POLITECNICO
MILANO 1863

Hydrological modelling for real time application

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Research group

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Cyprus Institute

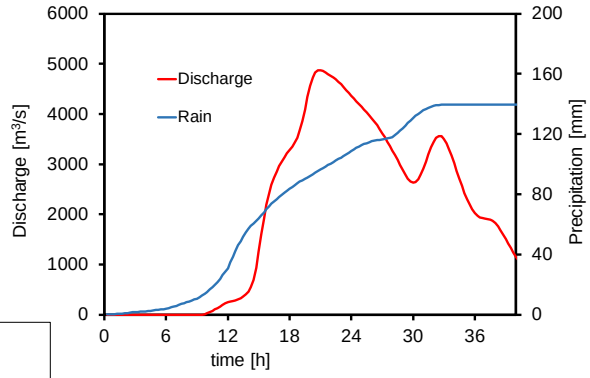
Tuesday, 19th March

INTRODUCTION

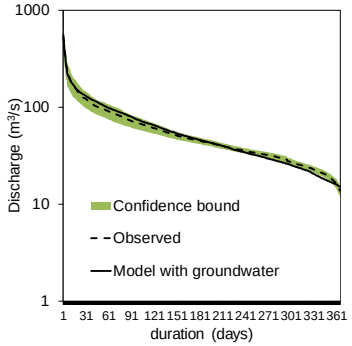
Typical hydrological model applications

Flood reconstruction

Florence, 1966 flood

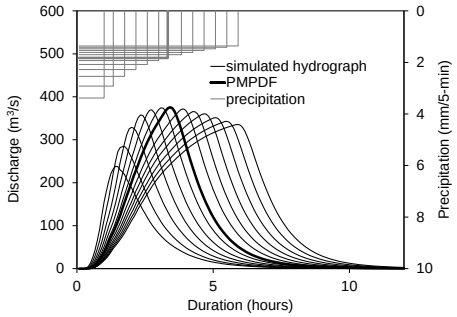


Water availability



Flow duration curve, river Toce

Design discharge



The critical event

POTENTIALS OF REAL TIME HYDROLOGICAL MODELLING

POLITECNICO MILANO 1863

Fondazione Politecnico di Milano

GOOD WATER OR BAD WATER? CHALLENGES FOR THE FUTURE

WORLD WATER DAY 2016 CONFERENCE

22nd MARCH 2016

The right amount of water is good.
Too much or too short is bad

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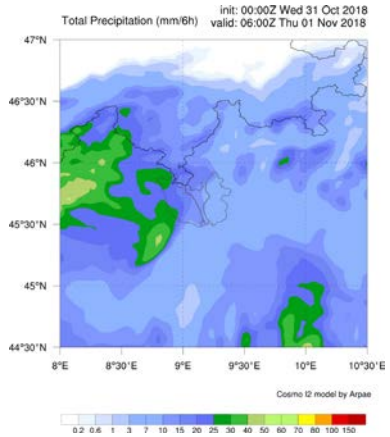
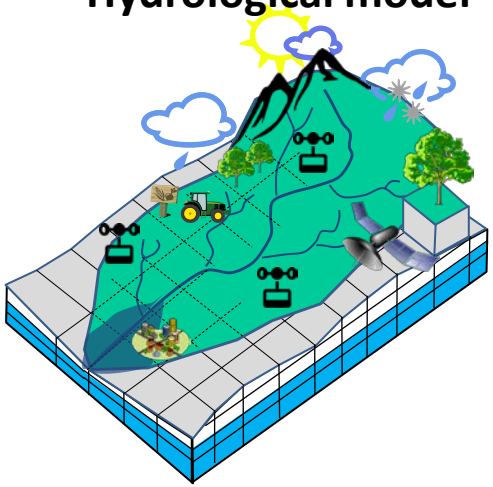
REAL TIME FORECST

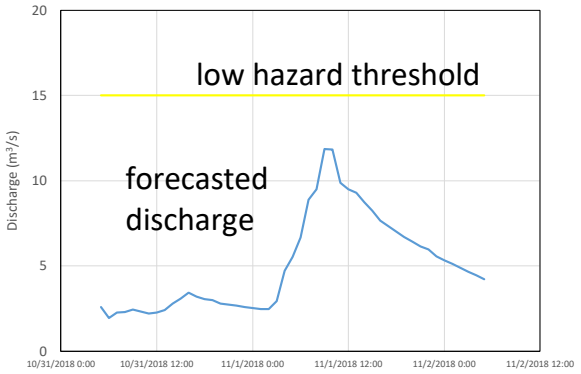
Precipitation forecast

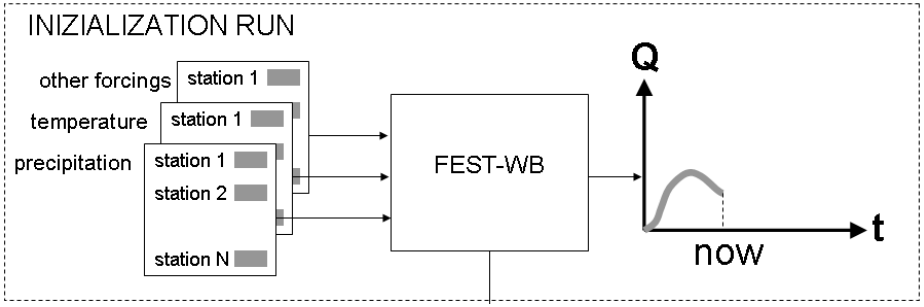


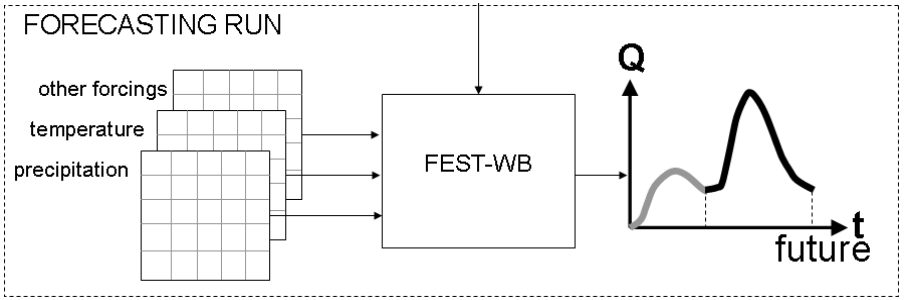
Hydrological model



Flood forecast







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FLOOD IN MILAN

1976

2018

2010

2014

Credits:
milano.repubblica.it
ansa.it
milanotoday.it
LaPresse/Federico Ferramola

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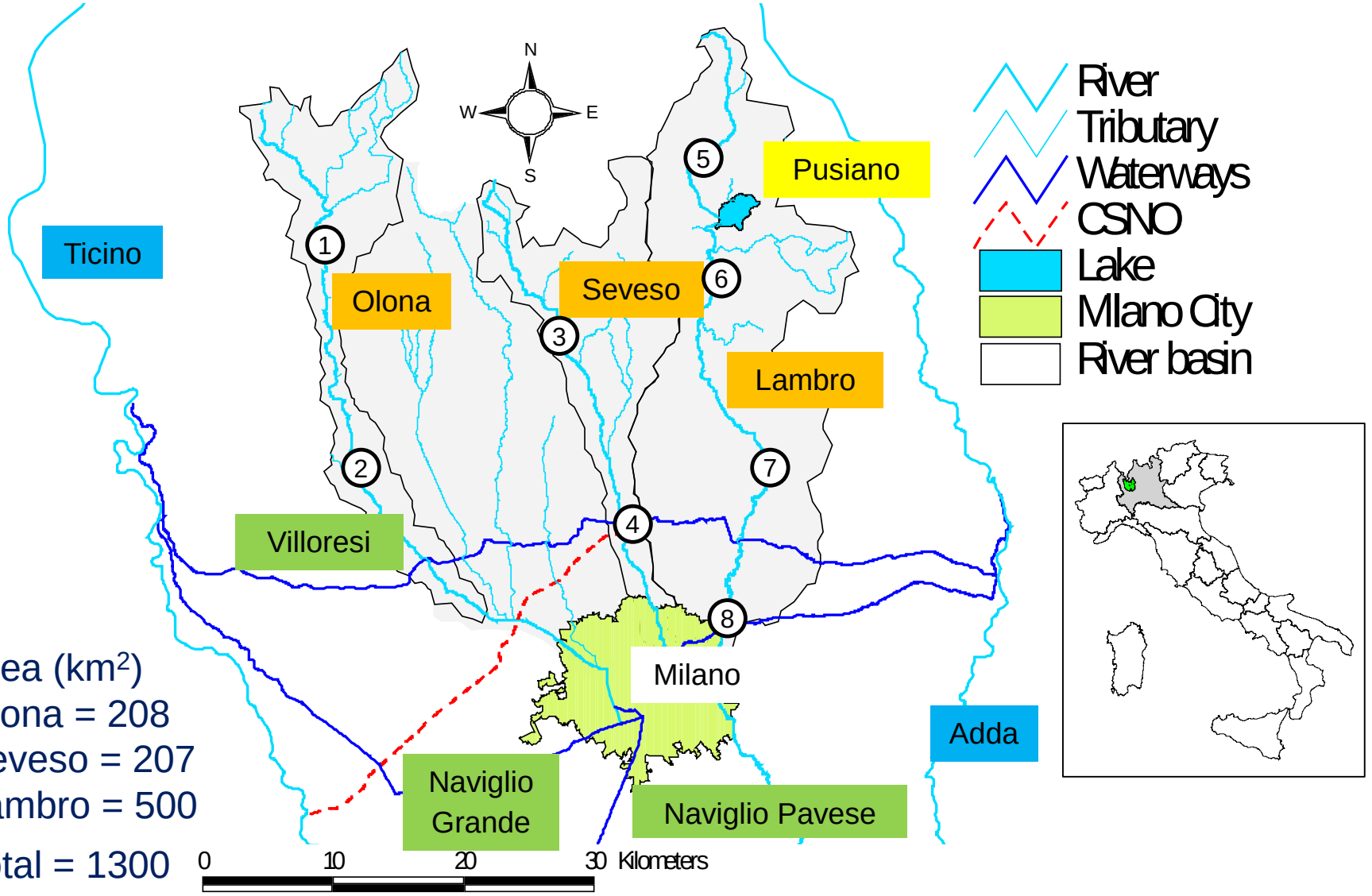
Rivers in Milan



Area (km^2)
Olona = 208
Seveso = 207
Lambro = 500

Total = 1300

The bypass channel on Seveso river

Bypass channel (CSNO, acronym from Italian “Canale Scolmatore di Nord Ovest”). Built from 1954 to 1980. Discharge capacity 30 m^3/s

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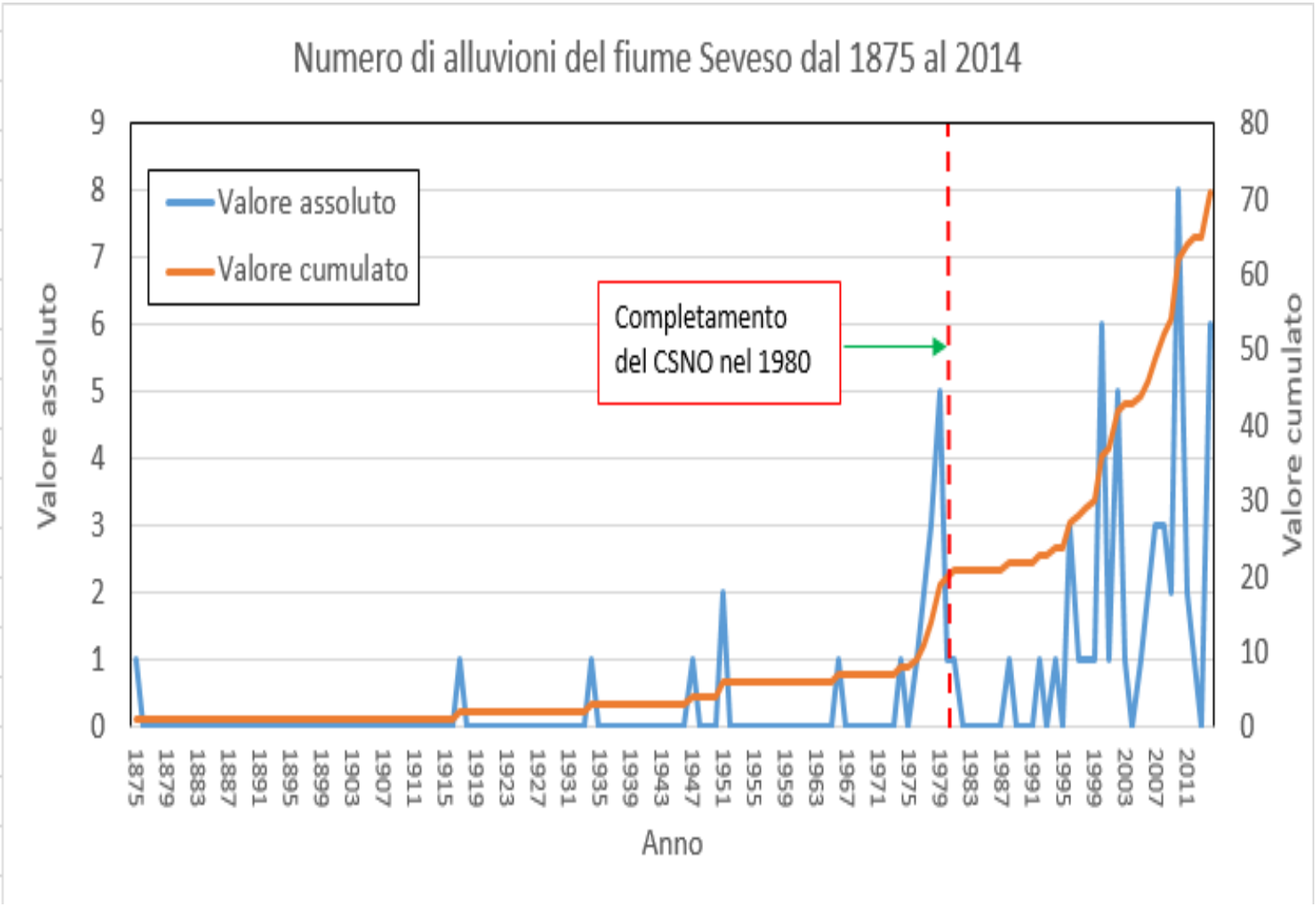
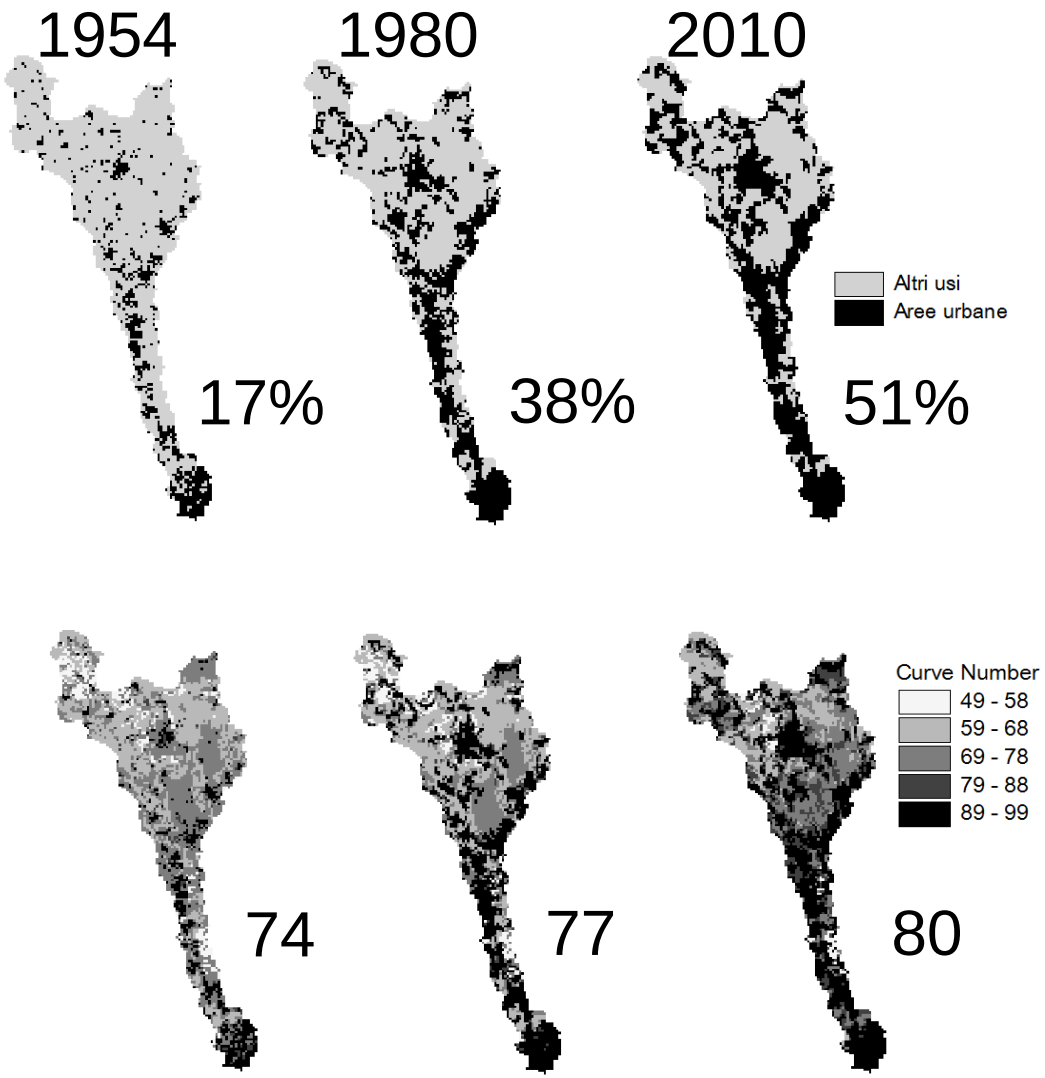
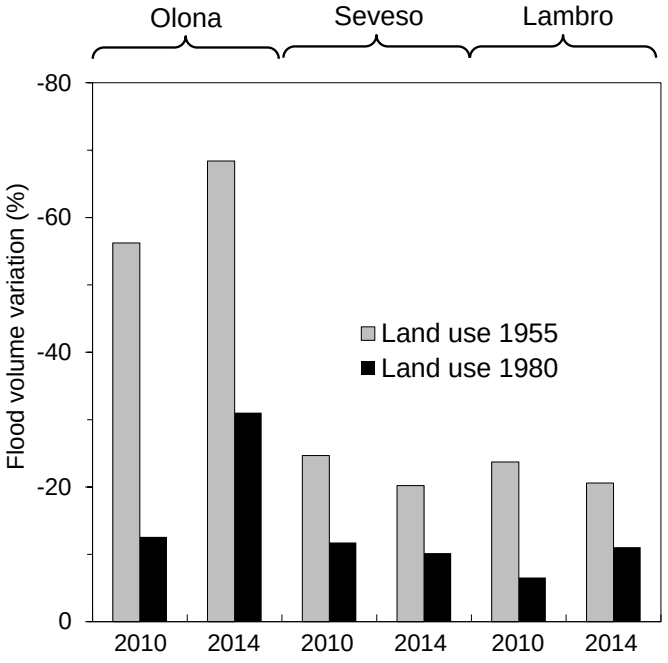
The bypass channel on Seveso river



Land use change



Seveso river basin



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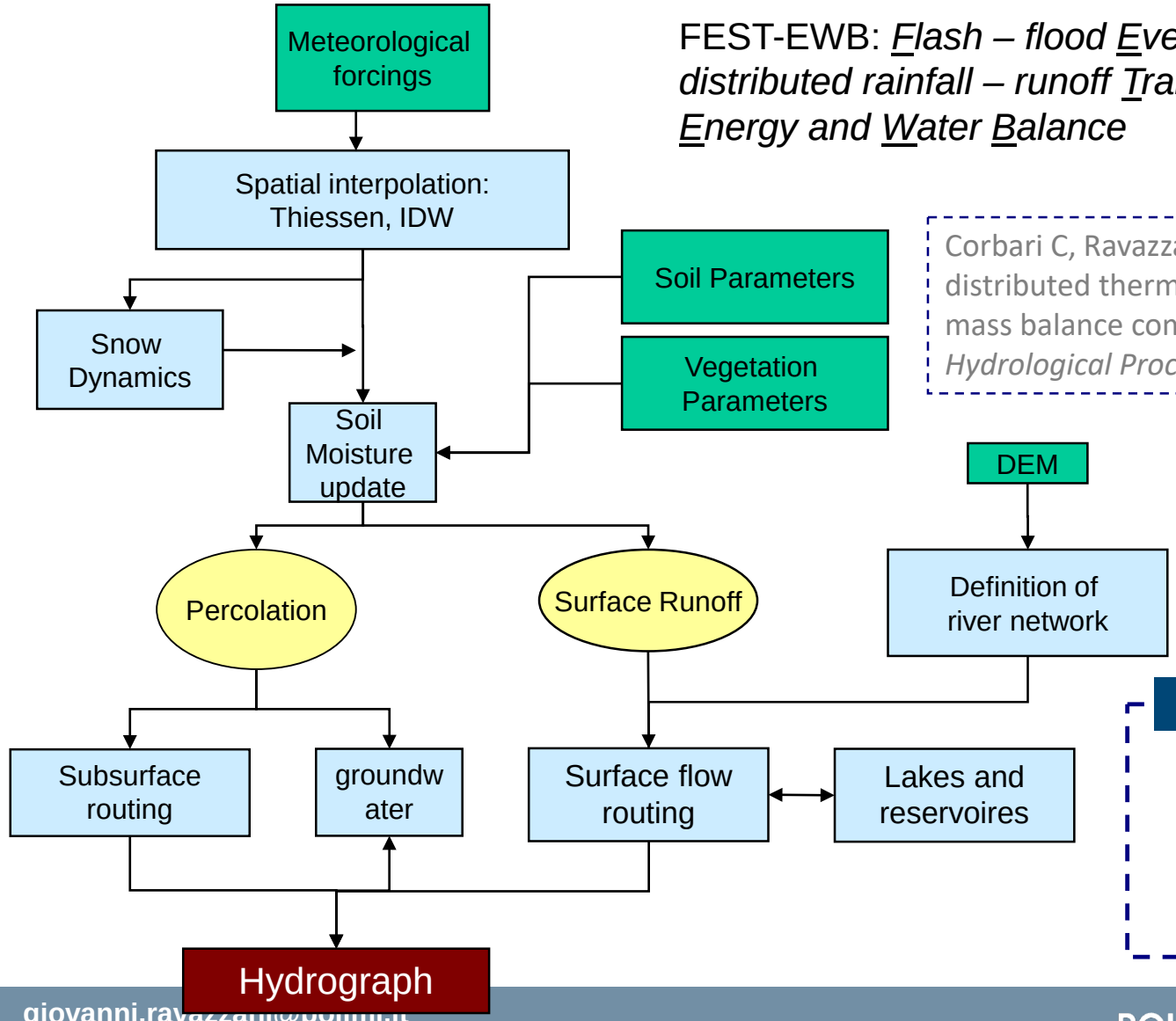
THE FEST HYDROLOGICAL MODEL



FEST-EWB: *Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation – including Energy and Water Balance*

Corbari C, Ravazzani G, and Mancini M, 2011: A distributed thermodynamic model for energy and mass balance computation: FEST–EWB. *Hydrological Processes* 25(9), 1443-1452

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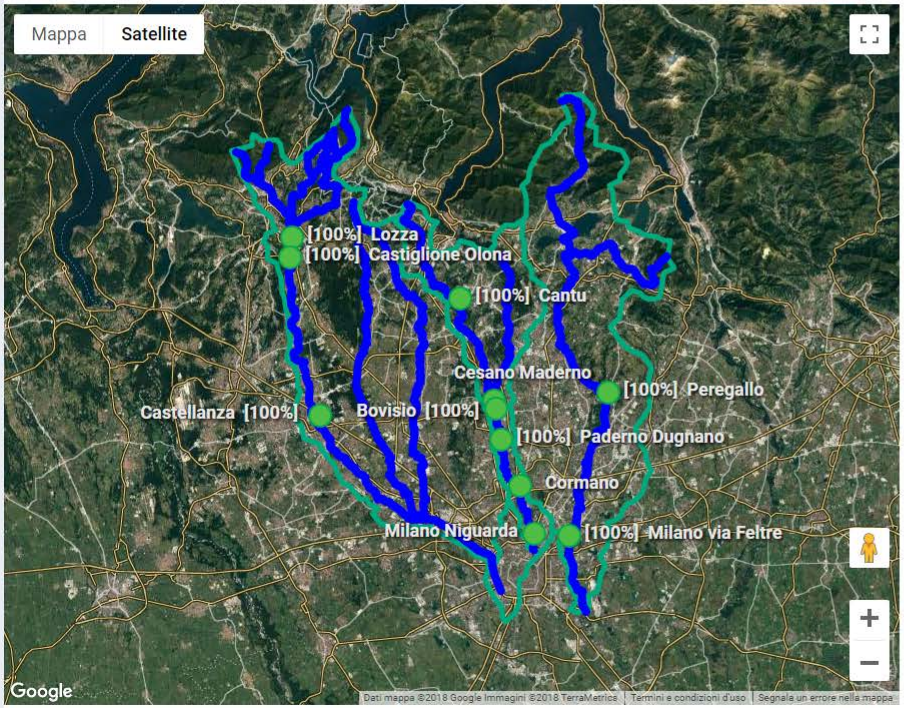
Real time flood forecast for Seveso-Olona-Lambro - SOL

http://sol.mmidro.it

QUANDO ARRIVERÀ LA PROSSIMA PIENA?

SOL ti fornisce in tempo reale una previsione sulla possibile futura esondazione con un anticipo di **24-36 ore.**

Clicca sui pallini nella mappa per maggiori dettagli - Vuoi approfondire? CLICCA QUI



nessuna criticità | criticità ordinaria | criticità moderata | criticità elevata

Stazione	27/11/2018	28/11/2018	Shift 28/11/2018	29/11/2018
Lozza	(100 %)	(100 %)		(100 %)
Castellanza	(100 %)	(100 %)		(100 %)
Cantu	(100 %)	(100 %)		(100 %)
Paderno Dugnano	(100 %)	(100 %)		(100 %)
Peregallo	(100 %)	(100 %)		(100 %)
Milano via Feltre	(100 %)	(100 %)		(100 %)
Bovisio	(100 %)	(100 %)		(100 %)
Castiglione Olona	(100 %)	(100 %)		(100 %)
Modelli disponibili:	33	33	--	33

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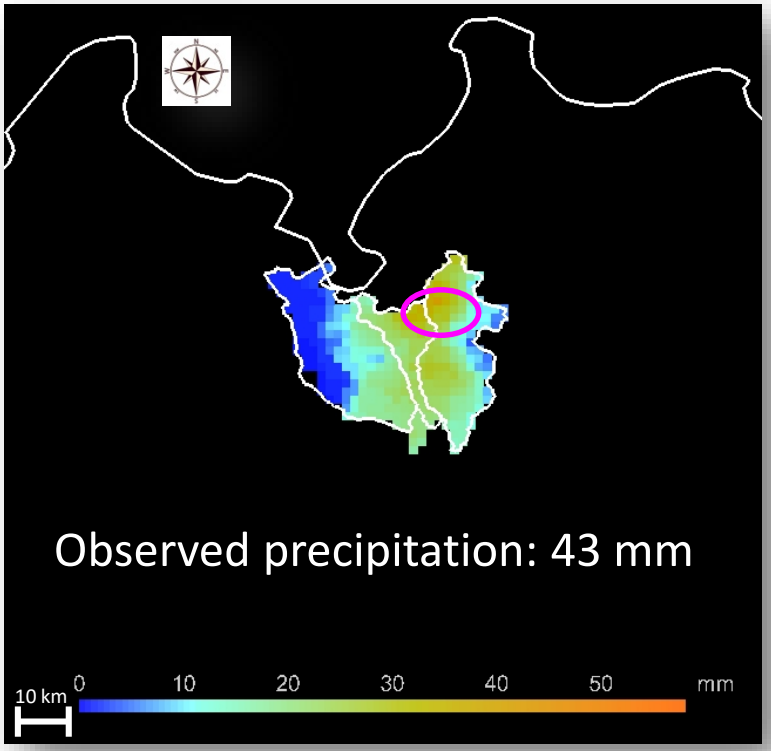
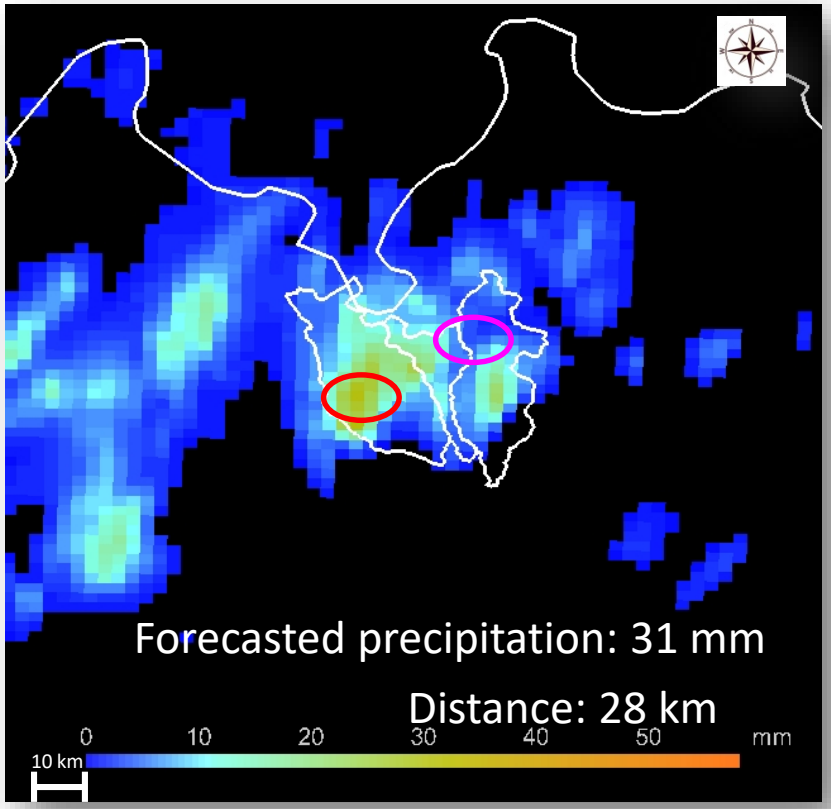
Uncertainty of deterministic forecast



00:00UTC-08/07/2014

01:00UTC-08/07/2014



20:00UTC-07/07/2014

21:00UTC-07/07/2014

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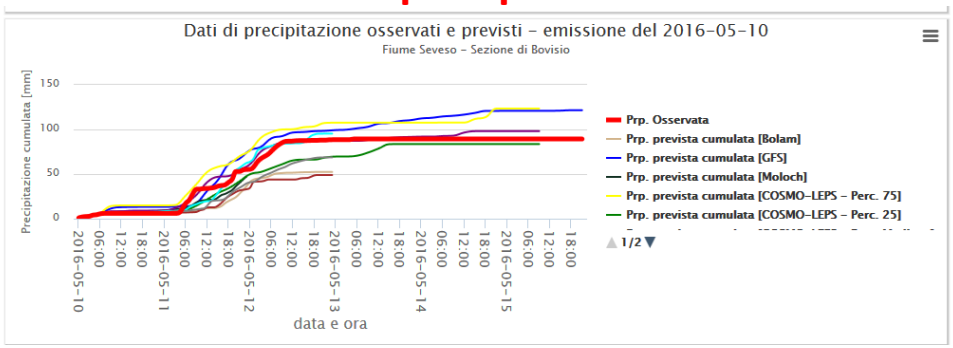
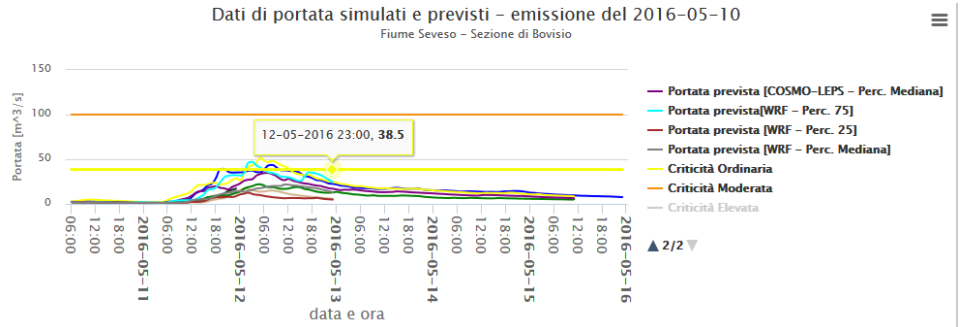
SOL multimodel approach

Multi-model precipitation forecast



Hydrograph forecasts & discharge thresholds



Deterministic models

GFS	50 km, Δt 3h, +144h
Bolam	11 km, Δt 1h, +72h
Moloch	1.5 km, Δt 1h, +45h

Cosmo-i2	2 km, Δt 3h, +48h
Cosmo-i7	7 km, Δt 3h, +72h

Ensemble models

COSMO-LEPS	7 km, Δt 3h, +132h 16 ensemble
WRF	5.5 km, Δt 1h, +72h 8 ensemble

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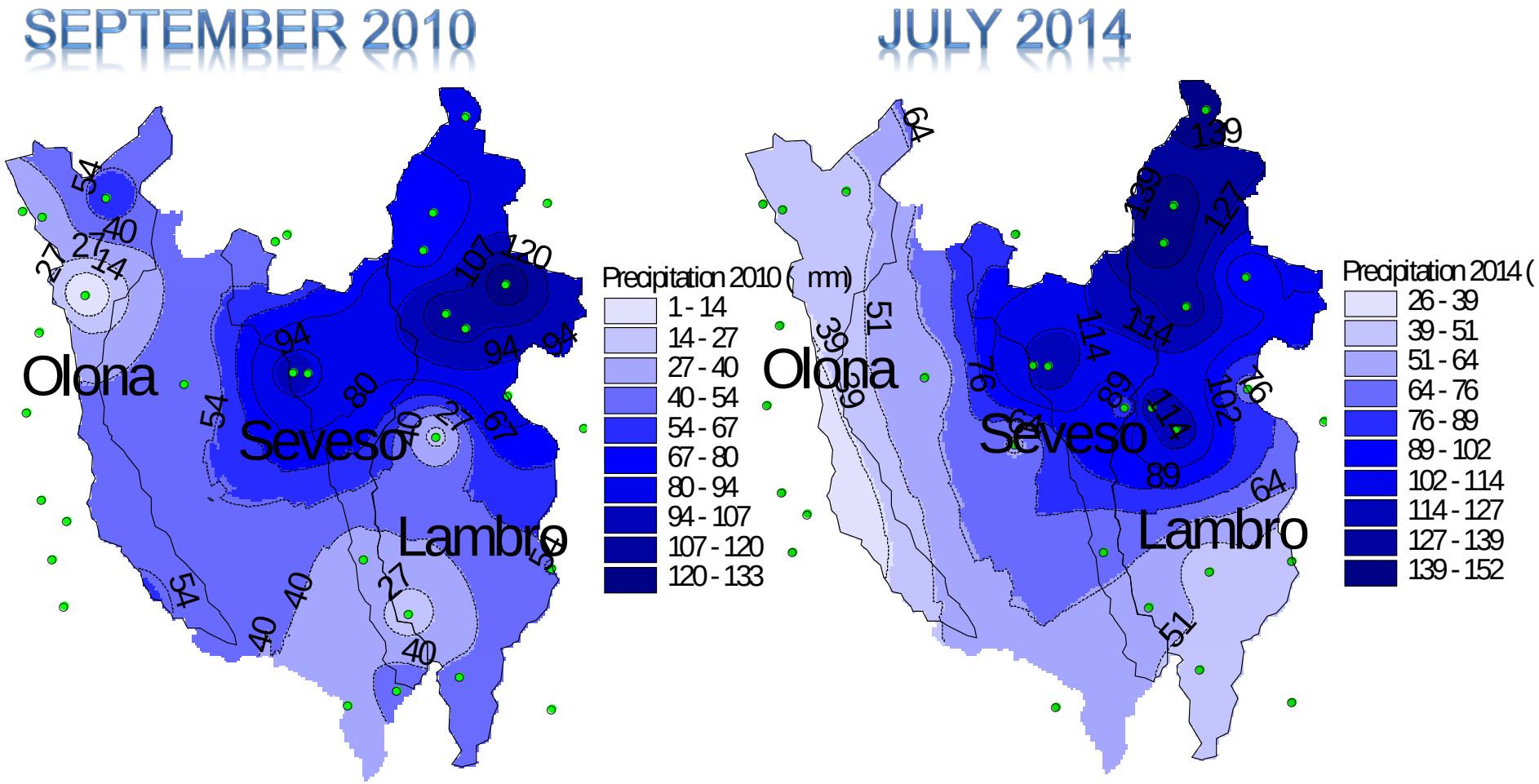
Re-analysis of two major convective flood events

Ravazzani et al., J.Hydrol., 2016



Warning threshold exceeded on Seveso and Lambro basins

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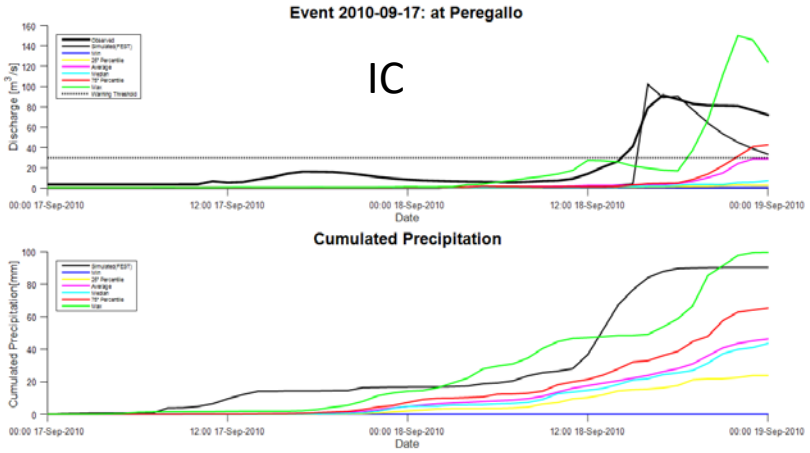
Performance of 2010 event

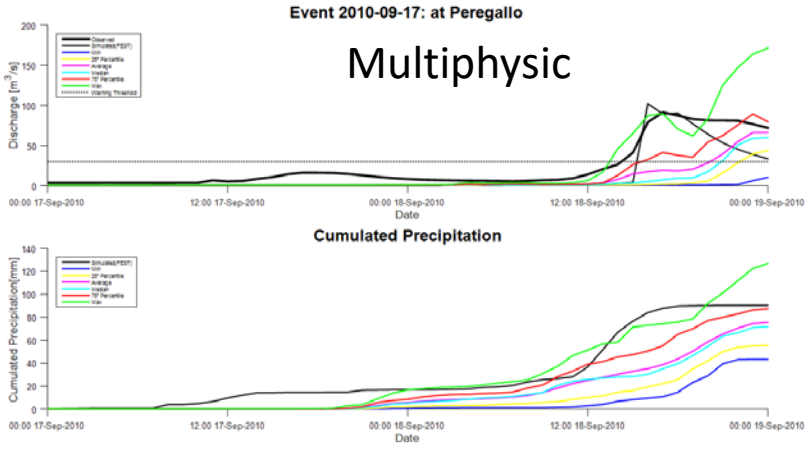
SEPTEMBER 2010

percentage of ensemble members exceeding the warning threshold

Exceeding Threshold		Seveso	Lambro	
		Cantu	Peregallo	Milano
9/17/2010	IC	20.0%	35.0%	10.0%
	Multiphysic	50.0%	85.0%	40.0%

Multiphysic has the best performance





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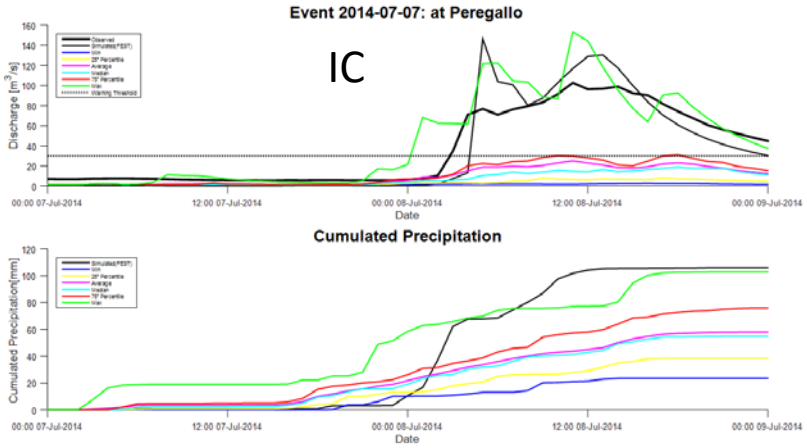
Performance of 2014 event

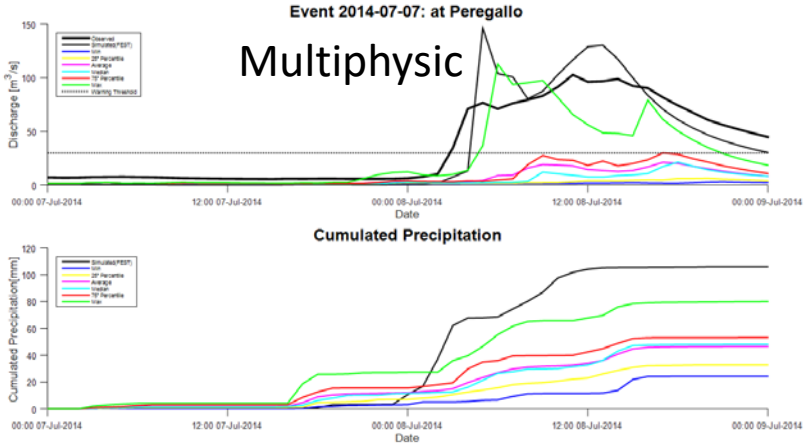
JULY 2014

percentage of ensemble members exceeding the warning threshold

Exceeding Threshold		Seveso	Lambro	
		Cantu	Peregallo	Milano
7/7/2014	IC	25.0%	50.0%	10.0%
	Multiphysic	25.0%	50.0%	10.0%

IC and Multiphysic perform the same
Event very difficult to predict





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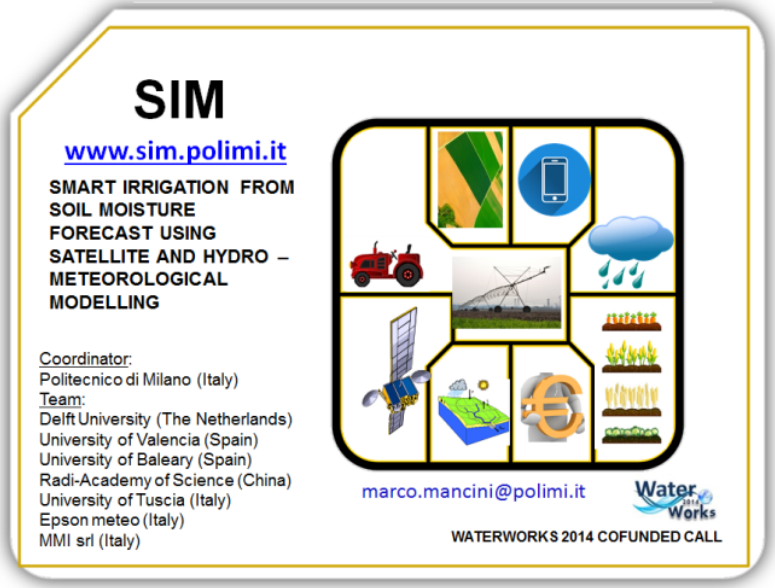
The SIM project for irrigation management

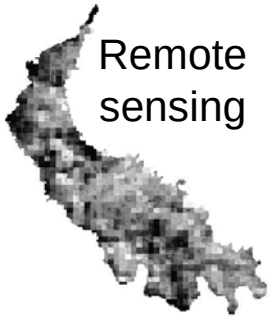
SIM: Smart Irrigation from Soil Moisture Forecast using Satellite and Hydro Meteo Modelling

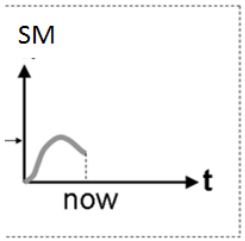
www.sim.polimi.it



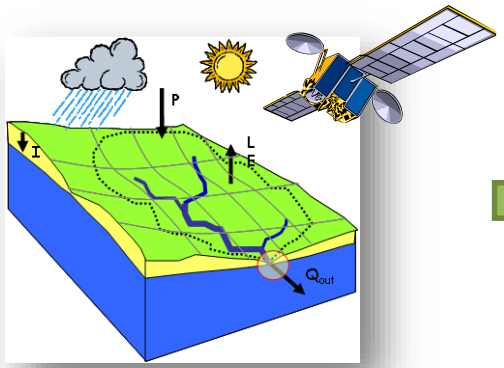
The SIM methodology

Initial State

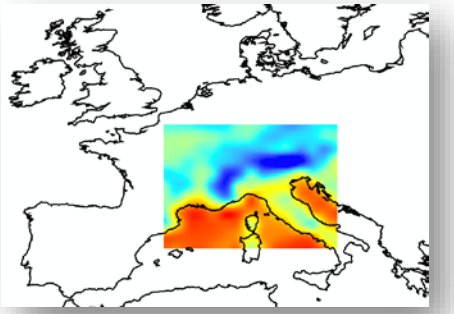




Hydrological Modeling and Satellite data

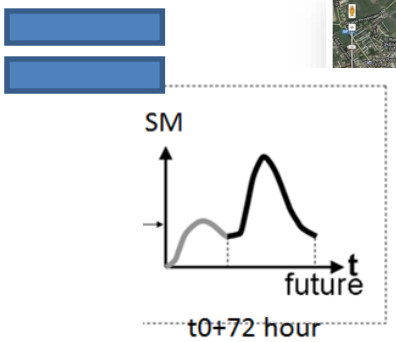


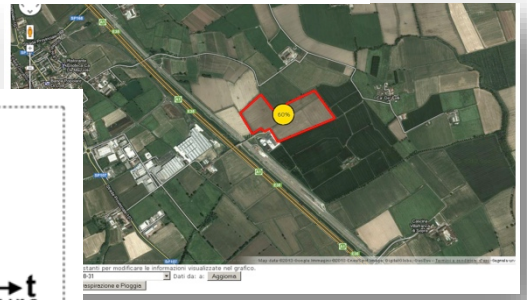
Meteorological Forecast



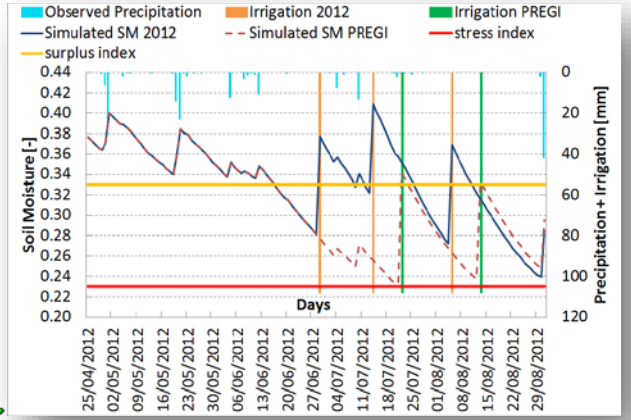
MONITORING AND FORECAST SOIL MOISTURE DYNAMIC

Management at farm scale





Management at irrigation consortium scale



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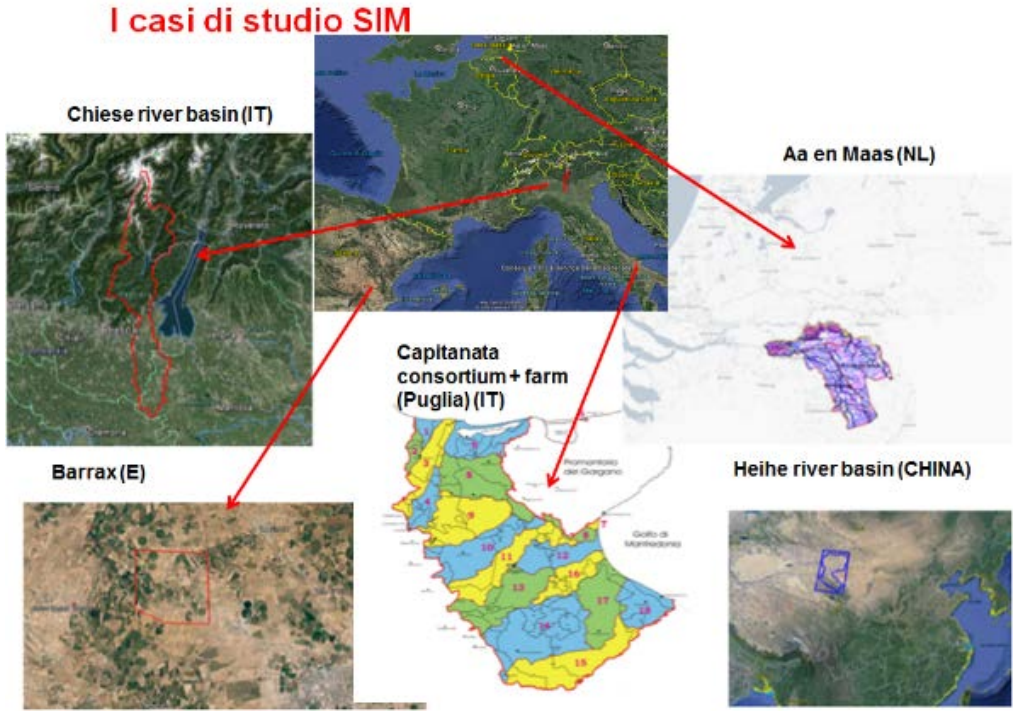
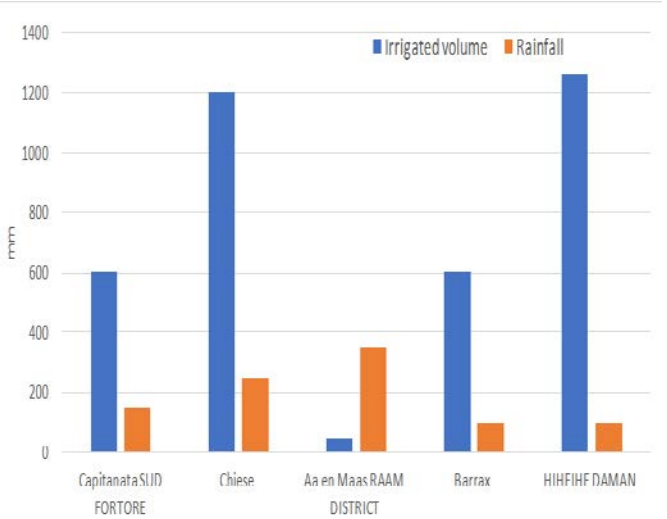
The SIM case studies



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

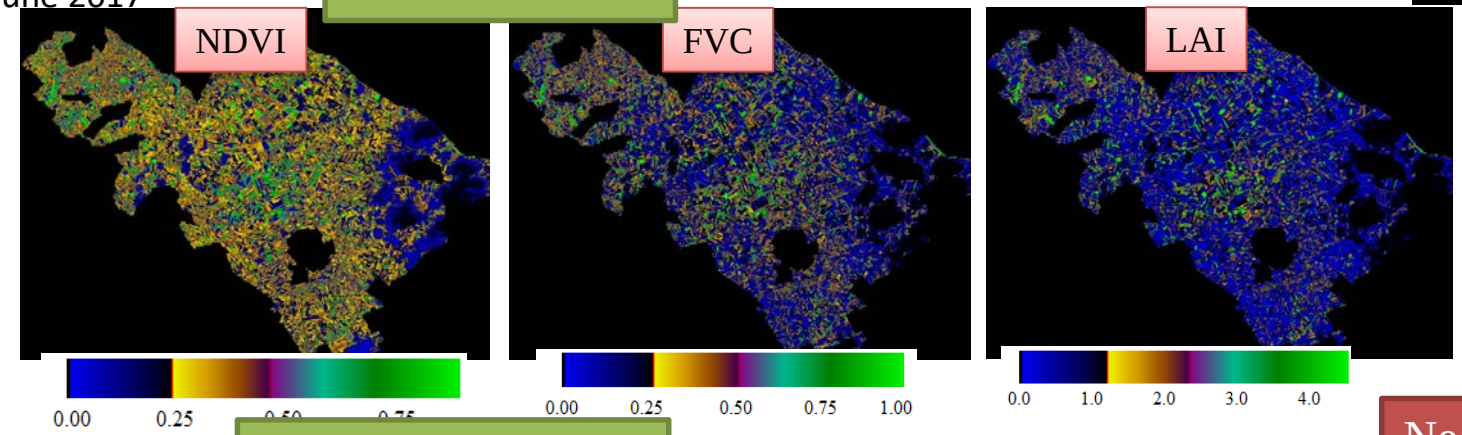


Consortium	Irrigated surface	Irrigation technique	irrigation timing
Chiese (IT)	20000 ha	flooding irrigation	fix scheduled 7,5 days
Capitanata SUD Fortore district (IT)	50000 ha	drip (70%) & spring (30%)	on demand
AA en Maas RAAM distritct (Ne)	12600 ha	sprinkler	on demand
Barrax ITAP (SP)	1500ha	central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

Satellite data supporting Hydrological model

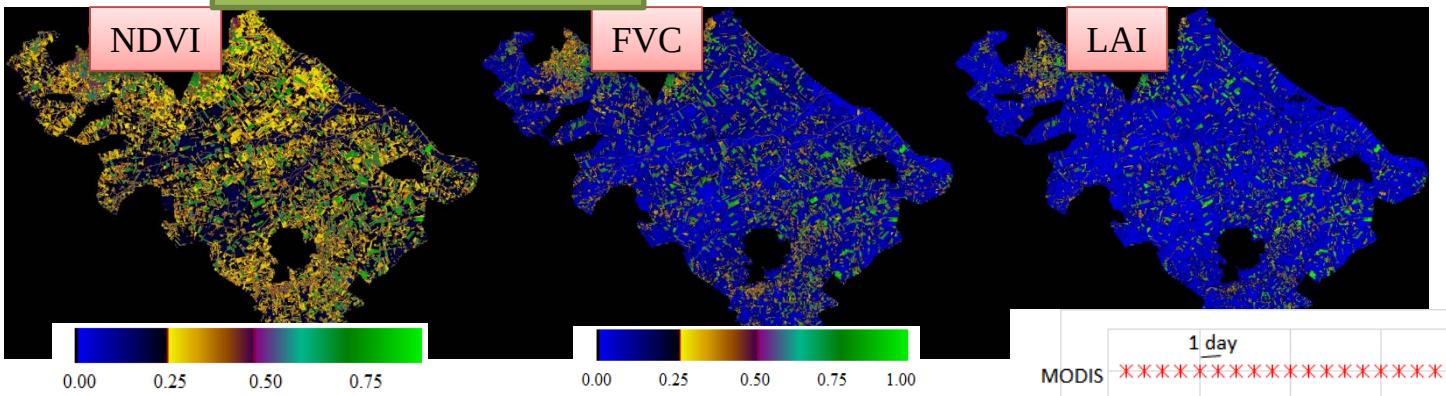
5 june 2017

SENTINEL-2 MSI

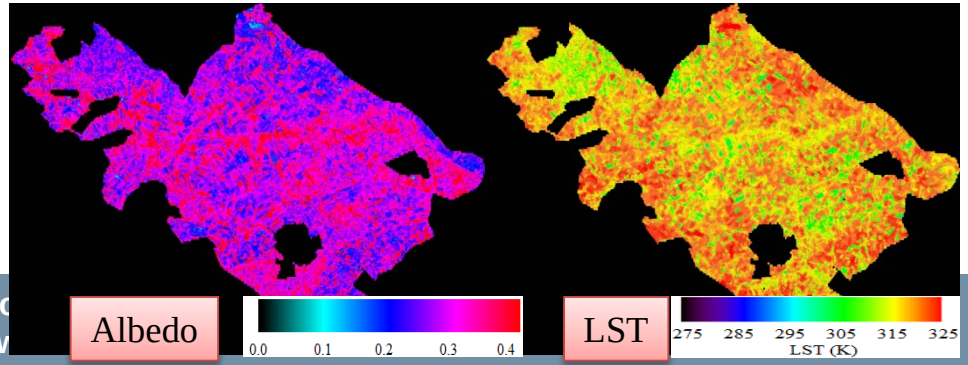


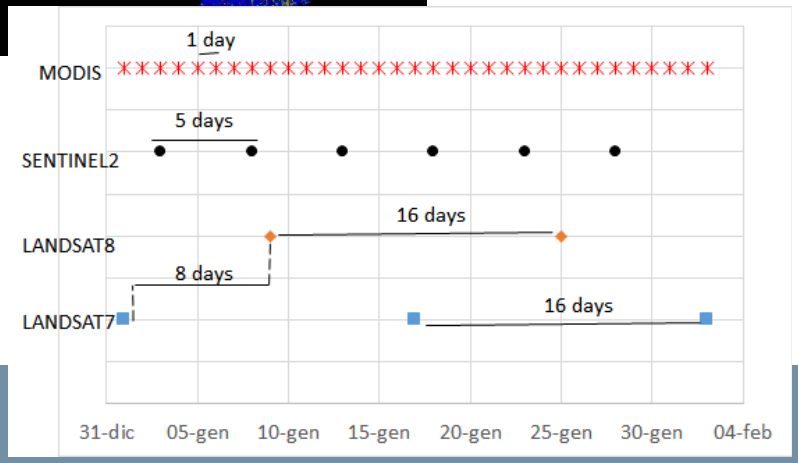
Sobrino and all 2017

LANDSAT-8 OLI/TIRS



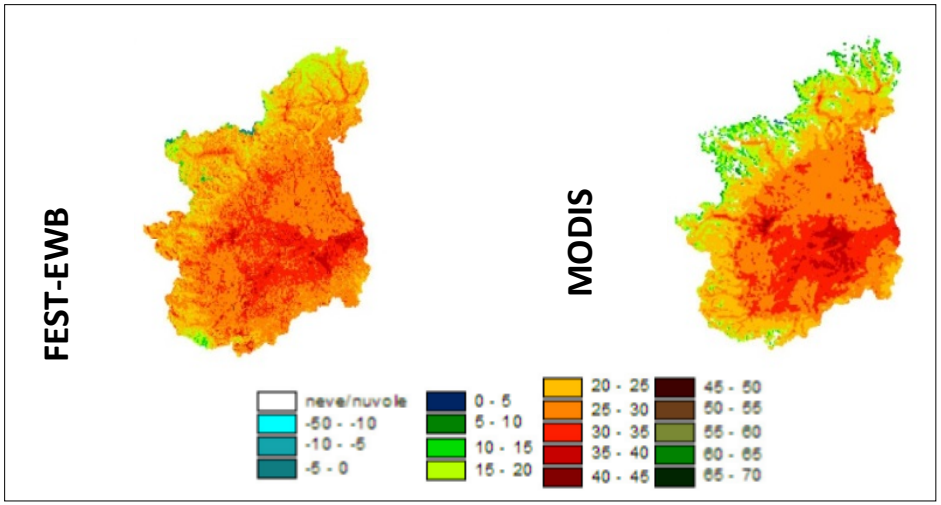
Near real time images





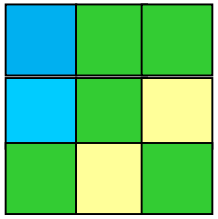
Satellite data supporting Hydrological model

Hydrological model soil & vegetation parameter pixel wise calibration using Land Surface Temperature)

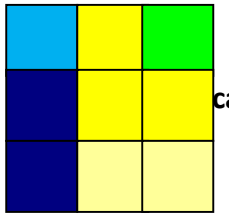


$$\Delta T(.) = Min(RET(.) - LST(.))$$

Not calibrated



Tuning soil / vegetation parameters



calibrated

Each pixel is multiplied by a **local factor** which depends on the temperature matrix differences

Soil parameters: **Increased spatial variability**

Corbari et al., 2015, hydrological science journal
Corbari an Mancini, 2014, j. hydrometeorology

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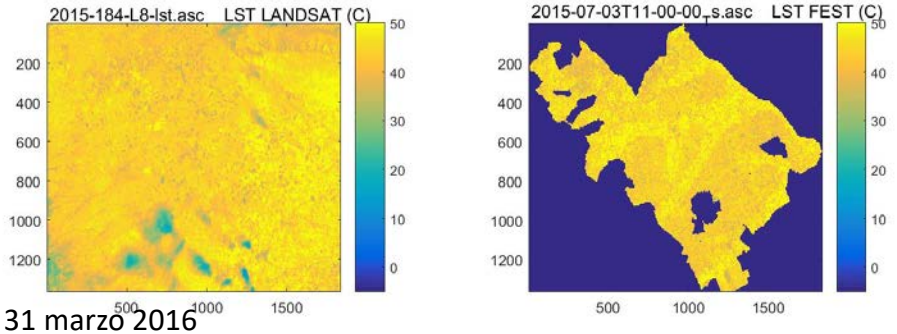
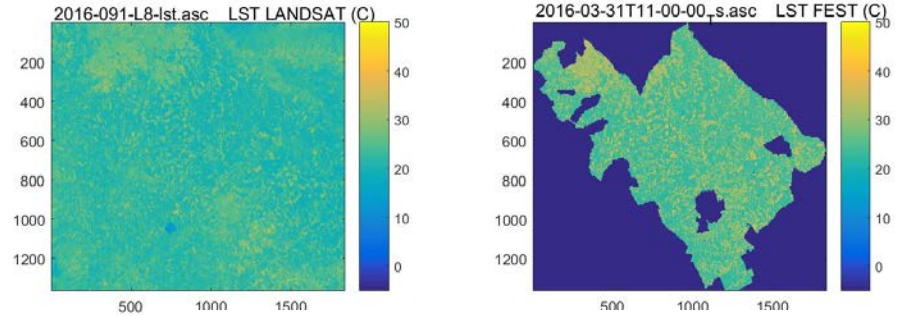
Satellite data supporting Hydrological model

3rd July 2015 LANDSAT 8



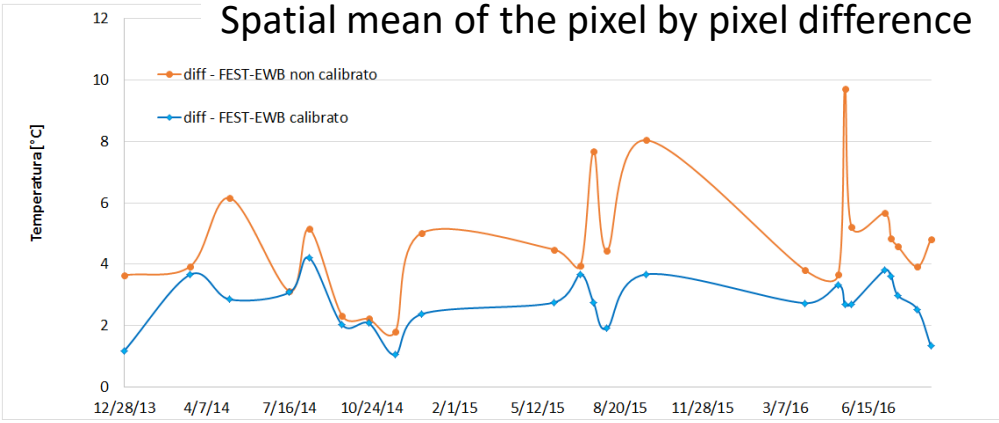
31 marzo 2016



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

Spatial mean of the pixel by pixel difference



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

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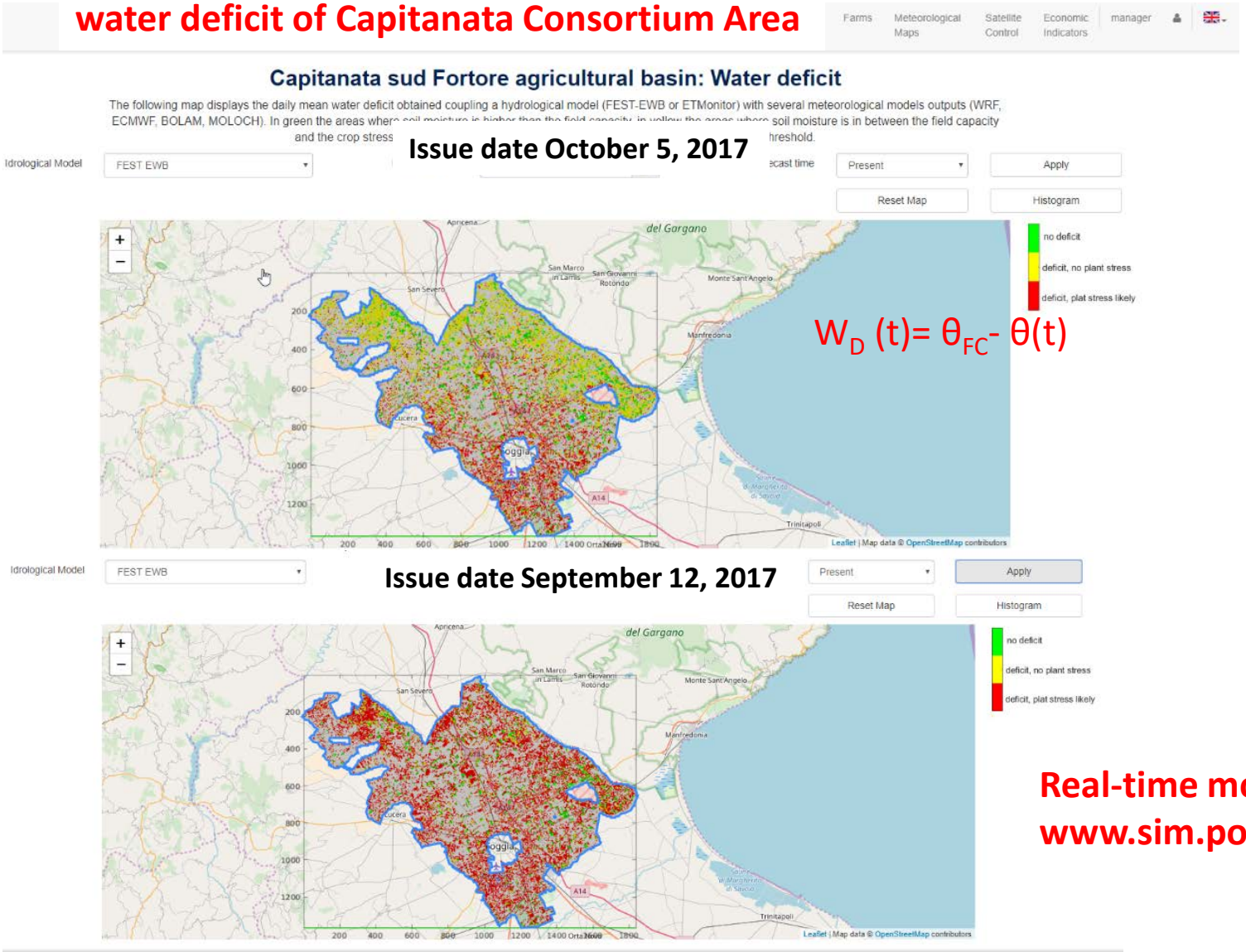
The SIM web-dashboard – consortium scale

water deficit of Capitanata Consortium Area



Real-time monitoring: www.sim.polimi.it

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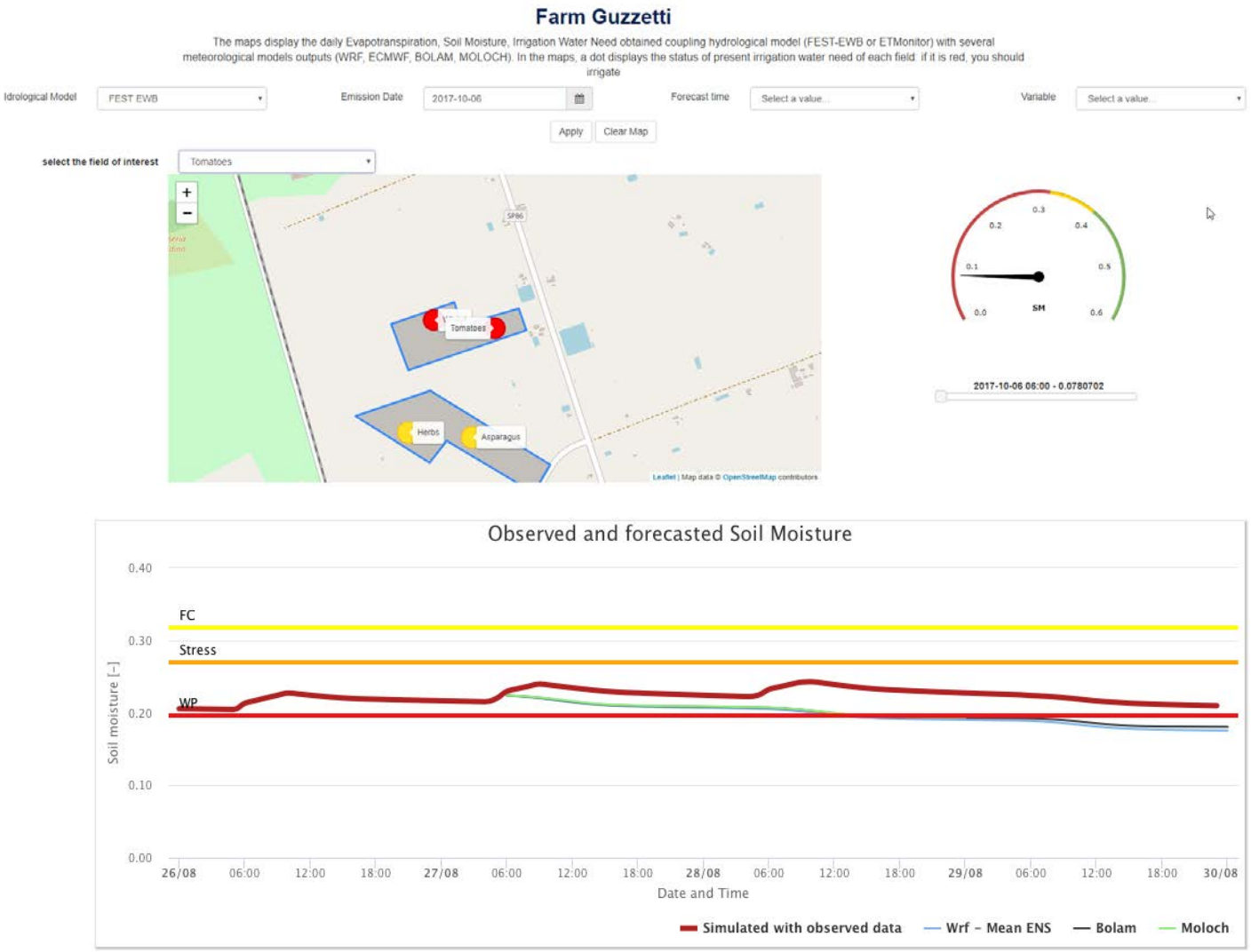
The SIM web-dashboard – farm scale



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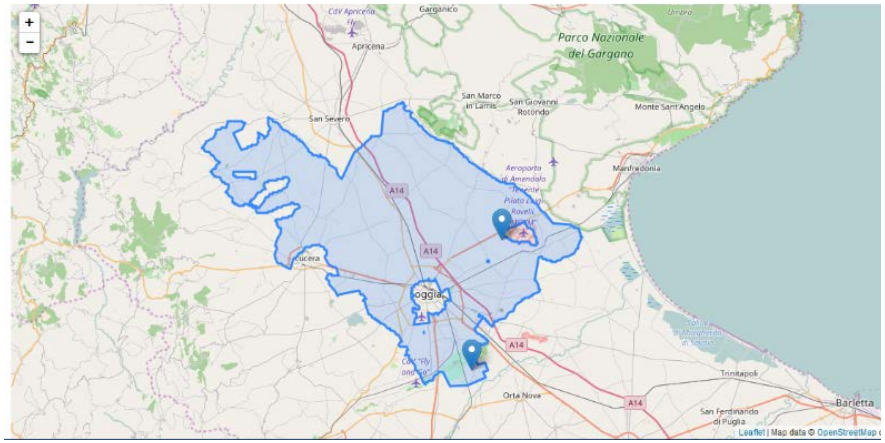
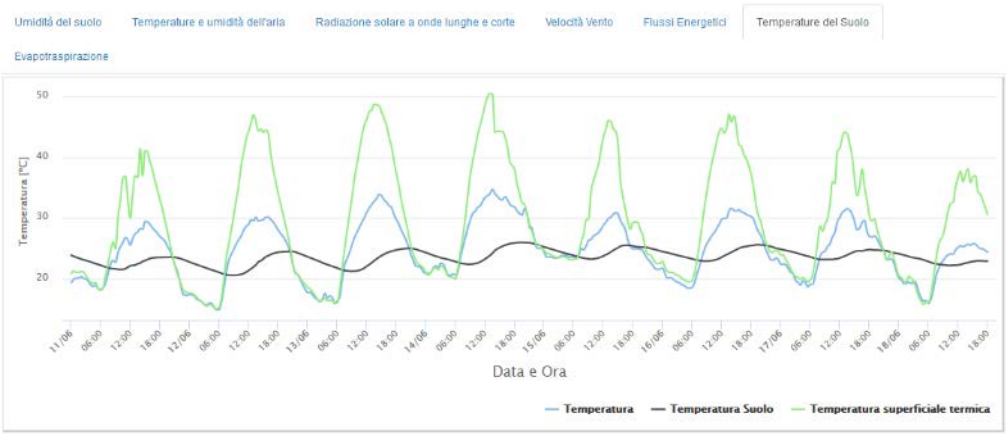
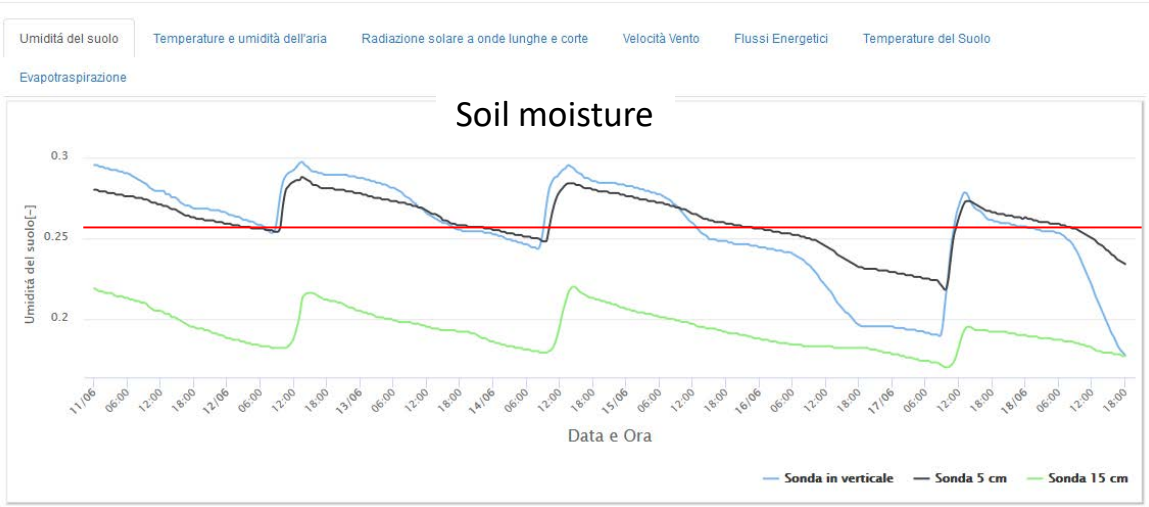
The SIM web-dashboard – real time monitoring

Real time monitoring stations

IRRIGATION DISTRICT FARM Areas







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Reanalysis results

Tomatoes comparison

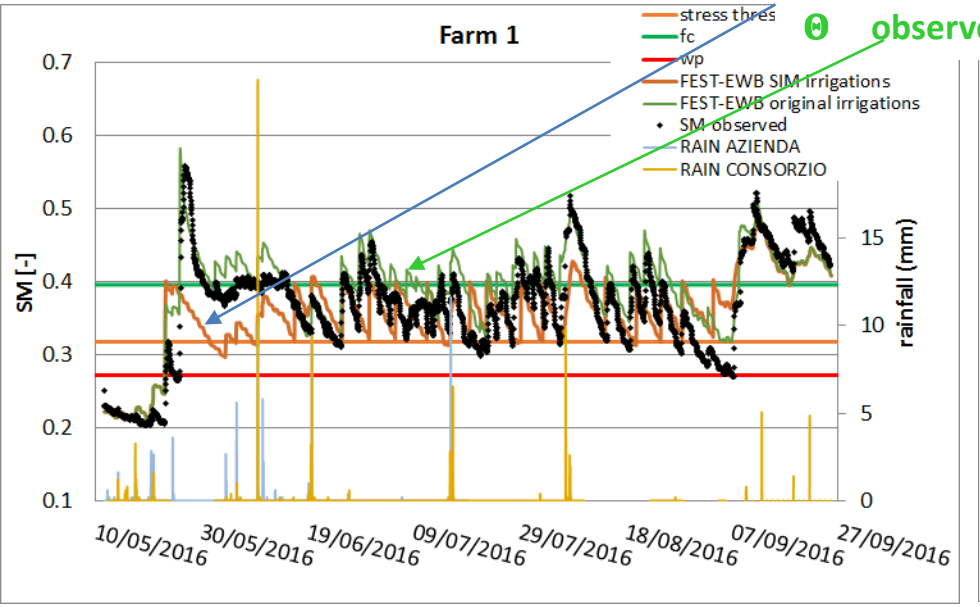
Irrigation rate and timing reduction of percolation losses

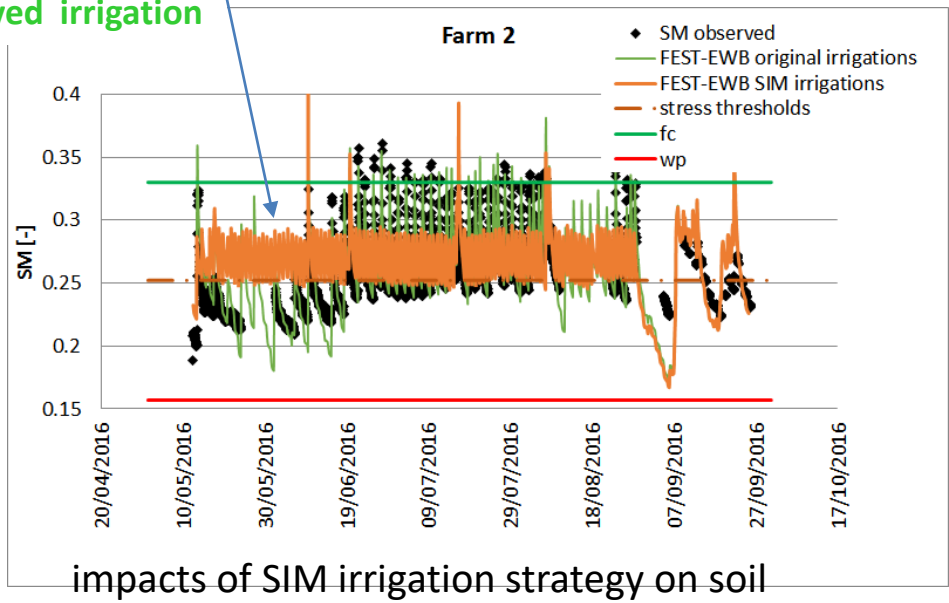
Silty clay soil

Sandy soil

θ SIM IRRIGATIONS

θ observed irrigation





		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

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Concluding remarks

Real time application of hydrological models are useful for managing both flood events and irrigation scheduling

In dense urban area flood forecasting systems are good solutions to mitigate flood risk. Multimodel approach is required for convective events

Satellite images provide near real time information to update hydrological models

Soil moisture forecast can decrease water consumption for irrigation and help farmers to decrease production costs

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THANK YOU FOR YOUR ATTENTION