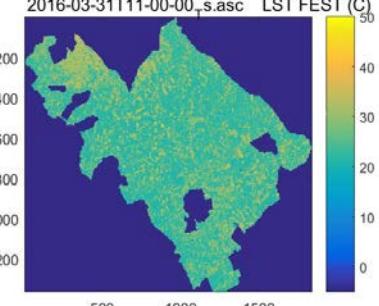
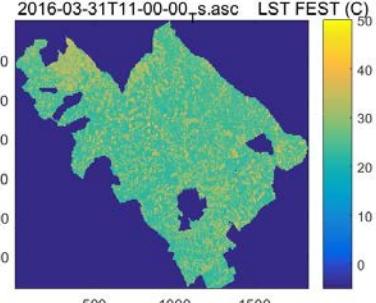
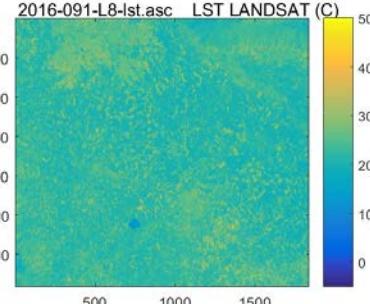
FEST-EWB not  
calibrated



FEST-EWB  
calibrated



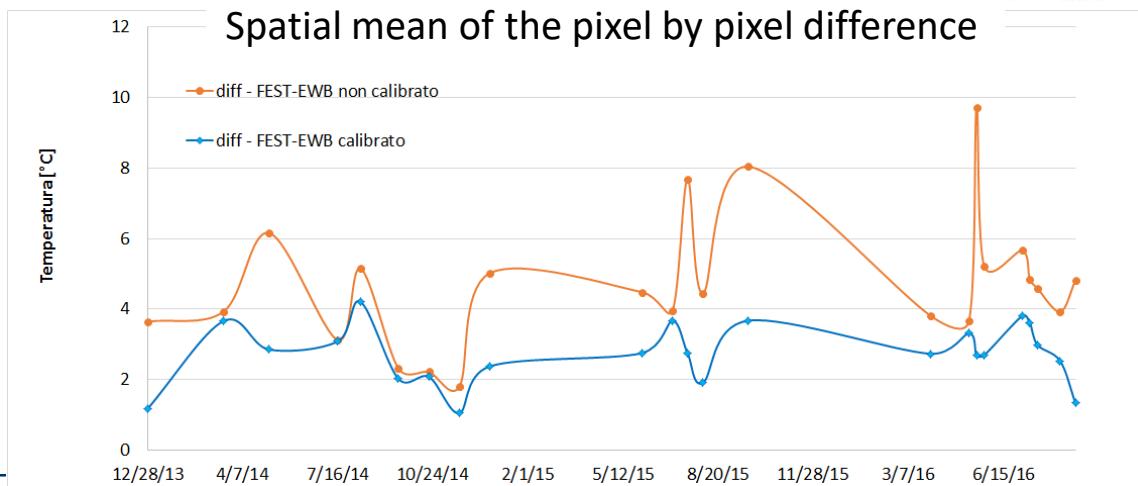
31 marzo 2016



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**



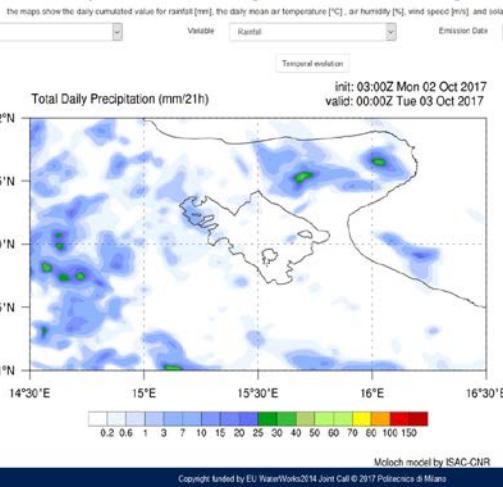
Mean error 5 °C without calibration  
Mean error 2.5 °C whit calibration



# USE OF METEOROLOGICAL FORCINGS in The operative tool for real time monitor and forecast irrigation water needs

## Multi meteorological INPUTS

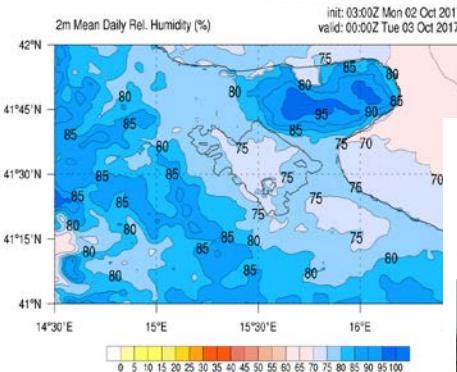
Capitanata Sud Fortore agricultural basin: Meteorological Forcings



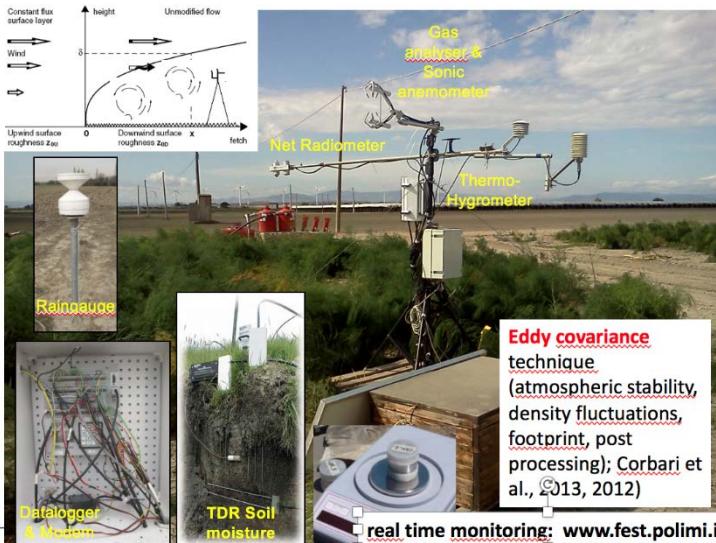
Capitanata Sud Fortore agricultural basin: Meteorological Forcings

The maps show the daily cumulated value for rainfall [mm], the daily mean air temperature [ $^{\circ}$ C], air humidity [%], wind speed [m/s], and solar radiation at 12:00 UTC [W/m<sup>2</sup>].

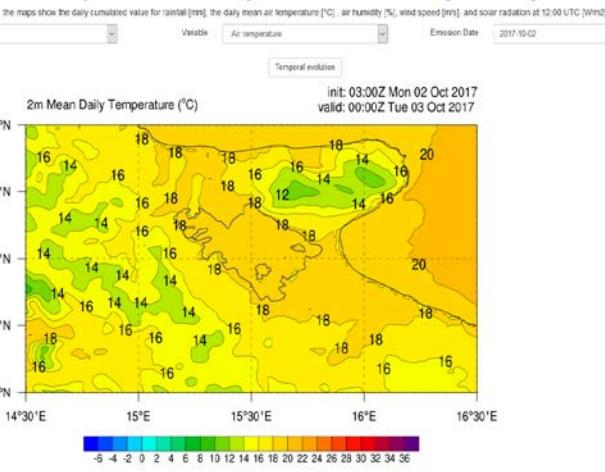
Meteorological Model: Moloch | Variable: Rainfall | Emission Date: 2017-10-02 | Temporal evolution: 03:00Z Mon 02 Oct 2017 | Validity: 00:00Z Tue 03 Oct 2017 | Apply



Local control tower



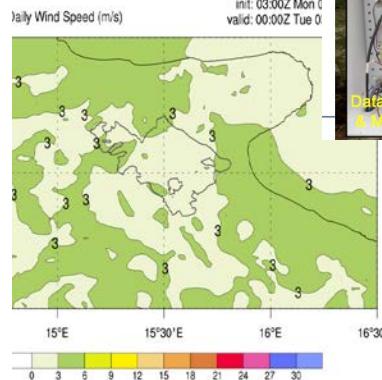
Capitanata Sud Fortore agricultural basin: Meteorological Forcings



Capitanata Sud Fortore agricultural basin: Meteorological Forcings

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Meteorological Model: Moloch | Variable: Air temperature | Emission Date: 2017-10-02 | Temporal evolution: 03:00Z Mon 02 Oct 2017 | Validity: 00:00Z Tue 03 Oct 2017 | Apply





# Meteorological models as INPUT data to FEST-EWB hydroloigcal model

## Moloch

spatial resolution: ~ 1.5 km,  $\Delta t$  1h, forecast horizon +45h



## Bolam

spatial resolution: ~ 11 km,  $\Delta t$  1h, forecast horizon +72h

## ECMWF

spatial resolution: ~ 9 km,  $\Delta t$  6h, forecast horizon +240h,  
by University of Balearic Islands



## ECMWF (50 ens +1)

spatial resolution: ~ 18 km,  $\Delta t$  6h, forecast horizon +240h  
50 ensembles

## WRF (8 ens)

spatial resolution: ~ 5.5 km,  $\Delta t$  1h, forecast horizon +72h, 8 ensembles, by  
Epson Meteo Centre



# Satellite Data in an operative tool for real time irrigation water needs forecast

## The SIM dashboard WATER INFORMATION SYSTEM

Real-time monitoring:  
[www.  
sim.polimi.it](http://www.sim.polimi.it)

### Capitanata sud Fortore agricultural basin: Water deficit

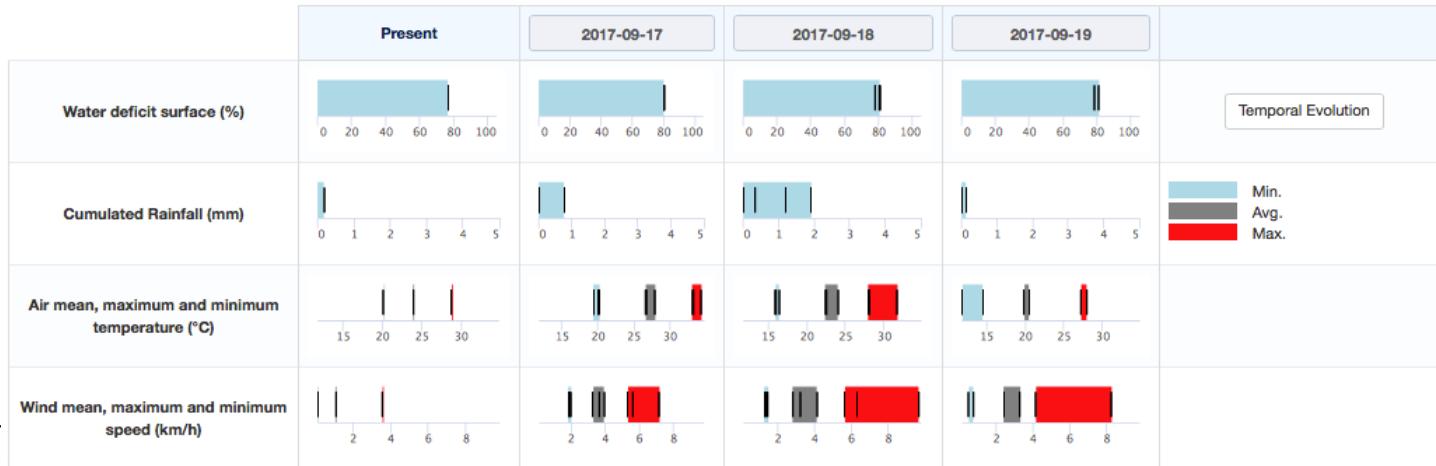
The following map displays the daily mean water deficit obtained coupling a hydrological model (FEST-EWB or ETMonitor) with several meteorological models outputs (WRF, ECMWF, BOLAM, MOLOCH). In green the areas where soil moisture is higher than the field capacity, in yellow the areas where soil moisture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



$$W_D(t) = \theta_{FC} - \theta(t)$$

Daily spatial mean for the agricultural basin

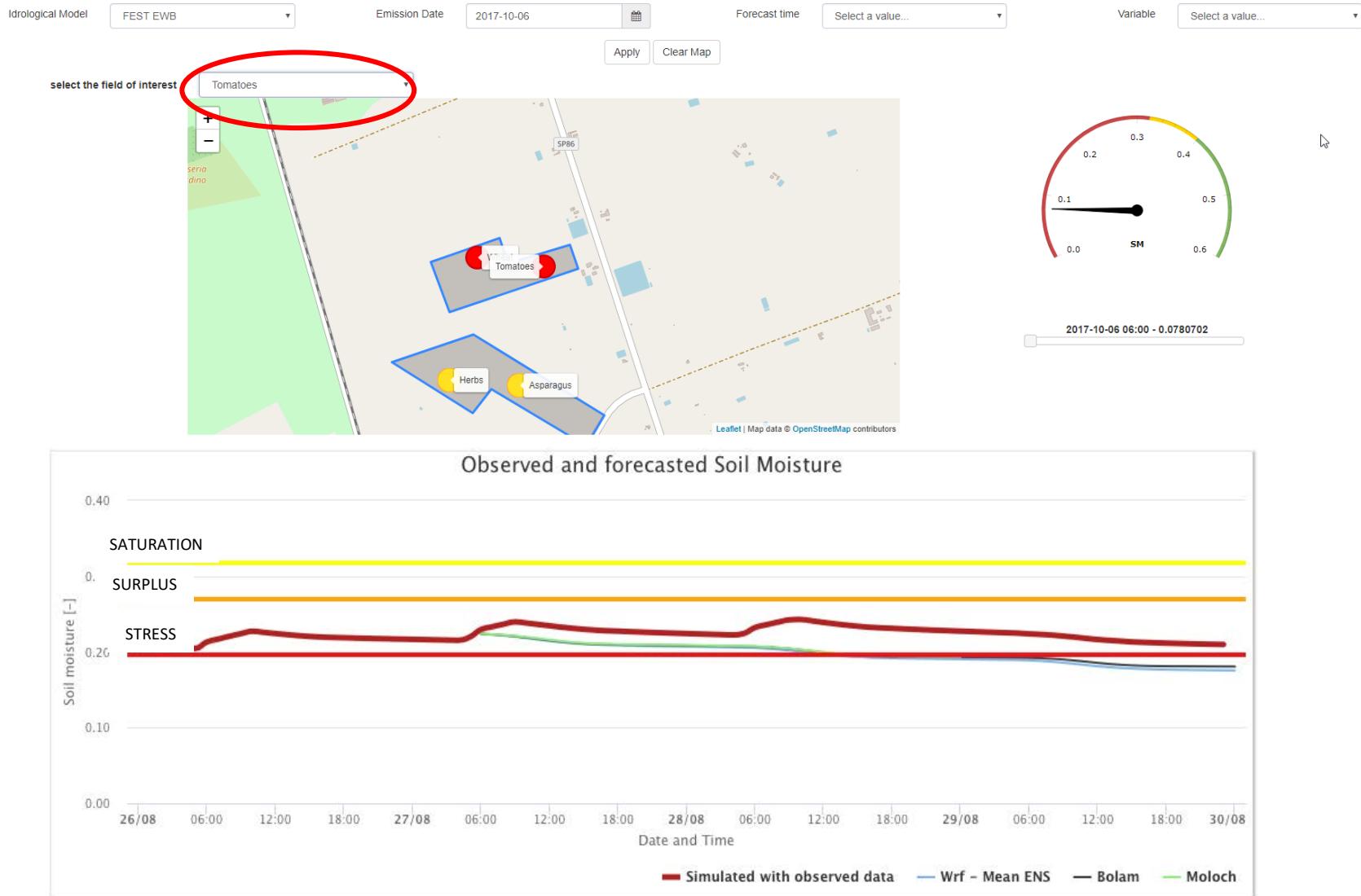
Daily spatial mean for present and forecasted hydro-meteorological outlooks. The "Present" column is computed with observed meteorological data. The highlighted sector refers to interval of hydro-meteorological model outlooks.





# The dashboard for real time monitor and forecast irrigation water needs

## IRRIGATION DISTRICT FARM Area: IRRIGATED FIELD WORKING in PROGRESS

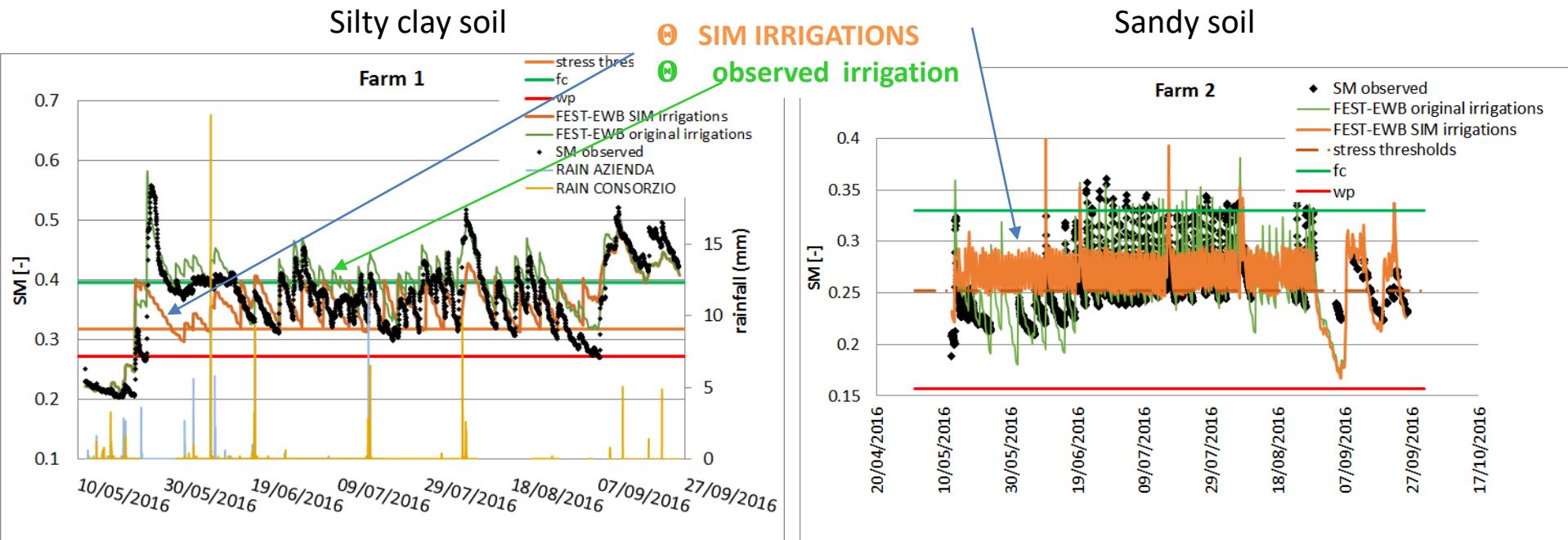




# SIM IRRIGATION STRATEGY : REANALYSIS RESULTS

## Tomatoes comparison

### Irrigation rate and timing reduction of percolation losses



		Irrigation (mm)	Number of irrigations	Rainfall cum (mm)
Farm 1	Observed	547.9	27	145
	SIM	322.3	15	145
Farm 2	Observed	646.6	43	150
	SIM	590	90	150

impacts of SIM irrigation strategy on soil moisture behaviour respect the moisture interval between the FC and the plant stress thresholds

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



## CONCLUSION: The role of web based real time WATER INFORMATION SYSTEM



Satellite land observations support model calibration and parameterization

Hydrological model is able to catch soil moisture dynamic

The SIM system can effectively foster parsimonious use of water for irrigation

# GRAZIE PER L'ATTENZIONE

Grateful thanks to INT.  
organizations & programs



esa - most china dragon cooperation

copernicus  
observing the earth